COAL RESOURCE STUDY

OF

COMOX BASIN - NANAIMO SERIES VANCOUVER ISLAND - BRITISH COLUMBIA

Preliminary Environmental Assessment

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The "Preliminary Environmental Assessment Report" and the "Sand and Gravel Resource Study" were originally part of a large report submitted in 1975 by M. P. Curcio (Coal Resource Study of Comox Basin - Nanaimo Series - Vancouver Island - British Columbia).

All of the geological information now resides in Report #694, which is a compilation of data from various sources. It was felt that grouping all of the borehole and geology information for the Comox Basin into one report would allow for easier interpretation of the data. Please refer to #694 if this information is required.

WELDWOOD

OF CANADA LIMITED

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INTRODUCTION

The changes which occurred in energy use in the 1950's resulted in a general cessation of the coal industry on Vancouver Island. Coal has been economically important in the area from the time of the opening of the first mine at Comox Lake in 1875 until the closing of the last of the large mines at Tsable River in 1966. Today, with newer extraction methods and increasing energy demands, Weldwood of Canada Limited are examining their reserves (The Vancouver Island Coal Properties) with a view to determining the feasibility of a mining program.

The following report is designed to assist Weldwood of Canada Limited by providing a summary of existing environmental information, identifying potential environmental constraints, and indicating to what extent deficient subject areas will require subsequent original research. This preliminary environmental assessment generally coincides with Weldwood's exploration program. If and when a decision is made to proceed with a mining plan, this report will form an important component of the Environment Impact Assessment.

Since potential mining zones have not been delineated, this report is of necessity general in scope. Particular emphasis has been given to the marine and terrestrial environments in the vicinity of Union Bay, which has been selected as a potential plant site and dock loading facility.

The subject areas considered in this report have been broadly divided into those of a physical, a biotic and a social nature. Within each, the amount of information provided varies greatly between individual subject areas. This reflects differences in the amount of information available rather than the importance given to particular subject areas. Since social impact tends to be site-specific in nature, these aspects have been dealt with in much less detail than the physical and biotic aspects.

PART 1

SUMMARY OF EXISTING INFORMATION

PART I - SUMMARY OF EXISTING INFORMATION

A. THE STUDY AREA

The Vancouver Island Coal Properties comprise 118,000 acres of land along the east-central part of Vancouver Island. Oriented in a northwest-southeast direction, they extend from approximately 49° 21' N to 50° 00' N latitude and 124° 39' W to 125° 30' W longitude. Surface rights to the Properties are held by more than 10 other interests, including the Crown.

For the purposes of this study, the strip of land between the Properties and the coast of the Strait of Georgia is also being considered (Figure 1). As well, the western boundary of the holdings has been enlarged slightly to simplify the highly irregular property boundary. This area is hereafter referred to as the Weldwood Study Area.

The Study Area is approximately 10 miles wide and 55 miles long, extending from Campbell River in the north to Horne Lake in the south. In elevation, it ranges from sea level to around 3000 feet.

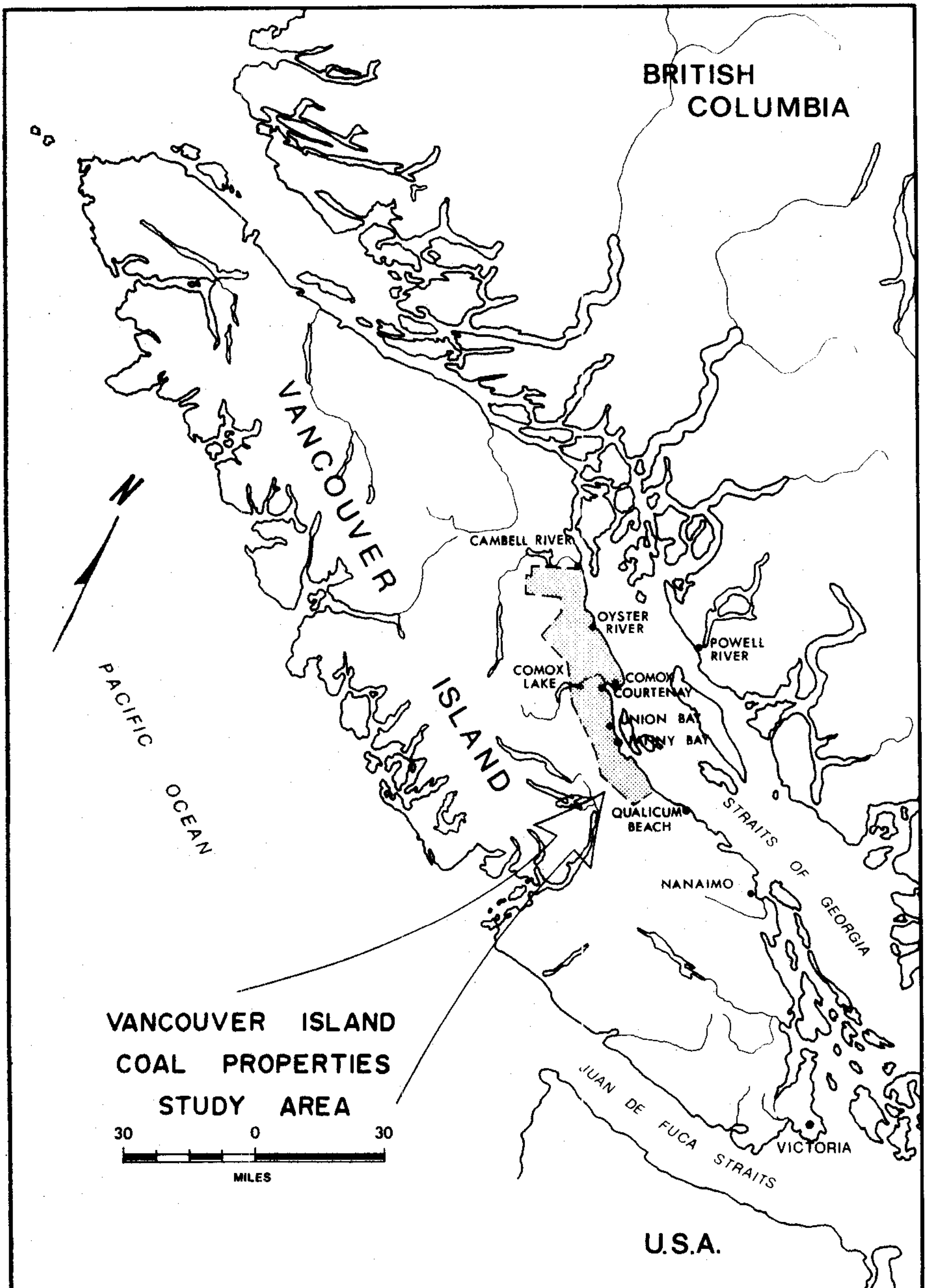

BRITISH
COLUMBIA
VANCOUVER
ISLAND
N
PACIFIC
OCEAN
CAMBELL RIVER
OYSTER
RIVER
POWELL
RIVER
COMOX
LAKE
COMOX
COURTENAY
QUALICUM
BEACH
STRAITS OF GEORGIA
NANAIMO
VANCOUVER ISLAND
COAL PROPERTIES
STUDY AREA
30
0
30
MILES
JUAN DE FUCA STRAITS
VICTORIA
U.S.A.

FIG. 1

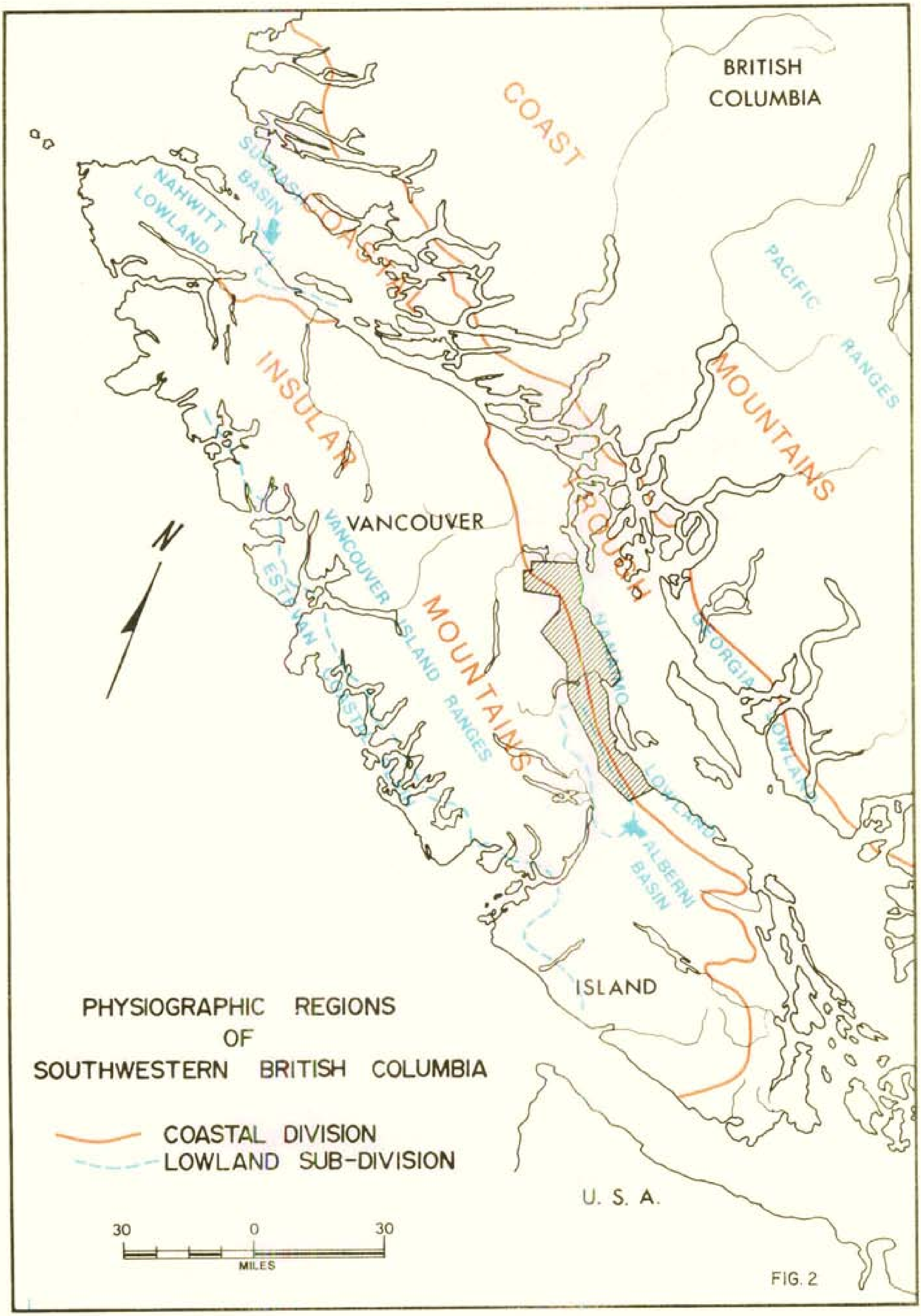
B. PHYSICAL ASPECTS

B.1. Topography & Physiography

The Study Area is almost entirely contained within the Nanaimo Lowland of the Coastal Trough physiographic division. This lowland extends along the eastern coast of Vancouver Island from Sayward in the north, around to River Jordan on the southwest coast (Figure 2). Although almost 175 miles long, this low-lying strip seldom exceeds 15 miles in width, and generally lies below the 2000 foot contour line (Holland 1964). The lowland is flanked on the west by the Vancouver Island Ranges of the Insular Mountain physiographic division.

During the Pleistocene epoch, the Lowland was entirely covered by ice which further contributed to the low relief by eroding promontories and depositing a thick layer of glacial and glacio-fluvial materials. The weight of the ice cover caused a general subsidence of the land surface, which in Recent times, has shown a return to pre-Pleistocene levels. The level of isostatic rebound has been about 400 feet at Nanaimo, 500 feet at Qualicum and 600 feet at Campbell River (Day *et al.* 1959). During rebound, rivers and streams incised deep gullies in the marine and glacial deposits and a series of raised beaches were formed above the present shoreline.

The present undulating topography consists mainly of low, forested ridges separated by narrow valleys aligned in a northwest to southeast direction. Many of the rivers and streams have developed flood plains in their lower courses with sizeable deltas at their mouths. The principal rivers of the Study Area are the Qualicum, Tsable, Puntledge Tsolum, Oyster, and Quinsam. Comox, Wolf, Quinsam and several smaller lakes are contained wholly or partly within the Area.



PHYSIOGRAPHIC REGIONS OF SOUTHWESTERN BRITISH COLUMBIA
BRITISH COLUMBIA
COAST MOUNTAINS
PACIFIC RANGES
INSULAR MOUNTAINS
COASTAL TROUGH
VANCOUVER ISLAND
VANCOUVER ISLAND RANGES
SUQUASH BASIN
NAHWITT LOWLAND
ESTEVAN
COASTAL
NANAIMO LOWLAND
GEORGIA LOWLAND
ALBERNI BASIN
U. S. A.
N
COASTAL DIVISION
LOWLAND SUB-DIVISION
30 0 30
MILES

FIG. 2

B.2. Climate

The southern tip of the Study Area lies within the Cool Summer Mediterranean climatic zone of Koppen (Figure 3), while the area north of 49° 30' is considered part of the Marine West Coast zone (Chapman 1952). The former is characterized by dry, cool summers, with less than 1.2 inches precipitation in the driest summer month and average temperatures of less than 71.6° in the warmest month. The latter zone is also characterized by cool summers, but with greater summer precipitation (driest summer month greater than 1.2 inches). Further subdivision becomes difficult as local conditions continually modify the weather, with this effect increasing as topography becomes more diverse.

On the regional level, the mountains act as barriers to the movement of air masses, with the greatest effects felt where mountains are high and gaps between them infrequent. Air which does move east across the mountains is altered, losing much of its moisture, and causing a drying effect on the leeward slopes (i.e. eastern Vancouver Island).

Locally, aspect plays a large role in modifying conditions. Amount of precipitation, length of snow cover, amount and intensity of sunshine, and air and soil temperatures vary greatly over short distances depending upon slope exposure. Marine and continental influences are also important in determining local. as well as regional climates.

Climatological information for east-central Vancouver Island is compiled by the Meteorological Branch, Canada Department of Transport. Long-term records are available for Campbell River, Oyster River, Cape Lazo, Comox Airport, Courtenay, Cumberland, Qualicum River Fisheries Research Station and Cameron Lake. Data are most complete for the

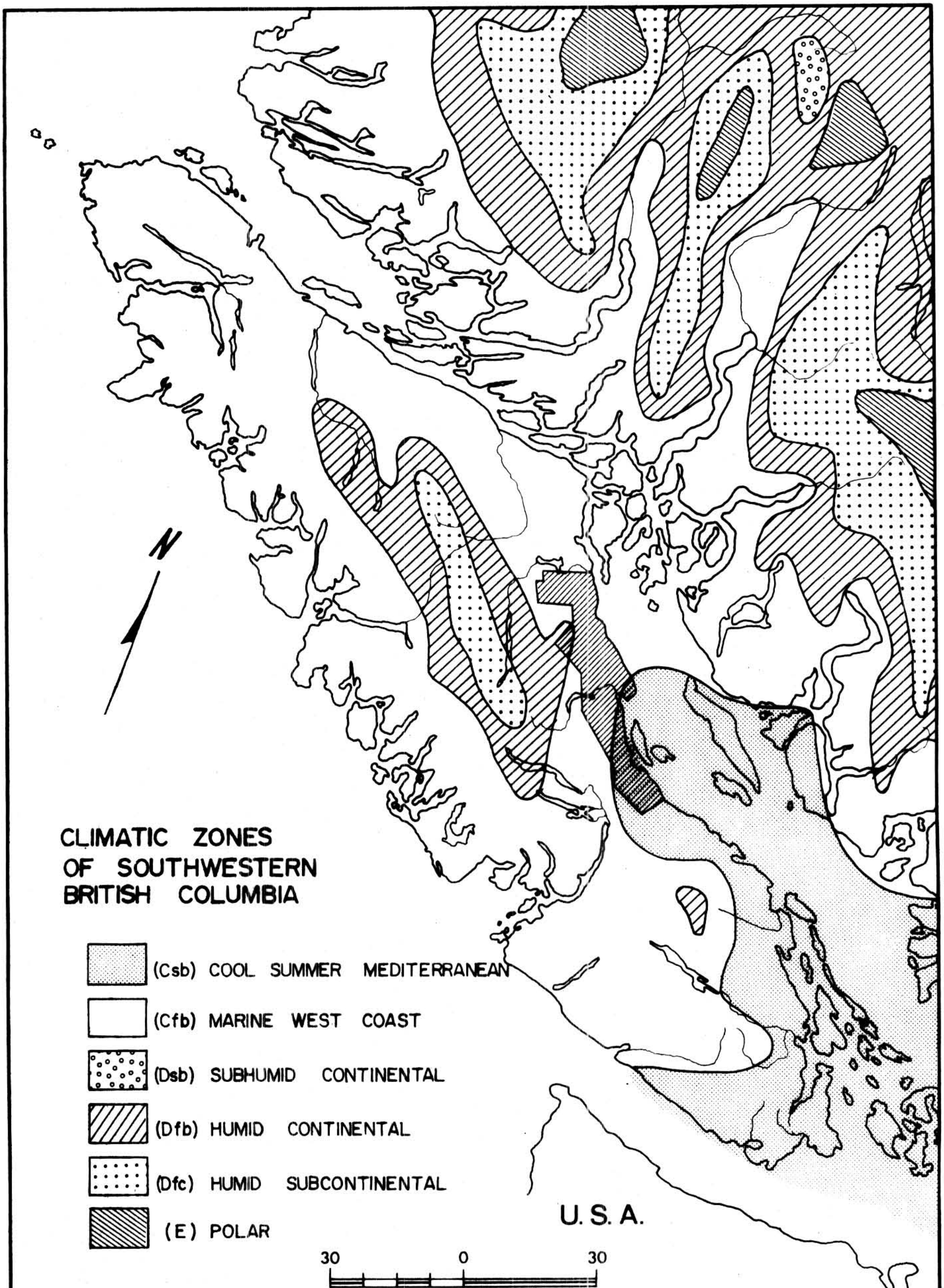

CLIMATIC ZONES
OF SOUTHWESTERN
BRITISH COLUMBIA
(Csb) COOL SUMMER MEDITERRANEAN
(Cfb) MARINE WEST COAST
(Dsb) SUBHUMID CONTINENTAL
(Dfb) HUMID CONTINENTAL
(Dfc) HUMID SUBCONTINENTAL
(E) POLAR
N
U.S.A.
30
0
30
MILES

FIG. 3

stations at Cape Lazo, Comox and Cumberland; temperature and precipitation averages; norms, and extremes for these stations are summarized in this report (Appendix I). Although frequently seasonal in nature, additional data are available from a number of privately operated stations throughout the Study Area.

At the three stations selected to represent the area, highest and lowest mean daily temperatures occur in July and January, respectively with yearly averages appearing similar (48.3° - 48.8°F). Mean daily maximum and minimum temperatures vary more between stations than do mean daily temperature, with Cumberland, the most inland station, experiencing the highest mean maximum and lowest mean minimum temperatures. Record high temperatures occur in July and January exhibits the record lows. Cumberland, with its higher elevation (523 ft asl) and more inland location, has the lowest and highest recorded temperatures in the Area.

Mean total precipitation ranges from 40.56 inches in Cape Lazo to 58.50 inches in Campbell River. Total precipitation is least in July and August and greater in December. For all six stations represented, almost half of the total precipitation falls between November 1st and January 30th with at least 75 percent falling in the six month winter period (October 1 to March 30). In all months most of this falls in the form of rain which constitutes 90 (Cumberland) to 94 (Cape Lazo) percent of all precipitation. The two stations at higher elevation, Cumberland and Cameron Lake (605 ft asl) receive the most snow over the longest period (7 months). Maximum precipitation recorded for a 24 hour period can be substantial as shown by a 4.45 inch maximum recorded at Comox Airport, with comparable values at other stations during the rainiest months of December and January.

Surface winds on eastern Vancouver Island are strongly modified by local topography (Kendrew and Kerr 1955). Comox, most exposed seaward to the southeast and landward to the northwest, receives most of its winds from those directions. Southeastern breezes are the most frequent with mean wind speed ranging from 7 mph (late summer) to 9 mph (late winter and spring). On less exposed sites, the winds may be deflected greatly from the barometric gradient by the diverse topography.

Cloud cover and fog are relatively common in this area, but both are notably reduced in summer (Appendix I). The amount of cloud cover differs little from morning to afternoon but, in winter, afternoons are slightly cloudier than mornings and in summer the reverse is true *(Ibid.)*.

In general, east-central Vancouver Island has a mild climate less strongly modified by maritime influences than the west coast of the island. Both annual and summer precipitation values are lower here than anywhere on the Canadian Pacific coast except the southeastern tip of the island near Victoria. Temperatures are moderately warm in summer, but rarely become very cold in winter. Surface winds are light and cloud cover, although heavy in winters is sufficiently absent in summer to provide many sunshine hours.

B.3. Surficial Geology

The basement bedrock underlying most of the Study Area is of volcanic origin, and generally comprises altered basaltic and andesitic lavas and pyroclastic rocks of the Triassic Vancouver Group (Fyles 1963). Also included in this group are belts of quartzite and green schist, chert, argillite, greywacke and limestone. In places granodiorite bodies cut the basement volcanic and sedimentary rocks. Overlying these rocks across most of the coastal lowland are basins of soft shale, sandstone and conglomerate. These sediments include both marine and non-marine beds and are of late Cretaceous age.

Additional information on the bedrock geology of Vancouver Island is available from Gunning (1931), Muller and Carson (1968), Douglas (1970) and Muller (1971). Geological information pertaining to the existence of coal in the area can be found in Richardson (1872), Clapp (1913), MacKenzie (1922) and Buckham (1947).

Surficial deposits vary from Pleistocene to Recent in age. During the Pleistocene at least two separate Cordilleran ice sheets covered the area, scouring the sides of mountains and the bottoms of valleys and depositing glacial material over the landscape. Fyles (1963) described these surficial deposits and developed a 'standard' succession (Table 1) that serves as a regional basis for their stratigraphic subdivision, although locally the sequences may vary. More detailed information on the composition of major stratigraphic units with respect to environment of deposition, is presented in Table 2.

The principal surficial deposits consist of two groups of glacial deposits, separated by an interstadial succession of non-glacial deposits and overlain by a variety of post-glacial marine and fluvial

Table 1. 'Standard' succession used as the basis for stratigraphic subdivision of the surficial deposits of the Study Area (adapted from Fyles 1963)

UNIT	COMPOSITION OF DEPOSIT	MAXIMUM THICKNESS (ft)	STRATIGRAPHIC UNIT
8	Gravel, sand, silt and clay of marine and fluvial origin; complex	80	Capilano Sediments
7	Till, grey and sandy	100	Vashon Drift
6	Sand, white, horizontally stratified, current-bedded; local beds of gravel and plant-bearing silt	250	Quadra Sediments
5	Silt, fine gravel, sand peat and wood; distinctive orange-green colors	25	Quadra Sediments
4	Clayey silt; contains stones and marine shells; massive	80	Quadra Sediments
3	Silt and clay, laminated	5	Quadra Sediments
2	Till, grey, silty to sandy; contains gravel and silt interbeds	70	Dashwood Drift
1	Sand, silt and clay	50+	Mapleguard Sediments

Table 2. Major stratigraphic units and their composition with respect to environment of disposition (from Fyles 1963).

UNIT	GLACIAL	GLACIO-FLUVIAL	GLACIO-LACUSTRINE	MARINE (including glacio-marine)	MARINE SHORE	MARINE DELTAIC	CHANNEL FLOODPLAIN	LACUSTRINE	ALLUVIAL FAN	SLOPE	UPLAND SWAMP
Salish Sediments (deposits related to present marine, river and lake levels)					Gravel, sand silt, and clay at present shoreline	Gravel, sand silt, and peat in deltas along Georgia Strait and Alberni Inlet	Gravel, sand silt, and peat along streams	Gravelly shoreline deposits, gravel, sand, and silt in deltas	Poorly sorted gravel and silt	Colluvium talus landslide rubble	Peat and muck
Capilano Sediments (deposits related to former marine, river and lake levels)				Clay, stony clay, silt, sand, poorly sorted till-like mixtures, contains marine shells, rare wood and leaves, local basal laminated clay, silt, sand and gravel.	Stony wave-washed lag veneer, gravel, sand, silt, clay, till-like materials, contain marine shells, rare driftwood and leaves.	Gravel, sand and minor silt, contain rare marine shells and driftwood.	Gravel, minor sand and silt beneath terraces	Gravel and sand terrace deposits, silt and clay, (not clearly distinguished from glacio-lacustrine deposits)	Poorly sorted gravel and silt in fans and depression fillings, stony lag veneer		
Vashon Drift (glacial deposits)	Grey till, sandy to clayey texture	Gravel, sand and silt forming ice-contact deposits	Sand and gravel, laminated silt and clay							Landslide rubble in part mixed with glacio-fluvial gravel	
EROSION SURFACE (Relief of Several Hundred Feet)											
Quadra Sediments (non-glacial deposits)				Clay, stony clay, silt, containing marine shells local basal laminated clay and silt.			Sand, minor silt and gravel, local peat, peaty soil, and leaf a layers				
					Silt, pebble gravel, sand and cobbly lag gravel, distinctive orange-green coloring, contain peat, peaty soil, driftwood						
Dashwood Drift (glacial deposits)	Grey till, silty to sandy texture, contains silt and gravel lenses										
Mapleguard Sediments (non-glacial deposits)							Sand, silt and clay.				

deposits. These deposits are, from youngest to oldest: Salish sediments, Capilano sediments, Vashon drift, Quadia sediments, Dashwood drift and Mapleguard sediments.

The youngest group of post-glacial deposits, collectively called Salish sediments, are the product of changes in the present sea, river and lake levels. They are presented by flood-plain, channel and alluvial-fan deposits along rivers; and sea lakeshore and deltaic deposits.

Capilano sediments, related to former sea, river and lake levels, consist of marine deposits, marine-deltaic deposits and river-channel and flood-plain deposits. Deposition of the sediments began when remnants of glacial ice still occupied parts of the area and continued through most of post-glacial time until the seashore became established at the present level (±20 feet).

The term 'Vashon drift' is applied to the group of glacial deposits that appear to relate to a single glaciation, that being the most recent. These deposits consist of sandy till on the coastal lowland and loamy or clayey till on mountain slopes and in mountain valleys. Ice-contact glacio-fluvial deposits of gravel and sand also belong to this group. These latter deposits result from accumulations in streams along glacier margins and ice-contact deltas.

Lying between Vashon drift and Quadra sediments is an erosional surface caused partly by the Vashon ice and partly by fluvial processes.

Quadra sediments consist of interglacial strata found between the Vashon and Dashwood drifts. The main constituents of these sediments are a lower layer of marine 'clay and stoney 'clay' with basal lenses of unfossiliferous laminated clay; a middle layer of plant-bearing silt, gravel and sand; and a thick upper layer of white sand with gravels and plant-bearing silts.

Dashwood drift is not lithologically distinct from Vashon drift, therefore its recognition was possible only where it underlay Quadra sediments, its position in the 'standard' succession. Elsewhere, deposits of this group were arbitrarily included with Vashon drift *(Ibid.)*. This till comprises a grey, unoxidized mixture of boulder to clay-sized particles that disintegrates under the action of rain or weather and has associated beds and lenses of gravel, silt, clay, and sand.

Mapleguard sediments underlie the Dashwood drift. Their origin is somewhat unclear, but they may be outwash or glacial lake deposits preceding the Dashwood glaciation, or non-glacial deposits from a former interstadial or interglacial interval. They consist primarily of medium-grained grey sand interspersed with beds of thinly laminated grey silt and clay.

Several maps are available depicting the distribution of these surficial deposits (Fyles 1959, 1960 and 1963). Copies of these maps have not been included in this report.

Gravel and sand suitable for concrete aggregate and road building are found principally amongst the ice-contact deposits of the Vashon drift and the terraced delta deposits of the Capilano sediments. Additional sources of gravel and sand are found in modern deltas, alluvium in valley bottoms, river terraces along valley walls, alluvial fans and talus cones, beach bars and in deposits beneath the Vashon till.

Soils result from the modification of surficial deposits by the interaction of biological and climatic influences under particular moisture conditions for particular time intervals. Local differences in the nature of soils in this region have been caused, in part, by differences in the texture and stoniness of parent materials, the slope of the ground surface and the moisture relationships within the ground, all of which are related to the local geological conditions.

Where Quadra sediments come close enough to the surface to influence soil formation, dry, coarse textured, sterile soils of the Qualicum series result. Vashon till, the most widespread soil parent material above the limit of marine submergence, supports stony or gravelly and sandy loam to loam textured soils. Soils of the Royston and Quinsam series belong to this group. Glacio-fluvial and delta terrace deposits of Capilano origin develop very dry sterile soils that have been assigned to the Qualicum series. Soils developed on the fine to medium textured parent materials of these deposits are fairly well suited to agriculture, but are drier than marine soils of similar texture. Most soils of the lowlands of Vancouver Island have their origin in marine deposits of the Capilano sediments. These soils vary greatly in texture with coarse textured types having little resistance to summer drought. Dashwood, Bowser, Qualicum and Shawnigan series soils belong to this group. Where the parent material is finer textured, Parksville, Puntledge, Tolmie, Fairbridge and Cowichan series soils may develop. These latter soils are of moderate to high agricultural potential, and because they generally rest on clay, they tend to resist summer drought. Soils developed on modern alluvial deposits of the Salish sediments may be of the Cassidy or Chemainus series, the former being of coarse texture, the latter of finer texture and higher agricultural value. Figure 4 will assist in identifying the geological materials upon which typical soils of the Study Area develop.

