



The Highland Landscape

**An ecological evaluation
of land suitability for urban development
in the southern portion of the Highland District,
Capital Region of British Columbia**

by
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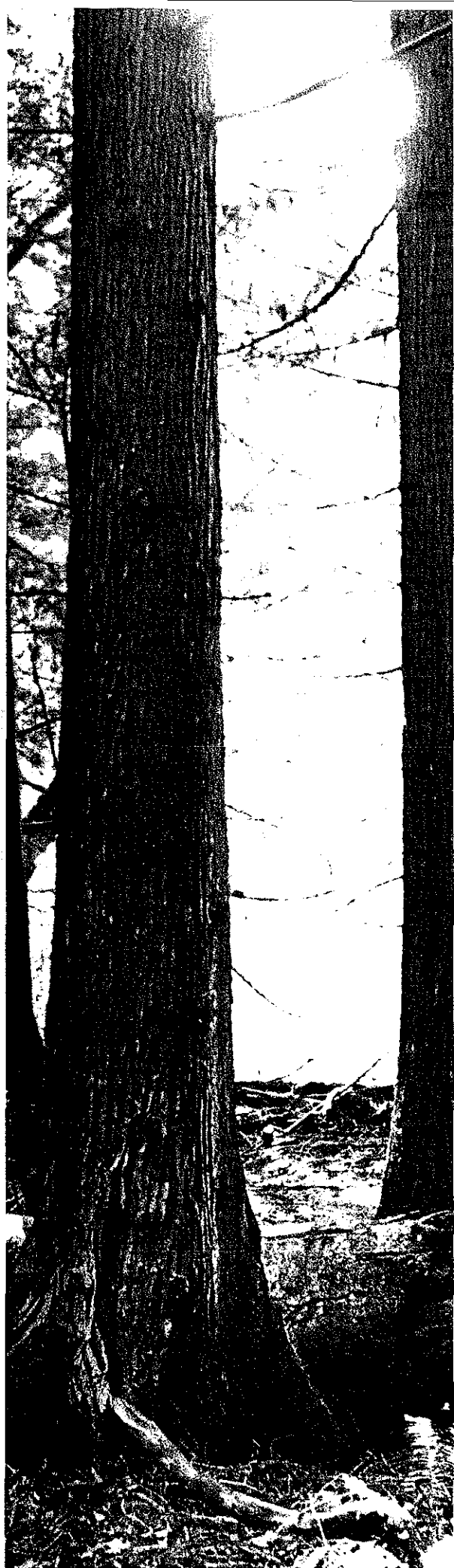
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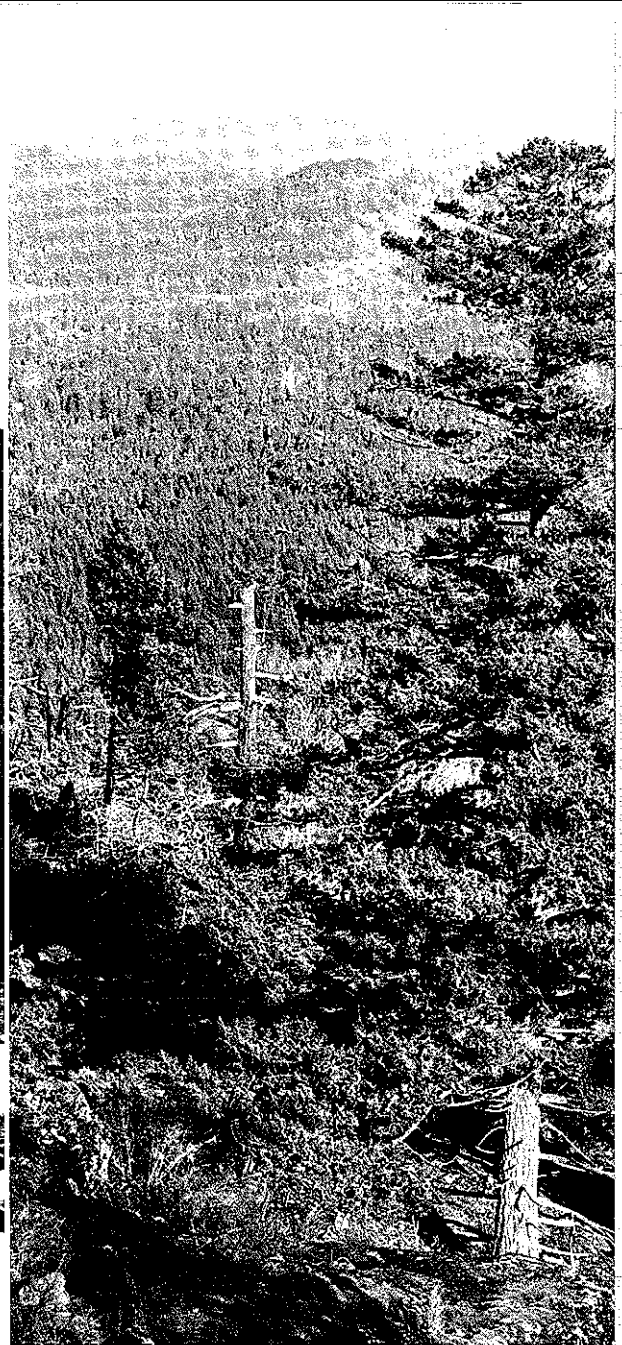
ABSTRACT

General information, history, climate, physiography, geology, soils and hydrology of the area proposed for development in the southern Highland District of the Capital Region of British Columbia are summarized. Eight landscape units were described in terms of their physical, environmental and vegetational characteristics, and a map was prepared showing the distribution of these units throughout the area. Each landscape unit was evaluated for its suitability for the proposed development, social costs and the impact of urbanization and resulting human activity on the environment, soils and vegetation. The purpose of this study is to provide the environmental background for planning a community in an area covered entirely by second-growth forest.

RESUME

Sommaire des informations d'ordre général, de l'histoire et des conditions climatiques, physiographiques, géologiques, pédologiques et hydrologiques de la zone proposée pour le développement du district sud "Highland" de la Région de la capitale de la Colombie Britannique. Description de huit unités de paysage d'après leurs caractéristiques physiques, écologiques et floristiques, avec carte montrant la distribution de ces unités à travers la dite zone. Évaluation de chaque unité de paysage quant à son appropriation au développement envisagé, à ses coûts sociaux et aux effets de l'urbanisation et de l'activité humaine qui en résulterait sur l'environnement, les sols et la végétation. Cette étude vise à fournir les données écologiques pour étayer la planification d'une communauté dans une zone entièrement couverte par une forêt de seconde venue.







INTRODUCTION

The trend of population distribution in Canada shows a remarkable degree of metropolitan growth. This tendency will continue, regardless of growing opposition, because cities provide better job opportunities and a greater variety of life-styles. Realistic planning policies must accept some growth as inevitable, and aim at enhancing the quality of life and improving the efficiency of services and administration.

Since population growth cannot be halted or diverted elsewhere, it must be judiciously distributed in a manner that conforms with the physical, social and economic goals of the Region, incorporating the capacity of the Region to realize its objectives. The planned development must be based on awareness of the need to manage natural resources. The aim of this planning must be to create, from a natural landscape, an inhabited environment in which the expected population can be accommodated without excessive despoilation of nature.

Planning requires presentation and examination of the costs and benefits of possible alternatives. This requires a population projection and housing market analysis, with determination of demand by type, price and location, and the resolution of demand in relation to supply.

Recognition of the inventory of the site, including all inherent natural processes as social values, must precede any prescription for its use. Planning then becomes a problem of evaluation. Often the characteristics of the natural processes are such that the site is suitable for a multiplicity of land uses. Flat areas with deep, well-drained soils may be suitable for agriculture and forestry, as well as development, intensive

active recreational, institutional and commercial use and possibly industrial use. Areas of diverse topography and high scenic interest are suitable for open space, passive recreation and conservation, and may be highly desirable for residential development. Where two or more uses are equally suitable, society must make the choice.

Conflicts of interest need to be resolved. Multiple use of some areas may be permitted where intrinsic values are not in danger of being destroyed. Elsewhere, because of scarcity, values, natural limitations or legal restrictions, certain resources may represent such a high value that they must be preserved within the development area and thus constitute an inflexible element controlling the pattern of the development.

In the Capital Region, an adequate area of suitable land is available for development. The high and continuously rising land values around the urban areas forecast the imminence of further growth. But uncontrolled growth would assume the same form as it has in the past, spreading without discrimination and slowly but surely obliterating the beautiful landscape of the Region.

In 1973, a study was conducted in the Capital Regional District of British Columbia (1) summarizing, on an area of approximately 200 square miles (500 km²), the natural resources and their potential relative to urban development. In broad terms, it covered climate, atmospheric pollution dispersal, geology, soils, including their stability and suitability for septic fields, hydrology, water supply, flooding and ponding, vegetation, forest and agricultural suitability, wildlife inventory, recreation and present land use.

Because of the large area of the region and topographic variation, several possibilities presented themselves to direct future development into certain areas (2). On the basis of this preliminary study, the Official

Regional Plan for the Victoria Metropolitan Area designated approximately 3,500 acres (1500 ha) of land in the southern part of the Highland District for future urban development (3).

However, to implement the planned substantial modification of population distribution, which would replace the urban sprawl by compact urban areas surrounded by contiguous open space areas, large-scale public land ownership was needed. By now, most of the area under consideration is in public ownership or purchases are being negotiated.

The present study is a detailed survey of the environmental characteristics of the proposed site, pertinent to the expected development. It intends to show that each area has an intrinsic suitability for certain land uses and that certain areas lend themselves to multiple coexisting land uses. It explains why development may take place in certain areas and why other areas should be reserved for open space.

The approach is simple, logical and rational; it is based on what is known about geology, climate, hydrology, soils and plant and animal ecology. While the conclusions are subjective, any person accepting the evidence of these sciences would probably reach similar conclusions. However, they should be improved and modified as new information becomes available.

The mapping was done from low-level (approx. 300 ft., 90 m), color photo transparencies (scale 1:2400) taken at the time of leaf flushing. While vegetation had not developed fully to obscure the ground, the differences in color of developing leaves permitted identification of the most important species. This detailed air survey eliminated the necessity of extensive groundwork. The resulting landscape unit map is an expression of physical and ecological factors. Original maps were drawn at a scale of 1:2400 (1 inch = 200 feet). The scale of the present map is 1:10,000.