The geological history of the Area is an important factor in a consideration of the environment of an area. It is instrumental in determining local hydrological and soil conditions which in turn are important in determining the distribution of vegetational communities and their corresponding animal populations.

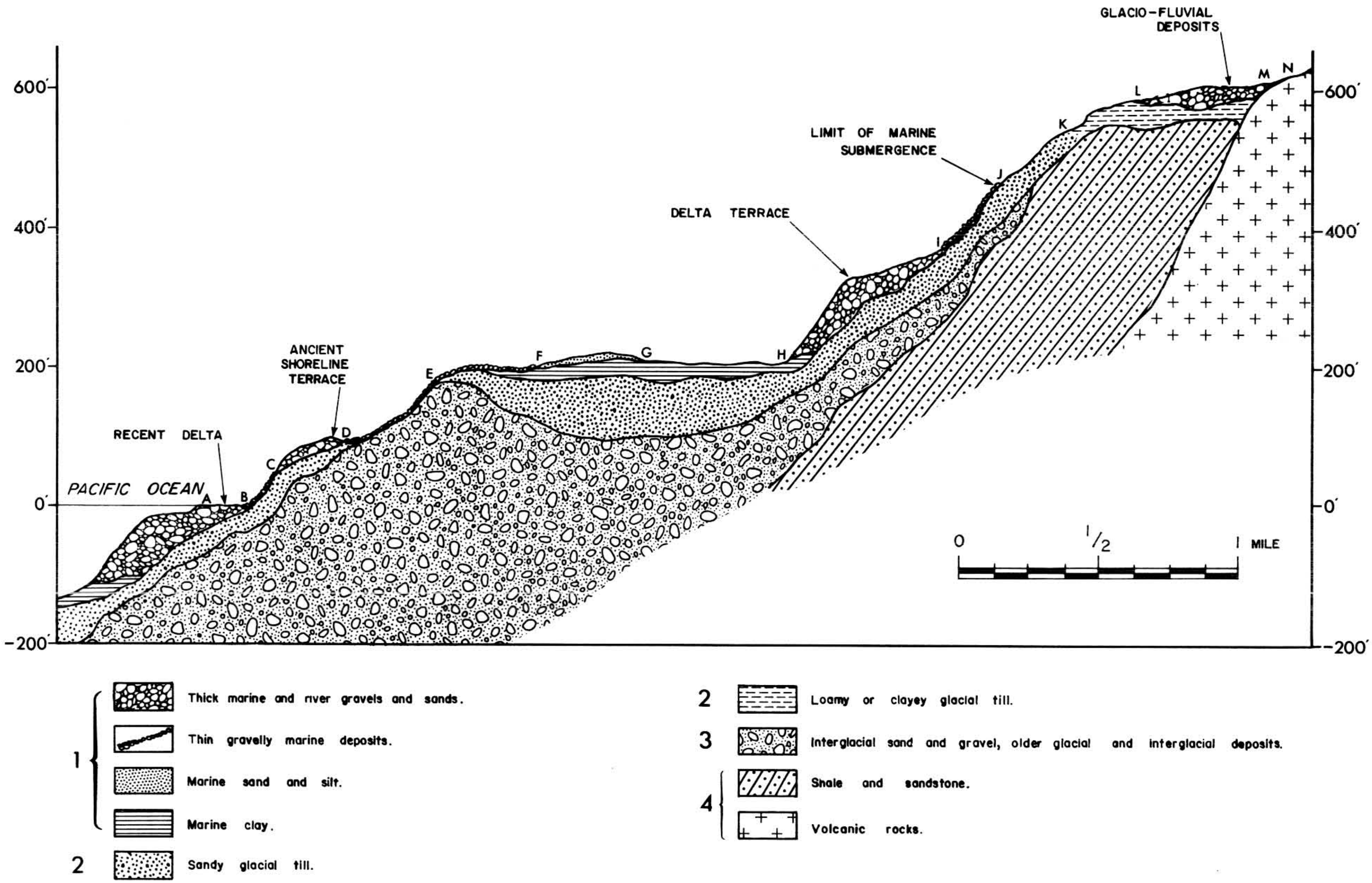
Figure 4. Diagrammatic vertical section showing the relationship between geology and soils in the Nanaimo Lowland

KEY TO LETTERED SOIL SERIES TYPES

A - B	Cassidy, Chemainus
B - C	Dashwood, Bowser
C - D	Qualicum
D - E	Qualicum
E - F	Dashwood, Bowser
	Parksville, Shawnigan
F - G	Puntledge, Merville
G - H	Cowichan, Fairbridge
H - I	Qualicum
I - J	Dashwood, Bowser
J - K	Shawnigan
K - L	Royston
L - M	Qualicum
M - N	Rock

KEY TO NUMBERED SURFICIAL DEPOSITS

1	Salish and Capilano
2	Vashon
3	Quadra, Dashwood
	Mapleguard and older
4	Bedrock



600′
400′
200′
0′
-200′
PACIFIC OCEAN
RECENT DELTA
ANCIENT SHORELINE TERRACE
DELTA TERRACE
LIMIT OF MARINE SUBMERGENCE
GLACIO-FLUVIAL DEPOSITS
A
B
C
D
E
F
G
H
I
J
K
L
M
N
0
1/2
1 MILE
1
Thick marine and river gravels and sands.
Thin gravelly marine deposits.
Marine sand and silt.
Marine clay.
2
Sandy glacial till.
2
Loamy or clayey glacial till.
3
Interglacial sand and gravel, older glacial and interglacial deposits.
4
Shale and sandstone.
Volcanic rocks.

FIG. 4

B.4. Pedology

A soil survey of southeastern Vancouver Island was conducted as a co-operative project between the Experimental Farms Service of the Canada Department of Agriculture, the British Columbia Department of Agriculture and the University of British Columbia (Day *et al.* 1959). This report is presently the most comprehensive reference available on soils (including physical and chemical properties) in the Study Area and forms the basis for the following summary.

Under any given set of climatic and biological conditions, soils vary from place to place depending on the composition of the parent material, the slope of the ground surface, and the moisture relationships of the soil. The wide variety of soils on eastern Vancouver Island are a reflection of the above criteria. In particular climate has a pronounced effect on soil development in the region. The cool Mediterranean climate of the southern portion of the Nanaimo Lowland, with its high moisture deficiency and low rainfall, encourages oak-grassland vegetation, which results in black soils, high in organic matter and moderate in pH and base saturation. The maritime climate found in northern parts of the lowland and characterized by high rainfall and low moisture deficiency, tends to promote development of brightly colored and strongly leached soils of strong acidity and low base saturation. Podzols and peat deposits are more common under these conditions. In addition, a transitional zone between the two climatic regions is here partly responsible for creating intermediate soil conditions.

Due to this wide variety and the large scale necessary for map delineation only a general description of the soils occurring in the Study Area is included in this report. This description is summarized in

Table 3 and the general relationship between soils, topography and parent material is illustrated in Figure 4. Table 3 also outlines the productive ability of each soil series with respect to agriculture and forestry. These potentials are based on soil texture, depth, moisture holding capacity, natural fertility drainage, topography and stoniness and on known occurrence of native vegetation (recent and historical) respectively *(Ibid.)*.

Soils within the Study Area show a universal deficiency of water for crop production. Irrigation is used in many areas to supplement natural supplies and increase production. Accumulating evidence indicates that deforestation and land clearing at higher elevations contribute to the summer depletion of soil moisture at lower levels *(Ibid.)*. It is therefore important that good water management accompany any development plan.

Table 3. Summary-description and productive ability of soil series occurring on the Study Area.

SOIL SERIES	PARENT MATERIAL	TEXTURE	DRAINAGE	AGRICULTURAL POTENTIAL	FORESTRY POTENTIAL
Qualicum	Coarse-textured fluvial, glacio-fluvial, aeolian, marine	Loamy and gravelly loamy sands	Rapid	None-Low	Medium
Cluster			Fair	Low	Medium
Fairbridge	Fine-textured marine	Silt loam to silty clay loam	Good	High	Medium
Cowichan		Clay loam	Poor	Medium	Medium
Merville	Medium to fine-textured, marine	Loam	Fairly good	Medium-High	Low
Puntledge		Silt loam	Fair	Medium	Medium-High
Tolmie		Loam	Poor	Medium	Medium-High
Dashwood	Coarse-textured marine	Loamy to gravelly loamy sand	Good	None-Low	High
Bowser		Loamy sand	Fair	Low	Medium-High
Sayward		Loamy sand	Fair	Low	High
Parksville		Sandy loam	Poor	Low	Medium

Table 3. Continued.

SOIL SERIES	PARENT MATERIAL	TEXTURE	DRAINAGE	AGRICULTURAL POTENTIAL	FORESTRY POTENTIAL
Haslam	Shallow, medium-textured glacial till	Shaly loam	Good	Low	High
Royston	Medium-textured glacial till	Gravelly sandy loam	Good	Low	High
Sandwick		Gravelly loam	Good	Medium	Low
Shawnigan	Coarse-textured glacial till	Gravelly sandy loam	Good	Low	Medium-High
Quinsam		Gravelly sandy loam	Good	None	Medium-High
Arrowsmith	Organic material	Peat	Poor	None	Low
Chemainus	Alluvium	Sandy to silt - clay loam	Undifferentiated	Medium-High	Medium-High
Cassidy		Gravelly to sandy loam	Undifferentiated	None-Low	Medium

B.5. Hydrology

B.5.1. Surface Hydrology

Hydrological data are compiled by the Water Survey of Canada and published by the Water Resources Branch, Canada Department of the Environment. Daily discharge data from manual gauging stations are published together with monthly and yearly means. Total and instantaneous discharge data are also available for most of the stations in the Study Area (Table 4, Figure 5). Monthly hydrographs have been prepared for a number of these stations for which long term records are available (Figures 6, 7 and 8).

The mountainous and undulating terrain of the watersheds in the area tends to produce steeply graded, shallow streams that are prone to a high degree of water level fluctuation. This fact, coupled with the prevailing climatic conditions wherein most of the moderately heavy precipitation falls as rain in the fall and winter months, contributes to the characteristic hydrograph configurations. Calculations performed to determine approximate average annual runoff show that this amount is large, indicating rapid and complete drainage throughout the area. Factors which contribute to the completeness of drainage include the steepness of slopes, the removal of forest cover, and the relatively high erodibility of the soil surfaces. In some cases (as noted in section B.5.2.), groundwater contributes to the base flow inflating the apparent amount of runoff.

No specific information on the stream bed gradient, drainage density or bifurcation ratios has been gathered for the purposes of this report. Subject areas related to water quality are closely inter-related with fisheries biology. For this reason, consideration of water quality,

Table 4. Hydrometric survey data for selected rivers and streams in the Vancouver Island drainage (synopsis data only).

STREAM	TYPE OF FLOW	DRAINAGE AREA (sq. mi.)	MEAN ANNUAL DISCHARGE (cfs)	TOTAL ANNUAL DISCHARGE (ac.ft.)	MAX. DAILY DISCHARGE (cfs)	MIN. DAILY DISCHARGE (cfs)	MAX. DAILY DISCHARGE TO 1973 (YEAR) (cfs)	MAX. INSTANT. DISCHARGE TO 1973 (YEAR) (cfs)
Quinsam R.	regulated	108.0					7,700 (1968)	-
1970			213	155,000	1,560	43.0		
1971			345	250,000	3,400	65.5		
1972			363	264,000	2,820	51.0		
1973			298	215,000	3,240	34.0		
Oyster R.	natural flow	70.0					4,690 (1915)	-
1914			-	-	3,000	90.0		
1915			-	367,000	4,690	35.0		
1916			508	-	3,500	40.0		
Black Cr.	natural flow	-					-	-
Tsolum R.	regulated	99.7					6,770 (1973)	8,840 (1966)
1970			262	189,000	3,160	3.9		
1971			380	275,000	6,510	8.8		
1972			-	-	4,140	8.1		
1973			426	308,000	6,770	6.8		
Browns R.	natural flow	33.2					6,450 (1968)	-
1966			-	-	3,060	-		
1967			207	150,000	1,170	1.4		
1968			263	191,000	6,450	4.0		
1969			-	-	1,780	7.0		
Puntledge R.	regulated	225.0					11,100 (1966)	12,800 (1966)
1970			1,060	766,000	1,870	438.0		
1971			1,550	1,120,000	4,800	624.0		
1972			1,350	983,000	6,860	613.0		
1973			1,350	979,000	8,480	544.0		
Puntledge R.*	regulated	175.0					8,920 (1941)	-
1949			917	664,000	6,080	335.0		
1950			1,210	874,000	4,450	360.0		
1951			824	597,000	2,470	290.0		
1952			1,090	791,000	4,160	320.0		

Table 4. Continued.

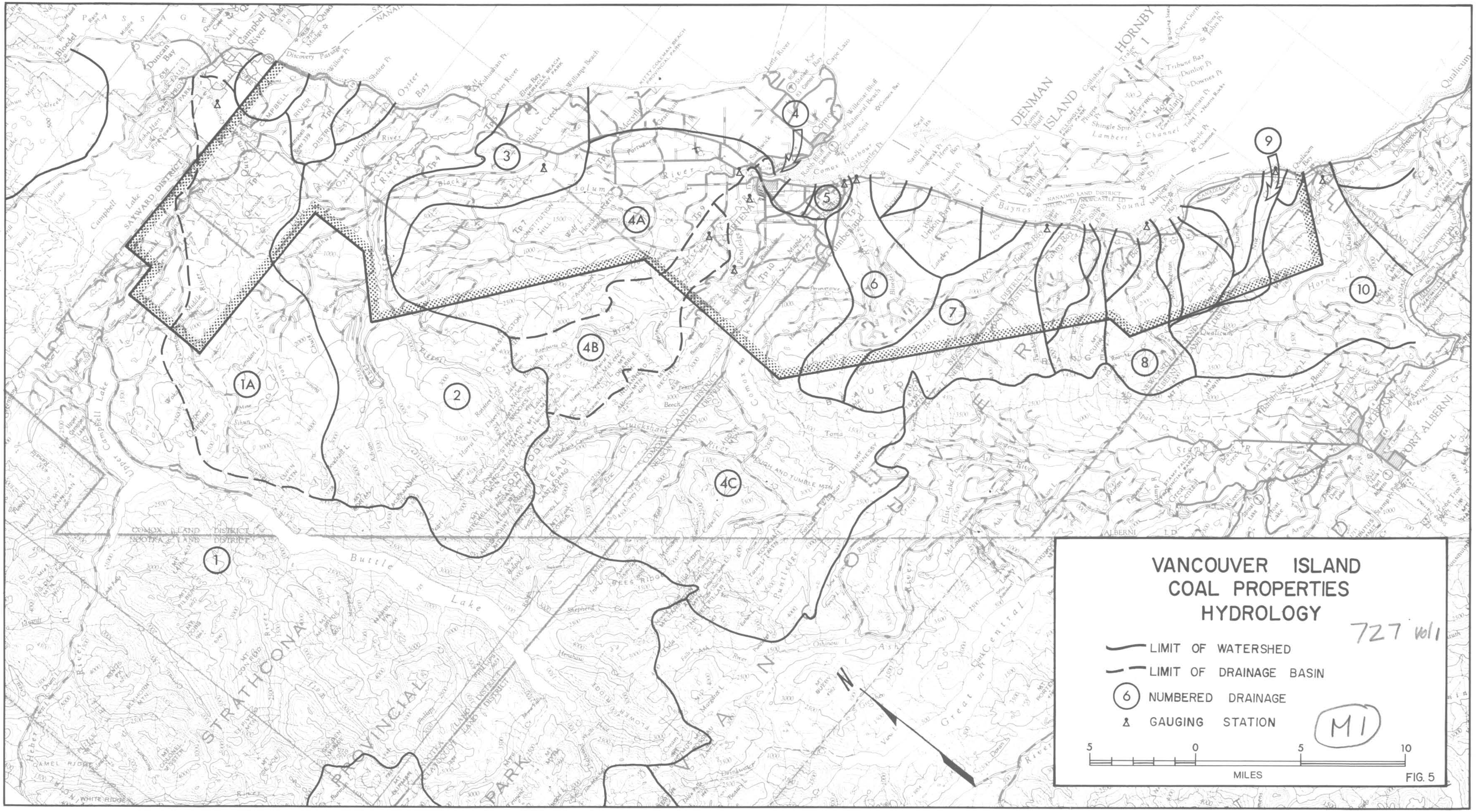
STREAM	TYPE OF FLOW	DRAINAGE AREA (sq.mi.)	MEAN ANNUAL DISCHARGE (cfs)	TOTAL ANNUAL DISCHARGE (ac.ft.)	MAX. DAILY DISCHARGE (cfs)	MIN. DAILY DISCHARGE (cfs)	MAX. DAILY DISCHARGE TO 1973 (YEAR) (cfs)	MAX. INSTANT DISCHARGE TO 1973 (YEAR) (cfs)
Roy Cr.	natural flow	-					-	-
1971			-	-	-	0		
Trent R.	natural flow	-					302 (1973)	-
1971			-	-	-	0.51		
1972			-	-	289	0.20		
1973			-	-	302	0.45		
Tsable R.	natural flow	41.3					8,100 (1960)	-
1970			185	134,000	2,220	7.7		
1971			289	210,000	3,700	26.9		
1972			275	199,000	3,850	9.5		
1973			263	190,000	4,750	8.8		
Rosewall Cr.	natural flow	16.7					2,540 (1968)	-
1969			-	-	-	0		
1970			66.3	48,000	1,040	-		
1971			108.0	78,100	1,660	0.15		
1972			99.2	72,000	1,540	-		
Nile Cr.	regulated	6.9					797 (1973)	-
1970			24.6	17,800	418	6.1		
1971			34.6	25,100	324	7.7		
1972			37.6	27,300	592	7.7		
1973			37.7	27,300	797	4.4		
Qua[illegible]	natural flow	43.0					2,460 (1961)	-
1958			-	-	2060	1.0		
1959			186	135,000	938	6.3		
1960			-	-	1,170	6.8		
1961			252	183,000	2460	2.3		

* data collected upstream from previously mentioned station

Figure 5. Watersheds and major drainage basins of east-central Vancouver Island*

1. Campbell River	4C. Puntledge River
1A. Quinsam River	5. Roy Creek
2. Oyster River	6. Trent River
3. Black Creek	7. Tsable River
4. Courtenay River	8. Rosewall River
4A. Tsolum River	9. Nile Creek
4B. Browns River	10. Qualicum River

* Only those drainages for which surface water data is presented have been identified.


VANCOUVER ISLAND
COAL PROPERTIES
HYDROLOGY
LIMIT OF WATERSHED
LIMIT OF DRAINAGE BASIN
6 NUMBERED DRAINAGE
GAUGING STATION
5 0 5 10
MILES
727 Vol 1
M1
FIG. 5

MONTHLY DISCHARGE HYDROGRAPH

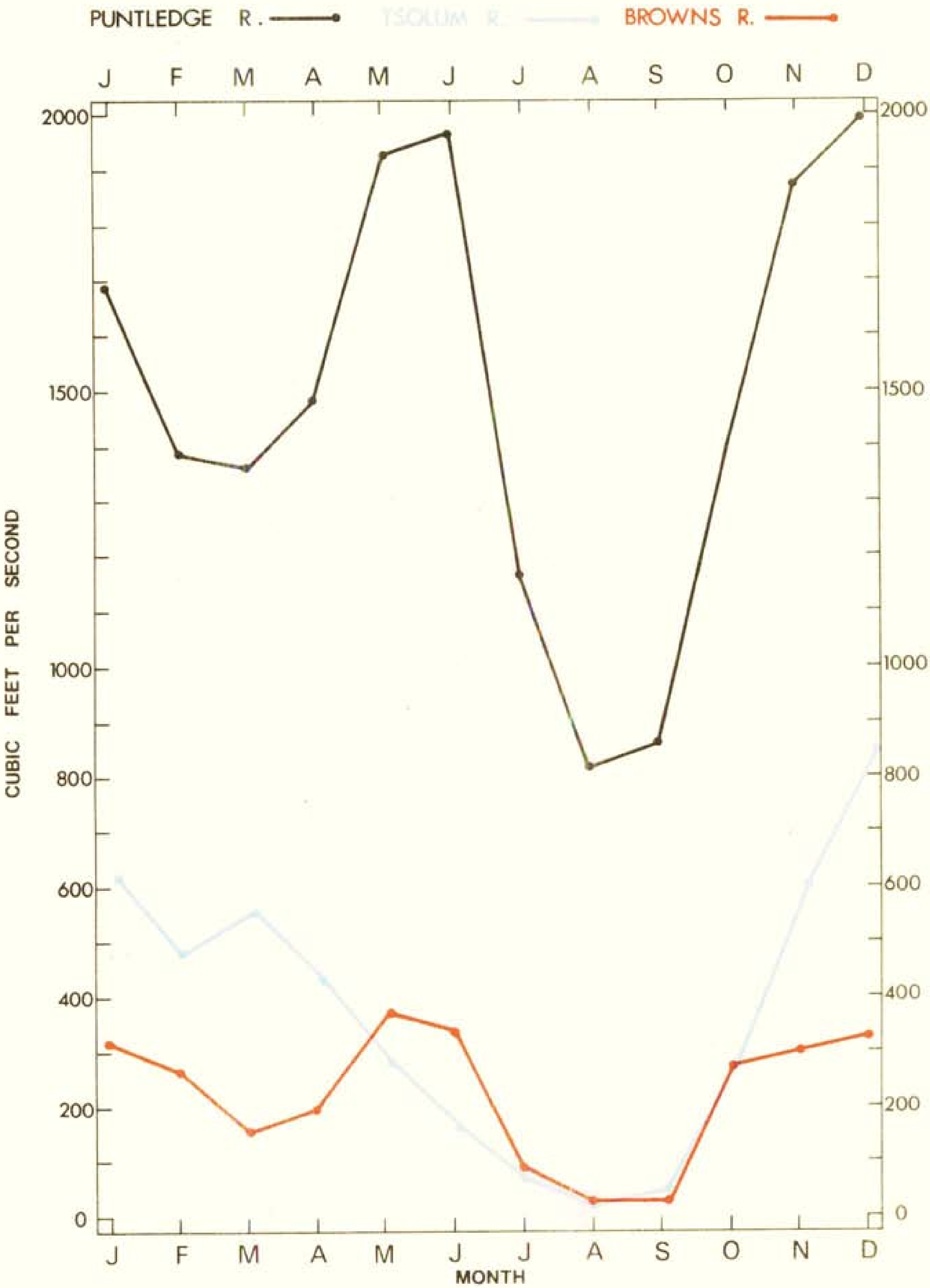
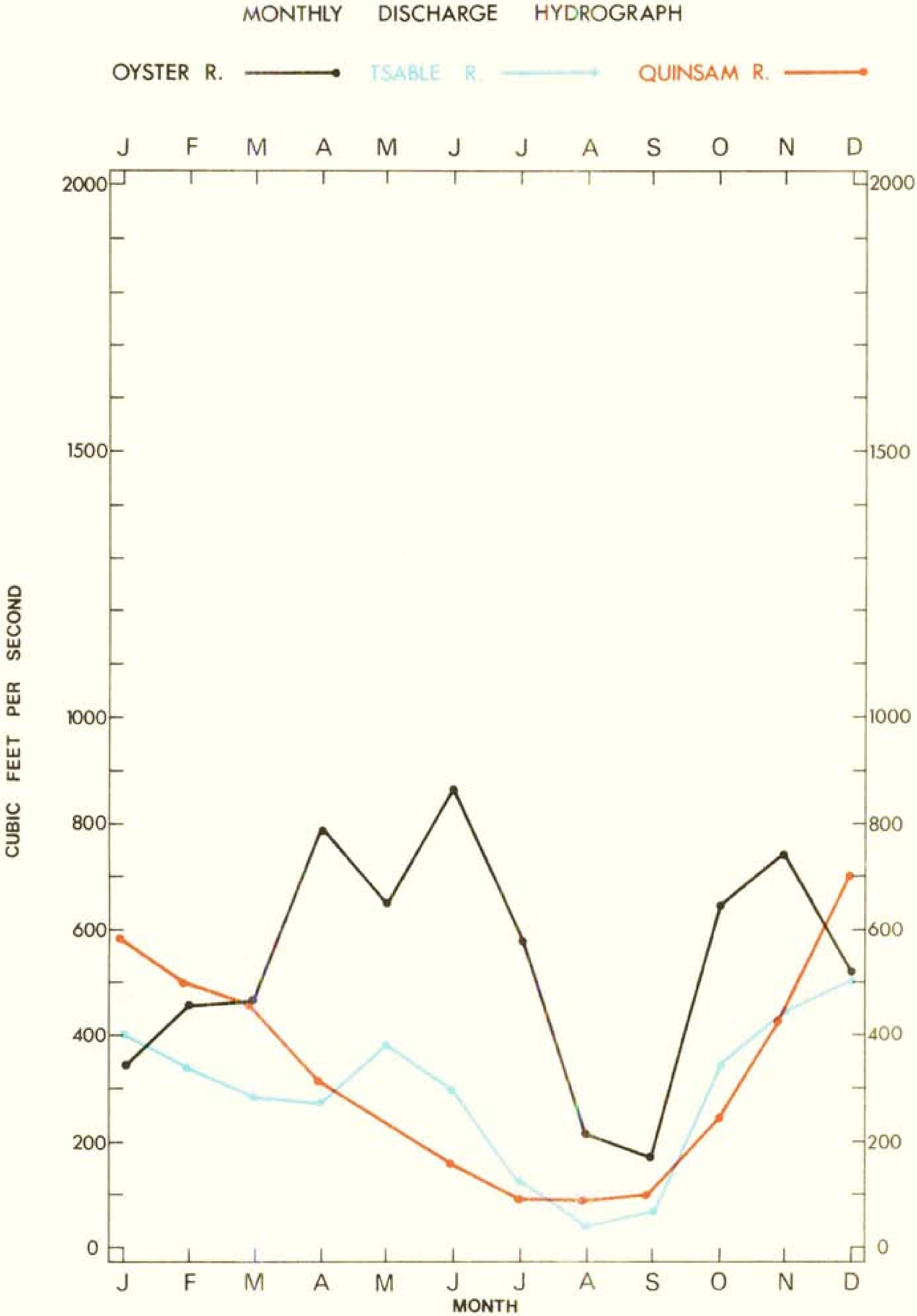


FIG. 6



MONTHLY DISCHARGE HYDROGRAPH
OYSTER R.
TSABLE R.
QUINSAM R.
J F M A M J J A S O N D
2000
1500
1000
800
600
400
200
0
CUBIC FEET PER SECOND
MONTH

FIG. 7

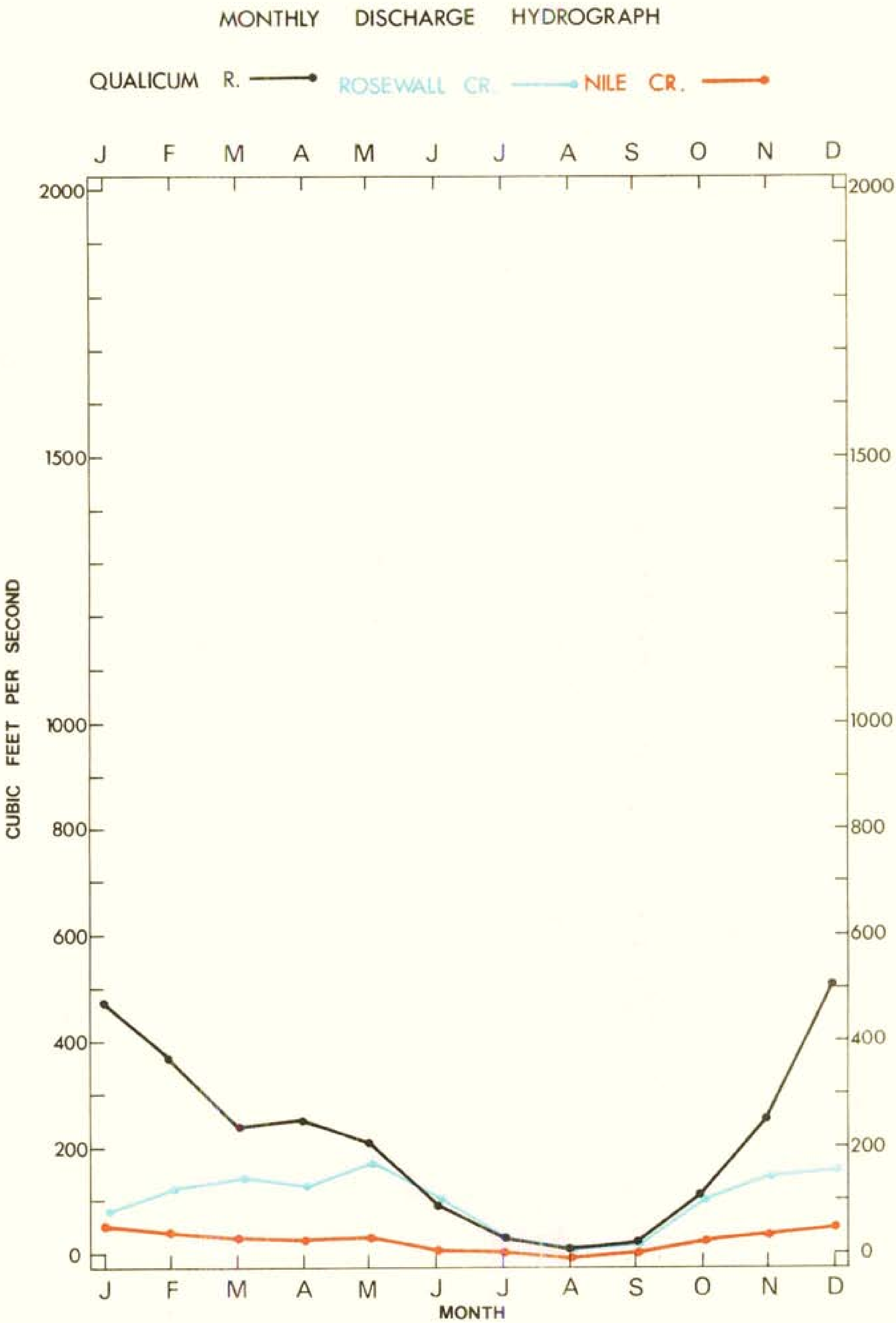

MONTHLY DISCHARGE HYDROGRAPH
QUALICUM R.
ROSEWALL CR.
NILE CR.
J F M A M J J A S O N D
2000
1500
1000
800
600
400
200
0
CUBIC FEET PER SECOND
MONTH

FIG. 8

sedimentation and siltation characteristics of rivers and streams in the Study Area is given in the section of Fisheries (C.2.1.).

B.5.2. Groundwater Resources

Groundwater supplies of eastern Vancouver Island occur mainly in unconsolidated surficial deposits. Bedrock yields little groundwater, and this source is very unpredictable in that water is encountered only if fractured or fissured zones are intercepted during drilling. Water-bearing deposits in the thick layers of gravel and sand are of two general types: those found above the impervious Vashon till which consist of free or unconfined aquifers and confined aquifers beneath the Vashon till. Above the Vashon till, aquifers are located in glacio-fluvial deposits, marine deposits of silt and clay and, in places, sand and gravel of various origins including: (a) ice contact gravel and sand; (b) deltaic gravel and sand accumulated along former higher water courses; and (c) modern river bottom, alluvial fan and deltaic deposits (Halstead and Treichel 1966). Below the till, water-bearing deposits consist of fluvial sands and gravels of the Quadra sediments, the Mapleguard sediments, and other permeable deposits.

The following discussion considers water-bearing deposits chronologically, beginning with the most recent materials.

Salish sediments (related to present sea, river and lake levels) comprise coarse-textured recent alluvium lying in proximity to the ground surface. The water table in this alluvium lies within a few feet of the surfact, the shallow wells generally encounter permeable gravel and sand and yield sufficient water for domestic purposes (Fyles 1963).

Glacio-fluvial and fluvial terrace deposits (eskers, kames, ice contact terraces and raised deltaic and fluvial deposits), contain substantial domestic and farm groundwater supplies of good quality. In flat areas, the depth to the water table in these materials is relatively uniform, but in ridged or hummocky country the depth of water varies with the elevation of the ground surface *(Ibid.)*.

Marine and ground-moraine deposits yield small amounts of groundwater with coarser gravels providing the most reliable water supplies. However, because of their general near-surface position they are pollution susceptible.

The above water-bearing deposits overlying the Vashon till are normally recharged by precipitation and percolation from the surface, with the result that these supplies are somewhat less reliable than those from confined aquifers issuing from sub-Vashon deposits.

The deposits lying below the Vashon till consist of Quadra and Mapleguard sediments and other permeable deposits. Water from this source comes to the surface naturally as springs on the rolling lowland surface as well as along steep river banks. This water contributes substantially to the flow of several of the rivers in the Study Area, especially during the dry summer months, notably the Qualicum River, Nile Creek and others *(Ibid.)*. Wells drilled into the sub-till sediments usually yield moderate to large amounts of water (in places artesian due to the impermeable capping of till) except those in the fine Quadra sands which sometimes require special treatment before they will yield appreciable amounts of water (Halstead and Treichel 1966).

Table 5 outlines the sources of water that supply a sampling of existing water systems in and around the Study Area. Wells with highest yields normally arise from sub-till deposits or recent surface deposits, with all other layers providing only limited amounts of water. Addition-

Table 5. Sources of supply to a sampling of existing water systems in the Nanaimo lowland.

LOCATION	DEPTH OF WELL (ft)	SOURCE OF SUPPLY
Quinsam Indian Reserve	16	20,000 gal. storage tank from well dug into fluvial and recent channel deposits
Campbell River and North Campbellton	--	pipeline from John Hart Dam
Oyster Bay	43	well drilled into recent shore and flood plain deposits
Comox Air Base	44-80	well drilled into Quadra sediments
Comox Village	120	well drilled into Quadra sediments
Courtenay	--	Browns River to storage tank
Cumberland-Royston district	--	pipeline from Hamilton and Allen Lakes
Union Bay	--	pipeline from Langley Lake
Fanny Bay	--	Cowie Creek
Qualicum Beach municipality	90-118	well drilled into Quadra sediments
Parksville municipality	--	natural spring arising from Quadra sediments; Englishman River

ally, much of the water used for domestic purposes is transported from lakes and streams of the area.

The deficiency of water for crop production has long been a problem on southeastern Vancouver Island. Table 6 outlines possible sources of irrigation water for those soils with considerable agricultural potential. The need for irrigation is partly based on the moisture holding capacity which should be kept above two inches.

Water quality analysis of groundwater in the area in general indicates a low mineral content with considerable variability in total mineral content as well as hardness. Samples from underlying shales and sandstones have a higher mineral content due to the presence of higher concentrations of sodium, chloride and bicarbonate. Small amounts of fluoride were detected in bedrock samples, with hydrogen sulphide noted in these as well. Water temperatures average slightly higher than the mean annual temperature at 46 degrees F to 50 degrees F *(Ibid.)*. Table 7 is a representative sampling of data for wells on or near the Study Area, with figures for the amounts of various constituents given in parts per million (ppm). Wells with total hardness values of less than 60 ppm are considered soft, between 60 and 120 ppm medium to hard, and above 120 ppm, hard. The analyses in general indicate good quality groundwater with local variations of poorer quality. For example, excessive sodium in the well south of Courtenay renders the water unsuitable for agricultural use, the high iron concentrations especially in the well southeast of Merville result in unpleasant tasting water with staining and precipitation problems. The water from this well is unsuitable for domestic use.

In summary, the groundwater resources of the Study Area are of generally good quality and wide distribution, and provide water for domestic and agricultural as well as irrigation purposes. In some cases

Table 6. Possible sources of irrigation water for certain agricultural lands (adapted from Halstead and Treichel 1966).

SOIL SERIES	APPROXIMATE AREA	SOIL MOISTURE HOLDING CAPACITY	NEED FOR IRRIGATION	POSSIBLE SOURCE OF IRRIGATION WATER
Roston series	22,020 acres, Courtenay area	Moderately high, 3.9 inches	Desirable during growing season	Wells drilled to Quadra sediments inferred to underlie Vashon till
Sandwick series	1,690 acres, Courtenay area	Reasonably high	Desirable to increase crop yields	Wells drilled to Quadra sediments along Island Hwy; elsewhere source may be lacking
Merville series	Small areas at Courtenay and Errington	1.4 inches	Desirable	Wells drilled to Quadra sediments in Courtenay area; insufficient sources available for Errington
Puntledge series	11,705 acres, Courtenay and Parksville areas	1.6 inches	Required during July and August	Wells drilled to Quadra sediments between Courtenay and Merville; elsewhere unavailable
Chemainus complex	Scattered occurrence throughout area	2.1 inches in silt loam type	Desirable	Readily available through shallow dugouts or sandpoints

Table 7. Water analyses for a sampling of wells on or near the Study Area (from Halstead and Treichel 1966).

LOCATION	TYPE OF WELL	TOTAL HARDNESS	Ca	Mg	Na	K	Fe	Mn	HCO_3	SO_4	Cl	NO_3	SiO_2	SUM OF CONSTITUENTS	% Na
North of Courtenay	Quadra Aquifer	82.6	21.2	7.2	8.9	1.4	0.1	0.1	112.0	2.3	8.7	0	23	128.0	19.0
Southeast of Merville	Quadra Aquifer	94.5	23.1	9.0	13.5	1.7	3.9	T	138.0	7.1	6.2	0	13	142.0	20.0
West of Oyster River	Uncon- fined Aquifer	78.6	20.7	6.5	3.3	0.4	0.2	0	88.9	10.0	3.4	0	16	104.0	8.3
South of Courtenay	Uncon- fined Aquifer	69.8	22.3	3.5	19.3	1.2	0.3	0.4	261.0	6.3	202.0	0	14	571.0	85.0
Northeast of Cum- berland	Uncon- fined Aquifer	38.4	9.4	3.6	19.0	0.3	0	0	34.0	42.6	5.4	0	17	114.0	52.0
Miracle Beach Prov. Park	Bedrock Well	39.4	10.6	3.2	14.0	0.8	1.3	68.4	7.2	7.0	0	0	14	90.2	42.0

groundwater contributes to the volume of coastal streams and rivers. It is also likely that groundwater flow systems above the Vashon till are of local extent while those beneath the till are intermediate to regional systems.

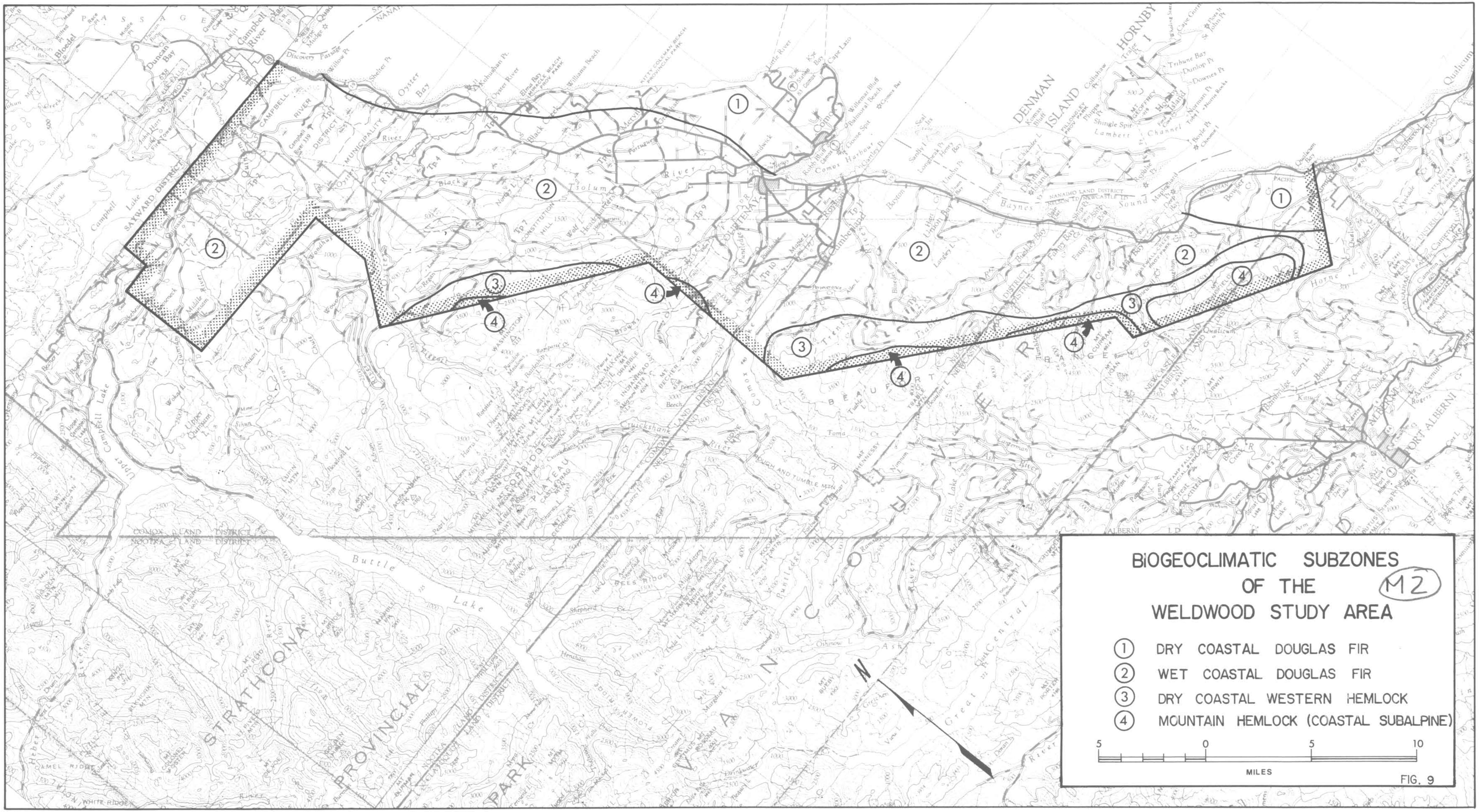
C. BIOTIC ASPECTS

C.1. Vegetation

The vegetation of western British Columbia has been extensively studied by Krajina and a succession of students working under his supervision. Literature dealing with classification schemes for British Columbia (and Vancouver Island) include Krajina (1959, 1965 and 1970) and Krajina and Spilsbury (1952 and 1953). Additionally, McMinn (1957, 1960 and 1965) was involved in research on water relations in eastern Vancouver Island forests. Mueller-Dombois (1959 and 1965) discussed Douglas fir associations during initial stages of secondary succession while Jablanczy (1964) worked on the effects of slash burning on the establishment and early growth of native conifer seedlings. Work has also been done on plant communities of Strathcona Provincial Park, adjacent to the Study Area (Kojima 1968).

The Study Area straddles three biogeoclimatic zones. Two of these have been sub-divided into dryer and wetter sub-zones. They are (generally distributed from dry coastal areas to more humid interior sections) Coastal Douglas Fir (drier sub-zone), Coastal Douglas Fir (wetter sub-zone), Coastal Western Hemlock (drier sub-zone) and Mountain Hemlock (sub-alpine) zone. Approximate mapping of these has been done by MacMillan-Bloedel Limited (1974) (Figure 9). Detailed botanical descriptions may be obtained from Krajina (1965 and 1970) and others. A summary of the physical conditions under which these zones and sub-zones develop is presented in Table 8.

Each biogeoclimatic zone is sub-divided into associations or overstory-understory groupings that relate to the substate composition, moisture relations and slope characteristics of localized sites. Since



BIOGEOCLIMATIC SUBZONES OF THE WELDWOOD STUDY AREA

FIG. 9

Table 8. Physical characteristics of the biogeoclimatic zones and sub-zones of the Study Area (adapted from Krajina 1969)

ZONE	ALTITUDE (ft.ASL)	CLIMATE* (from Koppen)	TOTAL ANNUAL PRECIPITATION (in.)	ACC. DAY-DEGREES OVER 43°F	SOIL ZONE
Coastal Douglas Fir (dry sub-zone)	0-1500	Cool Summer Mediterranean	26-40	1500-2500	Concretionary
Coastal Douglas Fir (wet sub-zone)		(Csb and dry Cfb)	40-65		Concretionary Brown (minimal podzol)
Coastal Western Hemlock (dry sub-zone)	0-1000 (north wind-ward side) 0-3000 (south wind-ward side)	West Coast Marine (Cfb and mile Dfb)	70-110	2500-3500	Ortstein Podzol
Coastal Western Hemlock (wet sub-zone)	1500-3500 (south lee-ward side)		110-262		Humus Podzol
Mountain Hemlock	1000-2500 (north wind-ward side 3000-5000 (south wind-ward side) 3700-6000 (south lee-ward side)	Human Sub-Continental (Dfb and Dfc)	87-170	1000-1500	Sub-alpine Humus Podzol

*Refer to Figure 3, in Section B.2.

the Coastal Douglas Fir zone (wet sub-zone) is the most widespread in the Study Area, the associations of this zone will be discussed here. For information on associations within other zones, the reader may consult Orloci (1965) or Krajina and Spilsbury (1953).

Salal-Lichen Association. This association occurs primarily within Douglas fir *(Pseudotsuga menziesii)* stands although lodgepole pine *(Pinus contorta)* may be present. It is best developed on exposed ridges, south-facing slopes, gravelly terraces and on coarse, thin, excessively drained soils. These sites are usually very dry. The understory salal *(Gaultheria shallon)* is dwarfed and prostrate; lichens are abundant on the ground and on the trunks of trees.

Salal Association. Douglas fir dominates this association too, but scattered western hemlock *(Tsuga heterophylla)*, grand fir *(Abies grandis)* and western redcedar *(Thuja plicata)* are sometimes present. This association occurs on moderate slopes with a relatively deep glacial till or outwash substrate. Soils are typically leached with hardpan layers. Drainage is good. The well-developed shrub layer, dominated by salal, precludes the development of extensive herb or moss layers.

Moss Association. This association is dominated by Douglas fir, and develops on lower deep-soiled slopes, drumlin flanks and alluvial terraces. The soils are slightly leached and moderately well drained, although a deep gley layer is sometimes present. Mosses are well-developed and abundant, but herb and shrub layers are poorly developed.

Swordfern Association. This association may be dominated by either Douglas fir or western redcedar. Grand fir and western hemlock may also be present in small numbers. The swordfern association develops on gentle valley bottom slopes, mid-slope depressions, creek banks and low alluvial plains. The underlying soils are rich and moist, with a gleyed B horizon. Drainage is fair to poor. The well-developed herbaceous layer is dominated by swordfern *(Polystrichum munitum)*.

Skunk Cabbage Association. These forests are dominated by western redcedar, and occur in very wet sites such as saturated slope bases, depressions with surface seepage and creek fans and shores. Rich, wet muck soils predominate and are underlain by gley. Drainage is poor. The understory layer is variable, but usually rich, with skunk cabbage *(Lysichitum americanum)* dominating.

Maidenhair Fern Association. The overstory conifer is western redcedar. This association usually develops on alluvial floodplains, on rich, banded, fine-textured soils. Drainage is good. The well-developed herbaceous layer contains maidenhair fern *(Adiantum pedaturn)*, wild rose *(Rosa nutkana)*, Solomon's seal *(Smilacina stellata)* and stinging nettle *(Urtica lyallii)*.

Sphagnum Bog Association. The major tree present is lodgepole pine. This association is typically found along lake margins and in depressions. Underlain by organic *Sphagnum* peat soils, these sites are constantly saturated. Characteristic of these areas are Labrador tea *(Ledum groenlandicum)* and various *Sphagnum* species.

These associations vary greatly in their productivity, ranging from the unproductive *Sphagnum* bogs to the highly productive Swordfern and Maidenhair Fern associations. Many other understory plants are characteristic of these sites. For details, see Mueller-Dombois (1965) or Krajina and Spilsbury (1953)

Logging has pronounced effects on plant community structure and composition. Generally, understory species do not disappear after logging and burning, but their relative abundance may be altered greatly, according to the degree of disturbance and time of logging. In addition, a variety of weed species move in to mask the presence of the characteristic species. These weeds comprise a small group of dominants: the widely distributed fireweed *(Epilobium angustifolium)* and pearly everlasting *(Anaphalis margaritacea);* the intolerant wet-site weeds such as lettuce *(Lactuea biennis)*, hawksbeard *(Crepis capillaris)*, bull thistle *(Cirsium vulgare)* and Canada thistle *(C. arvense);* the intolerant dry-site weeds such as white hawkweed *(Hieracium albiflorum)*, cudweed *(Gnaphalium microcephalum)* and hairy cat's ear *(Hypochaeris radicata);* and others including the fireweeds *Epilobium paniculatum, E. adenocaulon*, the ragwort *Senecio sylvaticus*, and annual sow thistle *(Sonchus asper)*. A number of semi-tolerant forest weeds also increase in abundance and widen their distributions. Unlike those species mentioned above, these plants are present in the undisturbed forest, although they did not attain dominance there. These are broadleaf maple *(Acer macrophyllum)*, red alder *(Alnus rubra)*, thimbleberry *(Rubus parviflorus)*, trailing blackberry *(R. vitifolius)*, western black raspberry *(R. leucodermis)* and bracken *(Pteridium aquilinum)*.

The information gained through forest removal during logging should be useful in revegetation studies related to open pit coal mining, since the autecological characteristics of the species will not change, and their biology is moderately well understood.

C.2. Fish and Invertebrates

C.2.1. Introduction

In this section, the fisheries resources in the Study Area are described. There is an extensive literature on this subject. The sources emphasized either deal with fish, shellfish or other invertebrates in the Study Area itself, or contribute pertinent information from studies conducted elsewhere in southern British Columbia waters. Some important sources which present large quantities of data on a stream-by-stream basis have been summarized in this report. The reader is referred to the original sources for details. The literature on some topics, particularly ecological aspects of the economically important fishes, is vast and no attempt has been made to summarize all of this information. While this review outlines the major sources of information, it should be noted that research by various provincial and federal agencies continues and several useful reports are in preparation.

In the following sections, the aquatic habitats and resources in both fresh and marine waters, within or adjacent to, the Weldwood leases are examined (Figure 1). The marine environments described are Baynes Sound and Union Point.

C.2.2. Freshwater Resources in the Study Area

The Weldwood leases lie within a region of exceptional importance to freshwater fisheries. Virtually all of the streams and lakes support salmon and/or trout populations and these form the basis of substantial commercial and sport fisheries.

For many decades, interest and concern over fishery resources have been great, and numerous baseline and management-oriented studies have been conducted. One illustration of the value of this resource is the number of fish hatcheries and/or spawning and rearing channels (some experimental) which have been constructed on streams in the Study Area. They include the Big Qualicum River, Puntledge River, Quinsam River, Tsolum River and Rosewall Creek.

An extensive body of information has resulted from this work although the earlier data are outdated in many cases. The relevant material is basically of two kinds:

a) data (often "raw data") describing some biological, chemical or physical characteristics of watersheds in the Study Area, and

b) literature describing aspects of the ecology of fish and invertebrates found within the Study Area.

The first kind of information, presented commonly in stream surveys or stream catalogues, is available for many streams which flow through the Weldwood leases. Walker and MacLeod (1970) have produced a very useful stream catalogue for Statistical Area No. 14, which includes a large portion of the Study Area, and this information is frequently drawn upon in the present report. This catalogue provides a brief physical description of the streams as well as general comments on anadromous fishes present, their spawning areas and escapements (1947-1968).

Additional stream and lake surveys in the Study Area have been conducted over the past 25 years by the Nanaimo Office of the B.C. Department of Recreation and Conservation, Fish and Wildlife Branch. These unpublished reports and data sheets are kept on file. The agency also has on file a series of 1:50,000 topographic maps showing portions of streams utilized by anadromous and resident fish, and indicating the location of known spawning areas and stream sections judged to have potential, marginal or no value as fish habitat. While these maps illustrate general fisheries conditions, they do not present actual survey data and therefore may lack accuracy in some cases (G. Reid, pers. comm.).

While this first type of information provides an initial and valuable overview of the study area, not all streams and lakes have been surveyed and many waterbodies have received only cursory attention. Furthermore, site-specific data for particular stream sections within the Weldwood leases are not available.

The second kind of information, detailed ecological studies, is well advanced, especially for fishes with sports or commercial value. The current status of this information is that most aspects of the biology (e.g. growth, diet, reporduction, etc.) of the important fishes are documented. However, special studies would be necessary to determine how the fish populations in particular streams might be affected by future developments.

(i) General Description of Freshwater Habitats

The Study Area includes all but the smallest drainages which flow into the Strait of Georgia between the Big Qualicum and Campbell rivers (Figure 5). The larger streams passing through sections of Weldwood leases are the Quinsam, Oyster, Courtenay, (Tsolum and Puntledge), Trent, Tsable and Big Qualicum drainages. The upper reaches of 14 smaller streams also lie in or near the leases: Simms, Black, Roy, Hart (Washer), Cowie, Wilfred, Waterloo, Rosewall, McNaughten (Cook), Chef, Lymn, Nile and an unnamed creek. The lakes in this area include Quinsam, Wolf and Comox lakes, as well as several smaller ones.

Much of the area lies within Statistical Area No. 14 (Fisheries Service, Department of the Environment) which has been described by Fyles (1963) and Walker and MacLeod (1972). The latter authors state (paraphrased):

> Area 14 measures approximately 65 miles by 18 miles and is part of the east central district of Vancouver Island. This area consists of a series of northwest trending mountain ranges (summits 3000-5000 feet) bordered on the northeast by lowland measuring from two to ten miles in width and averaging four miles. The lowland surface rises gradually from the seashore to meet the steeper mountain slope at elevations from approximately 300-700 feet.
>
> This is a relatively dry coastal area with an annual rainfall of 40-60 inches in the northern part and 30-40 inches in the southern area. The summer and early fall rainfall is generally in the order of 2 inches. Stream flows are at a minimum during the summer months; generally runoff increases in the late fall with the onset of rain and attains maximum volumes during the winter months through rainfall and periodic snow melt.
>
> The area has shown a steady development based on agriculture, lumbering, mining and fishing. Logging operations over the past 100 years have removed practically all of the mature forest from the readily accessible areas, and the majority of these now support second-growth stands. Mining may have adversely affected salmon populations in the Trent and Tsable rivers by the escapement of mine effluents into these streams. The diversion of water, land clearing and draining for agricultural purposes presents problems in maintaining stream flows through low rainfall periods, particularly in the Tsolum River and Black Creek where the situation threatens to reduce the high rate of coho production. The general development of the area poses serious fishery problems (domestic water use, property bank protection, poaching) in a number of small streams which are principally coho salmon producers.

Water quality data are generally lacking for streams and lakes in the Study Area. Presumably, detailed records are maintained in the streams where hatcheries and spawning channels exist, but in other areas information is sparse. Some survey data (major ions) are available for Comox Lake and other lakes near the Study Area (on file, Nanaimo Office, Fish and Wildlife Branch). More detailed studies have been conducted on Great Central Lake (e.g. Stephens *et al.* 1973).

(ii) Fish

Fresh waters in the Study Area are inhabited by three genera of economically important fish: salmon (*Oncorhynchus*), trout (*Salmo*) and char (*Salvelinus*). The salmon include chum (*O. keta*), pink (*O. gorbuscha*), chinook (*O. tshawytscha*), coho (*O. kisutch*), sockeye (anadromous *O. nerka*) and kokanee (freshwater resident *O. nerka*). The trouts are cutthroat (*S. clarki*), rainbow (freshwater resident *S. gairdneri*) and steelhead (anadromous *S. gairdneri*). The single char, the Dolly Varden (*S. malma*) is present. The body of information on each of these species is vast and, as previously mentioned, no attempt has been made to review this literature. However, several references which provide ecological information on the streams and fishes in the Study Area specifically, have been listed in Table 9.

An important feature of the Study Area is the existence of sizeable waterfalls, impassable to fish, on many of the streams. Typically, these waterfalls are located in the mountain foothills, the physiographic boundary between the Coastal Lowlands and the Beaufort Range. Anadromous salmon and trout are found only downstream of such barriers while resident trout are distributed throughout the drainages. Within the Study Area, those stream sections used by anadromous fish and resident sport fish are

Table 9. Selected list of sources, other than catalogue and file data, which provide information on streams and fishes specifically within the Study Area.

Stream	References
Oyster River	Narver and Withler, 1971
Tsolum River	Narver and Withler, 1971; Bams, 1972
Puntledge River	Narver and Withler, 1971; Marshall, 1973
Tsable River	Narver and Withler, 1971
Rosewall Creek	Smith, 1969
Chef Creek	Wickett, 1964; Cooper, 1969, 1970
Lymn Creek*	Mason, 1974a, 1974b
Nile Creek	Neave, 1947, 1966; Wickett, 1951, 1954, 1958
Big Qualicum River	Lister and Walker, 1966; Peterson and Lyons, 1968; Lister and Genoe, 1970; Narver and Withler, 1971; Burns, 1971; Anon., undated

*not in Gazeteer, but "enters Deep Bay".

illustrated in Figures 10 and 11 respectively.

The distributions of the individual salmon and trout species in the Study Area are shown in Figures 12 through 20 (based on information gathered from Walker and MacLeod (1970) and unpublished surveys by the Nanaimo Office, Fish and Wildlife Branch). These maps indicate a widespread utilization of the study streams. A further demonstration of the importance of these streams is apparent in the numbers of spawning salmon and steelhead in Statistical Area No. 14 (Table 10). These escapement records, for the years 1947-1968, also illustrate the relative abundances of different species.

Walker and MacLeod (1970) provide the following species synopsis for salmon in this area:

Chum:

This is the principal salmon species within Area 14 and is represented in total by fall-run fish. Major size chum populations occur in three streams, namely Puntledge, Big Qualicum and Little Qualicum rivers and minor populations in fourteen streams.

The general level of the stocks at this time is good and the opportunity for increase is excellent through the development of the Big Qualicum River and the application of scientific management principles.

Pink:

This species has been reduced to almost negligible numbers in Area 14. This has come about as a result of the decline of major stream stocks to roughly 1/10 of former abundance (Puntledge, Oyster, Tsolum) and to the near elimination of the majority of small populations (Tsable, Cook, Nile, Little Qualicum and Englishman rivers). In general, the even numbered stock was strongest. The loss of pink salmon is speculated to be due to lower freshwater survival arising from a combination of streambed deterioration of spawning and incubation areas, a reduction in minimum flows particularly at the time of upstream migration and an increase in maximum flows, and direct harassment by man.