GENERAL DESCRIPTION AND HISTORY

The proposed development site is located about 10 miles (16 km) from the City of Victoria, 2 miles (3 km) north of Highway No. 1, on Millstream Road (Fig. 1). The centre of the area consists of a shallow basin, 300-500 feet (100-170 m) above sea level. The basin is protected along the western boundary by high relief, Mt. Finlayson, a steep cone of Sicker volcanic material (6), 1365 feet (410 m) high, and massive Skirt Mt., 1120 feet (336 m) high. North of the basin, the land rises to over 700 feet (210 m), double-peaked Scafe Hill, 850 feet (250 m), being the highest point. The topography is generally rugged, even in the basin.

From the amount of charcoal in the soil, it appears that the area has had an extensive fire history. Fires in 1854 and 1860, probably caused by man, killed all small trees on an area of at least 600 acres (approx. 2.5 km²) north and west of Florence Lake and opened the stands for grazing sheep and cattle. The area was periodically re-burned to suppress shrubs and encourage vetches. South of McKenzie Lake, a fire in 1885 destroyed all trees on an area of over 500 acres (2 km²). Smaller fires were frequent throughout the area.

The first forest inventory took place in 1875. The sites were generally low in productivity; the average height of mature Douglas-fir was only 80 feet (24 m). But Victoria and Esquimalt provided nearby markets, and from 1877, several gangs of cordwood cutters operated in the accessible areas of the southern Highlands. Logging activity started around 1884 in the Craigflower Creek drainage and, in 1885, the eastern part of the study area was extensively logged and slash burned (Fig. 2). The logging was in the form of "highgrading", and removed only the best Douglas-fir. It is probable that some logging also took place in the Millstream Creek drainage. From the location of old roads, it appears that the sawmill was located in Millstream Creek near Esquimalt Harbour. But evidence of any earlier logging activity is obscured by large-scale logging and slash burning which took place in the Millstream drainage in 1920 and 1921. This logging was also a form of highgrading, and left low-quality trees standing. These trees were gradually removed from 1936 to 1942.

Slash burning and wild fires prepared the soil, and small-scale logging and highgrading left trees for ample seed source within a short distance. The area regenerated predominantly to Douglas-fir, but red cedar, red alder and bigleaf maple on moist sites, and lodgepole pine, arbutus and oak on dry sites, usually constitute an important portion of forest composition. Because of past history, the area is a mosaic of different age groups, but stands that originated after the 1920 to 1921 logging are most common, especially west of Millstream Road. East of Millstream Road, after logging during 1885 and fires from 1880 to 1896, a large area regenerated to Douglas-fir. Several stands which originated at that time still exist, others were logged when they reached commercial size and thus young age groups (less than 30 years) are also well represented.

Since the time of logging, evidence of human activity in most of the area is minimal. Sites capable of bearing trees are generally overstocked; thinning would increase their growth and improve their appearance. A few permanent residences were built along Millstream Road and around Teanook Lake, but their influence does not extend beyond their immediate vicinity.

CLIMATE

The climate of the study area is influenced by two regularly occurring, large-scale air flow patterns. Winds blowing from the northeast bring comparatively cloudless weather. During periods of southwesterly flow, the terrain differences produce striking local variations in cloudiness and precipitation. While Victoria and the eastern lowlands of Saanich Peninsula may be completely cloud free in the drier air that follows a frontal passage, Finlayson and Skirt mountains act as cloud generators and send lines of clouds and showers eastward along their outrunning ridges. These cloud patterns are consistent over the study area and occur even when conditions are barely adequate for cloud formation.

More frequent and heavier cloud cover in the study area results in higher precipitation, amounting to about 45 inches (1100 mm) annually, compared to 26 inches (650 mm) at Gonzales (Fig. 2b). The precipitation is highly seasonal, with about 85% occurring from October to April (Fig. 3b). Summers are dry. While exact data are not available, extrapolations (4) suggest that 2 inches (50 mm) of rain in 24 hours may

Fig. 1. Location of the study area in relation to the existing municipalities and major parks (heavy line).



Fig. 2. Aerial photograph of the area and its immediate vicinity

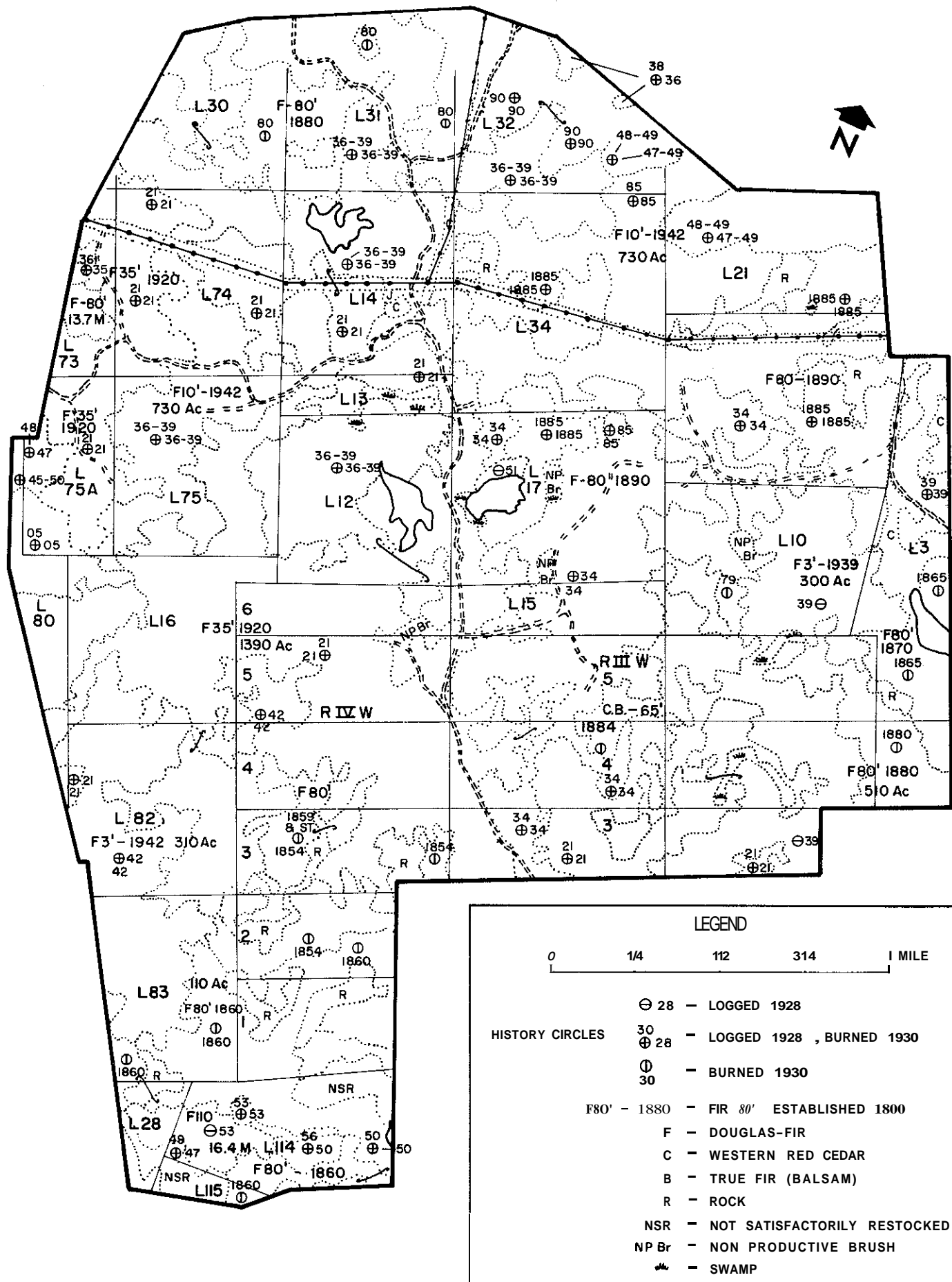


Fig. 3. Forest cover map - History from 1854 to 1956.

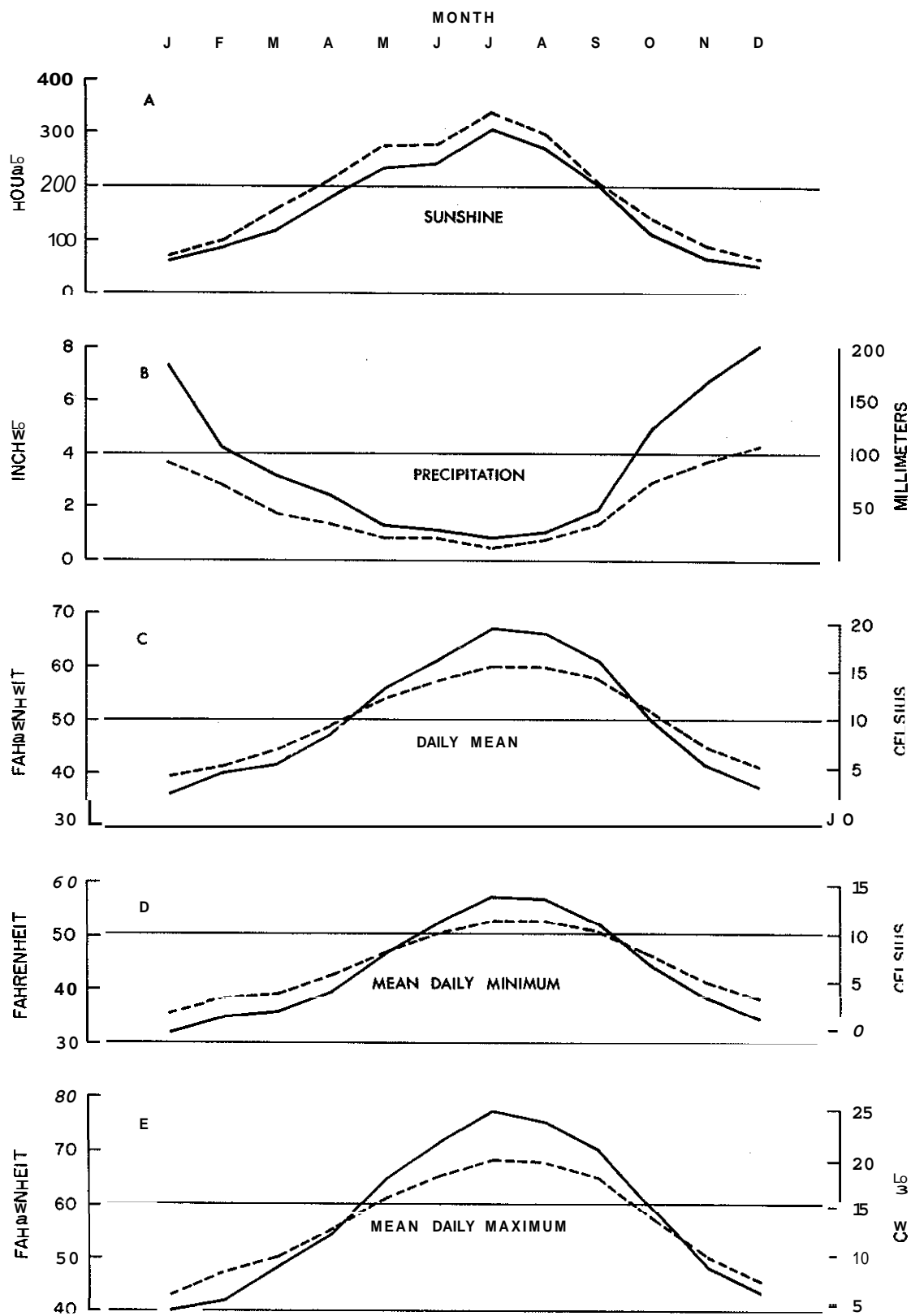


Fig. 4. Sunshine, precipitation and temperature of the study area compared to Victoria

occur several times a year and that 4 inches (100mm) in 24 hours probably has occurred during the past 25 years. On an average, 3 inches (75 mm) of precipitation are in the form of snow. The snow cover ranges from as little as 6 inches (15 cm) in some years to about 36 inches (90 cm) in others and may last from a few days to about 7 weeks. A snowfall of more than 24 inches (60 cm) is known to have fallen in 24 hours.

The study area has approximately 1900 hours of sunshine annually (4), about 300 hours less than Gonzales Observatory (Fig. 3a). The difference is most noticeable in early mornings during spring and fall; in summer, when the air is drier, the cloud pattern is similar to that of Victoria.

Generally, temperatures of the study area are colder in winter and warmer in summer than in adjacent areas to the east and south. The mean daily temperature in January is approximately 36°F (2°C) compared to 39°F (4°C) at Gonzales; the mean daily temperature in July is about 67°F (19°C) compared to 61°F (16°C) at Gonzales (Fig. 3c). Mean daily temperature maxima and minima are also more extreme in the study area (Figs. 3d and 3e). Extrapolations (4) indicate that the extreme minimum temperature in the past probably dropped below zero Fahrenheit (-18°C), and that temperatures of 10°F (-12°C) may occur every few years. Temperature maxima of 90°F (32°C) are not uncommon, and above 100°F (38°C) are possible with about a 25-year frequency.

The high relief along the western boundary protects the lowland from winds. Lack of turbulence permits cold air, which drains from sparsely covered higher rock outcrops, to accumulate in low-lying areas. Consequently, the growing season is shorter in the study area than in the more exposed eastern parts of Saanich Peninsula. The frost-free period averages about 190 days compared to Gonzales with 280 days or Saanichton with 230 days. Any large-scale clearing may compound the frost problem unless proper management is undertaken. Building and road construction may re-direct the flow of cold air and cause frost damage where it was not experienced before.

The topography of the study area is conducive to fog formation. However, because of continuous forest cover, it is not a serious problem at the present time, but any large-scale clearing will increase radiation cooling and the incidence of fog.

It is unlikely that air pollution resulting from urbanization will become a problem in the study area. However, lack of air turbulence and frequent temperature inversions, especially during calm weather in the fall, may temporarily increase the amount of air pollutants.

PHYSIOGRAPHY, GEOLOGY AND SOILS

The physiography of the area can best be described in terms of geological history. The bedrock originated during Carboniferous and Devonian periods. It is composed of volcanic material, mainly meta-andesite, but locally, dacite, tuff, breccia or greenschist predominate (5). The topography has been modified during several glacial and interglacial periods. The present landscape is a result of Pleistocene glaciation that occurred 10,000 to 15,000 years ago. During glaciation, massive ice sheets advanced from the north, overriding most of Vancouver Island, and completely filled the straits between the island and the mainland. The weight of ice depressed the land mass approximately 300 feet (90 m) relative to sea level. As the glacier melted, the ice was replaced by sea water and the land gradually uplifted. Glacial meltwater established drainage patterns, cut river channels, and subsequent erosion further modified the terrain and surficial materials.

With the exception of the south-western portion, the study area has low relief (Fig. 4). Rock outcrops, smoothed by the glacier, bare or covered with about an inch of organic soil on a few inches of mineral soil, are frequent throughout the area.

Because the study area has an altitude of more than 300 feet (100 m), marine deposits are non-existent. Generally, on moderate slopes, glacial till soils predominate. They often have two distinct layers. The lower layer, a mixture of sand 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 the consistency of concrete.

As the glacier retreated, the loose material lying within and upon the ice was deposited over the terrain. Where it was not subsequently transported 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 angular rocks from different sources. This layer of loose till rests on the compressed, impervious till or on bedrock. Together with some weathered products of the substratum, it constitutes the mass from which the soils developed.

Gravity and large volumes of rapidly moving meltwater and subsequent erosion removed glacial deposits from high elevations and steep slopes, exposing the bedrock. Large rocks were deposited at the foot of

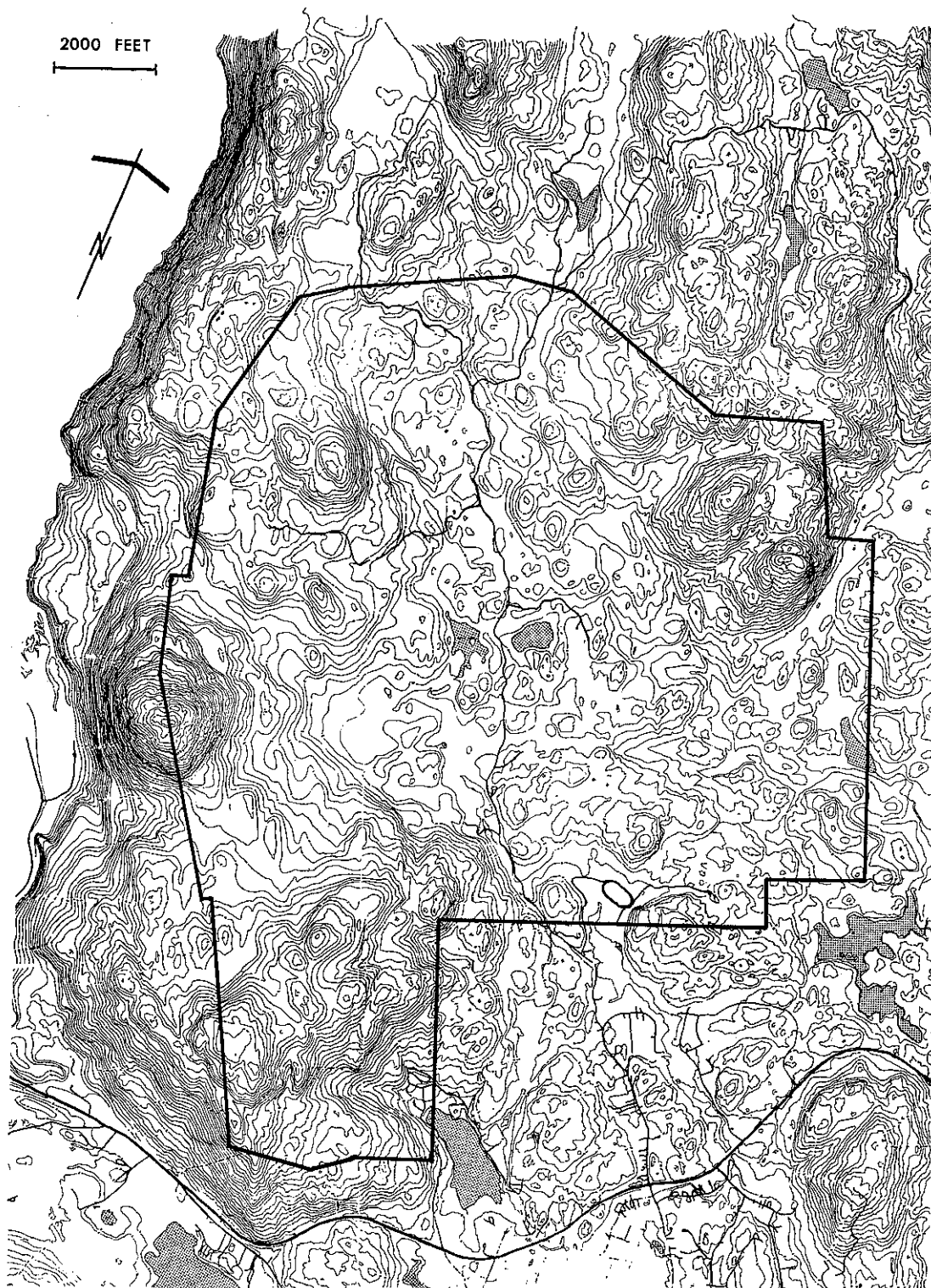


Fig. 5. Topography of the area.

slopes, and gravel and coarse sand in the low-lying areas and along the streams. Fine-textured material was carried further to the south beyond the study area and into the sea. After the ice receded, the volume and velocity of water was reduced and erosion progressed slowly. A thin capping of fine sand was deposited over gravelly sands in low-lying areas and along the banks of streams. Periodic flooding during periods of rapid run-off continues the deposition of fine material upon the current flood plains.

Colluvial action, weathering, erosion and the addition of organic material, living and dead, have produced the present soils. They are generally coarse-textured, ranging from gravelly sands to sandy loams. The surface mineral horizon is darker from deposition of organic compounds leached from organic horizons. Iron and aluminum oxides, leached from the upper horizons, have produced a reddish color at a depth of about 6-20 inches (15-50 cm). Plant roots are distributed throughout, but usually form a dense mat near the surface where nutrients are most abundant, and often on the surface of the compacted till where seepage water flows.

HYDROLOGY

The soil moisture deficit in the study area is about 13 inches (330 mm), but varies considerably with aspect, exposure, soils and ground cover. The onset of moisture deficit is around the 1st of May. It ends by the end of September and, by the end of October, the soils are saturated. Summer precipitation (about 7 inches, 170 mm) does not increase runoff and stream flow because the rains are light and water is absorbed by dry and porous soils. Streams, swamps and lakes depend entirely on the ground water supply. In some lakes (e.g. Teanook), the water level drops below the outlets, swamps become dry and creeks become trickles seeping through the gravel.