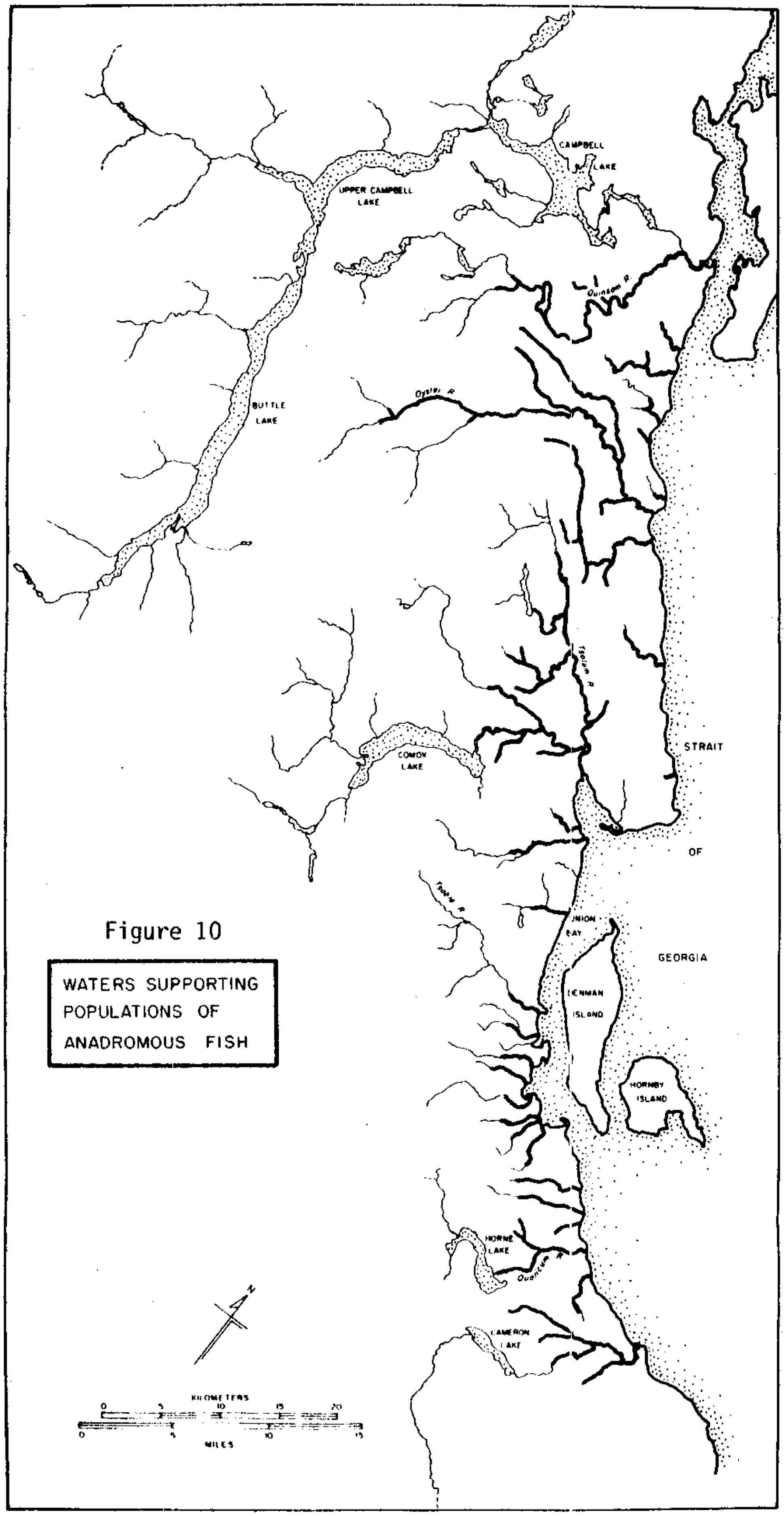


Figure 10

WATERS SUPPORTING POPULATIONS OF ANADROMOUS FISH

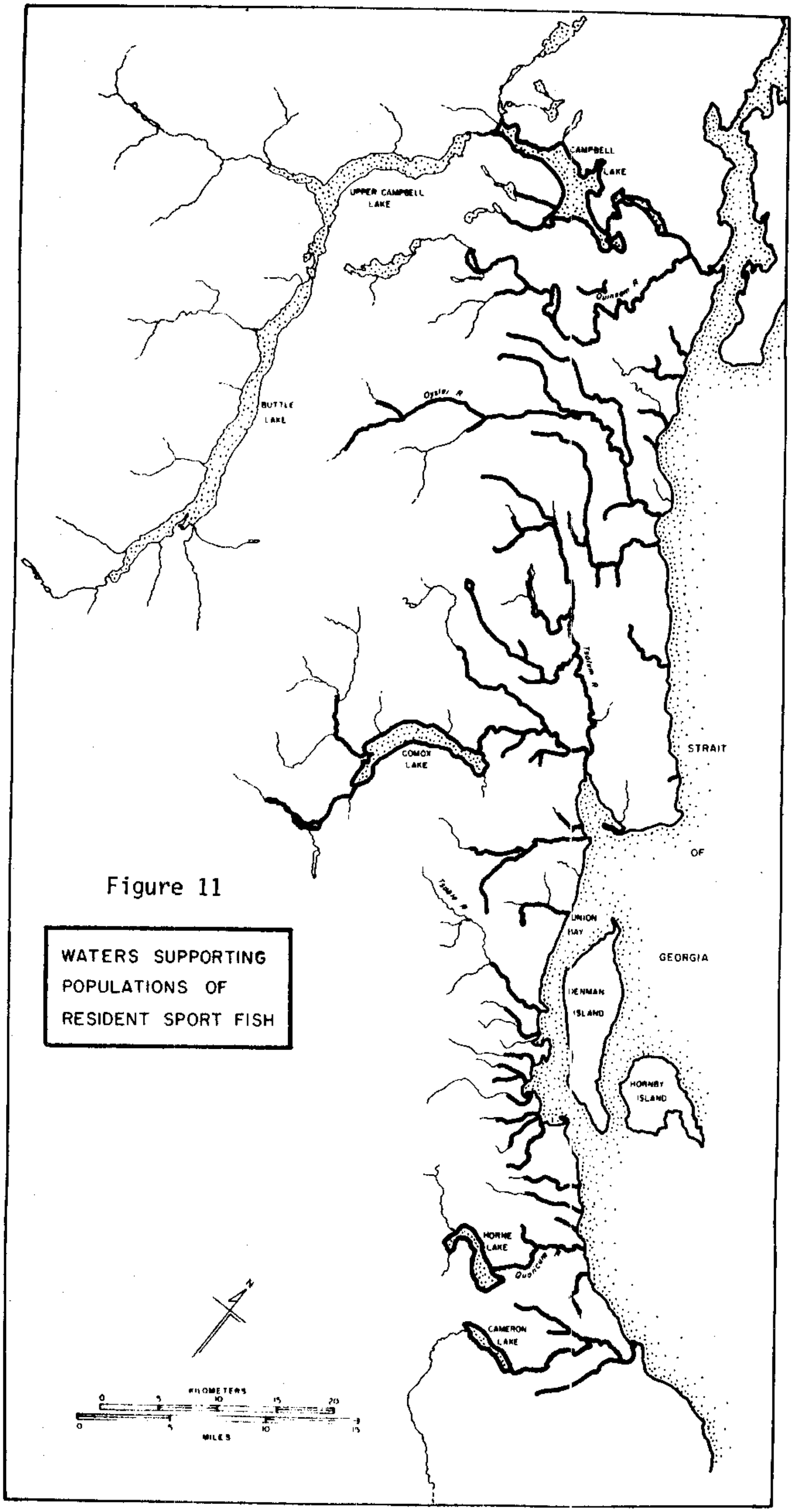


Figure 11

WATERS SUPPORTING POPULATIONS OF RESIDENT SPORT FISH

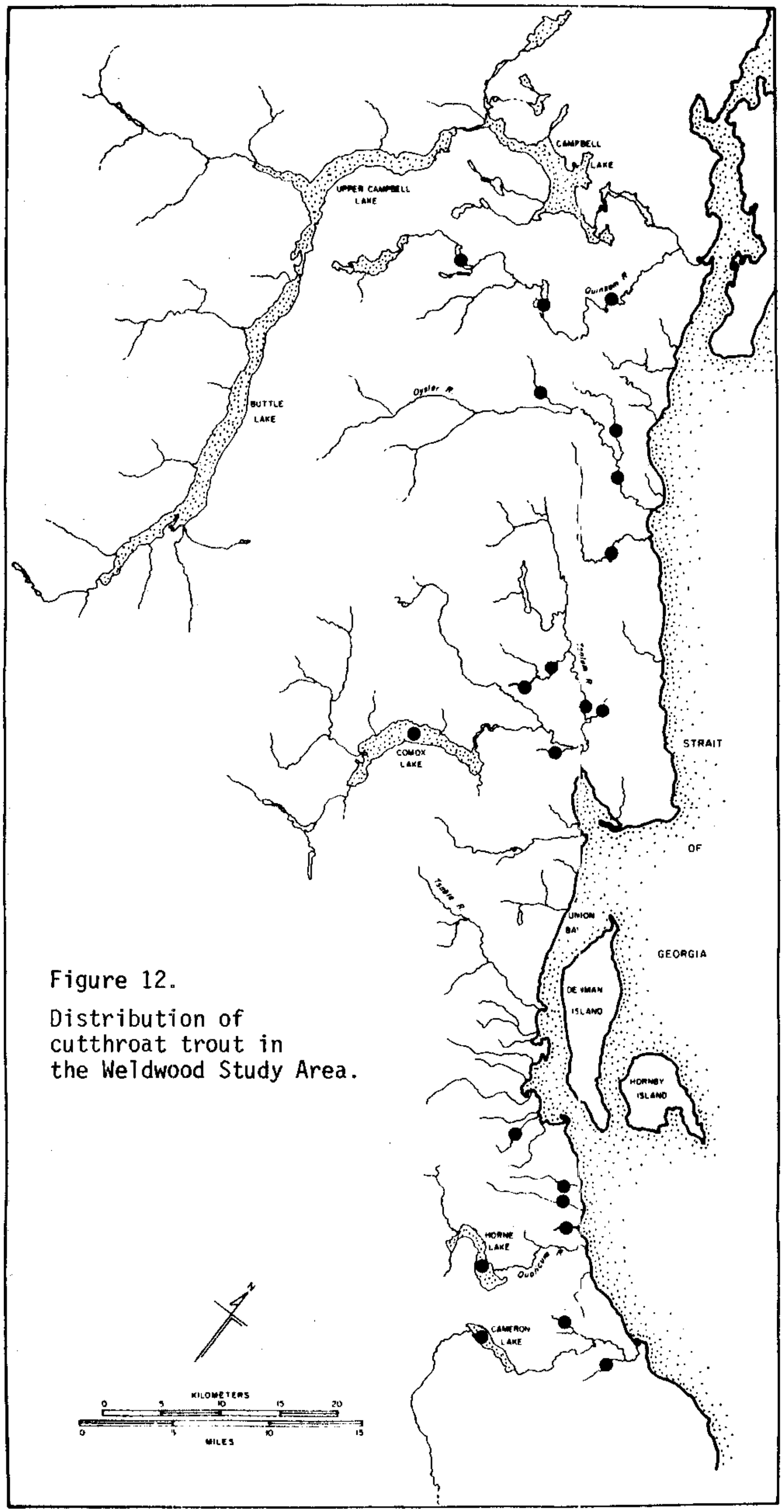


Figure 12.
Distribution of cutthroat trout in the Weldwood Study Area.

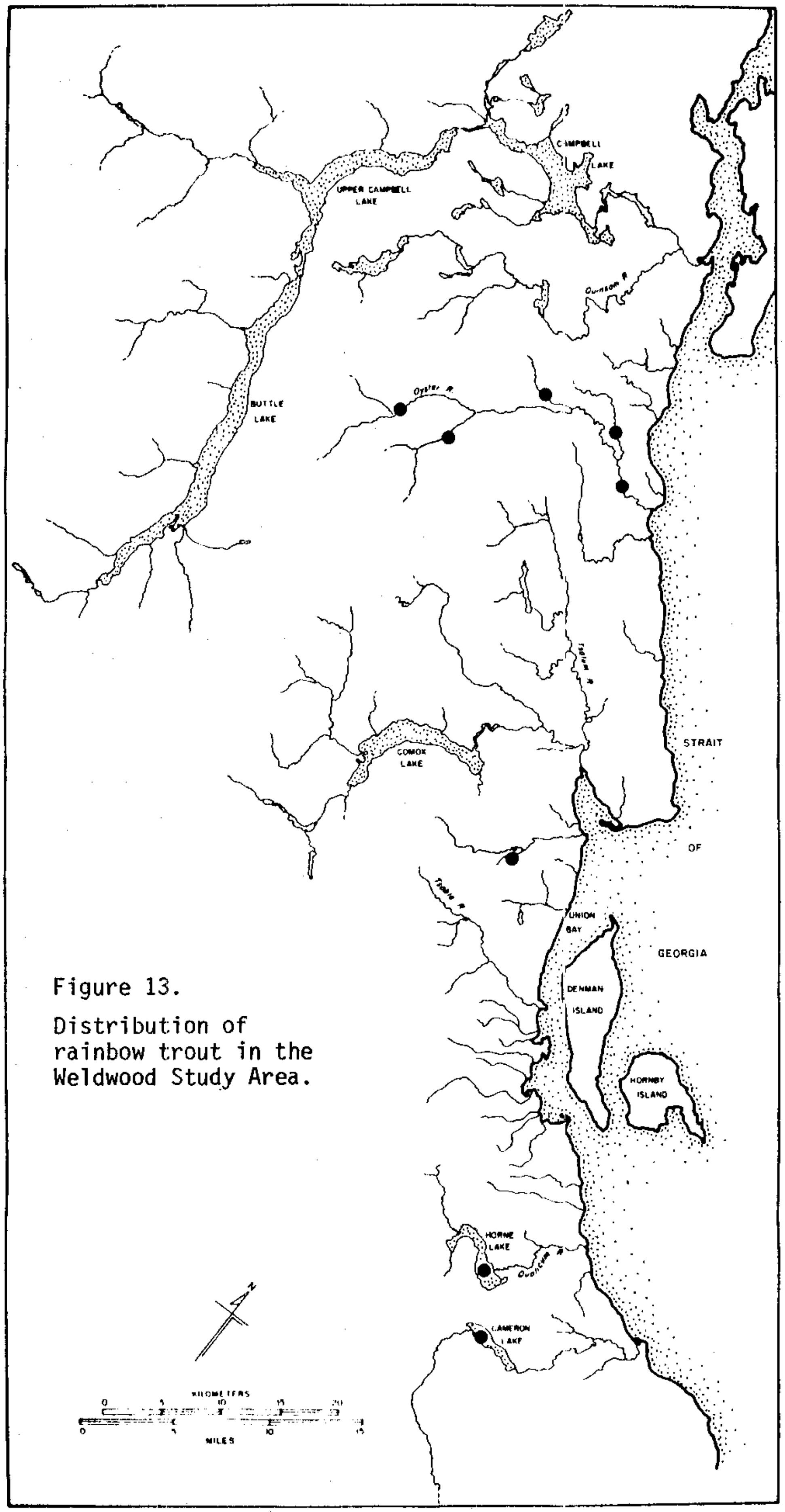


Figure 13.

Distribution of rainbow trout in the Weldwood Study Area.

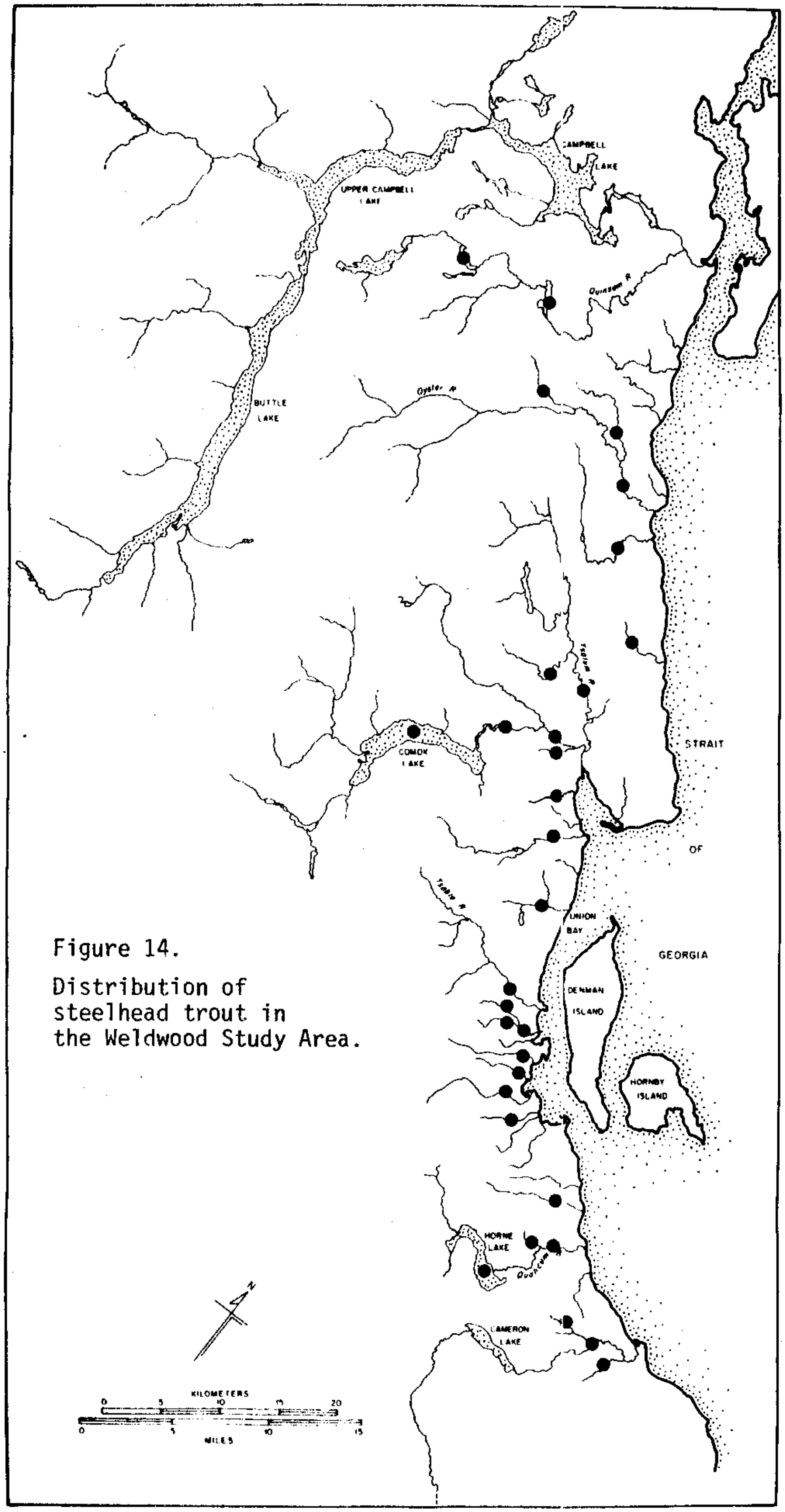


Figure 14.

Distribution of steelhead trout in the Weldwood Study Area.

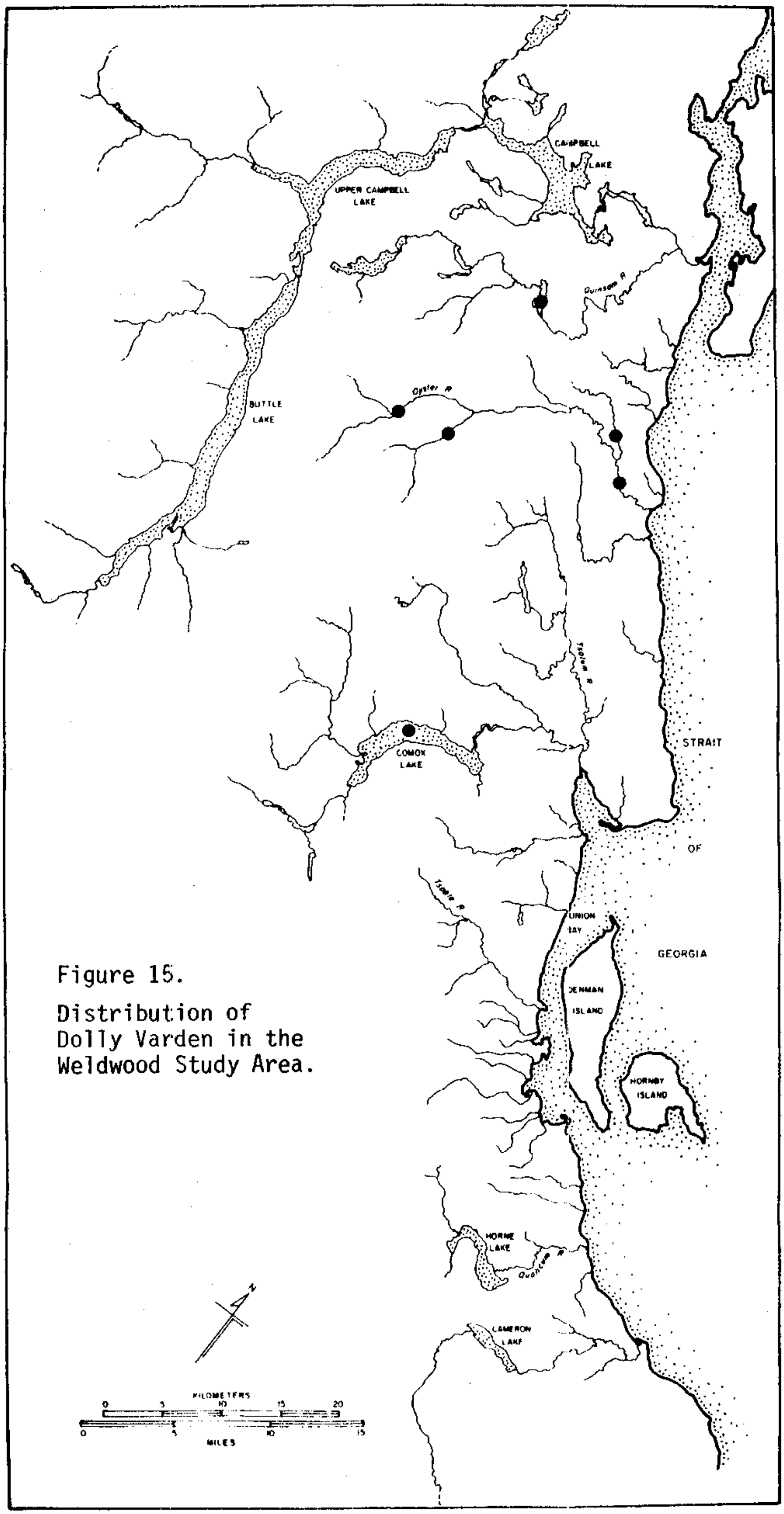


Figure 15.

Distribution of Dolly Varden in the Weldwood Study Area.

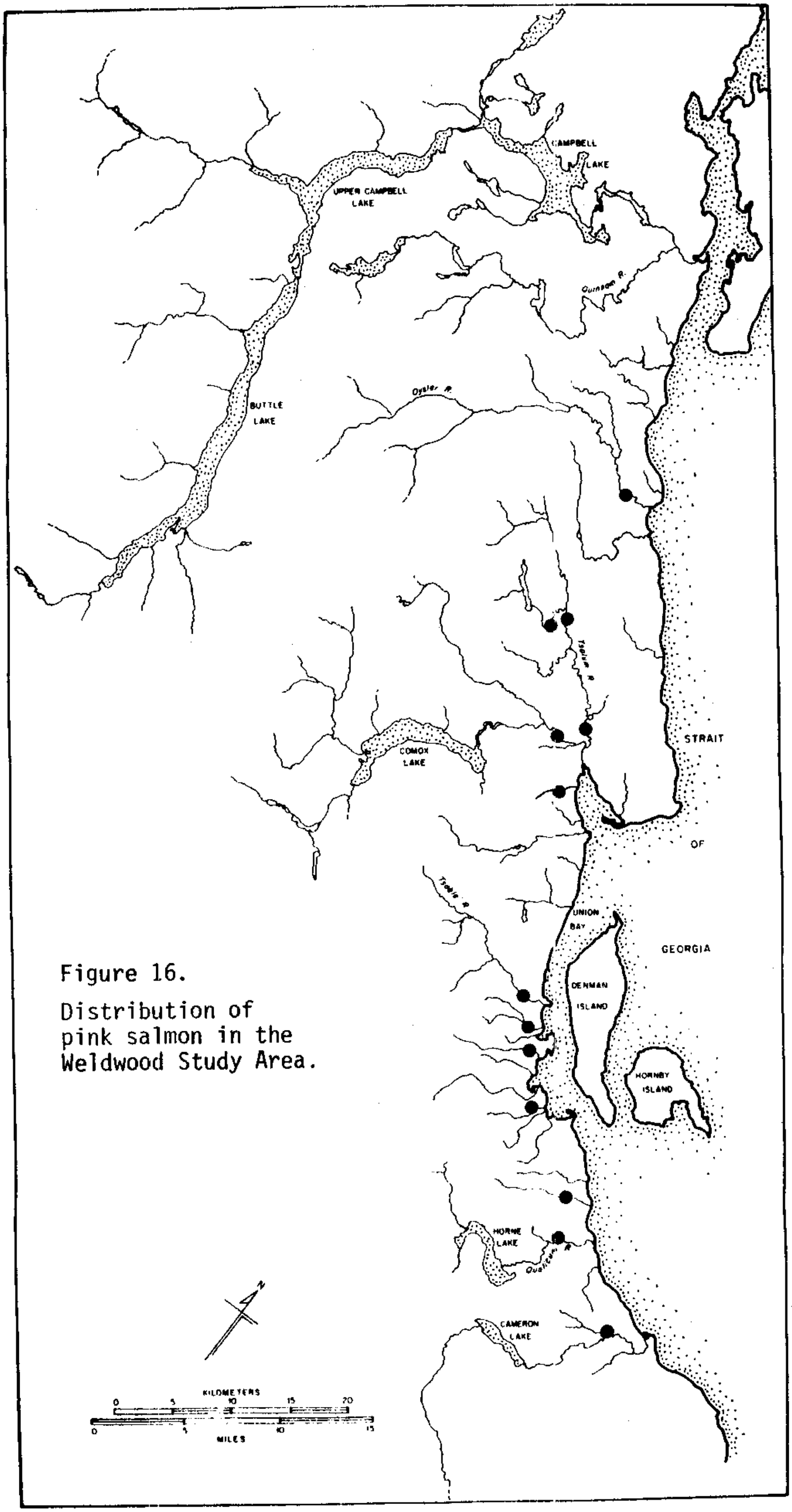


Figure 16.

Distribution of pink salmon in the Weldwood Study Area.

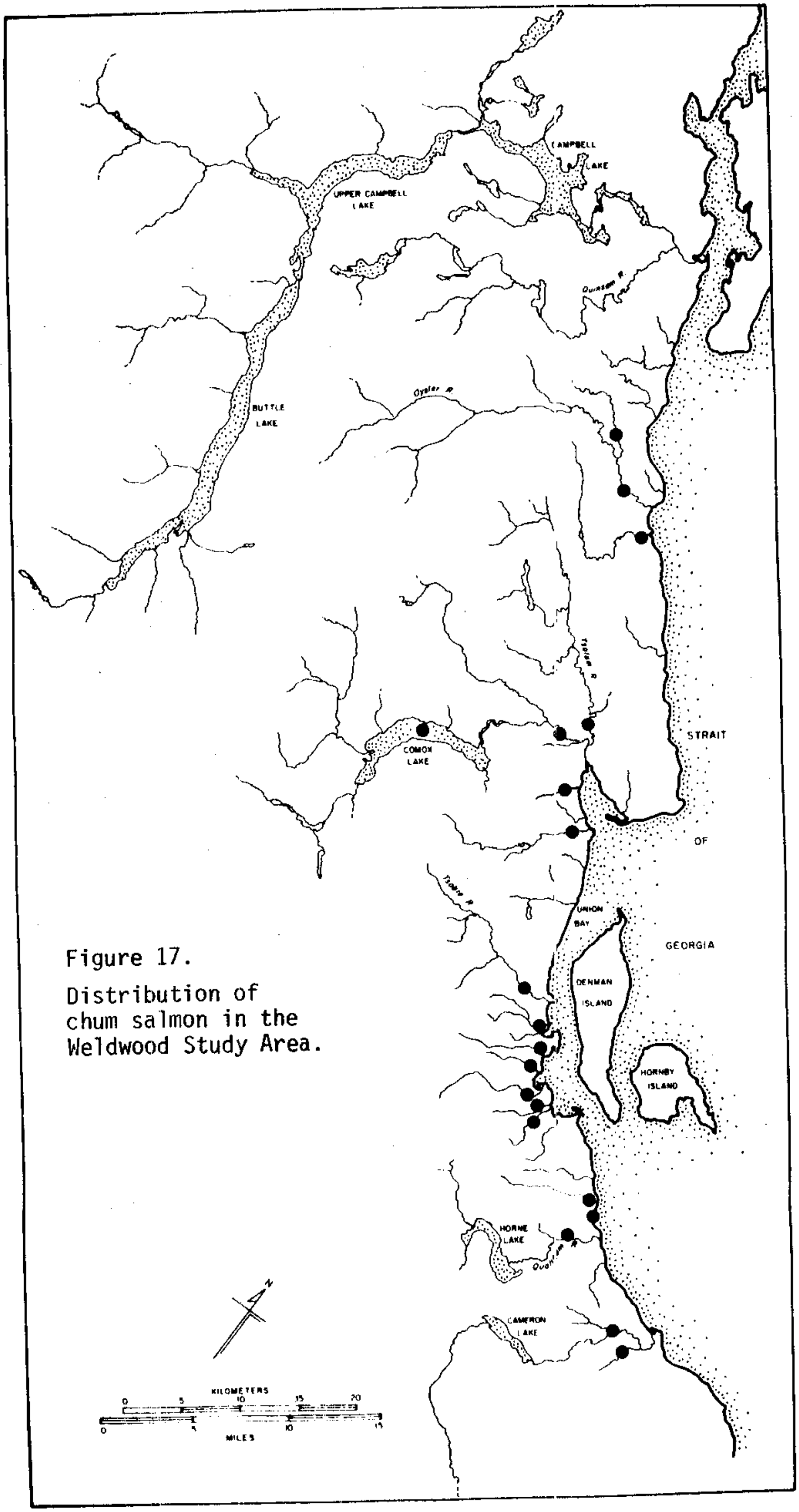


Figure 17.
Distribution of chum salmon in the Weldwood Study Area.