Allowing 4-6 inches (100-150 mm) of precipitation for winter evapotranspiration, 2-5 inches (50-120 mm) for water storage capacity of the soils, which becomes available for evapotranspiration during the growing season, and 6-10 inches (150-250 mm) for ground water storage, a total of approximately 20-25 inches (500-600 mm) of water is available for runoff in the study area during the winter (October to April). This amount of water is so great that the lakes, through which the main streams flow (e.g. Matson), have their entire content flushed out at least every 2 to 3 weeks.

Even lakes situated off the main stream (e.g. Teanook) have their water exchanged at least twice during the winter.

During the winter, lake and stream water is soft; during the summer, the content of dissolved minerals increases. Water quality and purity are very high, although algae are fairly abundant in summer; in winter turbidity may be frequent. The main constituent of turbidity is suspended sediment (e.g. 40-80 ppm in May). Water color is brown from decomposing vegetation. Light penetration (Secchi disc) is about 12 feet (3.5 m) in May (7).

The temperature of lake water starts to increase in late March, and in late July and August, the upper layers are usually around 70°F (22°C). The cooling starts around the middle of August and the "turnover" occurs at around 48°F (9°C), usually in late October. During the winter, the water temperature remains relatively steady between 40 and 44°F (4 and 7°C).

Ground water resources were not studied. From information collected in other parts of the Highland District and western Saanich, the water wells in the study area would have to be at least 130 feet deep, with those on higher ground probably as much as 300 feet deep. The amount of ground water would suffice only for a low population density.

The study area encompasses parts of four drainage systems (Fig. 4). About 40% of the area is drained by Craigflower Creek, flowing southward into Portage Inlet; about 55% by Millstream Creek, flowing southward into Esquimalt Harbour, and about 5% drains directly into Finlayson Arm to the west. A small area of Skirt Mt. drains into Goldstream River which flows into Finlayson Arm.

Craigflower Creek has its headwaters in the steep parts of the Highlands, only a portion of which is on the map area (Fig. 1). Shallow, rocky, thinly forested slopes prevailing there are a source of rapid, concentrated runoff. The western side of the central drainage, comprising most of the Craigflower drainage on the map, has generally low, hilly topography with frequent rock outcrops and deep soils in between. The runoff from this area is moderate but prolonged. Before the stream enters McKenzie Lake and the main Craigflower channel, stabilization of the flow takes place as water passes through a network of swamps. Consequently, the lower reaches of Craigflower Creek have a fairly uniform flow.

Millstream Creek has its headwaters to the north of the map area. The runoff from the steep, rocky ridges with shallow soils and thin forest cover is rapid, but stabilization takes place on coarse till, colluvial and

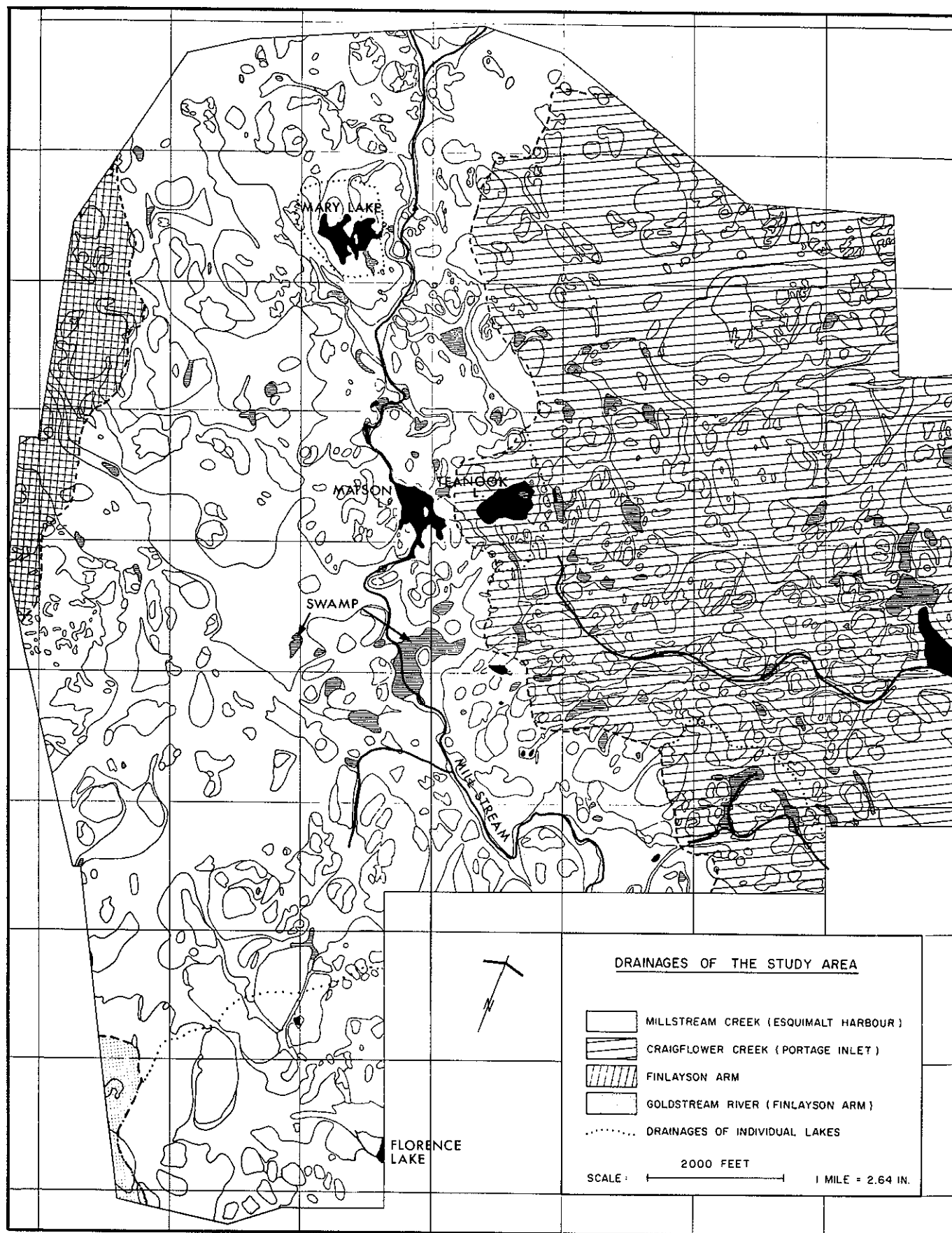


Fig. 6. Drainage systems.

alluvial soils in depressions separating the ridges. In the main valley, consisting of permeable post-glacial alluvial gravels with several shallow lakes and swamps, the flow is delayed and staggered. The map area of Millstream watershed consists of a wide valley of low hills and depressions. This part is more wooded than the headwaters and has a slow and prolonged runoff. Consequently, the flow of Millstream Creek through the map area is fairly even. The Florence Lake area, which drains into the lower reaches of Millstream Creek, has a steep topography with shallow soils. It is subject to fast runoff, and the lake, having a low gradient and slow discharge channel, is subject to wide fluctuation in size and depth.

Western slopes north of Mt. Finlayson have topography and soils similar to the upper watersheds of Millstream and Craigflower creeks. The runoff is fast and water drains through several gullies directly into Finlayson Arm of Saanich Inlet.

The small area of Skirt Mt. that drains into Goldstream River is composed only of rock outcrops and soils less than 6 inches (15 cm) deep. Water holding capacity is minimal; the runoff is very rapid, but concentration of runoff does not take place because of the immediate proximity of the drainagedivide.

LANDSCAPE UNITS

The landscape units mapped in the study area are composite units that take into consideration physiography, exposure, slope, soils, drainage and vegetation to express similarity in habitats, within the general environment already described. The scale of the map (1:10,000) does not allow depiction of small intrusions that occur within each landscape unit. Intimate mosaics of several units had to be shown either by the most prevalent unit or by the average unit, as deemed best for each situation. The mapping is based on the assumption that the boundary lines between the units are definite and the habitat on one side of the line differs significantly from that on the other side. While this is true in most cases, in others the boundary lines are subjective interpretations.

1. Solid rock landscape unit (Figs. 7 and 8)

The solid rock landscape unit comprises hill tops and steep slopes of exposed volcanic rock smoothed by glacial abrasion. Within the study area, it can occur at

Fig. 7 In solid rock landscape unit, the rock was smoothed by glacial abrasion and soil is non-existent.