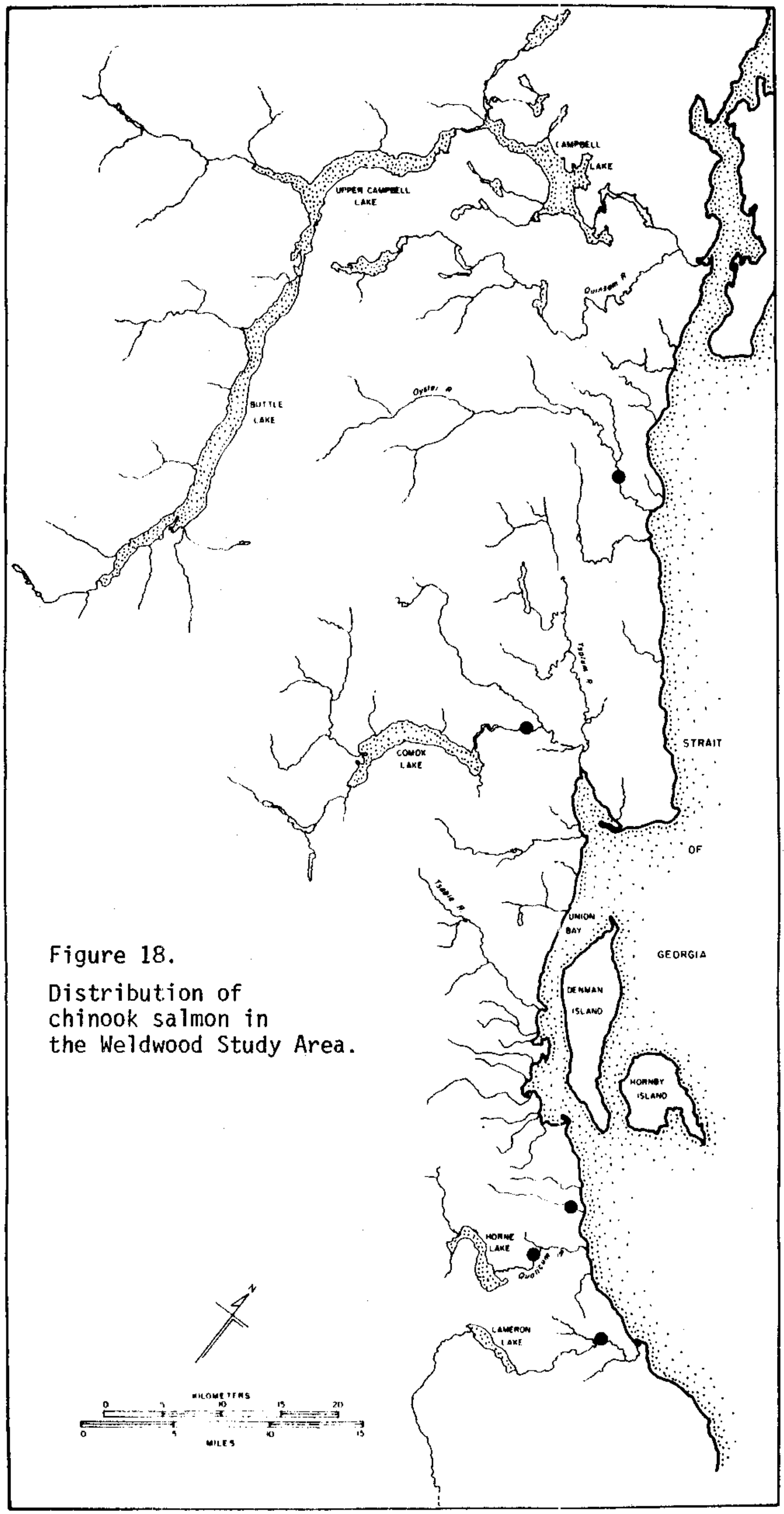


Figure 18.

Distribution of chinook salmon in the Weldwood Study Area.

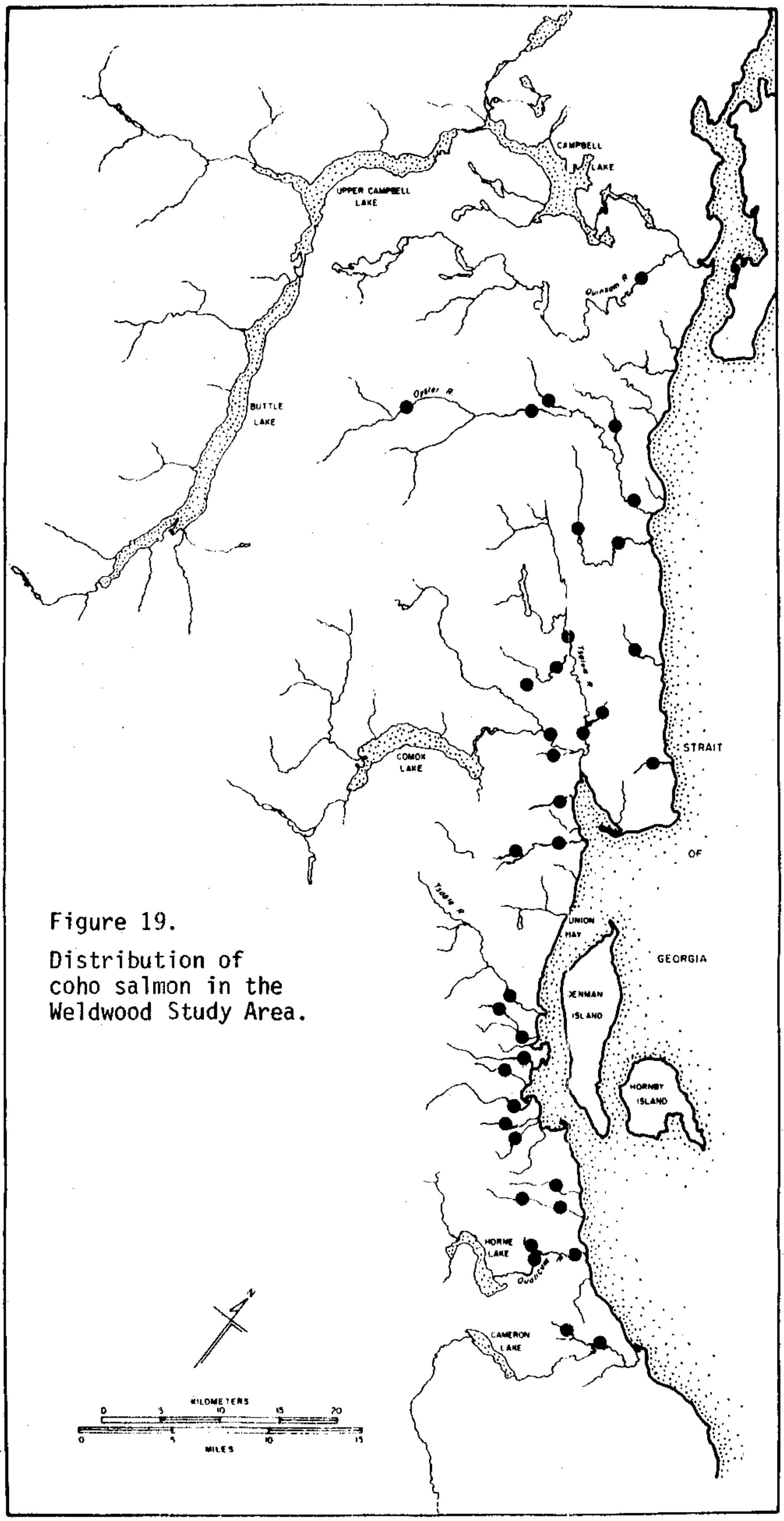


Figure 19.

Distribution of coho salmon in the Weldwood Study Area.

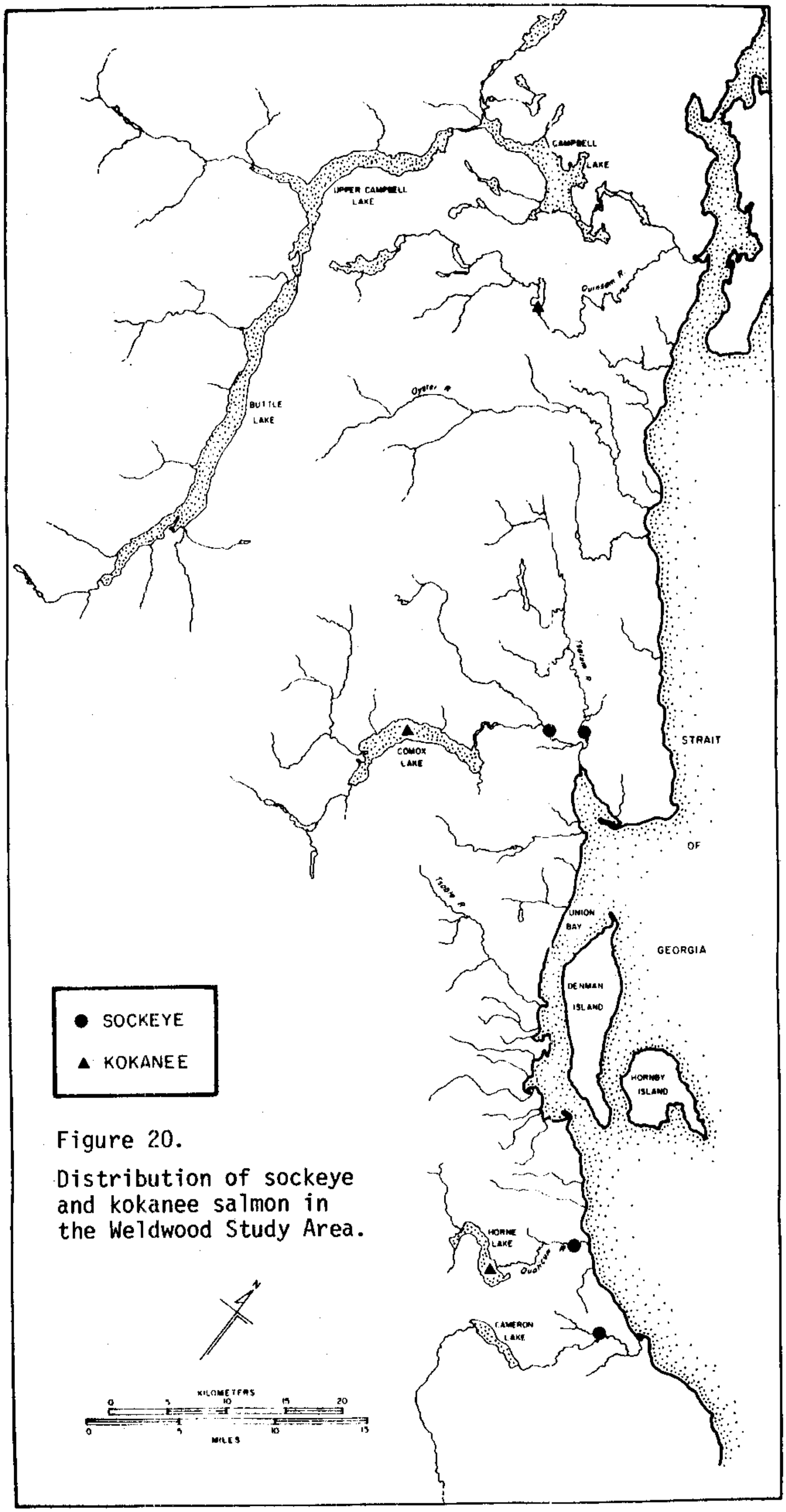


Figure 20.

Distribution of sockeye and kokanee salmon in the Weldwood Study Area.

Table 10. Escapement records for Statistical Area No. 14, which includes many streams in the Study Area. Not included is the Quinsam River. Streams in Area 14 but not in the Study Area are the Little Qualicum River, Englishman River, French Creek and Craig Creek (Walker and MacLeod, 1970).

Year	Sockeye	Chinook	Coho	Chum	Pink	Steelhead
1947		11,050	23,900	321,750	84,950	3,575
1948		11,000	13,350	217,650	90,750	1,000
1949		11,225	35,575	109,250	37,625	875
1950		8,750	17,200	227,650	126,625	6,125
1951		23,125	23,600	266,550	206,265	25,200
1952		11,450	70,400	115,425	217,295	13,325
1953		12,700	35,800	150,775	58,500	19,475
1954		24,025	34,975	160,450	192,525	17,975
1955	75	14,000	26,975	120,875	56,450	6,700
1956	75	12,025	22,875	43,150	58,800	9,975
1957	75	13,275	27,225	105,150	101,500	9,150
1958	650	24,000	34,525	141,875	186,975	11,450
1959	76	13,836	33,750	192,025	20,062	9,600
1960	100	9,344	22,875	145,800	14,875	7,575
1961	75	6,536	22,700	73,100	16,625	7,125
1962	28	3,437	26,625	126,225	7,751	7,650
1963	-	4,419	27,072	154,750	18,626	8,225
1964	50	9,627	69,450	114,625	2,450	25
1965	61	4,943	24,200	38,050	5,850	400
1966	25	10,295	40,200	137,850	24,825	-
1967	20	9,029	10,250	119,500	5,604	-
1968	275	23,090	14,850	306,500	12,700	-

REMARKS: Current spawning populations of steelhead trout in Area 14 are estimated to be in the same order as those up to 1963.

Chinook:

This species has decreased in abundance within the 1960's largely because of significant reductions in the summer and fall runs to the Puntledge River. As a result of lowered production within the Puntledge system, an important sport fishery at Comox has been reduced. The Big and Little Qualicum rivers support fall run fish.

Coho:

The coho are more generally distributed than the other species but there is a danger of eventually losing the small-stream populations due to the encroachment of man who will modify the stream environment and impose poaching pressures. Losses of coho salmon may be compensated for by utilizing headwaters in some of the larger streams (Puntledge, Big Qualicum and Little Qualicum rivers).

Sockeye:

This species is absent from Area 14.

Walker and MacLeod (1970) rank the three most important streams in the area by species:

				Pink	
Rank	Chinook	Coho	Chum	odd year	even year
1	Puntledge	Oyster	Qualicum	Tsolum	Tsolum
2	Qualicum	Tsolum	Little Qualicum	Puntledge	Oyster
3	Little Qualicum	Black	Puntledge	Oyster	Puntledge

Fish information for lakes situated in the Weldwood leases is sparse. Comox Lake, the largest lake in the Study Area (surface are 4936 acres; maximum depth 358 feet) supports populations of chum, kokanee, steelhead, cutthroat, Dolly Varden, threespine sticklebacks and sculpins. Quinsam Lake (279 acres; maximum depth 70 feet) has a similar fish fauna except that it lacks chum salmon and sticklebacks. Fish populations in the remaining lakes in the Study Area (e.g. Gilson, Mirror, Maple, Teal, Wolf and Langley lakes) have apparently not been inventoried.

(iii) Invertebrates

Lake dwelling invertebrates in the Study Area have received little attention. Some survey data are available for Comox Lake and other lakes near the Study Area (on file, Nanaimo Office, Fish and Wildlife Branch). More detailed investigations have been conducted in nearby Great Central Lake (e.g. Kennedy and LeBrasseur 1975).

Similarly, there are few data on invertebrates in the study streams. Outside the Study Area, however, investigations have been conducted on invertebrate drift in Kinkade Creek (Little Qualicum drainage) and Robertson Creek (Mounce and Mundie 1972) and on the effects of logging on invertebrates in Kinkade Creek and the Chemainus River (J. Mundie pers. comm.). Mounce (1973) has compiled an introductory guide to the stream insects of southern Vancouver Island.

C.2.3. Marine Resources of Baynes Sound and Union Point

In view of the proposed construction, development and shipping activities which would occur in or adjacent to the marine waters at Union Point, it is essential to identify the existing marine resources in the area. The whole of Baynes Sound is reviewed as there are few data available for Union Point itself. In addition, it is possible that currents in the Strait may extend the effects of the Union Point development to oyster and clam grounds throughout the Sound.

There are three principal marine resources in Baynes Sound: salmon, oysters and clams. These and other existing resources are described in this section.

(i) General Description of Baynes Sound and Union Point

Baynes Sound is a large marine channel located between Denman Island and the mainland of Vancouver Island (Figure 1). The sound extends approximately 18 miles, averaging one to two miles in width and 100 to 180 feet in depth along its center. Although the sound is open to the ocean at both ends, the northwestern end is bordered on the ocean side by Comox Bar, a large gravel bar extending from Denman Island through the Seal Islets to the Vancouver Island mainland near Balmoral Beach (about 1.5 miles east of Comox). Water depths along Comox Bar are shallow, averaging only 4 to 6 feet.

Currents in Baynes Sound are variable and influenced by wind direction.

Eighteen streams discharge into the sound. These streams, ranging in size from 1.5 to 8 miles in length, drain the foothills of the Beaufort Range and the Coastal Lowlands. All but the smallest support anadromous salmon populations.

Small estuaries exist where these streams enter the channel and, between the estuaries, extensive beaches have formed in the protected waters of the sound. Substrates in much of the intertidal zone consist of mud, shells and gravel.

Water quality in Baynes Sound is generally excellent and much of the intertidal region has been designated as public reserve for shellfish (Photo 1) or has been leased with foreshore rights to oyster growers. However, there are some exceptions. Near the populated centers of Comox Harbour, Union Point and Deep Bay, the waters have been polluted by domestic sewage and shellfishing is prohibited.

Union Point is unique in one noteworthy respect. The entire Point has been overtopped with coal waste materials from a coal processing plant. This plant operated for many years until finally closed in 1959. As the waste pile from the processing plant grew in size, it overflowed into the intertidal zone to a depth of some 18 feet (M. Curcio pers. comm.).

Hart (Washer) Creek, a small single-channel stream, meanders through the northwestern edge of the slack pile, forming a small estuarine area at Union Point.

With the passing years, the surface of the slack pile in the intertidal region has been washed free of the smallest coal fines by tidal action and the substrate is now relatively stable. Although no quantitative measurements are available, the kinds of intertidal organisms found during low tide in the washed coal materials appear similar to those found on other beaches. At Union Point, amphipods or beachhoppers (*Orchestoidea*) inhabit the high intertidal zone. Nearer the ocean, the low tide surface is covered with barnacles, oyster shells and ubiquitous shore crabs (*Hemigrapsus*). Nemerteans, ghost shrimp and Manila clams (*Venerupis japonica*) are also abundant, and sculpins utilize the intertidal reaches of Hart Creek. In the pools at the ocean's edge, crabs, barnacles, oysters (*Crassostrea gigas*) and oyster drills (*Ocenebra japonica*) are abundant.

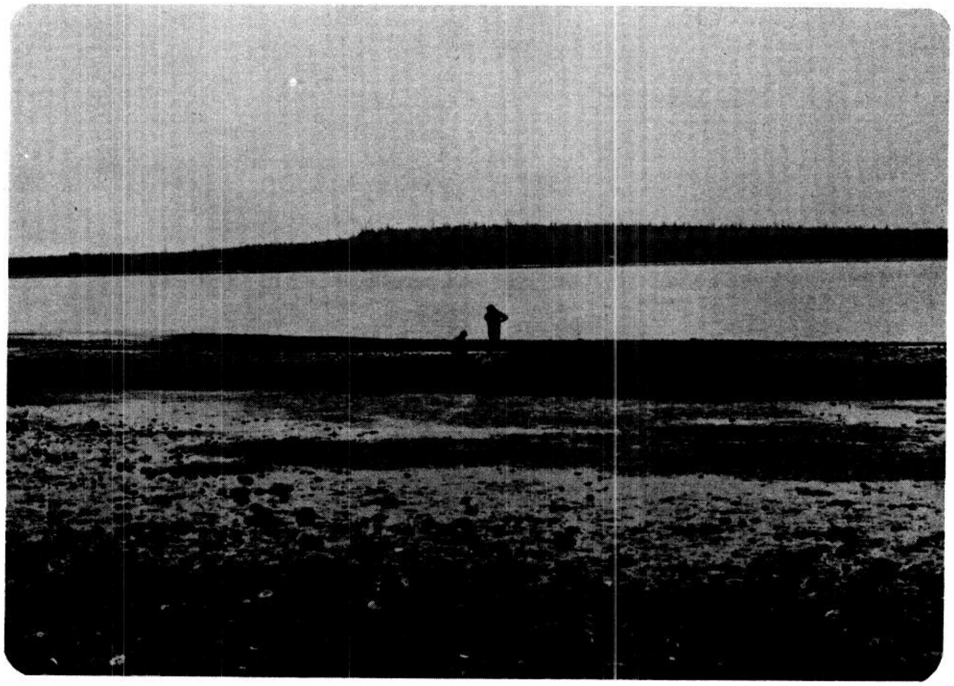


Photo 1. Clam diggers at Union Bay tidal flats. This section of coast is important for its shellfish resources.

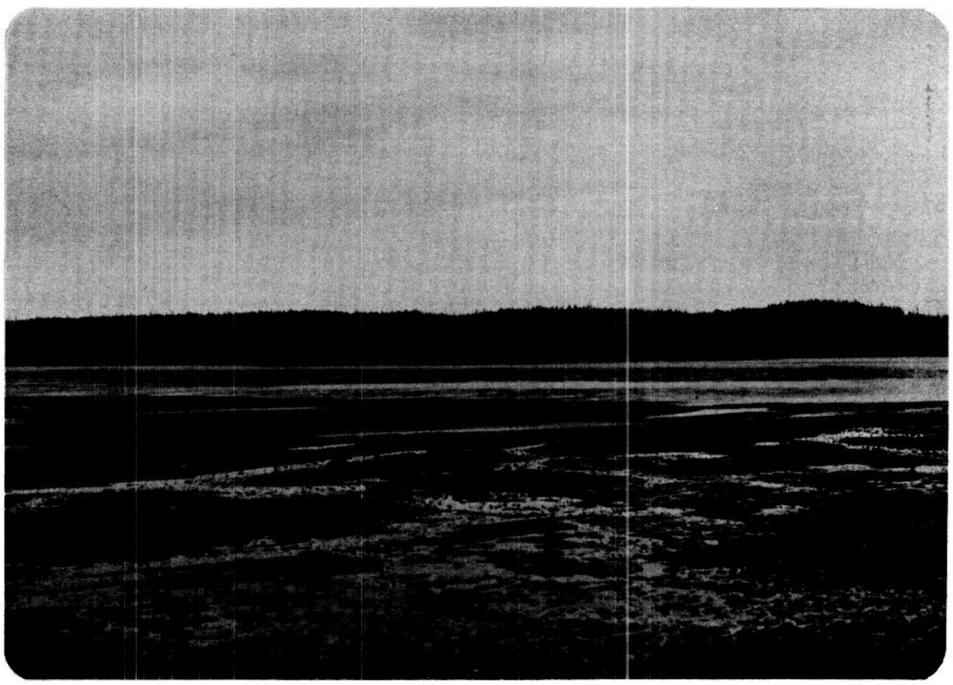


Photo 2. The estuary habitats are some of the most vulnerable with regard to ocean-borne pollution. This is the Rosewall Creek estuary.

(ii) Shellfish

Shellfish include a variety of hard-shelled marine invertebrates (principally bivalve molluscs) many of which are harvested for domestic or commerical purposes. The importance of shellfish, principally oysters, in Vancouver Island fisheries is substantial. Quayle (1969) recounts the history of commercial shellfishing in the area and concludes that "only the brightest future may be forecast for this industry". Sport fishing for oysters and clams is also very popular amount residents, and, as evidenced by travel brochures, shellfish form a significant attraction for the tourist trade.

Information concerning the general biology of shellfish found in the Study Area, particularly those with a commercial value, is available in the literature. For many years, investigations have been conducted at the Pacific Biological Station at Nanaimo, with much of the work under the direction of Dr. D. Quayle (1960, 1969, 1971, 1972). Shellfish resources in the Study Area are discussed below.

Oysters

There are three species of oyster found in British Columbia waters:

a) the native oyster (*Ostrea lurida*), a small oyster, widely distributed but not abundant,

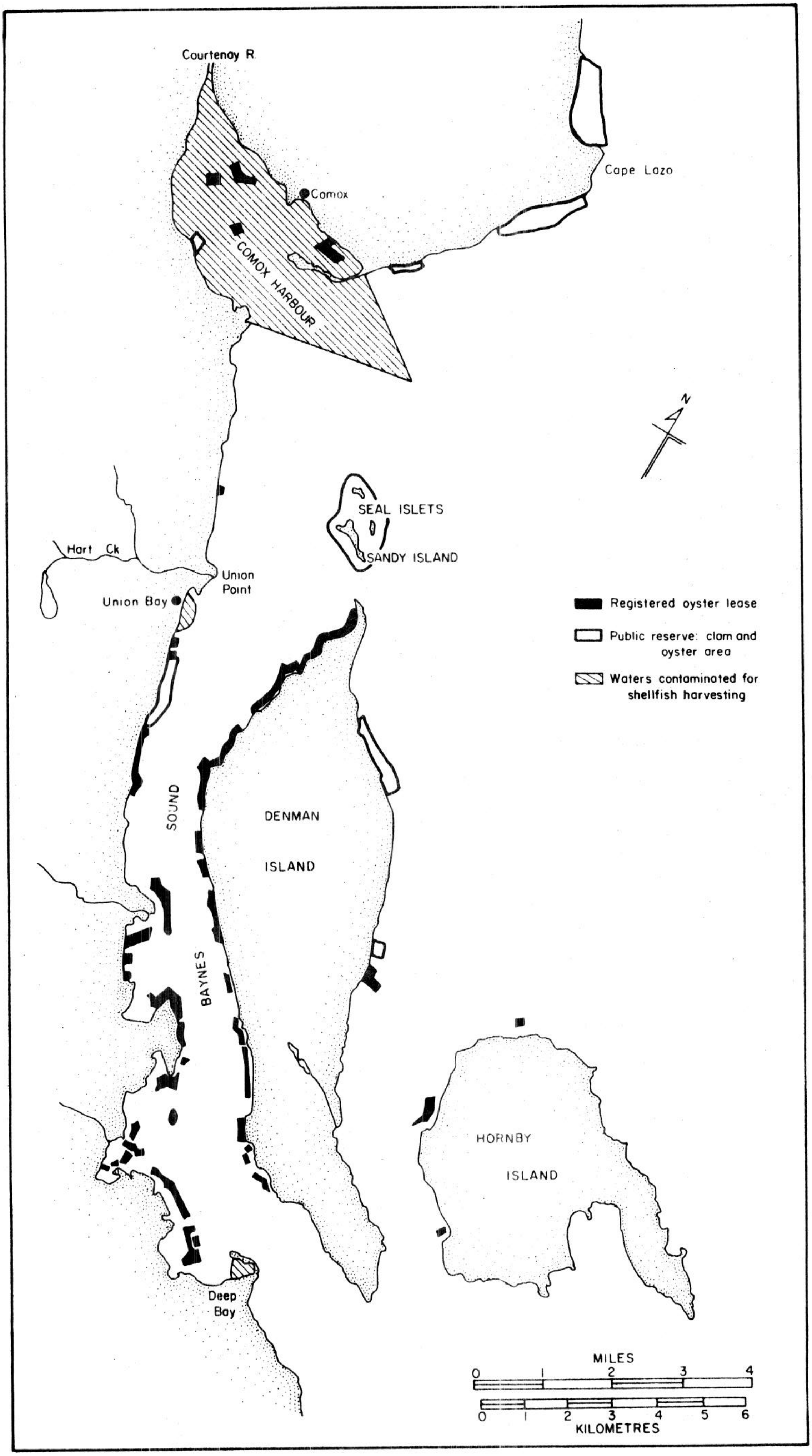
b) the Atlantic oyster (*Crassostrea virginica*), limited in distribution to Boundary Bay in British Columbia, and

c) the Pacific oyster (*Crassostrea gigas*), commercially abundant in selected areas as the result of culturing practices. The well-being of populations of the latter species is a primary concern with respect to the proposed Weldwood development at Union Point.

Successful culturing of the Pacific oyster can be accomplished only where specific habitat requirements are met. These include suitable water quality, substrate, intertidal height and protection from wave action. Productive oyster grounds are located in several areas in southern British Columbia, especially the intertidal waters of Baynes Sound. In fact, as measured by the number of registered oyster leases, Baynes Sound is the single, most important commercial oyster area on the West Coast of Canada. Fully 42% of the 166 leases in British Columbia are located here (British Columbia Department of Recreation and Conservation, Marine Resource Branch). Furthermore, it should be noted that virtually all suitable oyster grounds are already leased (Quayle 1969). This statement pertains to current culturing practices and does not include areas which may lend themselves to raft culturing. However, Baynes Sound is an area where additional shellfish mariculture could be made possible by the use of rafts.

Figure 21 shows the location of oyster leases in Baynes Sound and their proximity to Union Point. Also indicated are the locations of public reserves where oysters and clams are available for recreational fishing. Additional public reserves are under consideration by the Marine Resource Branch (Frank Cope pers. comm.) and a new oyster processing plant at the southeastern tip of Union Point is under consideration by the Oyster Growers' Association. It should be apparent that the whole of Baynes Sound

Figure 21. Location of registered oyster leases, public reserves and contaminated water in Baynes Sound (redrawn from British Columbia Department of Recreation and Conservation, Marine Resource Branch).


Courtenay R.
Comox
Cape Lazo
COMOX HARBOUR
N
SEAL ISLETS
SANDY ISLAND
Hart Ck
Union Point
Union Bay
Registered oyster lease
Public reserve: clam and oyster area
Waters contaminated for shellfish harvesting
SOUND
BAYNES
DENMAN
ISLAND
HORNBY
ISLAND
Deep Bay
MILES
0 1 2 3 4
0 1 2 3 4 5 6
KILOMETRES

is a prime shellfish region, most of which is already designated for public use or for the commercial production of oysters.