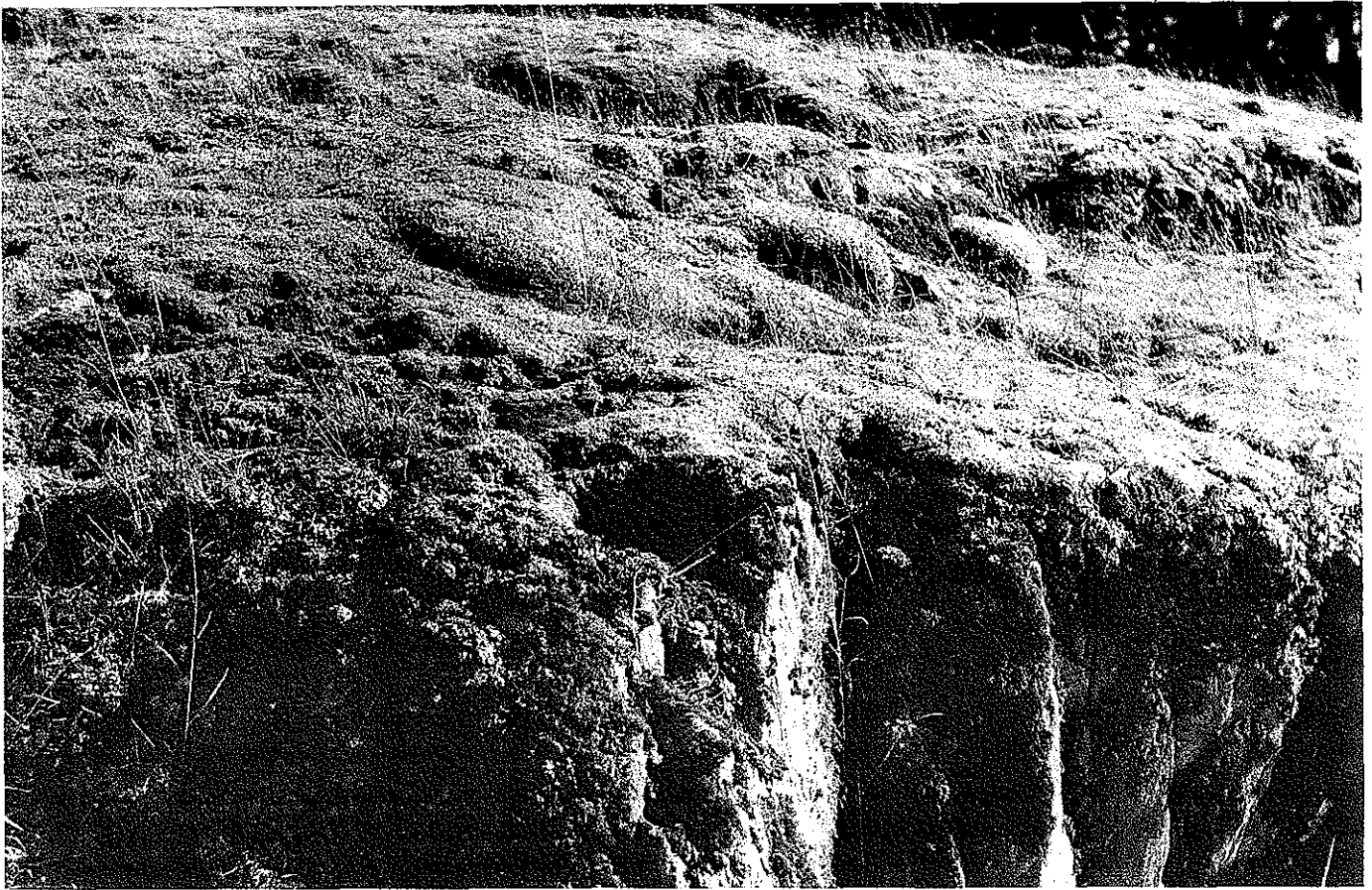


Fig. 8. Solid rock landscape unit comprises steep cliffs: access may be difficult.

any elevation. Soil is either non-existent, or occurs as a very thin layer of coarse sand, derived from the weathering of rock "in situ". The mineral soil is dark in color due to the incorporation of organic material from decomposing remains of lichens and mosses.

By the composition of vegetation, the solid rock landscape unit corresponds with the Garry oak - shrub community (1). Stunted trees (Garry oak, arbutus, Douglas-fir and lodgepole pine) and shrubs (ocean spray, salal and bearberry) are widely spaced, growing only where their roots can penetrate into crevices. The bare rock surface itself is covered with crustose lichens and mosses. The dense carpet of moss retains sufficient moisture into late spring to allow a host of spring flowers to grow. While the diversity of species involved is not great, their abundance makes the spring aspect of the solid bedrock site spectacular. Blue-eyed Mary, satin flower, fringe-cup, camas and monkey flower are probably most conspicuous in the open, whereas "rockland ferns" (*Polyypodium* and *Pityrogramma*) are frequent in shaded areas and on north-facing cliffs.

Because of the steepness of the terrain and general lack of soil, the natural vegetation cover is easily damaged and, when disturbed, requires considerable time to become re-established. To maintain the natural vegetation, while allowing for recreational use, 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 these sites may create "desert" conditions, devoid of all life.

The massive bedrock provides a solid foundation for any type of structure and, for residential development; this landscape unit, with open space and attractive vegetation, provides a desirable environment. However, levelling, provision of access and services and construction will be costly. Because the soil is extremely shallow and internal drainage non-existent, except through rock crevices, the runoff, after the moss layer is 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.

This unit is ideally suited for open-space and green-belt purposes, especially since it does not require any buffer zone. The uniqueness and scarcity of this unit warrants consideration of its conservation, at least where it still occurs in its natural state.

Fig. 9.

In broken rock landscape unit. trees grow in crevices of the rock.

Fig. 10.

Boulder fields are forested, main species being Douglas-fir.



2. Broken rock landscape unit (Figs. 9 and 10)

This unit coincides approximately with the Arbutus-Douglas-fir community (1). It occurs where a thin mantle of soil (less than 6 inches, 15 cm) has accumulated over bedrock, where boulder fields were deposited by the glacial action or where the bedrock was broken up at the surface by weathering processes and the soil accumulated in interstices. The lithic soil has little development except for organic staining. The rocks are overgrown by crustose and fruticose lichens and mosses but, in crevices, where moisture is retained, trees and shrubs become established. The tree species are identical to those that occur on the solid bedrock (Unit 1), with arbutus usually most common. The presence of Douglas-fir depends on logging history and stage of development of the stand. The tree spacing, while open, is dependent on the nature of the rock material and the amount of accumulated soil, and is usually somewhat denser than on the solid rock unit. Most species of shrubs, forbs and mosses occurring on solid bedrock occur also in this unit, but several deep rooted species are also present, where soil depth permits their survival. Shrubs, such as rose, huckleberry, trailing blackberry, Oregon grape and salal; forbs, such as tiger lily, easter lily, chocolate lily, star flower, lady slipper, buttercups, and grasses occur frequently.

Because the microsite varies from bare-rock surface to deep fissures filled with organic material, the stability of the ground vegetation is also variable. Trampling will cause denudation of the rocks and loss of thin patches of soil. The greatest damage would occur during the dry summer months, when the moss layer is dry and brittle and the coarse sand is prone to being shifted about. Well marked trails, to control traffic, should be provided to prevent damage to the vegetation and soil.

If preservation of the natural vegetation is not desired, the broken rock landscape unit is amenable to many uses. Consolidated bedrock is close to the surface to provide good foundation support for large buildings. This site usually provides an attractive setting for residential development, with open-grown arbutus, Garry oak, Douglas-fir and interesting spring flowers. However, steepness of slope may impose limitations. In construction, the size of rock particles determines the difficulties of their removal, from large boulders requiring blasting to rocks easily moved by blade. Generally, provision of access and services will be costly. Landscaping will require the addition of fill and top soil. Internal soil drainage is usually good, but because of the steepness of the terrain, the runoff

may create serious erosion problems. Similar to the solid rock landscape unit, an intensive residential development will degrade the aesthetic beauty of the unit.

The broken rock landscape unit is also ideally suited for open space or greenbelt purposes and warrants consideration for conservation where it occurs in its natural state.

3. Shallow soil landscape unit (Figs. 11, 12 and 13)

This unit is the most prevalent; it occupies sites of intermediate position and was little disturbed by settlement or agriculture. It corresponds approximately with the Salal - Oregon grape plant community (1). Typically, it occurs on moderate slopes where soils have accumulated to a depth of 6 to 36 inches (15 to 90 cm). 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 and a grayish-brown lower horizon. A grayish, thin, eluviated layer at the surface may be present. Because of the general paucity of fine-textured mineral and organic material, released nutrients not absorbed by plants are leached during winter rains. Consequently, the fertility of the soil is low. While stable when covered by vegetation, these sites are prone to rapid erosion when the vegetation is removed and the soil disturbed, especially on steeply sloping land. As in most dense coniferous forests, Douglas-fir in this landscape unit is prone to wind-throw and wind-break after opening of the stand. Invasion by shrubs and weeds is common, but does not hinder the regeneration of trees.

On the drier sites of this landscape unit, such as flat hill tops, where soils are usually less than 18 inches (45 cm) deep, and on southern exposures, stands of Douglas-fir with a mixture of lodgepole pine, arbutus and Garry oak predominate. Where soils are deeper, and on the northern slopes, Douglas-fir and grand fir prevail and stands are often excessively dense. Salal and Oregon grape are characteristic plants for this unit. On the drier sites, rose, broom and trailing blackberry, and on moister sites, huckleberry,

Fig. 11. Shallow soil (12 inches, 30 cm) over bedrock support open stands of arbutus and Douglas-fir.

Fig. 12 Where soil accumulated over boulder fields, open stands of Douglas-fir are common.



11



12



Fig. 73 Dense stand of Douglas-fir with salal ground cover on mineral soil of about 3 feet (1 m) depth, over broken rock.

juneberry and ocean spray are common. Because of a dense tree and shrub cover, the shade intolerant forbs are not abundant. Lupine, vetches, strawberry, yarrow and buttercup occur around the stand edge and in openings, while shade tolerant star flower and easter lily may 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 *Eurynchium oregonum*, *Hylocomium splendens*, *Rhytidiadelphus loreus* and *Dicranum* spp. Lichens are common on tree bark and branches.

This landscape unit offers little obstruction to residential development, and the loss, in a small area, of this generally common unit is an insignificant social cost. Further, the influence of human activity will not extend far beyond the area intensively used. Resiliency inherent in this unit will reduce any damage to the natural environment. Solid rock within 36 inches (90 cm) in depth provides an excellent foundation support, and loose, gravelly, sandy soil can easily be moved for construction or installation of services. However, sloping terrain may force local limitations on residential development. Landscaping and ground maintenance should not be difficult, except on steep

slopes where protection from erosion will be needed.

This landscape unit has an excellent carrying capacity for recreation, but the dense coniferous forest and shrubs make it 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 playgrounds and other intensive recreational uses. Because natural vegetation will hardly be suitable for intensive recreational use, 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, which are wind-firm, and natural forest edge should be left as boundaries around artificial openings wherever possible.

This landscape unit has low forest productivity, but if profit is not the main motivation, greenbelts could be combined with commercial forest production to defray some costs. Selective logging and patch logging would even enhance the aesthetic value of the greenbelt. In the study area, greenbelts can be planned to best fit the proposed development, as no stands were found with an exceptionally high value or which would warrant special consideration.

4. Deep soil landscape unit (Figs. 14 and 15)

This unit occupies lower slopes of hills and flat lowlands. Ecologically, it corresponds approximately with Swordfern and Swordfern - Salal plant communities (1). The soils are derived from coarse-textured glacio-fluvial material, which accumulated in lowlands, and often became covered with alluvial deposits of variable thickness. Generally, they are of loam or sandy-loam texture with gravel and larger stones present in variable proportions. The soil depth is usually more than 40 inches (1 m). The loose soil material is underlain either by bedrock or a layer of compact till which is essentially impervious to water and root penetration. Oxides and silicates of aluminum, iron and magnesium, leached from upper horizons, are deposited in lower layers. Seepage water is present over the impervious horizon for at least a part of the growing season. Because of the presence of seepage, a secondary concentration of roots occurs on the top of the impervious layer.

The combination of a large volume of loamy soil, moderate level of nutrients, fairly good water-holding capacity and seepage during at least part of the growing season provide, within the regional climate, good conditions for plant growth. Site index for Douglas-fir varies from 130 to 160 feet (38 to 48 m) at 100 years,

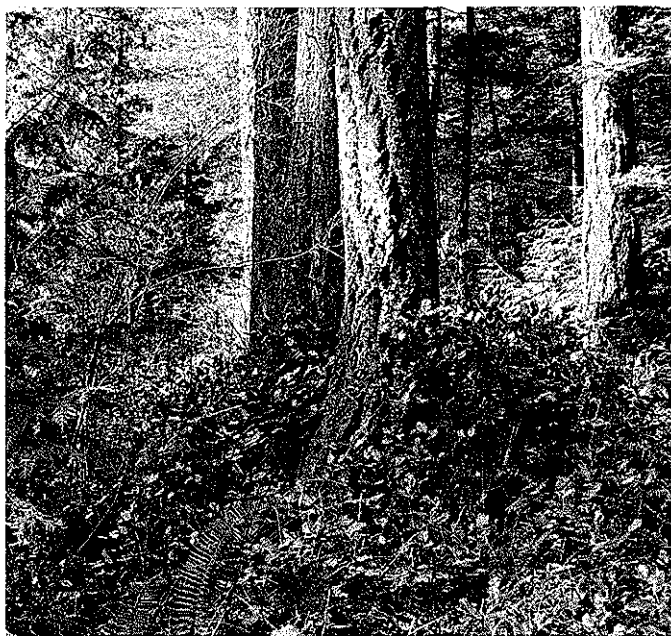


Fig. 14. Large Douglas-fir with cedar understory and swordfern and salal ground cover are typical for deep mineral soils on lower slopes.

Fig. 15. Deep mineral soils, when disturbed, regenerate usually to alder; later, Douglas-fir and cedar take over.



which is the highest forest productivity within the study area. Douglas-fir, grand fir, western red cedar, western hemlock, red alder, bigleaf maple and western dogwood form a closed canopy and eliminate slow-growing, shade intolerant arbutus and Garry oak from stand composition. However, on disturbed sites, lodgepole pine may become established and persist until overgrown and shaded by other species. The most abundant shrubs are willow, honeysuckle, salal and flowering currant under the tree canopy, and ocean spray, snowberry, goat's beard, buffalo berry, nine-bark, blackberry and rose along the forest edges and in openings. Numerous species of forbs occur, including those listed for the shallow soil landscape unit, plus orchids, lily-of-the-valley, trillium, vanilla leaf, foam flower, bedstraw, swordfern and several grasses and sedges. Numerous species of mosses, such as *Eurhynchium oreganum*, *Hylocomium splendens*, *Plagiothecium undulatum*, *Dicranum* spp. and liverworts cover the forest floor, stumps and logs, whereas *Isoetes spiculiferum*, *Orthotrichum* spp. and *Hypnum* spp. are common epiphytes on trees.

In the study area, the deep soil landscape unit is the best suited of all the units present, for residential or other development. Its loss will not be serious because it is a common constituent of the Vancouver Island landscape; although, in the study area, it covers only 9% of the terrain. Apart from damage to vegetation, which is generally intolerant to heavy trampling, this unit can sustain heavy use without serious harm. The influence of human activity will not extend far beyond the disturbed area.

Compacted till provides a good base for foundations, and the deep, loose surface soil permits inexpensive installation of underground services and roads. Removal of the loose soil overlying the compacted till produces essentially sterile conditions for many years. Provided the upper soil layers are preserved, landscaping and ground maintenance will not be a problem and erosion on the flat topography is rarely serious. Runoff and internal drainage are slower than on the previous unit, but rapid enough to prevent flooding. Drainage systems may be required where

Fig. 16. Cedar, with remains of alder, Some swordfern, but ground usually bare, because of shade and prolonged flooding, are typical for the organic soil unit.



impediments, such as foundation walls, restrict the natural flow of seepage water.

This landscape unit is probably not particularly attractive for hiking, being overgrown by coniferous forest and dense shrubs, but its carrying capacity for intensive recreation, such as sports fields and playgrounds, is excellent. Such development, of course, would mean replacing the original vegetation with lawns or a hard surface. Steep banks along water courses will need to be protected by vegetation to prevent erosion. Where heavy use and destruction of the vegetation can be expected, cribbing, meshing or other mechanical protection of the banks may be necessary.

Opening of the forest will expose the trees to wind. To minimize wind damage, the same measures should apply as mentioned in the previous unit.

This landscape unit has a good forest productivity, and the stability of its soils and resiliency of its vegetation suggest an excellent potential for greenbelt with multiple use forest management. The value of forest products would probably pay for protection, road construction and maintenance, and recreation facilities.

Under suitable management, this landscape unit could be used for orchards or grazing, but the lack of incorporated organic matter, the stony texture of the soil and insufficient inherent fertility constitute limitations to any form of intensive agriculture.

5. Organic soil landscape unit (Figs. 16 and 17)

This unit occupies flat, depressional areas, which were originally small shallow lakes or shallow bays of larger lakes. It includes the wet end of the Swordfern plant community and the Cottonwood-Crabapple-Willow community (1). The surface soil is formed by decomposing organic material of variable thickness from as little as 1 to more than 10 feet (30cm to more than 3 m). The mineral component of the surface layer usually consists of dust or fine textured sediment resulting from periodic inundation. However, with increasing depth, the proportion of mineral material of alluvial or lacustrine origin gradually increases. If the surrounding terrain is flat, the mineral component is mainly loam; if the terrain is steep, it may contain a considerable proportion of gravel and cobbles. Below this layer, which is still dark from high organic content, a layer of colluvial origin may occur, consisting of gravel and rocks embedded in a sandy or loamy matrix. This layer is usually underlain by compacted, glacial till or bedrock.



Fig. 17. Where more light penetrates to the ground, ferns under cedar canopy may be frequent.

Because of the naturally impeded drainage, free water is always available below the surface, but occurs at the surface only after heavy winter rains.

This landscape unit receives seepage containing nutrients from surrounding slopes, and nutrients are usually plentiful in the organic material. However, because of poor aeration, the cation exchange is dominated by hydrogen, resulting in acidic conditions and slow decomposition of the organic materials. Consequently, the release of the nutrients is slow and the unit is not very productive.

Western red cedar, grand fir, western hemlock, big-leaf maple, red alder, cottonwood and, occasionally, Douglas-fir on humps are the main tree species occurring in this unit and often form closed canopies, willow, crabapple and spirea are common in the shrub layer and, after opening, take over the entire area and prevent the re-establishment of trees.

Swordfern, vanilla leaf and miners lettuce are the most characteristic understorey species, but locally, foam flower, lady fern, lily-of-the-valley and bed-straw may be common. Bracken fern, grasses and sedges become abundant after opening. Mosses are plentiful on litter, logs, stumps and, as epiphytes, on trees. *Eurhynchium oreganum*, *Hylocomium splendens*, *Isoetes macrospora*, *Hypnum* spp., *Plagiothecium* spp. and *Brachythecium* spp. are the most common ones. Also, several species of liverworts occur in this unit.

The depressional position with impeded drainage and deep organic material with a high water holding



Fig. 18. *Spirea bog occurs where water is above ground surface for about 6 months a year*

capacity provides a water storage facility during floods, thus equalizing the stream flow. Occasional flooding makes this landscape unit unsuitable for residential development. Further, the organic material is not stable enough to support foundations or road beds. When drained, it will decompose, settle and shift. Any interference with the tree layer will result in extensive wind-throw, because the trees are shallow-rooted in the soft, light organic material of low-consistency. Buffer zones around this unit are mandatory to maintain the trees.

For similar reasons, this unit is unsuitable for intensive recreation. It is not especially attractive for hiking or other low intensity recreation and, during winter rains, it may be inaccessible. The vegetation, generally shallow-rooted because of the high water table, will be damaged, if trampled. This unit does, however, provide a habitat for a variety of wildlife and, therefore, attracts attention of persons interested in outdoor education.

Because of the environmental limitation, this unit is suitable only for green belt and wildlife habitat. Harvesting of trees is impractical because of almost certain wind damage, and subsequent difficult reforestation caused by invasion of spirea.

6. Bogs (Figs. 18 and 19)

This landscape unit also occupies depressional areas with impeded drainage which, after the retreat of the glacier, were probably shallow lakes. The ice first deposited a layer of till over scoured bedrock, and meltwater subsequently laid down a layer of glacio-fluvial material. Alluvial sediments were deposited annually with each flood from surrounding hills. Because of a slower rate of sedimentation, or because of a greater depth of water and different vegetation, the fill-in process has not reached the stage of the previous unit.

During the winter months, free water occurs above the surface and, after heavy rains, the area may be flooded to a considerable depth. During the summer months, free water may be 8 to 20 inches (20 to 50 cm) below the surface.

Trees are rare in this unit because of the high water table and insufficient aeration of the soil. Red alder, hawthorn, crabapple and cascara may be present in shrubby form. Spirea and willow form a dense, continuous cover. Grasses, sedges and bulrushes are usually abundant, if not suppressed by spirea. Skunk cabbage, cress and Indian hellebore may occur in



Fig. 19. A variation of spirea bog is a skunk cabbage bog.



Fig. 20. Where water is at ground surface for most of the year, the fen vegetation is dominated by cat-tails.

patches. 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 are unsuitable for residential development. Drainage is usually impractical because of the low gradient of the outlet. Even when drained, the organic material, often more than 10 feet (3 m) thick, would not provide a solid foundation, and costly dredging and filling would be necessary to raise the area above the level of winter floods. For similar reasons, recreational use is also impractical. However, the organic soil material could be excavated and used to improve the topsoil or for mulching. The bog would then become a lake. If the shore is suitable and can bear a heavy recreational pressure, for example, landscape unit 3 or 4, and on-shore facilities could be provided, this artificial lake could have a high recreational potential.

During the summer, bogs are important wildlife habitats. Study of wildlife could be an important educational and recreational function of this landscape unit. During the winter, bogs serve as flood control basins by slowing water movement and controlling the flow extremes. In the study area, this function is very important because soils are generally shallow and the runoff is rapid.

Due to environmental limitations imposed on any kind of construction within this landscape unit, and because of the value of this unit in stream flow and flood control, it is recommended for open space purpose.