A final point should be made concerning this valuable marine resource. "The darkest cloud in the relatively bright future of the oyster industry in British Columbia is pollution" (Quayle 1969). Quayle (1972) points out that "already in the British Columbia oyster industry, 40% of the leased oyster beds have been closed or restricted owing to sewage pollution and another 10% are affected by industrial pollution. This situation will likely become worse ... particularly in the Strait of Georgia" (Photo 1).

With respect to the Weldwood activity at Union Point, a serious potential problem is one of siltation when, and if, the intertidal coal-waste deposits are mined. High turbidities cause oysters to cease feeding, and furthermore, siltation of rearing grounds would likely result in a high mortality among first year oysters (D. Quayle pers. comm.). Parsons (1972) ranks this problem as being of "medium to low local severity" in the Strait of Georgia region.

Clams

Several species of edible clam are found in the intertidal waters of Baynes Sound (Quayle 1960, 1972). The important species include the butter clam (*Saxidomus giganteus*), native littleneck clam (*Protothaca staminea*), Manila clam (*Venerupis japonica*), cockle (*Clinocardium nuttallii*) and horse clam (*Tresus capax*).

Clams are harvested principally by the public, although some commercial utilization of butter clams has taken place since about 1920 in the Seal Island area across the channel from Union Point (Quayle 1972). The shallow waters surrounding Seal and Sandy islands appear to contain some of the more productive clam beds in Baynes Sound. Bourne and Smith (1972) report that horse clams on the beaches of Seal Island have a good recreational and moderate commercial potential. Scallops are apparently not present in the area (Bourne 1969).

Other Shellfish

Other shellfish such as crabs and shrimp have received relatively minor attention from recreational and commercial fishermen in the Baynes Sound area.

(iii) Fish

Like many other areas along the eastern coastline of Vancouver Island, Baynes Sound provides prime sport fishing for salmon (e.g. Grindle 1975). The area must also be view as a migration route for salmon since many of the rivers draining into this area support anadromous salmon populations.

In addition, Forrester and Smith (1974) describe an experimental trawl fishery for groundfish in the Union Point area. They state that "the area is currently regulated to produce a small sustainable yield of English sole (the predominant species) ... "Fishes caught and their relative abundance were: 72% English or lemon sole (*Parophrys vetulus*), 10% Pacific cod (*Gadus macrocephalus*), 3% starry founder (*Platichthys stellatus*), and 2% lingcod (*Ophiodon elongatus*).

Two studies mention spawning grounds of marine fish located in Baynes Sound. Outram (1959) identifies several sites which are used as spawning areas by the Pacific herring (*Clupea pallasi*). These include Union Point, Comox Harbour and Deep Bay. Taylor (1946) discusses the spawning grounds of the lemon sole.

Additional general information on marine fishes is presented by Hart (1973) and a very extensive bibliography on fisheries in the Strait of Georgia region (including freshwater and marine locations in the Study Area) has been compiled by McInnes *et al.* (1974).

(iv) Other Information

Additional sources of information on marine species occurring in the Study Area are found in the bibliography by McInnes *et al.* (1974) and in the British Columbia Provincial Museum handbooks on barnacles (Cornwall undated), intertidal univalves (Griffith 1967) and seaweeds (Scagel 1971).

Coastal work has been conducted in nearby Nanoose Bay (Herlinveaux *et al.* 1966) and Lymn Creek estuary in Deep Bay (Mason 1974a). The Nanaimo River estuary has received considerable attention (e.g. Parker and Kask 1974; Smith 1972) and is currently the site of ecological studies being carried out by the Fisheries Research Board of Canada, Pacific Biological Station, Nanaimo. Ongoing estuarine surveys are also being conducted by the B.C. Department of Recreation and Conservation, Fish and Wildlife Branch. The closest area to Union Point that has been surveyed in the Courtenay estuary (K. Kennedy pers. comm.). For the deeper waters of the Strait of Georgia near

Denman Island, species and biomass data for benthic invertebrates are presented by Ellis (1968).

C.3. Wildlife

C.3.1. Introduction

A few publications are available which identify rare and unique wildlife species in Canada. Some of these point out that the isolation of island populations tends to create a unique fauna, and Vancouver Island populations are an example of this phenomenon. More than a dozen species and subspecies of mammals are confined to Vancouver Island because of this isolation. Birds, because of their high mobility, are not isolated in this way and for this reason do not show the same uniqueness. However, Vancouver Island provides valuable wintering and staging habitat for many species which breed further north. Because of the exceptionally mild winter climate of southwestern British Columbia, some species that regularly occur here are found nowhere else in Canada.

In this section, emphasis has been placed on species considered either (1) rare or endangered, (2) economically important or (3) requiring rare or unique habitats. Particular attention has been given the distribution and status of these species within the Study Area. Additional information on life history and habitat preference has only been described inasmuch as it relates to a consideration of environmental impact. The reader is referred to original sources for details.

C.3.2. Birds

C.3.2.1. Introduction

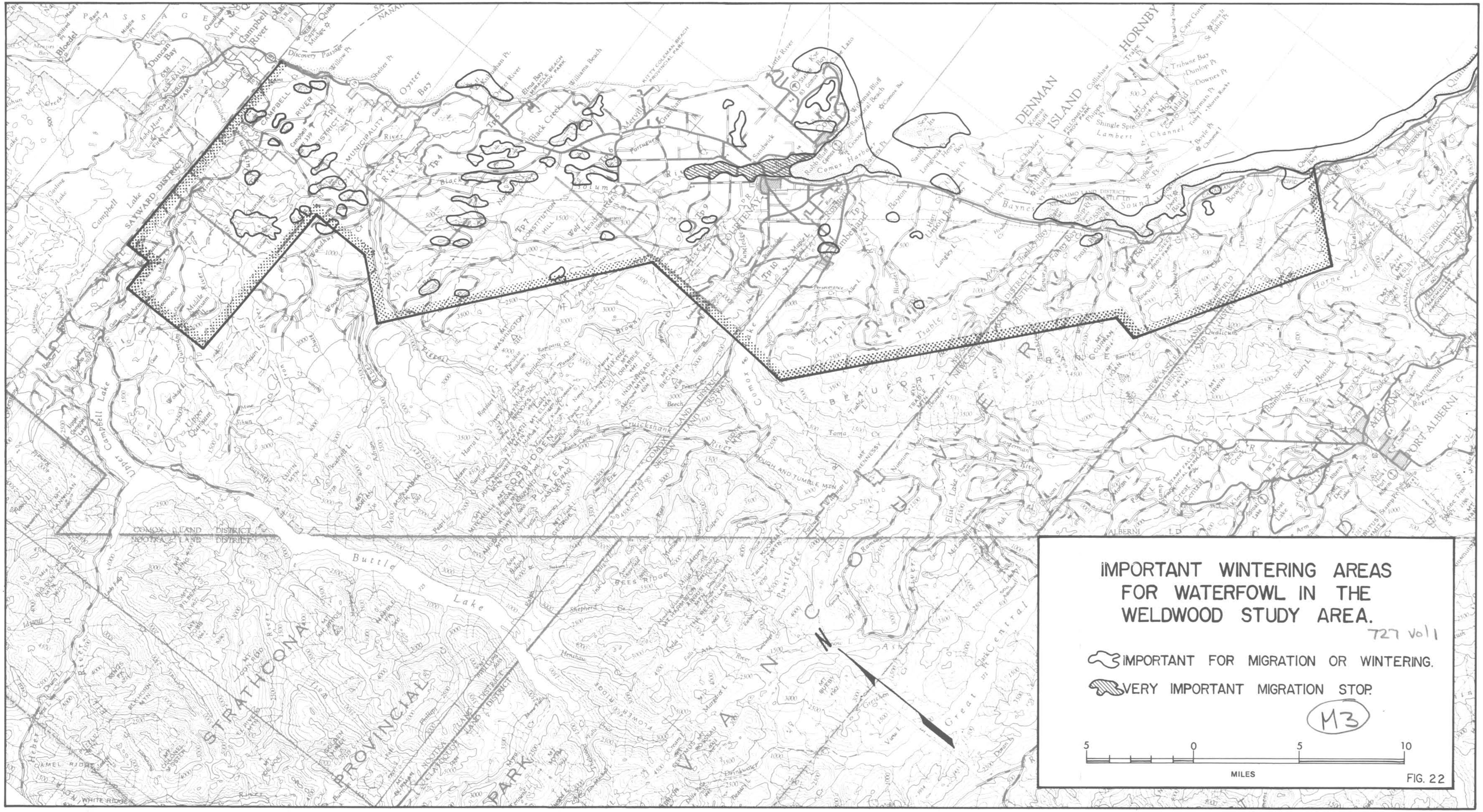
The bird life of the Study Area is documented primarily in descriptive works compiled by interested local naturalists. Site-specific scientific study is almost completely lacking, consequently, the information presented here is general in nature, and in many cases, extrapolation of detailed information has been necessary. Most of this information has been drawn from British Columbia sources.

The following sub-sections deal mainly with groups that are either economically important or of particular aesthetic value. Relevant details on the biology of selected species are included where this was deemed necessary. With other groups, only a general discussion is provided.

C.3.2.2. Waterfowl

The economic importance of waterfowl makes them a subject of much concern where development threatens to reduce their habitat. For this reason, special attention has been directed toward a discussion of the seasonal distribution and habitat requirements of waterfowl.

Waterfowl utilize eastern Vancouver Island primarily for wintering and staging. Very few species breed in the Area. The ameliorated climate, which is responsible for keeping many freshwater lakes and ponds free of ice year round, makes the southwestern portion of British Columbia a particularly attractive winter range. The productive estuary habitats along the eastern Vancouver Island coast are also very attractive to wintering birds (Figure 22). Of the 26 waterfowl species considered in Table 11, all but three winter in the area, but only seven regularly breed



IMPORTANT WINTERING AREAS FOR WATERFOWL IN THE WELDWOOD STUDY AREA.

FIG. 22

Table 11. Species of waterfowl present on the Study Area and their seasonal status.

BIRD SPECIES	SEASONS PRESENT			
	Summer	Fall	Winter	Spring
Trumpeter Swan		P	P	P
Canada Goose		P		P
Brant		P	P	P
Mallard	B	P	P	P
Pintail	P	P	P	P
Green-winged Teal	B	P	P	P
Blue-winged Teal	B			P
Cinnamon Teal	B			P
American Widgeon		P	P	P
Shoveller		P	P	P
Wood Duck	B			P
Ring-necked Duck		P	P	P
Canvasback		P	P	P
Greater Scaup	P	P	P	P
Lesser Scaup		P	P	P
Common Goldeneye		P	P	P
Barrow's Goldeneye		P	P	P
Bufflehead		P	P	P
Oldsquaw		P	P	P
Harlequin	P	P	P	P
White-winged Scoter	P	P	P	P
Surf Scoter	P	P	P	P
Common Scoter	P	P	P	P
Hooded Merganser	B	P	P	P
Common Merganser	B	P	P	P
Red-breasted Merganser		P	P	P

*P = present; B = breeding

there. Therefore, the importance of inshore waters and open lakes and ponds as wintering habitats should not be underestimated.

The Canada Land Inventory map for waterfowl capability (summarized in Figure 22) at scale 1:250,000, indicates that important coastal wintering and staging areas are located at Oyster Bay, Comox Harbour (Photo 3), Union Bay and from Buckley Bay to south of the Study Area. Critical wintering and staging habitat is located in the Comox estuary (Photo 4). The shallow waters surrounding Sandy Island and the Seal Islets off Denman Island are also considered important for wintering and staging waterfowl.

A number of these inshore areas could be influenced by the development of harbour facilities at Union Bay, therefore their importance should be carefully considered when details of that facility are more completely known. Inland lakes would seem to be of secondary importance as waterfowl habitat because of the localized effects of future mining operations. However, should these habitats be threatened by open pit extraction, consideration would have to be made to the breeding and wintering potential of the specific freshwater system to be affected.

One of the primary dangers with respect to sea ducks and geese would be the threat presented by oil ballast water from shipping vessels using the Union Bay facility. Sea-going waterfowl are present on the water almost constantly, and in many cases are helpless on land. Oiled feathers which impair the buoyancy of these birds, would almost certainly be fatal.

An additional danger to salt water and freshwater species alike would be the effect any operation would have on food supplies. Since estuaries provide most of the food for sea ducks and geese the impairment of these habitats is a potential problem.

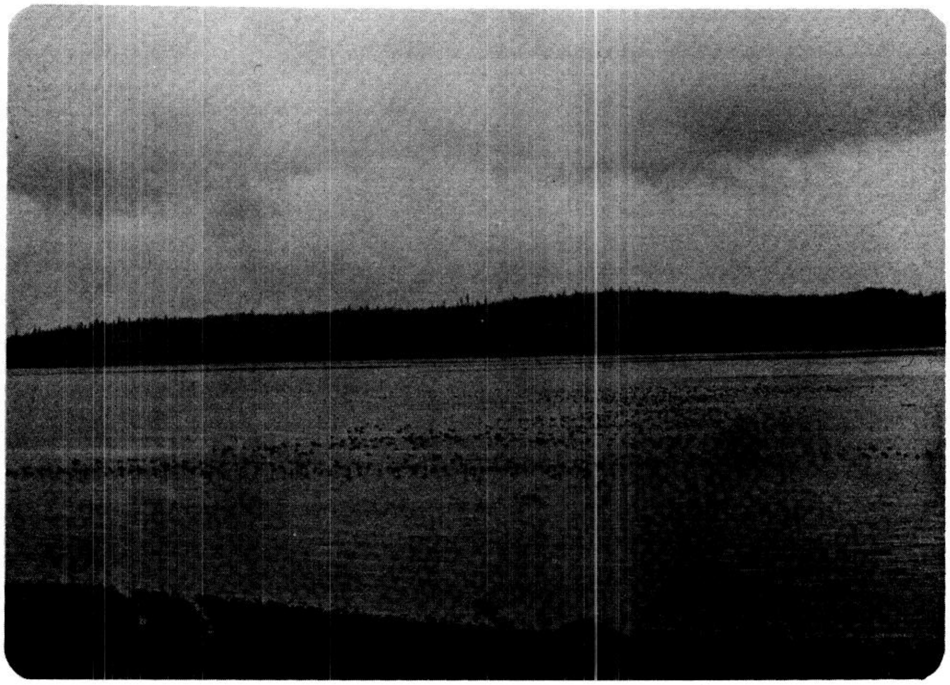


Photo 3. The Comox Harbour - Baynes Sound area is important for staging and wintering of waterfowl. A view of Scoters and Harlequin ducks at Fanny Bay.

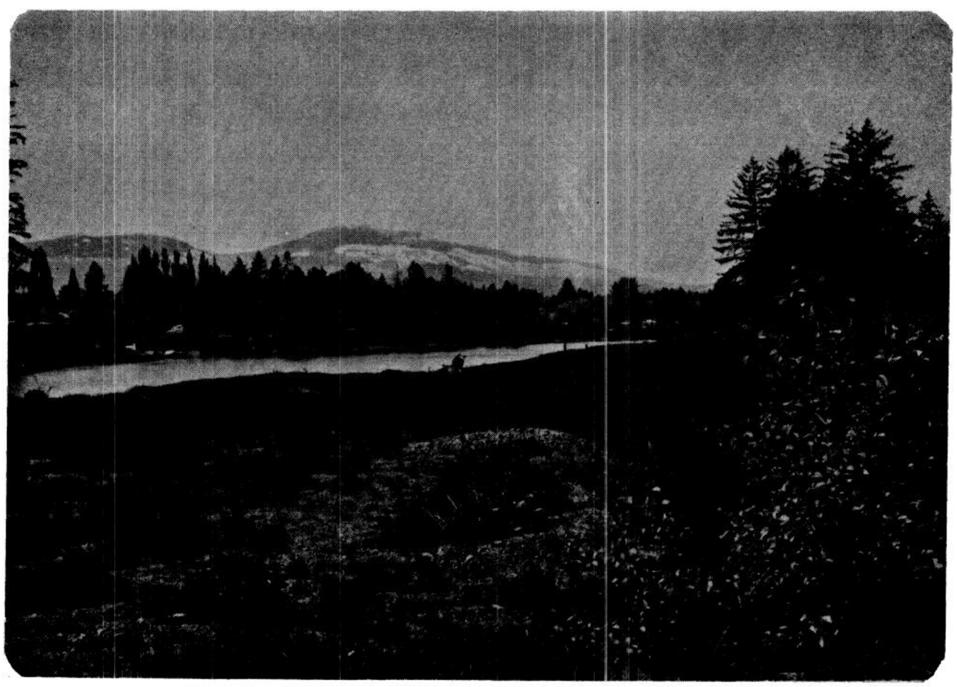


Photo 4. The Comox estuary looking northwest toward Mount Washington.

Table 12 summarizes the food habits and requirements of a selection of waterfowl species present in the Study Area. Several of these species rely heavily on marine vegetation for food, and many more utilize shellfish and other marine invertebrates extensively. The reader is referred to Jewett *et al.* (1953) and Guiguet (1967) for more detailed information on food habits. The following species accounts summarize the status and distribution of waterfowl associated with the Study Area.

(i) The Whistling Swan *(Olor columbianus)* has been recorded as wintering on Vancouver Island, but these were probably sick or diseased birds that could not complete the fall migration to the wintering grounds in the Western United States (Munro and Cowan 1947). However, these birds are sighted regularly in migration.

(ii) The Trumpeter Swan *(Olor buccinator)* is considered to be a common winter resident in the Area (Henderson and Capes, undated). It is improbably that any members of this species regularly breed on Vancouver Island but unauthenticated reports indicate that isolated instances of nesting may occur (Smith 1971).

The island is used extensively for wintering by these swans. Surveys conducted between 1969 and 1971 produced a population estimate for the winter of 1970-71 of about 1100 birds, an increase of 129 percent over the three year period (Table 13). The increase in the number of wintering swans on the east coast of the island (89 percent) was somewhat less than the average for the whole island. The change is attributed to increased survival rates and immigration from other wintering areas (Smith and Blood 1972). It is apparent that Vancouver Island is important as a wintering area

Table 12. Summary of food habits of selected waterfowl species.*

DUCK SPECIES	FOOD ITEM										
	Fresh Water Vegetation	Marine Vegetation	Grain	Insects	Crustaceans	Shell-Fish	Other Molluscs	Herring Eggs	Salmon Eggs	Salmonid Fish	Other Fish
Trumpeter Swan	X	A									
Canada Goose	A		X				A				A
Brant		X									
Mallard			X				A				
Pintail	X		X	A							
Green-winged Teal	X						A				
American Widgeon	X	X		A	A						
Shoveller	X						A				
Wood Duck	X			A							
Ring-necked Duck	X			A							
Canvasback	X	X									
Greater Scaup		A			A		X	X	X		
Lesser Scaup		X			X		X	A			
Common Goldeneye					X						A
Barrow's Goldeneye				A		X					A
Bufflehead				A		X					A
Oldsquaw		A			X	X	A	A		A	A
Harlequin				A	A		A				
White-winged Scoter				A	X	X		A			
Surf Scoter					A	X	A				A
Common Scoter				A	A	X	A				A
Hooded Merganser				A	A	X	X			A	A
Common Merganser				X	X				X	X	X
Red-breasted Merganser				A	A					X	X

*X = major food item; A = minor food item.

Table 13. Indicated increases in numbers of swans (Trumpeter Swans) wintering on Vancouver Island from 1969 to 1971 (from Smith 1971)

AREA	1968-69	1970-71	TOTAL INCREASE	PERCENT INCREASE
East Coast	187	353	166	89
Alberni area	41	176	135	329
West Coast	113	253	140	124
TOTAL	341	782	441	129

since the total North American population size was estimated at about 3400 (Hansen *et al.* 1971) from breeding ground counts in Alaska. Other wintering areas include Montana (346 swans in 1971), Idaho (66 swans in 1971), Wyoming (87 swans in 1971), and south-eastern Alaska (Godfrey 1966; Planz 1971). The distribution of wintering swans on Vancouver Island is illustrated in Figure 23. These numbers may vary between years.

Wintering Trumpeter Swans are found near shallow lakes and sheltered estuaries (Smith and Blood 1972). Their specific location is dependent upon the time of year and the severity of the winter. Table 14 illustrates the importance of sheltered estuaries to wintering swans during severe weather. These estuaries are heavily relied upon in critical periods when bodies of fresh water are frozen (Smith 1971). In view of this apparent dependence, Smith and Blood (1972) commented, "the Vancouver Island Trumpeter appears endangered by the accelerating process of estuarine deterioration in the area. Important causes of estuarine depreciation include industrial waste disposal, land fills, dredging, harbour development, log-booming activities, residential development and other related causes".

(iii) The Canada Goose *(Branta canadensis)* is considered an uncommon transient along the east coast of Vancouver Island and it is probably observed only when bad weather conditions along the west coast of the island force it to follow a migratory route through the inside passage of Georgia Strait (Pearse 1945). Rare cases of nesting may occur in the vicinity of the Study Area (Hardy 1954).

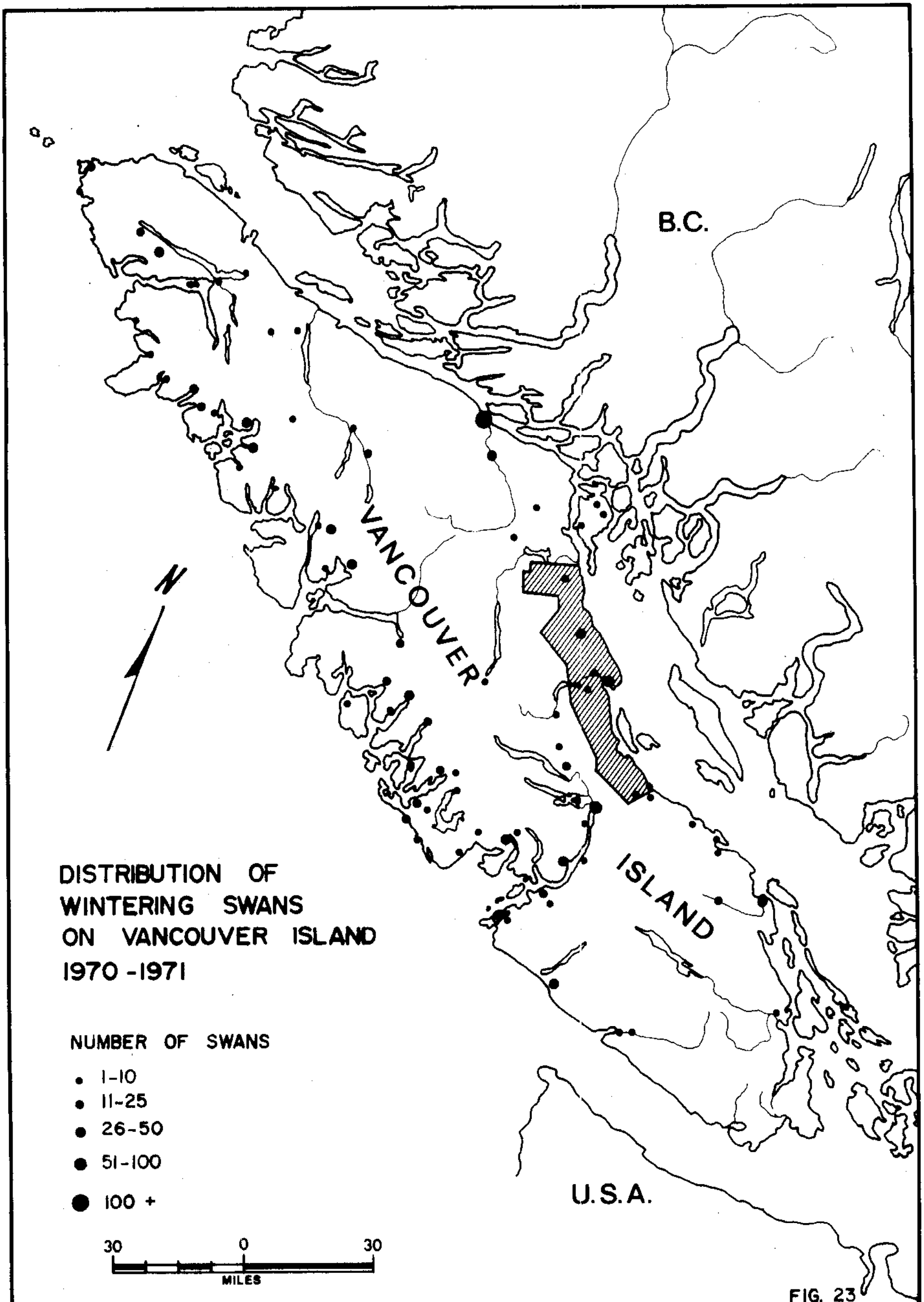

B.C.
VANCOUVER
ISLAND
N
DISTRIBUTION OF
WINTERING SWANS
ON VANCOUVER ISLAND
1970 -1971
NUMBER OF SWANS
1-10
11-25
26-50
51-100
100 +
U.S.A.
30
0
30
MILES

FIG. 23

Table 14. Changes in the proportion of swans wintering in different habitat types on Vancouver Island in three successive years (from Smith and Blood, 1972)

YEAR	WINTER WEATHER	SALT WATER ESTUARY	LAKE OR RIVER
1968-69	very cold	79%	21%
1969-70	very mild	64%	36%
1970-71	moderate	63%	37%

(iv) The Brant *(Branta bernicla)* is known primarily as a spring transient in the Area (Henderson and Capes, undated). Most spring migrators pass close to shore during March, April and early May, with flocks stopping to feed at various points along the route (Guiguet 1967). Occasionally, groups of non-breeders remain all summer. The fall migration usually passes far out to sea, but small flocks are regularly noted moving south through the Strait of Georgia. Many of these birds probably remain to winter along the coast -- the only wintering locations for this species in Canada (Godfrey 1966). Brooks (1904) reported "large numbers" present at Comox in the winter of 1903-04; observation indicated that about eight percent of these were of the Atlantic sub-species *(B.b. hrota)*. In winter and during migration, Brants are found closely associated with shorelines where eel grass *(Zostera)*, their staple food, is present (Brooks and Swarth 1925; Godfrey 1966).

(v) White-fronted Geese *(Anser albifrons)* and Snow Geese *(Chen caerulescens)* are both considered uncommon transients in the Comox area (Henderson and Capes, undated). Both may be seen moving northward in April and May with White-fronts returning in September and October (Munro and Cowan 1947); Snow Geese move south somewhat later (November). Over 20,000 Snow Geese winter on the Fraser delta, Iona Sea, Lulu and Westham Island.

(vi) The Mallard *(Anas platyrhynchos)* is the most common and widespread species of duck in western North America (Munro 1943). The Study Area and the coastal plain of southwestern British Columbia and northwestern Washington support the largest population of wintering Mallards on the Pacific Coast. In addition, large numbers of these ducks utilize small lakes and sheltered bays in the Area for staging en route to, and from, more northerly breeding grounds. Population levels of Mallards are lowest in summer when the residual population is small and scattered. Nesting occurs throughout the summer range; nesting habits are described by Godfrey (1966).

(vii) The Pintail *(Anas acuta)* is a common transient in the Area. In addition, a small number winter along the British Columbia coast and a few have been recorded as breeding in the Area (Munro and Cowan 1947). Vancouver Island lies in the path between the most important nesting ground (Alaska) and the main wintering areas (Oregon and California), therefore, spring migration moves large flocks of birds north along the coast in early March (Munro 1944). Authenticated cases of breeding in southwestern British Columbia are rare *(Ibid.)*. Southward migration through the Area is in late August or September. Because of a limited food range, the Pintail is restricted to fields, ponds, and marshes. In this way, its winter distribution is controlled by weather conditions; only in mild winters are large populations able to winter in the vicinity of the Study Area *(Ibid.)*.

(viii) The Green-winged Teal *(Anas carolinensis)* is common on eastern Vancouver Island in winter, but few breed in this region (Brooks and Swarth 1925). The coastal trough lies along the Pacific Flyway, causing large concentrations of ducks to be found in a relatively small area. Fall migration takes place between October and January, with a peak in November (Munro 1949a). In winter, the distribution is limited by food range, and thus by weather, but it is thought that the Green-wing may be slightly more abundant in the Area than Pintails which are similarly limited *(Ibid.)*. Local movements are common during winter, as inland ponds freeze. In spring, migratory concentrations have been observed in southwestern British Columbia, but these birds soon proceed north and inland to nest, and indications are that the main migration has passed by the first week of April. Small numbers of birds remain for the summer, but these probably represent non-breeders.

(ix) The Blue-winged Teal *(Anas discors)* is an uncommon summer resident in the Area (Henderson and Capes, undated), as is the Cinnamon Teal *(Anas cyanoptera)*. Southern British Columbia (including southern Vancouver Island) is the northern limit of the range of the Cinnamon Teal, and nesting is rare in the Study Area (Laing 1942). No members of this species winter in Canada (Guiguet 1967). The Blue-winged Teal is a bird of the interior, but small numbers are present on Vancouver Island in spring and summer. Because of the difficulty in differentiating between females of these species, definite nesting records of either are hard to obtain (Munro and Cowan 1947). However, both species are known to nest on the ground near water (Godfrey 1966).

(x) The American Widgeon *(Mareca americana)* or baldpate is common along the Vancouver Island coast in winter, but is absent in summer (Guiguet 1967). In autumn and winter, some members of the population are constantly present along the shoreline, while others utilize sheltered bays as resting places only, travelling to fields inland to feed (Munro 1949b). Another small segment of the population seems to be sedentary on flooded fields, moving to the coast when these freeze over. In dry years, this group of the population is small, but in wet years it may be fairly large. The numbers of baldpate are swelled considerably in spring, when an influx of transients stops to feed on ponds and in flooded fields.

This species is unusual in that it is regularly found in the company of diving ducks and coots. This association is commensal, with baldpates taking discarded plant food from the divers when they return to the surface. The habit is particularly beneficial to baldpates in winter when shoalwater feeding grounds are frozen over *(Ibid.)*.

(xi) The Shoveller *(Spatula clypeata)* is an uncommon winter resident of the Area, yet sightings are regular where their freshwater habitat remains open year round. Breeding takes place in the British Columbia interior, and it is doubtful if nesting occurs in the Study Area.

(xii) The Wood Duck *(Aix sponsa)* is an uncommon summer resident in the Study Area (Henderson and Capes, undated). The species breeds where it finds suitable habitat (woodland lakes, ponds and streams) over most of Vancouver Island, but no wintering members remain in the fall (Brooks and Swarth 1925; Munro and Cowan 1947). Nests usually are constructed in hollow trees, often in abandoned Pileated Woodpecker *(Dryocopus pileatus)* nests (Guiguet 1967).

(xiii) The Ring-necked Duck *(Aythya collaris)* and Canvasback *(Aythya* *valisineria)* are both uncommon winter residents in the Area (Henderson and Capes, undated). The Canvasback is limited to a narrow coastal strip, where it is found in sheltered bays as well as large open lakes and slow rivers (Guiguet 1967). The Ring-necked Duck contrasts this habit by rarely being found on open or salt water, but spending its winters on ponds and small lakes where these are open.

(xiv) The Greater Scaup *(Aythya marila)* is a common winter resident in the Area, and non-breeding individuals may also be seen in the summer. Greater Scaup move slowly up the coast to their arctic breeding grounds in spring, and large groups have been seen feeding on spawning herring between late February and early April (Munro 1941). The southward migration passes in October and November, when large mixed flocks of Greater and Lesser Scaup *(A. affinis)* may be seen all along the inshore coast. The wintering groups of Scaup which remain, vary in number, and move between fresh and salt water habitats. They congregate in sheltered bays, and sometimes become quite fearless of man *(Ibid.)*.

(xv) The Lesser Scaup *(Aythya affinis)* is an uncommon winter resident in the Area; its numbers are never as great as those of the Greater Scaup. In this season, birds frequent small lakes to a large extent, but are also seen on the ocean in mixed flocks with a larger scaup species.

(xvi) The Common and Barrow's Goldeneyes *(Bucephala clangula)* and *(B. islandica)* are both winter residents of the Area, with the former being notably more common (Guiguet 1967). The Common Goldeneye prefers salt water habitats more than its cousin, but both are found near coastal lakes and rivers (Jewett *et al.* 1953; Godfrey 1966).

(xvii) The Bufflehead *(Bucephala albeola)* is a common winter resident over all of Vancouver Island. The region is used as a staging area for transients moving to nesting grounds in the British Columbia interior, and to coastal wintering grounds farther south. Transients and wintering birds frequent salt water bays and estuaries (Godfrey 1966) when present at the coast. The species is more common on the west coast of the island than on the Study Area (Pearse 1928).

(xviii) The Oldsquaw *(Clangula hyemalis)* is a common winter resident in the Area. During the winter months, it is most often seen in sheltered locations along the coastline, although it is sometimes seen on open water inland. It breeds only in the arctic *(Ibid.)*.

(xix) The Harlequin *(Histrionicus histrionicus)* is common in the Study Area in winter, but summer sightings are more rare. The species may breed in remote locations on Vancouver Island (Brooks and Swarth 1925), but it is doubtful if breeding occurs in the Study Area. Males return to the coast from their mountainous breeding grounds in mid-June (Guiguet 1967) which may account for the species' presence along the coast in summer.

(xx) The White-winged Scoter *(Melanitta deglandi)*, Surf Scoter *(Melanitta perspicillata)* and Common Scoter *(Oidemia nigra)* are all fairly common winter residents along the eastern coast of

Vancouver Island. A small number of non-breeding members of these species are found here in summer as well, but breeding has not been reported for coastal British Columbia (Brooks and Swarth 1925; Munro and Cowan 1947; Guiguet 1967).

Scoters are closely associated with salt water except when breeding. They are most commonly seen on the water close to shore, and rarely haul out on beaches. This makes them particularly vulnerable to the effects of oily water (Jewett *et al.* 1953).

(xxi) The Hooded Merganser *(Lophodytes cucullatus)* and the Common Merganser *(Mergus merganser)* are both year round residents in the Study Area, with the latter being more abundant (Henderson and Capes, undated). These mergansers are primarly freshwater birds, utilizing clearwater lakes, ponds, and rivers for feeding (Godfrey 1966). Wintering populations are usually larger due to the influx of birds from breeding grounds in the interior of British Columbia (Guiguet 1967).

(xxii) The Red-breasted Merganser *(Mergus serrator)* does not nest in the Study Area, but is a common winter resident. These birds are more marine in habit than other mergansers, preferring coastal waters in winter (Godfrey 1966).

C.3.2.3. Other Water Birds

In this section, the status and distribution of a diverse group that includes diving birds, shorebirds, seabirds and waders, is summarized. Phylogenetically and ecologically they bear little relation to each other. Although they are not considered of economic importance, they have considerable aesthetic value and are a subject of continual interest by local natural history groups. Again reference is drawn to Jewett *et al.* (1953), Guiguet (1971a) and Godfrey (1966) for information on food habits and reproduction of these species.

(i) The Common Loon *(Gavia immer)* is considered an uncommon summer resident on east-central Vancouver Island (Henderson and Capes, undated). Field reconnaissance indicated that Common Loons nest on most inland lakes in the Study Area. These birds would be expected to move to inshore coasts in winter to join the immature birds which are found there in all seasons (Godfrey 1966).

(ii) The Yellow-billed Loon *(Gavia adamsii)* is a scarce winter visitent along the British Columbia coast (Munro and Cowan 1947). Small numbers of these birds are known to nest along the inshore areas near Comox (Godfrey 1966).

(iii) The Arctic Loon *(Gavia arctica)* is a common summer transient along the east coast of Vancouver Island but does not breed so far south. Presumably the birds that occupy these ranges in summer are non-breeders (Brooks and Swarth 1925). Arctic Loons are also fairly common along the coast during spring and fall migrations, and small numbers are usually present in winter (Guiguet 1971a).

(iv) The Red-throated Loon *(Gavia stellata)* is an uncommon winter resident of the Area (Henderson and Capes, undated). Normally, breeders occupy more northern ranges, but isolated cases of nesting have been recorded north of Courtenay (Pearse 1942, 1954). In winter, these birds frequent inshore areas, remaining closer to land than Arctic Loons (Godfrey 1966).

(v) The Red-necked Grebe *(Podiceps grisegena)* is a common resident along the coast near Comox in winter (Henderson and Capes, undated) but breeding records for Vancouver Island are very rare. It is very unlikely that this bird nests in the Study Area. In winter, these grebes are found along inshore coastal areas, but occasionally they are seen several miles from shore (Godfrey 1966).

(vi) Horned Grebes *(Podiceps auritus)* commonly winter along the coast in the Area, but breeding in British Columbia is confined to the interior of the province *(Ibid.)*. Wintering occurs along inshore areas, but individuals are sometimes seen well out to sea.

(vii) The Eared Grebe *(Podiceps caspicus)* is only an occasional winter resident. When these grebes are present in the Area, they inhabit the Coast (Godfrey 1966; Henderson and Capes, undated).

(viii) The Western Grebe *(Aechmophorus occidentalis)* a common winter resident in the Comox area (Henderson and Capes, undated), is most abundant in spring and fall during migration. Oyster Bay appears to be a major staging area for these birds on their way to (late April) and from (mid October) their nesting grounds in northern British Columbia (Pearse 1950). At these times, many thousands may be seen in the bay.

(ix) The Pied-billed Grebe *(Podilymbus podiceps)* is not as common as other grebes in the Area, but it is the only grebe known to nest on eastern Vancouver Island (Henderson and Capes, undated). These birds nest on ponds and lakes with emergent vegetation and commonly winter along the coast, although open freshwater areas are also utilized. This is the only grebe in British Columbia that makes extensive use of freshwater areas in winter (Guiguet 1971a).

(x) The White Pelican *(Pelecanus erythrorhynchos)* is considered an accidental transient in the Area (Henderson and Capes, undated). Individuals have been noted off Comox during northward migration (Laing 1942).

(xi) Double-crested Cormorants *(Phalacrocorax auritus)* are common residents in the Area (Henderson and Capes, undated). They are more abundant in winter than summer, and nesting is probably rare so far north on the island. These birds are common to lakes, rivers, and coastal areas throughout the year, but are rarely found far out to sea (Godfrey 1966).

(xii) The Brandt's Cormorant *(Phalacrocorax penicillatus)* is an uncommon winter resident in the Study Area (Henderson and Capes, undated). Winter and fall sightings in southern Georgia Strait are common, but breeding has only been recorded for the west coast of the island (Stirling and Buffam 1966). These birds frequent rocky coastal islets, which they use for nesting and roosting (Godfrey 1966).

(xiii) The Pelagic Cormorant *(Phalacrocorax pelagicus)* is a common year round resident along the coast of the Study Area, with breeding colonies being located off these coastlines. Colonies have been recorded at Tribune Bay on Hornby Island (Pearse 1956) and on small islets off the coast between Cape Lazo and Discovery Passage (Forttit 1973). Other nesting colonies probably exist. These birds are rarely seen far from salt water, where they rest on sand bars, rocky islands, cliffs, pilings and logs (Godfrey 1966).

(xiv) Albatrosses (Family Diomedeidae) have not been recorded as ranging in the sheltered waters of Georgia Strait.

(xv) Shearwaters and fulmars (family Procellariidae) are notably uncommon along the coasts of eastern Vancouver Island, although many species of this group occur regularly off the exposed west coast of the island. The Sooty Shearwater *(Puffinus griseus)* is reported to be occasionally common in the Strait of Georgia, however (Brooks and Swarth 1925; Godfrey 1966). The species is classified as a transient in the Area (Henderson and Capes, undated).

(xvi) The only member of the storm petrels (Family Hydrobatidae) to be seen regularly along the inside passage and in the Area is the Fork-tailed Petrel *(Oceanodroma furchta)*. Individuals are usually only seen far out to sea, however (Godfrey 1966).

(xvii) Within the family Stercorariidae (jaegars and skuas), only the Parasitic and Long-tailed Jaegars *(Stercorarius parasiticus* and *S. longicaudus)* are seen regularly on the Study Area, and these usually only during fall migration. Neither species is common, but the Long-tailed Jaegar is considered only accidental in the Area (Henderson and Capes, undated).

(xviii) Fourteen species of gulls and terns (family Laridae) are listed for the Area, with nine of these occurring regularly *(Ibid.)*. Yet only the abundant Glaucous-winged Gull *(Larus glaucescens)* breeds in the Area (Guiguet 1971b).

(xix) Six species of the family Alcidae (auks, murres and puffins) occur in the Area, but only three of these are found there regularly Henderson and Capes, undated). The Common Murre *(Uria aalge)* is seen throughout the year, and occasionally is common on land in winter (Pearse 1945). The Pigeon Guillemot *(Cepphus columba)* is found year round in the Baynes Sound area. The present status of a nesting colony located on Hornby Island is unknown (Pearse 1956). The Marbled Murrelet is a fairly common resident of the Area, frequenting coastlines and large lakes. It is not known where these birds nest (Munro and Cowan 1947). Other members of the group that are occasionally seen off eastern Vancouver Island are the Ancient Murrelet *(Synthliboramphus antiquus)*, Cassin's Auklet *(Ptychoramphus aleuticus)* and Rhinoceros Auklet *(Cerorhinca monocerata)*.

(xx) The American Coot *(Fulica americana)* is an uncommon summer resident in the Area (Henderson and Capes, undated). It is usually found in freshwater habitats. These birds are semi-colonial and small numbers probably breed in the Study Area.

(xxi) An array of shorebirds may be found along salt water beaches and in a variety of freshwater settings in the Study Area. Several species including the Black Oystercatcher *(Haematopus bachmani)*, Killdeer *(Charadrius vociferus)*, Spotted Sandpiper *(Actitus macularia)* and Common Snipe *(Scolopax rusticola)* breed there. Of the remaining 17 regular visitors, three are common winter residents [the Black Turnstone *(Arenaria melanocephala)*, Dunlin *(Erolia alpina)* and Sanderling *(Crocethia alba)*] and 14 are transients *(Ibid.)*. Habitat preferences are varied.

C.3.2.4. Upland Game Birds

Native upland game birds of British Columbia are all of the grouse and ptarmigan family (Tetraonidae). Most of these species are found at low elevations. Exceptions are the white-tailed Ptarmigan, inhabitant of sub-alpine meadows and forests and the Blue Grouse which winters in mature timber stands of high elevation. Within the group, a large variety of habitat preferences are displayed.

One factor that remains constant throughout the group is its high economic value. Table 15 provides statistics on hunter kills of grouse (Blue and Ruffed) on Crown Zellerbach lease land alone. The figures seem impressive. The remaining species are also prized by hunters but harvest statistics for these are unavailable.

An important point that separates upland game birds from all other groups of birds present in the Study Area, is that they are essentially non-migratory, although local seasonal movements do occur. This situation makes them more vulnerable than seasonal residents, to habitat disturbance.

(i) Blue Grouse *(Dendragapus obscurus)* are common year round residents of east-central Vancouver Island. Spring and summer breeding habitat of the species is open, dry natural clearings and logging slashes of the coastal lowland (Zwickel and Bendel 1972a). The winter range is in montane coniferous forests of the alpine-subalpine ecotone and on open ridges of the sub-alpine forest (Bendell *et al.* 1972).

Although Blue Grouse show tolerance to many types of summer habitats, ranging from bare soil to closed forest, early seral stage, open coniferous forests seem to be preferred. Studies con-

Table 15. Summary of numbers of grouse harvested from Crown Zellerbach leases, 1965-72*

AREA	1965	1966	1967	1968	1969	1970	1971	1972
Comox Lake	125	104		72	68	161	151	214
Wolf Lake	181	176		250	319	576	437	410
Oyster River	-	8		-	16	61	10	10
TOTAL	306	288	297	322	403	799	598	634

*Survey results conducted by Crown Zellerbach (Gibson pers.comm.)

ducted in the Quinsam Lakes area by Bendell, and in the Wolf Lake area by Zwickel indicate that optimal habitat for maintaining relatively high density populations is fairly open. Zwickel and Bendell (1972a) state:

> Breeding populations of Blue Grouse are practically nonexistent in dense, mature, lowland forests of the Pacific slope of North America. In primeval times, they likely bred in areas opened by fire, in limited natural openings among mature forests, and in the sub-alpine. Populations increase after the removal of lowland forests by logging, at times spectacularly. Within 5 to 6 years after logging, often followed by burning of the refuse, many populations seem to reach stability (Redfield *et al.* 1970). They stay at or near this level until regenerating forests become too dense to serve as breeding habitat. Since plant succession here is rapid, lowland areas usually become unacceptable for breeding within 10 to 15 years after logging, if planted to coniferous trees, or within 20 to 25 years, if unplanted.

Blue Grouse have been intensively studied on Vancouver Island (mostly within the Study Area) since the early work of Fowle (1944), and field study by Dr. Bendel and Dr. Zwickel and their students continues to the present time. Some of the more notable research papers have been by Bendell (1954, 1955a and 1955b), Bendell and Elliott (1966 and 1967), Redfield (1973a and 1973b), Zwickel (1965, 1972a and 1972b), Zwickel and Bendell (1972a and 1972b), Bendell, King and Mossop (1972) and King (1971 and 1973). The Blue Grouse is the only avian species on the Study Area for which site-specific information exists. The research literature that is available relates to the determination of how numbers of grouse in natural populations are regulated. Most of these research projects have dealt with populations on summer ranges, but King (1971) considered wintering populations as well.

Blue Grouse are a territorial species with adult (more rarely yearling) males establishing themselves on their territories in March or April. Established males show a high fidelity to a given site which they choose as yearlings or new adults. Females do not defend territories as such. The pair bond between males and females is extremely brief, ending with the female departing to begin nest building. Nests are usually located under trees, but sites under logs or stumps may also be chosen.

The food habits of Blue Grouse have also been well studied (Beer 1943; Stewart 1944; King 1973; Zwickel and Bendell 1972b). Table 16 outlines the results of crop analyses of grouse from two habitats. The analyses were carried out in 1962, only a few months after the Comox Burn study area was burned. No burning had taken place at Middle Quinsam since 1951, however, and some parts of it had not been fired since 1938. The occupation of such markedly different habitats is reflected in the dietary differences between birds involved. King (1973) found dietary differences between birds at high and low elevations, as well. He stated that they appeared to be related to the differing availability of food plants in the various habitats.

(ii) Ruffed Grouse *(Bonasa umbellus)* are also considered common permanent residents of the Study Area (Henderson and Capes, undated). This species is usually found in second growth alder and willow thickets which are found in wet areas such as along stream banks. It is a species of the lowland and is non-migratory (Godfrey and Marshall 1969). They rarely venture out into the dry open burns where Blue Grouse are at home. The selection of such different

Table 16. Crop analysis of incubating female Blue Grouse collected at Comox Burn (near Wolf Lake) and Middle Quinsam in 1962*

FOOD SPECIES	COMOX BURN		MIDDLE QUINSAM	
	% Freq.	% Vol.	% Freq.	% Vol.
Coniferous trees				
Douglas fir	50	9	56	36
Western hemlock	10	6	11	<1
Sitka spruce	20	<1	11	<1
Lodgepole pine			11	5
Western white pine			11	<1
SUB-TOTAL		15		36
Shrubs and Decid. trees				
Salal	60	22	22	9
willow	50	22	11	<1
Blueberry	30	2	22	11
Oregon grape	20	1	22	14
Dwarf woodl. rose	20	1		
current	10	1		
Red alder	20	<1		
spirea	50	<1		
Labrador tea	10	<1		
SUB-TOTAL		49		34
Herbs				
Bracken	40	20	44	6
Hypochaeris spp.	60	9	22	1
Vanilla leaf	40	4	11	<1
sedge	10	<1	11	18
False dandilion	10	<1	22	1
horsetail	10	1		
Rubus ursinus	20	<1		
Aytherium sp.	20	<1		
ragwort	10	<1		
Pogonatum sp.			11	5
SUB-TOTAL		34		30

*adapted from Zwickel and Bendell 1972b

summer habitats may be related to the greater dependence of Ruffed Grouse on water (Bendell and Elliott 1966). Aviary studies prove that given excess quantities of food and water, Ruffed Grouse drank about twice as much as the larger Blue Grouse.

Food habits of Ruffed Grouse on Vancouver Island have been studied by King (1969). Diets appeared similar to those of Blue Grouse, but no conifer needles were eaten (in spring and summer, at least). It was postulated that differing availability of food species in the respective habitats accounted for the difference.

(iii) The White-tailed Ptarmigan *(Lagopus leucurus)* is an uncommon resident of east-central Vancouver Island. Its distribution is restricted to high elevation alpine and sub-alpine meadows in summer, descending to forested mountain slopes in winter (Guiguet 1970). Individuals have been sighted on Mount Albert Edward in Strathcona Provincial Park; they were reported to be present above 5000 feet elevation (Hardy 1954). It is unlikely that they occur in numbers in the Study Area. Food habits studies have been conducted by Weeden (1967).

(iv) The California Quail *(Lophortyx californicus)* is native to Oregon and California, and was introduced to Vancouver Island in the 1870's. Populations built up tremendously (Guiguet 1970), but numbers dropped and today they are maintained at a relatively low level. The distribution of the species appears to follow that of Scotch broom, an introduced legume. This plant affords the little quail shelter from predators and weather, as well as food. The California Quail is most common on southern portions of the island, but its range extends at least as far north as Comox. It may suffer under occasional heavy snowfalls (Taverner 1934).

(v) The Ring-necked Pheasant *(Phasianus colchicus)* is also an introduced species to Vancouver Island; the date of introduction is unknown. Within the Study Area, pheasants are apparently restricted to agricultural areas around Courtenay and Comox. Crowing counts conducted by local Fish and Wildlife authorities indicate, however, that population sizes are lower near Courtenay than farther south on Vancouver Island (Blood and Smith 1974).

C.3.2.5. Birds of Prey

Two very different groups of birds are considered here -- the hawks, falcons and vultures (order Falconiformes) and the owls (order Strigiformes). All are birds of prey, the former feeding by day, the latter mostly by night. These species are economically important in that they are major predators of such serious agricultural pests as rodents. Raptors are of additional importance because of their aesthetic value. This aesthetic value has only been recognized in recent years when it was discovered that their numbers had, in some cases, been drastically reduced. The public is also becoming aware that these birds present very little threat to large mammals, that the instances of depredation are isolated, and that birds of prey serve a useful purpose to man.

(i) The Turkey Vulture *(Cathartes aura)* is a common summer resident and breeder in the Area (Henderson and Capes, undated; Godfrey 1966) and small numbers occasionally winter near the coast (Munro and Cowan 1947).

(ii) Five species of hawks occur in the Area. Of these the Goshawk *(Accipiter gentiles)*, Sharp-shinned Hawk *(A. striatus)*, Cooper's Hawk *(A. cooperi)* and Red-tailed Hawk *(Buteo jamaicensis)* are resident; one, the Marsh Hawk *(Circus cyaneus)* occasionally winters on Vancouver Island, and is sometimes seen during migration. All four residents breed in the Area, building nests in trees and all are species of the woodland and forest edge (Godfrey (1966).

(iii) The Golden Eagle *(Aquila chrysaetos)* is an uncommon resident in the Study Area, being mostly distributed in hilly habitats in summer, but occurring throughout at other times of the year. The species is more rare on the coast than in the interior of British Columbia *(Ibid.)*. Although breeding records are few, nesting does occur on the island (Munro and Cowan 1947). Nests are usually built on cliffs, but tall trees are sometimes used.

(iv) The Bald Eagle *(Haliaeetus leucocephalus)* is a somewhat more common resident in the Area. This species is usually found near water, and reconnaissance observations indicated several individuals habitually present along the coast adjacent to Baynes Sound. Sightings included Buckley Bay, Fanny Bay and Union Point. Other reports also indicate their common occurrence near the coast and their relative scarcity farther inland (Swarth 1912; Brooks and Swarth 1925). Nesting is usually in trees, although cliffs may be used as well (Godfrey 1966).

(v) The Osprey *(Pandion haliaetus)* is an uncommon summer resident of the Study Area. It is always found in the vicinity of water, as fish is its only food *(Ibid.)*. Ospreys most often nest in isolated trees, but telephone poles, cliffs and even the ground are acceptable sites. The same nest is used year after year, and these are sometimes located in loose colonies.

(vi) The Peregrine Falcon *(Falco peregrinus)* is considered an occasional transient through the Area (Henderson and Capes, undated) but recent evidence indicates more widespread nesting than was originally thought. Beebe (1971) has mapped 31 nest sites of peregrines on Vancouver Island. The species is very adaptable, and may be found in almost any type of habitat (Beebe 1974). Its local occurrence is determined by the presence or absence of its prey species. The peregrine that is found on the Study Area is of the subspecies *F.p. pealei*, a form that is confined to the Pacific coast from Oregon to Alaska. This is a distinctly maritime bird, frequenting seabird colonies and areas where seabirds and shorebirds are common *(Ibid.)*. Nests are usually located on cliff ledges (Godfrey 1966).

(vii) The Pigeon Hawk *(Falco columbarius)* is an uncommon winter resident sometimes remaining throughout the year. It is variable in its choice of habitat, sometimes being found in open woodland (summer), but usually found in open country such as marshes, mud flats, beaches and fields *(Ibid.)*. Nests are usually built in abandoned nests of other species such as magpies or crows, but may be located on cliff ledges, in hollow trees, or on the ground.

(vii) The Sparrow Hawk *(Falco sparverius)* is an uncommon summer resident in the Study Area. The species prefers open country, burntland and forest openings. Nests are located in hollow trees, or rarely, in cliff cavities or abandoned magpie nests *(Ibid.)*.

(ix) The Barn Owl *(Tyto alba)* is an uncommon resident of the Area, preferring open country and feeding chiefly on small mammals. Nests are built in old buildings, hollow trees and cliff cavities *(Ibid.)*.

(x) Typical Owls (Family Strigidae) include Screech Owls *(Otus asio)*, Great Horned Owls *(Bubo virginianus)*, Pygmy Owls *(Glaucidium gnoma)*, Short-eared Owls *(Asio flammeus)* and Snowy Owls *(Nyctea scandiaca)*. The first three of these are uncommon year round residents in the Study Area, frequenting open or broken forest habitats. Screech Owls and Pygmy Owls usually nest in holes in trees, often those left by woodpeckers. Great Horned Owls commonly choose old nests of hawks or crows, but sometimes tree or cliff cavities are acceptable. Short-eared Owls are grassland, meadow or marsh inhabitants. This species is considered an uncommon transient in the Study Area (Henderson and Capes, undated). Snowy Owls nest exclusively in the arctic and occasionally winter on Vancouver Island. In this season, open marshes, coastlines and lakeshores are frequented.

The Long-eared Owl *(Asio otus)*, Saw-whet Owl *(Aegolius acadicus)* the Burrowing Owl *(Speotyto cunicularia)* have also been recorded in the Area (Laing 1942).

C.3.3. Mammals

C.3.3.1 Introduction

The mammalian fauna of Vancouver Island is not extensive, including only 27 species as compared to 48 species on the adjacent mainland (Brooks, undated). Most of these are apparently found within the Study Area. Only those species known to be of economic importance, or of a rare or endangered status, are considered in this report.

C.3.3.2. Ungulates

The Canada Land Inventory (Alberni mapsheet 92F) has classed most of the Study Area as having slight or very slight limitations to the production of ungulates (Classes 2 and 3) and in addition, has indicated good capability for winter ranges (Classes 2W and 3W) inland from the coast (Figure 24). Wintering areas predominately comprise south and west-facing slopes below 2500 feet elevation. The major limitation listed for the Study Area is snow depth, which reduces the availability of forage and restricts mobility, normally forcing ungulates to winter at elevations below 2500 feet.

(i) The Columbian black-tailed deer *(Odocoileus hemionus columbianus)* is the more common of the two native ungulates of Vancouver Island. Its wide distribution and abundance make it an important consumptive resource. Results of Provincial Fish and Wildlife hunter check stations indicate the recreational importance of deer on Vancouver Island. In 1971, during the antlerless segment of the season, 2875 man days of deer hunting were recorded in the Campbell River area alone (Smith and Smith 1971). Awakened interest in non-consumptive use of wildlife has placed added importance on the

Figure 24. Ungulate capability of the Weldwood Study Area from CLI maps, 1967.

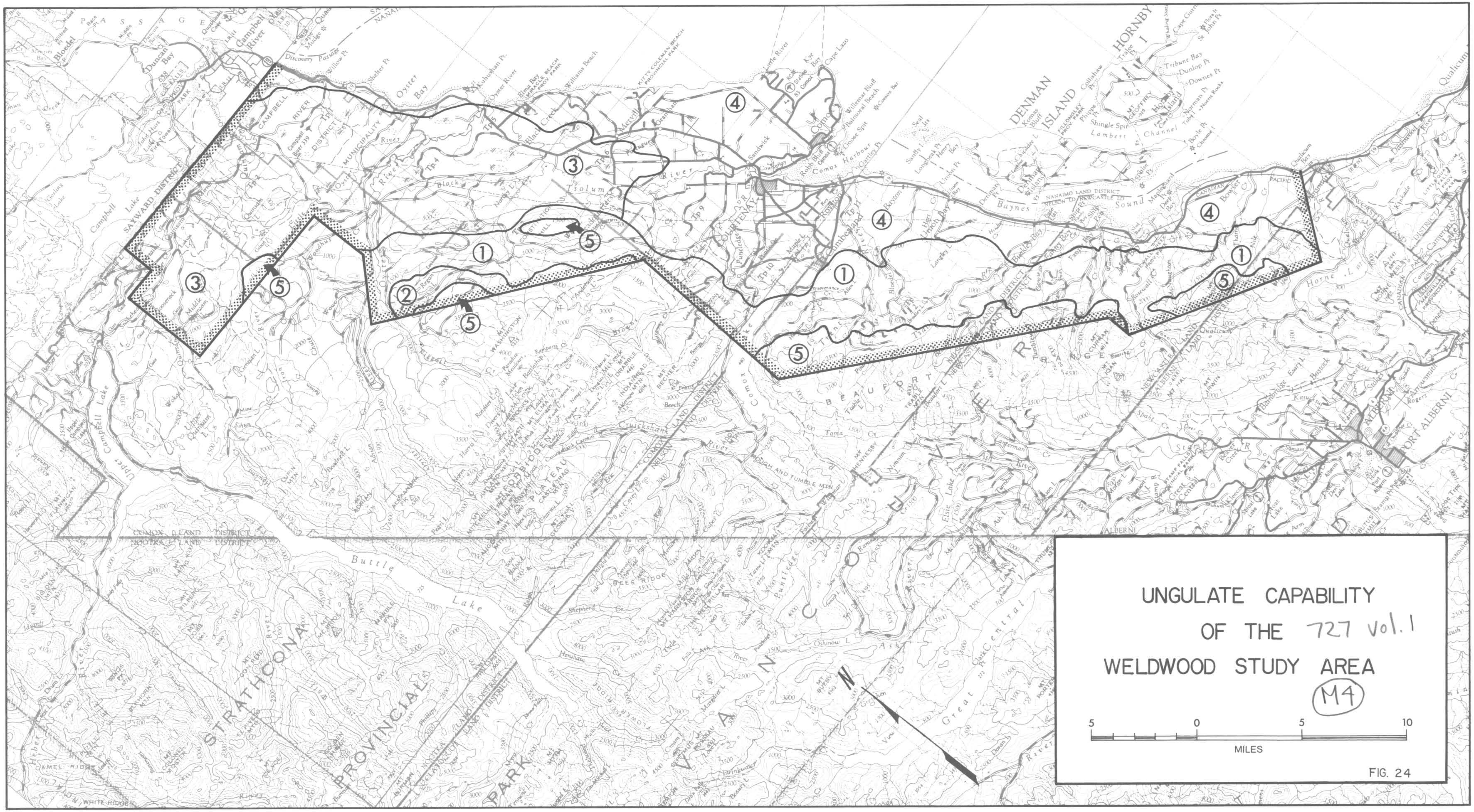
1 - Slight limitations to ungulate production include excessive snow depth; wintering area (Class 3, 2W).