7. Marshes (Fig. 20)

Technically, this landscape unit should have been called by the less known term "fen". It occupies shallow bays and shores of existing lakes, as well as some 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 the spring, are flooded to a considerable depth.

The surface soil is organic, as much as 10 feet (3 m) thick, and contains a variable proportion of fine mineral material of alluvial origin deposited during winter floods. Since the soil is permanently submerged, anaerobic acidic processes dominate and





decomposition of organic material is extremely slow. The organic layer is underlain by glacio-fluvial materials of sandy and loamy texture containing a variable amount of gravel and, below that, a layer of compacted glacial till or bedrock.

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 possibility, but could be important for outdoor education. 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 fen is a part, could be enlarged or a new lake created. This would greatly increase the recreational potential of the area, especially if surrounding landscape units could bear heavy recreational traffic.

An important function of this landscape unit, as in the preceding unit, lies in flood control and stream

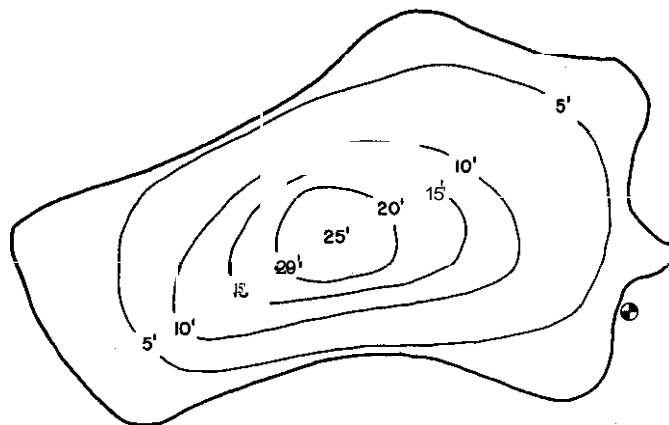
flow regulation. It **also** provides cover and food for many species of birds, mammals, reptiles and amphibians. On the negative side, it is a breeding ground for many species of biting insects, such as mosquitoes, sand flies, black flies, gnats and midges.

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.

8. Lakes (Figs. 21 and 22)

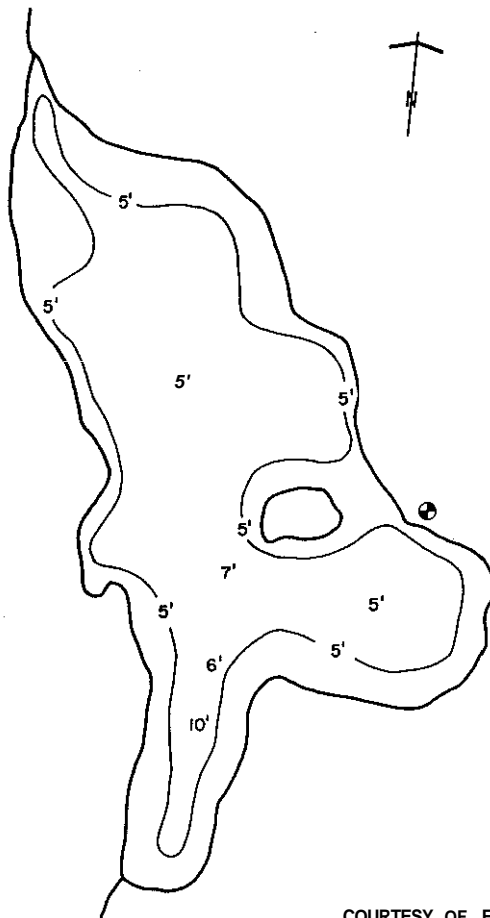
In the study area, the lakes were gouged in the rock matrix of the valley floor by progressing glaciers. In some places, they were partially filled by the abrasive till material carried beneath the ice mass. In other places the rock surface was scoured clean. **As** the ice retreated, a variable amount of glacio-fluvial material was deposited. This was subsequently covered with fine-textured alluvium, usually dark colored by 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.

< Fig. 21. Stone dam, built around 1920, created Matson Lake.



TEANOOK LAKE

ELEVATION _____	300 FT.	90 m
SURFACE AREA _____	8.1 ACRES	3.3 ha
VOLUME _____	63.3 AC./ FT.	80.000 m ³
MEAN DEPTH _____	7.8 FT.	2.4 m
MAX. DEPTH _____	25 FT.	7.5 m
PERIMETER _____	2.570 FT.	780 m
AREA, 20 FT CONTOUR _____	0.4 ACRES	0.2 ha
HEIGHT OF BENCH MARK ABOVE WATER LEVEL _____	5 FT. 6 IN.	1.7 m



MATSON LAKE

ELEVATION _____	APPROX. 350 FT.	105 m
SURFACE AREA _____	8.4 ACRES	3.5 ha
VOLUME _____	47 ACRE FT.	60.000 m ³
MEAN DEPTH _____	5.6 FT.	1.7 m
MAX. DEPTH _____	10 FT.	3 m
PERIMETER _____	3,300 FT.	990 m

COURTESY OF FISH AND WILDLIFE BRANCH
DEPT OF RECREATION & CONSERVATION - BRITISH COLUMBIA

Fig. 23. Depth of Teanook and Matson Lakes.

The lakes are generally shallow (Fig. 23). Most of the area of Mary Lake and Matson Lake is less than 6 feet (2 m) deep, with a maximum depth of about 10 feet (3 m). Teanook Lake is considerably deeper, with a maximum depth of about 30 feet (9 m). Steep banks are bare rock, moderately sloping banks are of stony glacial till and gently sloping banks are of alluvial silt or clay and, because of seepage and capillary action, are wet and turn easily 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.

Matson Lake and Mary Lake are shallow and consist of only epilimnion. The dissolved oxygen content of water is usually high throughout the year because of surface mixing and production by algae. In summer, especially in deeper Teanook Lake, during the period of temperature stratification when mixing and circulation do not occur, the oxygen level gradually decreases with depth.

Because the study area is sparsely settled, the main function of the lakes is in flood control and stream regulation. Recreational uses, such as swimming and fishing, or cultural and educational uses are minimal. With the proposed development, recreation pressure will increase, and it will be necessary to improve the recreational potential of the lakes, while protecting water quality and shores. Only Teanook Lake is deep and comparatively free of aquatic vegetation. However, its catchment area is very small. While flushing takes place during the winter, summer water exchange is non-existent. Mary Lake also has limited recreational potential, being shallow, with a small catchment area and only winter flushing. The best recreational possibilities exist in Matson Lake. Its present size and depth is the result of damming some 50 years ago. A permanent stream continuously exchanges water and complete flushing takes place every 2 or 3 weeks during the winter. Most of the shores are in landscape units 3 and 4, which possess a heavy use potential. However, the lake is shallow and muddy and aquatic vegetation restricts its use for swimming. The fact that the lake was created by damming suggests that it should be possible to drain and clean it. The dam could be reconstructed with an outlet at the base to allow for better winter flushing and to reduce sedimentation.

CONCLUSIONS AND RECOMMENDATIONS

The natural processes taking place in each landscape unit took thousands of years to develop and, while still going on, have approached a degree of stability and usually a healthy condition. The human interventions modify, in an unnatural way, the forces of nature. The changes in the environment are gradual and often not perceived to be the result of human activity. By the time the deterioration of the environment becomes obvious, the remedial actions are costly and have to be borne by the public.

To maintain a healthy environment and prevent long-term costly remedies, proper planning must precede any development. The objective of such planning is to apply ecological principles, and to turn the properties of and natural processes inherent in the individual landscape units into opportunities, and test them against the demands resulting from expected growth.

The following recommendations are, in fact, evaluations of the inventory in terms of social values. They are based on the assessment of natural processes which are taking place now, and on the changes of direction or intensity of these processes which are likely to occur as a result of construction of a community and following intensive residential use. Technical considerations are a part of monetary costs and, as such, are also social values.

In the study area, the site deemed best, in terms of socio-economic costs, for development is the deep mineral soil landscape unit (No. 4). The following facts support this contention:

- (a) **Loss** of a small area will be insignificant, because this unit is common on the east coast of Vancouver Island.
- (b) Road construction on flat terrain with loose soils will be easy and therefore relatively inexpensive.
- (c) Excavations for underground services and their installation will be easy and relatively inexpensive.
- (d) Stony 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.
- (e) The effect of human activity during construction will only be temporary and will not extend beyond the area actually disturbed.
- (f) This unit is excellent for sports fields, playgrounds, etc., because of its topography and soils.
- (g) Intensive recreation activity will cause little damage beyond surface soil compaction.
- (h) Soil erosion on flat terrain will be insignificant.

- (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.

Consideration must be given to the following reasons which detract from this unit's suitability for the development proposed in the study area:

- (1) Flat lowlands provide a rather unattractive environment for permanent living, with a poor view.
- (2) This is the most productive landscape unit in the study area 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 most serious constraint of this unit is that it only covers 9% of the area and it occurs in small patches. This is obviously unsatisfactory and other units must be considered, especially those occurring adjacent to this one.

Shallow mineral soil landscape unit (No. 3) on moderate slopes is also suitable for most types of development, and constitutes an alternative or addition for the following reasons:

- (a) This landscape unit is the most common one in the Highland District and loss of a small area will be insignificant.
- (b) Moderate slopes with a variable topography provide an aesthetic setting for residential development with an attractive view.
- (c) Solid bedrock within 3 feet (1 m) from the surface will provide an excellent support for foundations.
- (d) The effect of human activity during construction will not be great and will not extend too far beyond the area disturbed.
- (e) Stony sandy loams on moderate slopes are not prone to serious erosion.
- (f) Vegetation is resilient.
- (g) Occurrence of fog and unseasonal frost will be less frequent than on the deep mineral soil landscape unit (No. 4).

The shallow mineral soil landscape unit, however, possesses the following limitations:

- (1) Excavation, road building and installation of services will require frequent blasting of rocks and will be considerably more expensive than in unit No. 4.
- (2) Sloping and broken terrain is unsuitable for playgrounds and sports fields.
- (3) 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.

(4) Wind damage will be a problem.

The greatest asset of this landscape unit is that it covers over 50% of the study area and, combined with the previous unit, forms blocks large enough for the proposed development. Further, the properties inherent in one unit complement those of the other unit. The deep mineral soil unit should be reserved for main roads, main underground services and other uses, such as sports fields for schools, shopping and business centres and perhaps industrial areas, where flat topography is a must or, at least, an advantage. Residential areas should be on the shallower soils of 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.

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 hill tops and steep slopes, are covered with carpets of mosses over bedrock or shallow, lithic soils which 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. The 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 following landscape units are subject to periodic flooding and, as such, should be exempted from all development that could be damaged by high water.

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 path-

way should be provided.

The bog landscape unit, an important wildlife habitat, is usually densely overgrown by spirea, which forms an impenetrable barrier to human use.

The marsh landscape unit is also an important wildlife habitat and should be preserved wherever possible. However, because it is a breeding ground of biting insects, it is suggested that, close to built-up centres, this unit 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.

As long as effluents are not permitted to enter the lakes and streams, the quality of water should not be seriously affected by a large community nearby. Fertilizers, herbicides and insecticides, used in landscaping and gardens, will probably cause some deterioration of water quality. For example, nitrogen fertilizers, used on lawns, may eventually filter into the lake and increase the growth of algae. However, complete flushing of the lakes during winter peak flow should keep them clean. Recreational swimming and fishing should cause little concern but, under heavy use, there may be a build-up of algae by the end of summer. Motor powered boats should be excluded because all lakes within the study area are small. Provision of beaches, cleaning of the mud on the lake bottom and on-shore facilities would greatly enhance the recreational potential of the lakes. Recreational areas adjoining lakes should be in landscape units recommended for intensive uses (Nos. 3 and 4).

We realize that our recommendations are based on a subjective evaluation of the inventory. However, they are not based on sentiment, and aesthetics did not play an important part in the conclusions. With further study and increasing comprehension, they can be refined and improved, and as the needs and values of society change, they can be modified.

Their additional value is that they allow any planning proposal to be subjected to a test. 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 responds 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.

The recognition that certain areas are capable of sustaining several land uses should not be seen as a conflict, but as an opportunity to combine them into the socially most desirable pattern.

APPENDIX

List of Common Plants

		Landscape Units							
		1	2	3	4	5	6	7	8
Woody Plants									
Arbutus (Madrona)	Arbutus menziesii	●	■	●					
Bigleaf maple	Acer macrophyllum		●	●	■	e			
Blackberry	Rubus spp.			■	●				
Broom	Cytisus scoparius		●	■					
Buffalo berry	Shepherdia canadensis			●					
Cascara	Rhamnus purshiana					●	●		
Cottonwood	Populus trichocarpa				●	●			
Crabapple	Pyrus fusca					●	●		
Dogwood	Cornus nuttallii			●	■				
Douglas-fir	Pseudotsuga menziesii	●	●	■					
False box	Pachystima myrsinites				●				
Garry, oaks	Quercus garryana	●	■	●					
Goats beard	Aruncus sylvestris		●	●					
Grand fir	Abies grandis			●	■	e			
Hawthorn	Crataegus spp.					●	●	●	
Honeysuckle	Lonicera spp.			●	■				
Huckleberry	Vaccinium spp.			●	●				
Indian-plum	Osmaronia cerasiformis			●	●				
Kinnikinnick (Bear berry)	Arctostaphylos Uva-ursi	●	●	■					
Lodgepole pine	Pinus contorta	●	●	■					
Ninebark	Physocarpus capitatus				●				
Ocean spray	Holodiscus discolor		●	■	●				
Oregon grape	Mahonia nervosa		■	■					
Red alder	Alnus rubra			●	■	e			
Salal	Gaultheria shallon		●	■					
Saskatoon berry (Juneberry)	Amelanchier florida				■	e			
Snowberry (Waxberry)	Symphoricarpos albus		■	■					
Spiraea	Spiraea douglasii					■	■	●	
Spreading dogbane	Apocynum androsaemifolium		■						
Twin flower	Linnaea borealis		■	●					
Western dogwood	Cornus occidentalis						e		
Western hemlock	Tsuga heterophylla			●	■	●			
Western red cedar	Thuja plicata					■			
Wild Rose	Rosa spp.			●	●				
Willow	Salix spp.					e	.	●	

- - a common constituent of community
- preferred site; population best developed on the site

Forbs and herbaceous plants

Alumroot	<i>Heuchera ovalifolia</i>
Baneberry	<i>Actea rubra</i>
Bedstraw	<i>Galium</i> spp.
Bladderwort	<i>Utricularia vulgaris</i>
Bleeding heart	<i>Dicentra formosa</i>
Blue-eyed Mary	<i>Collinsia grandiflora</i>
Blue wild rye	<i>Elymus glaucus</i>
Bulrush	<i>scirpus</i> spp.
Buttercup	<i>Ranunculus</i> spp
Camas	<i>Camassia</i> spp.
Cat-tail	<i>Typha latifolia</i>
Chess grass	<i>Bromus</i> spp.
Chickweed	<i>Cerastium</i> spp. & <i>Stellaria</i> spp.
Chocolate lily (Rice root)	<i>Fritillaria lanceolata</i>
Clover	<i>Trifolium</i> spp.
Club moss	<i>Selaginella wallacei</i>
Columbia lily (Tiger)	<i>Lilium columbianum</i>
Columbine	<i>Aquilegia formosa</i>
Coral-root	<i>Corallorhiza</i> spp.
Cress	<i>Cardamine</i> spp. & <i>Cruc</i> rae
Dogbane	<i>Apocynum androsaemifolium</i>
Duckweed	<i>Lemna minor</i>
Easter lily	<i>Erythronium oregonum</i>
False Solomon's seal	<i>Similacina amplexicaulis</i>
Foam flower	<i>Tiarella trifoliata</i>
Fringe cup	<i>Lithophragma parviflora</i>
Indian paintbrush	<i>Castilleja</i> spp.
Knotweed	<i>Polygonum</i> spp.
Lady slipper	<i>Calypso bulbosa</i>
Lily-of-the-valley	<i>Maianthemum dilatatum</i>
Little hair grass	<i>Aira praecox</i>
Lupine	<i>Lupinus bicolor</i>
Marsh cinquefoil	<i>Potentilla palustris</i>
Meconella	<i>Meconella oregana</i>
Miners lettuce	<i>Montia perfoliata</i>
Monkey flower	<i>Mimulus</i> spp.
Northern mannagrass	<i>Glyceria borealis</i>
Orchids	<i>Habenaria</i> spp.
Ox-eyed daisy	<i>Chrysanthemum leucanthemum</i>
Pea Vine	<i>Lathyrus</i> spp.
Pearly everlasting	<i>Anaphalis margaritacea</i>
Phlox	<i>Collomia</i> spp.

Landscape Units

1	2	3	4	5	6	7	8
●	■	■	■	●			
	■	●					■
■	●						
	■	■			●	■	
	■	●	●				
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		Landscape Units							
		1	2	3	4	5	6	7	8
Pond lily	Nuphar polysepalum								●
Rattlesnakeplantain	Goodyear oblongifolia			●	■		■	●	
Reed Canary grass	Phalaris arundinacea								
Rush	Juncus sp.						■	■	
Satin flower	Sisyrinchium douglasii		■						
Saxifrage	Saxifraga spp.	●	■	●					
Sea blush	Plectritis congesta	■							
Sedge	Carex spp.					■	■	■	
Sheep sorrel	Rumex acetosella	●	■						
Shooting star	Dodecatheon hendersonii		●	■					
Skunkcabbage	Lysichitum americanum						■	●	
Spring gold	Lomatium utriculatum	●	■						
Starflower	Trientalis latifolia			●	■				
Stonecup	Sedum spathulifolium	■	●						
Strawberry	Fragaria spp.		●	●					
Thistle	Cirsium spp.		●	●					
Twisted Stalk	Streptopus amplexifolius			●	●				
Vanilla leaf	Achlys triphylla				■	○			
Velvet grass	Holcus lanatus				●	■	●		
Vetch	Vicia spp.		■	●					
Violets	Viola spp.	●	●	●					
Water Forget-me-not	Myosotis laxa							○	●
Water foxtail	Alopecurus geniculatus						■	■	●
Water shield	Brasenia schreberi							○	●
Water smartweed	Polygonum amphibium							○	●
Western trillium	Trillium ovatum				●				
Whitlow-grass	Draba verna	●	■	●					
Wild hyacinth	Brodiaea grandiflora		■						
Wild onion	Allium acuminatum	●	■						
Wintergreen	Pyrola spp.			●	■				
Yarrow	Achillea millefolium		■	■					

Ferns

Bracken	Pteridium aquilinum			●	●			
Golden-back fern	Pityrogramma triangularis	○	●	●	●			
Lady fern	Athyrium filix-femina							
Licorice fern	Polypodium vulgare	○	●					
Swordfern	Poistichum munitum				●	○		

Mosses

	Landscape Units							
	1	2	3	4	5	6	7	8
<i>Andraea rupestris</i>	●			●	■			
<i>Aulacomnium androgynum</i>			●	■	■			
<i>Brachythecium spp.</i>								
<i>Bryum spp.</i>		●	●					
<i>Ceratodon purpureus</i>		■	●					
<i>Dicranum spp.</i>		●	■	●				
<i>Drepanocladus uncinatus</i>			●	●	●			
<i>Eurhynchium oreganum</i>		●	■	●				
<i>Fontinalis antipyretica</i>						●	■	
<i>Grimmia spp.</i>	■	●						
<i>Hylocomium splendens</i>		●	●	■				
<i>Hypnum circinale</i>			●	■	●			
<i>Isoetecium spiculiferum</i>			●	■	■	●		
<i>Leucolepis menziesii</i>			●	■	●			
<i>Mnium spp.</i>								
<i>Plagiothecium</i>			●	■	●			
<i>Polytrichum piliferum</i>	■	●						
<i>Racomitrium spp.</i>	■	■						
<i>Rhizobmnium glabrescens</i>			●	●	●			
<i>Rhytidiadelphus loreus</i>		●	■	●				
<i>Rhytidiadelphus triquetrus</i>		■	●					
<i>Sphagnum spp.</i>				●	■	■	●	
<i>Tortula spp.</i>	■	●						

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Department of Environment
April, 1975

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LAND COVER DATA IN THE
 Pecos River Area
 FOR THE LAND-USE DATA

- 1. Agricultural Land (Crops)
- 2. Pasture
- 3. Forest
- 4. Shrubland
- 5. Grassland
- 6. Wetland
- 7. Water
- 8. Urban
- 9. Barren
- 10. Snow/Ice

0 10 20 30 40 50 60 70 80 90 100
 Kilometers