2 - Same as above with wintering habitat of slightly lower quality (Class 3, 3W).

3 - Very slight limitations to ungulate production include excessive snow depth; moderately good wintering habitat (Class 2, 3W).

4 - Slight limitations to ungulate production (Class 3).

5 - Moderate limitations to ungulate production (Class 4).


UNGULATE CAPABILITY
OF THE 727 Vol. 1
WELDWOOD STUDY AREA
M4
5 0 5 10
MILES
Campbell River
Discovery Passage
Oyster Bay
DENMAN ISLAND
HORNBY
Comox Harbour
Baynes Sound
Tsolum River
COURTENAY
Cumberland
Upper Campbell Lake
Buttle Lake
STRATHCONA PROVINCIAL PARK
BEAUFORT RANGE
VANCOUVER
COMOX LAND DISTRICT
NOOTKA LAND DISTRICT
NELSON LAND DISTRICT
NEWCASTLE LAND DISTRICT
ALBERNI
PORT ALBERNI
Great Central Lake
Horne L
Comox Lake
MT WASHINGTON
FORBIDDEN PLATEAU
1
2
3
4
5
FIG. 24

aesthetic qualities of the species. Deer are found throughout the island in a wide range of habitat types from alpine meadows to farmland (Smith and Davies 1975). They exhibit an ability to adapt to human presence and often may be found on the edge of urban areas.

Pertinent studies on the ecology of Columbian black-tailed deer include several conducted in Oregon (Einarsen 1946; McCullough 1964; Crouch 1966 and 1968; and Miller 1968), and another carried out in Washington (Zwickel *et al.* 1953).

Many workers have agreed that early seral stages of Douglas fir forests provide optimal habitat for deer production because of the higher nutrient value of the browse (Cowan 1945; Einarsen 1946). The use of early seral communities is correlated with larger size, better physical condition, higher fecundity and higher density populations of deer. The role of nutrition, along with other aspects of the biology of this species, are also discussed by Cowan and Guiguet (1965), Thomas (1970) and Banfield (1974).

In summer, black-tailed deer are widely distributed over logged and reforested land, where the combination of good quality food (open areas) and adequate shelter (mature timber blocks) result in optimal range characteristics. In winter, cover is important in offsetting the effects of deep snow, since snow accumulation is reduced in areas of mature standing timber. The early seral stage forests that provide such excellant summer range are severely limiting to deer in winter because the greater snow depths restrict movements and make most of the food unavailable (Edwards

1956). Studies conducted in Colorado on mule deer ranges indicate that snow over 18 inches deep essentially precludes deer use. Additionally, areas in which snow depths exceeded 12 inches, although traversed, were not used on a continuous basis (Wallmo and Gill 1971). Annual variation in snow depth and the seasonal progression of increasing snow depth resulted in a movement of deer between ranges in response to snow conditions (Gilbert *et al.* 1970). On Vancouver Island, black-tailed deer are excluded from winter ranges above 2500 feet elevation because of snow depth (Luckhurst, CLI - ungulates, sheet 92F). Deer move from their summer ranges at higher elevations, to mature and near-mature lowland forests, where weather conditions are less severe, snow depth is notably shallower, and arboreal lichens (a major winter food item) are available (Smith and Hopwood 1971).

Cowan (1945) summarizes the food habits of Vancouver Island deer populations. He relates availability of acceptable food items (in various plant communities) to actual food consumption in order to determine food preferences. More recent non-quantitative studies of black-tailed deer food habits include Edie and Harestad (1971) and Smith and Davies (1975). Table 17 shows seasonal variation in food habits. It is apparent that Douglas fir is a preferred browse species in certain seasons. Use of this species often results in heavy seedling mortality (Cowan 1945; Crouch 1966 and 1968).

Deer on the Study Area appear to be maintaining their populations at high levels. Deer harvest statistics available from Crown Zellerbach for areas encompassed by their timber leases

Table 17. Results of stomach analyses to determine seasonal variations in the diet of black-tailed deer (adapted from Cowan 1945)

FOOD ITEM	% UTILIZATION			
	Spring	Summer	Fall	Winter
Douglas fir	24	-	8	41
Alder	-	14	25	-
Willow	21	6	8	-
Maple	4	-	-	-
Dogwood	4	-	-	-
Misc. trees & shrubs	13	25	11	5
Salal	6	41	27	8
Thimbleberry	-	-	6	-
Grass & sedge	5	4	-	-
Blackcap	-	9	-	-
Bracken	11	4	-	-
Mushroom	-	-	13	4
Equisetum spp.	12	-	-	-
Usnea spp.	-	-	4	36

(Table 18) show continuing good harvests (Gibson, pers. comm.).

Studies are in progress to determine optimum range characteristics, with a view to improving management techniques (Hubert and Rochelle, pers. comm.).

(ii) The Roosevelt elk *(Cervus elaphus roosevelti)* is a subspecies formerly inhabiting much of the west coast rain forest of North America. Canadian populations are now restricted to Vancouver Island and Novakowski (1970) considers this subspecies to be endangered. Concern is being expressed for the future of this elk as populations are considered to be at record low levels (Janz 1974). Hunting seasons were discontinued on Vancouver Island in 1969.

Mainland populations of Roosevelt elk have been studied by Graf (1943), Schwartz and Mitchell (1945), Murie (1951), Harper (1961, 1971) and Trainer (1970). Edie and Harestad (971), van Drimmelen (1974), Smith and Davies (1975) and others have discussed Vancouver Island populations.

The *C.e. roosevelti* subspecies is generally larger and darker than other North American elk. Fecundity is low, possibly a result of low nutrient food over its range (van Drimmelen 1974).

Overhunting and habitat loss through logging are considered the main causes of the present population decline (Janz 1974) Because of their low fecundity, Roosevelt elk respond slowly to habitat improvement and hence management plans must be of a long term nature.

Preliminary analysis of several watersheds on northern Vancouver Island indicates that elk summer range consists of the lower portions of avalanche slopes and forested valley bottoms

Table 18. Summary of deer harvested from Crown Zellerbach leases, 1965-72*

AREA	1965	1966	1967	1968	1969	1970	1971	1972
Comox Lake	272	222		392	109	164	158	90
Wolf Lake	218	228		459	185	156	221	101
Oyster River	-	49		-	63	34	41	12
TOTAL	490	499	557	751	447	454	420	203

*Results of survey conducted by Crown Zellerbach (Gibson, pers. comm.)

(Smith and Davies, 1975). Preferred winter habitat consists of mature timber along valley bottoms, and usually contains a prominent *Vaccinium* understory interspersed with bogs and openings (Edie and Harestad 1971; Smith and Davies 1975). In addition to requiring large blocks of mature timber for wintering, movements between wintering areas takes place only along river valleys that are forested. Clearcut logging practices on winter range appears to be the major danger to future elk populations.

Preferred foods include salmonberry, skunk cabbage, stink current, huckleberries, and willow (Edie and Harestad 1971). Quantitative data on food habits are not available.

Small numbers of elk are known to occur over parts of the Study Area (Hubert, pers. comm.). Sightings have been reported in the Campbell River, Oyster River and Wolf Lake areas. Past records indicate that, historically, the entire Study Area was inhabited by elk (Cowan 1965), but changes in vegetation patterns due to logging have made it improbable that elk will repopulate much of their former range.

C.3.3.3. Predators

(i) The Vancouver Island cougar *(Felis concolor vancouverensis)* is found throughout the Island and the Study Area. Population densities on the Island are considered among the highest in North America (Dewar and Dewar 1975). The cougar is a frequent predator of small domestic stock and occasional incidents of interactions with humans have been reported. Early anti-predator sentiments resulted in bounties being placed on cougars, which remained in effect until 1957.

Provincial policy has changed over the years. The Department of Fish and Wildlife now states that "the importance of the cougar as an integral part of the wildlife of British Columbia cannot be over-emphasized and careful management must be maintained" (Spalding, undated). The cougar is now classed as a game animal although nuisance animals are still shot or removed by provincial officials.

Very little is known of the biology of the cougar on Vancouver Island although mainland populations have been the subject of many studies (Rabb 1959; Robinette *et al.* 1961; Hornocker 1970; and Seidensticker *et al.* 1973). Population studies using radio telemetry are currently being conducted in the Northwest Bay region, adjacent to the southern boundary of the Study Area (Dewar and Dewar 1975). These authors believe that the cougar population on their Study Area may be declining as a result of logging practices that open large areas of formerly forested land.

(ii) The Vancouver Island black bear *(Ursus americanus vancouveri)* is apparently abundant throughout the Study Area (Bailey, pers. comm.). While they are not considered an important game animal, many are incidentally shot by deer hunters. Nuisance animals are frequently removed or shot by provincial officials when there is evidence that they have attacked domestic stock or where found frequenting settled areas.

Black bears have been well studied throughout their North American range. Pertinent work on west coast populations include Brent and Bowhay (1956), Jonkel and Cowan (1964), and Poelker and Hartwell (1973). Studies on the Vancouver Island subspecies are lacking, but aspects of its biology probably do not differ significantly from that of mainland species.

(iii) Wolf populations on Vancouver Island comprise a separate subspecies *(Canis lupus crassodon)*. Novakowski (1970) considers the subspecies to be 'endangered'. He feels that populations are at a very low level due to early extermination programs and destruction of habitat by logging. More recently, others have voiced the opinion that wolf populations have recovered from earlier low levels to assume a stable condition (Bailey and Rogers, pers. comm.).

While wolves have been widely studied throughout North America and Eurasia (Garceau 1961; Pimlott *et al.* 1969; Mech 1970), quantitative data for Vancouver Island are completely lacking.

C.3.3.4. Furbearers

Although trapping is no longer an economically important activity within the Study Area, eleven species of potential economic value do occur. These include beaver *(Castor canadensis)*, muskrat *(Ondatra zibethica)*, marten *(Mustela vison)*, otter *(Lutra canadensis)*, red squirrel *(Tamiasciurus hudsonicus)*, fox *(Vulpes fulva)*, raccoon *(Procyon lotor)*, and weasel *(Mustela erminea)*. Data on the abundance and distribution of these species in the Study Area are completely lacking.

C.3.3.5. Marine Mammals

Although the killer whale *(Grampus rectipinna)*, harbour porpoise *(Phocoena vomerina)* and northern sea-lion *(Eumetopias jubata)* occur regularly in the Strait of Georgia, none apparently frequent Baynes

Sound. With the possible exception of harbour seals *(Phoca vitulina richardi)*, no marine mammals are known to give birth in waters adjacent to the Study Area (Cowan and Guiguet 1965; Pike and MacAskie 1969).

D. SOCIAL ASPECTS

D.1. Scenic Elements

In view of the increasing importance of the Area for recreation and tourism, aesthetic preservation of the landscape has emerged as an important consideration. Presently this use is largely confined to the near coastal region, which is serviced by the Island Highway.

With the exception of the Union Bay docking facility, coal development is expected to be located farther inland (M. Curcio, pers. comm.). It is probable, therefore, that with the provision of suitable 'visual buffers', conflicts in this area will not occur. Similarly, the prominence of untailored slack piles at Union Bay make it unlikely that the proposed developments will result in significant degradation of scenic quality (Photo 5).

A cursory reconnaissance of the Study Area indicated no features of an unusually beautiful or unique nature; however, several watercourses in the area have potential importance as 'wild' rivers. It is recommended that before large-scale development is undertaken, a scenic landscape inventory be conducted using one of the established techniques (e.g. Hamill 1971 and Sargent 1967). A scenic inventory should also consider the presence of negative elements of the landscape. This would include all externalities associated with previous coal mining and logging, including pits, slack piles, abandoned buildings and garbage dumps (Photo 6).

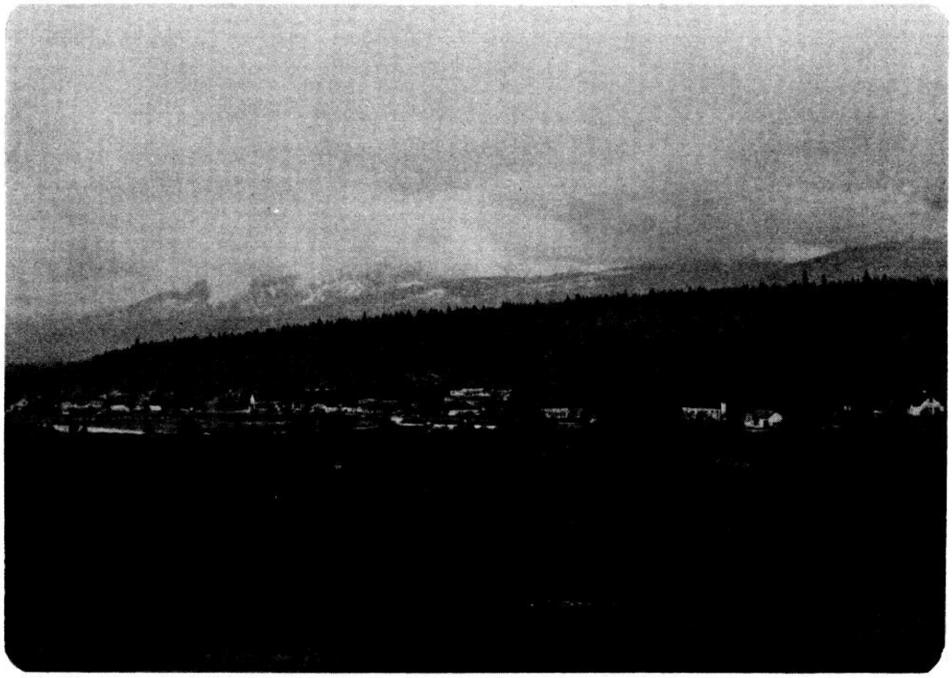


Photo 5. The Village of Union Bay as viewed from the site of the proposed loading facility.

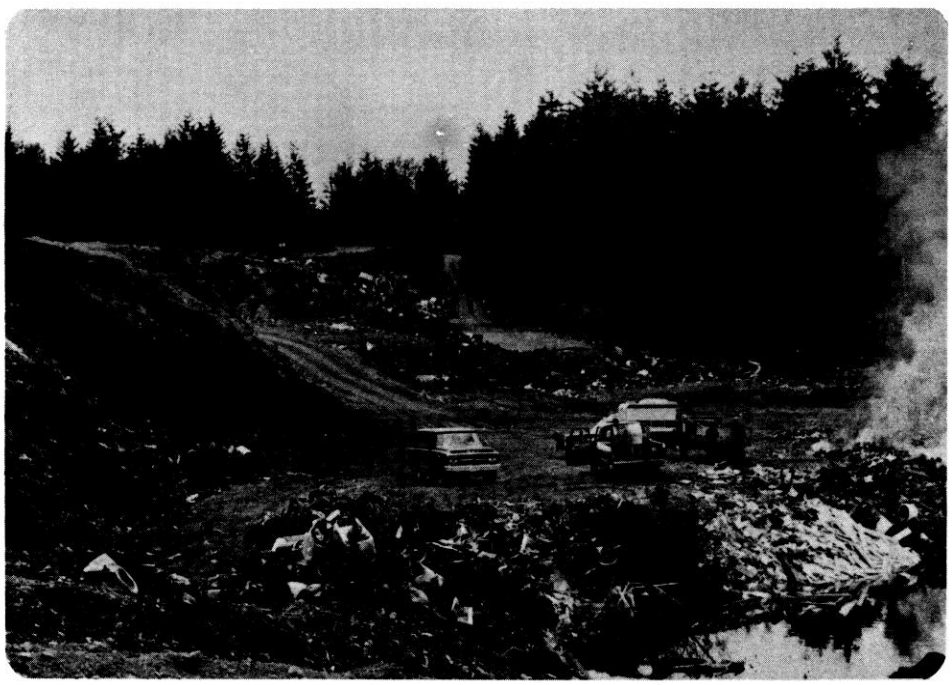


Photo 6. The site of former coal operations at Pigeon Pond. This pit is now used as a garbage dump.

D.2. Land Use

Canada Land Inventory maps showing present land use are available at scale 1:125,000 (refer to accompanying map folio for copy of 1:125,000 map). Most of the Study Area is classified under the general category of woodland, with only a small amount classified under cropland headings or as developed areas. Land use in the Study Area follows a generalized pattern, with developed and recreational land located near the coast, farmland farther west but parallel to the coast, and woodlands in the interior. Woodlands are less productive in the areas of high elevation (along the western boundary of the Study Area).

Wooded areas are held under three major types of tenure: (1) Crown land, (2) Crown land tree farm license, and (3) freehold. Very little wooded land is freeheld; this type of tenure is usually exercised over farmland. Provincial maps (scale 1:50,000) are available showing the extent of tree farm holdings, and mapping the forest cover for Crown lands. These forest cover maps would be very useful in mapping vegetation over the Weldwood leases. Similar forest cover maps containing tree farm information may be requested from the logging companies engaged in operations in the Area. Canada Land Inventory maps showing capability for forestry are not available.

There are approximately 250 farms in the Study Area, comprising a total of 23,320 acres. Slightly more than half of the farm acreage is considered unimproved with half of the unimproved land classified as woodland. About 90 percent of improved land is in crops or pasture. Principal farming activities are dairying and small fruit and potato growing. Farm size varies from just under three acres to almost one thousand acres. Small sized farms are the rule however, with at least half of these being under 70 acres.

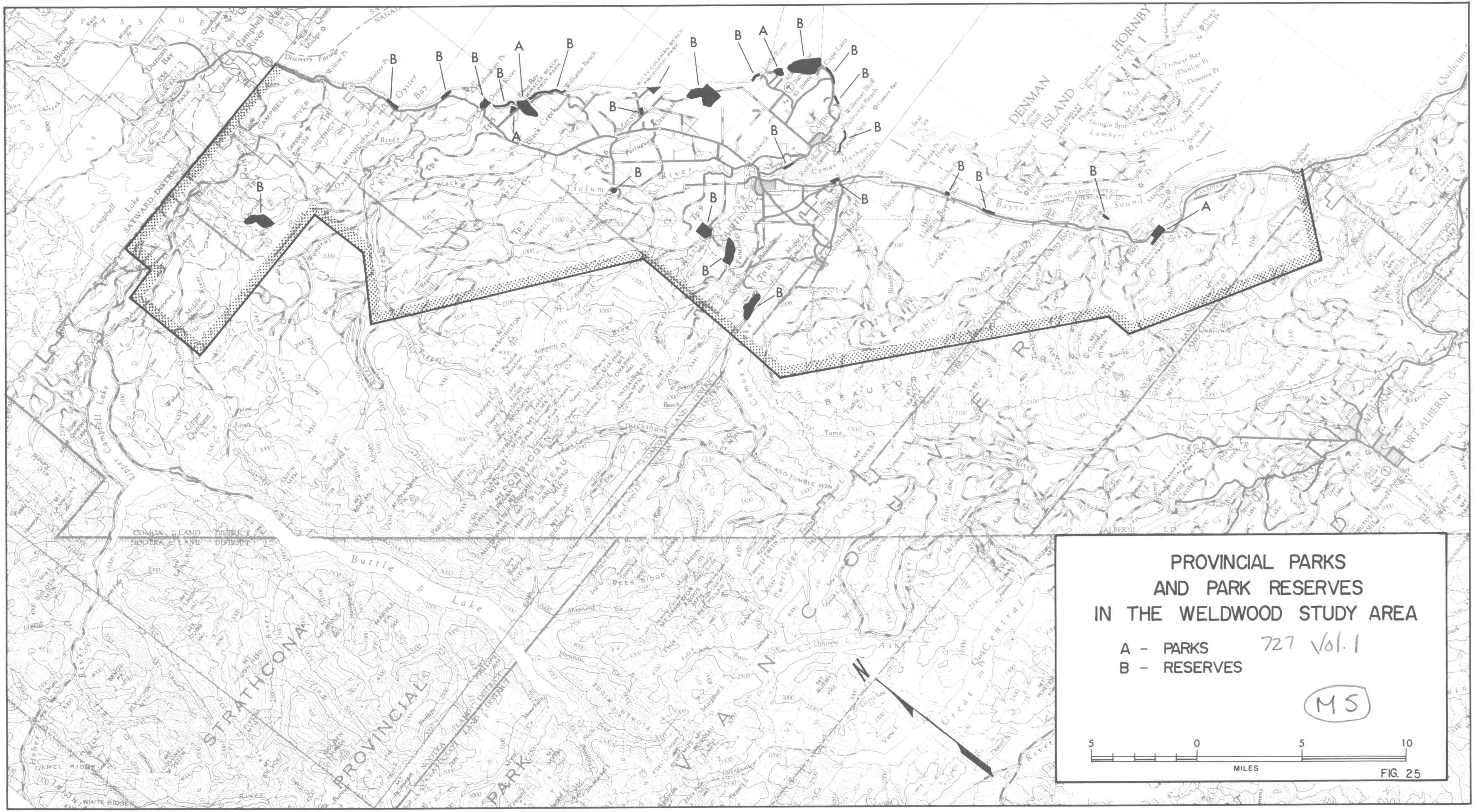
Canada Land Inventory maps covering the Study Area are available showing capability for agriculture at scale 1:50:000. Capability classes 7, 5, and 4 (no capability; permanent pasture or forage; and reduced range of crops with a large number of limiting factors) predominate, indicating that agricultural potential for the Study Area is low. Only a small amount of land is classified as 1, 2 or 3. These lands correspond to those presently under cultivation (Canada Land Inventory: Present Land Use).

Most recreational land is located near the coast; activities include swimming, boating, camping, fishing, shellfishing and hunting. The interior areas are also utilized for recreation, but their use is less intense. Hunting, fishing and camping are the principal activities engaged in here. It should be noted that other forms of land use do not necessarily preclude recreational use.

Four Provincial parks and 21 undeveloped park reserves are located in the Study Area (Figure 25). Most of these are small and are situated on the coastline.

Capability for recreation is shown on Canada Land Inventory maps (scale 1:250,000). Only a small proportion of the Study Area is classified as having either a very high, high or moderately high capability for recreation. These areas are largely confined to coastal areas where beaches, campsites and boating access are available. Most of the interior of the Study Area is classified as having low capability, with slightly better areas located adjacent to rivers and lakes.

The CLI maps may indicate lower recreational capability for inland areas than actually exists. These areas are extensively used by large numbers of hunters and hunter-campers during the autumn deer and grouse seasons.


PROVINCIAL PARKS
AND PARK RESERVES
IN THE WELDWOOD STUDY AREA
A - PARKS
B - RESERVES
727 Vol. 1
MS
MILES
5
0
5
10
FIG. 25

D.3. Human Demography

The Study Area, with the inclusion of the Campbell River District Municipality, contains the majority of the population of the Comox-Strathcona census division. The population estimate presented in Table 19 is therefore based on those census subdivisions contained wholly or partly within the Study Area. All of the Campbell River District Municipality has been included in this discussion, although only part of it is within the Study Area, because its relatively large population will be involved in any future development in the Area. The approximate distribution of the population in the Study Area is shown in Figure 26.

The Campbell River District Municipality has the largest population of any incorporated municipality within the Study Area. The town of Courtenay is the second largest incorporated municipality and the center of a metropolitan aggregation which extends to the nearby towns of Comox and Cumberland. Populations within unincorporated subdivisions are concentrated along the coast, especially in the area adjacent to the Island Highway, and in the vicinity of Courtenay, Comox and Cumberland. The 1971 rural farm population was 1023 people,distributed north of Courtenay. This is the largest farming concentration in the Area. Large population increases in the Comox-Strathcona district have been predicted for the next 25 years (Regional District of Comox-Strathcona, 1974).

The population of the Comox-Strathcona census division is largely British in origin, while German and French speaking peoples constitute the next largest segments. A breakdown of population according to religion for the town of Courtenay is given in Table 20. It is considered representative of the area. A breakdown by age groups for Courtenay is provided in Table 21. These figures indicate a large proportion of people in the older age groups.

Table 19. Population of Study Area (adapted from Statistics Canada 1971).

CENSUS SUBDIVISION	1941	1951	1956	1961	1966	1971
STUDY AREA						
Cumberland	885	971	1039	1303	1277	1718
Comox	-	714	1151	1756	2671	3980
Courtenay	1737	2553	3025	3485	4913	7152
Not incorporated Subdivision C	7249	7029	10662	10789	12175	11513
Not incorporated Subdivision B	-	-	-	-	70	112
Not incorporated Subdivision B*	-	-	-	-	460	417
OTHER AREAS						
Campbell River Village**	1986	3069	3737	-	-	-
Campbell River District	-	-	-	-	7825	10000
TOTAL	-	-	-	-	29391	34892

* Subdivision B of Nanaimo census division. All others within Comox-Strathcona census Division

** The Municipal District of Campbell River lies partly within the Study Area. Campbell River Village became the Municipal District of Campbell River before the 1966 Census.

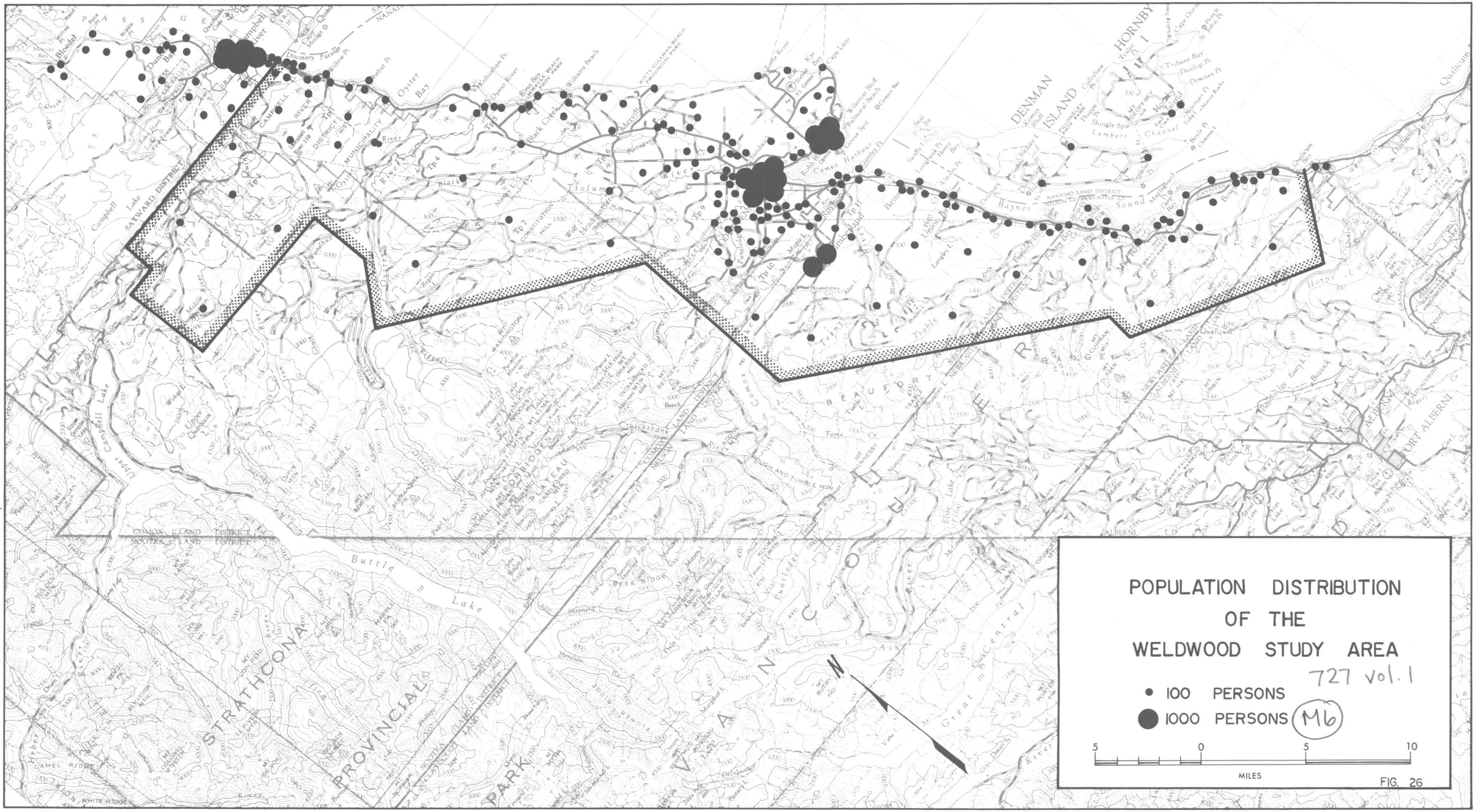

POPULATION DISTRIBUTION
OF THE
WELDWOOD STUDY AREA
727 vol. 1
• 100 PERSONS
● 1000 PERSONS
M6
5 0 5 10
MILES
FIG. 26

Table 20. Population of Courtenay by specified religious denominations, 1971 (from Statistics Canada.

Total	7285
Anglican	1440
Baptist	80
Greek Orthodox	45
Jewish	5
Lutheran	335
Mennonite	10
Pentecostal	75
Presbyterian	310
Roman Catholic	1270
Salvation Army	95
Ukranian Catholic	15
United Church	2630
Other	360
No Religion	615

Table 21. Population of Courtenay by sex and specified age groups, 1971 (from Statistics Canada).

AGE	M	F
0-4	325	315
5-9	385	380
10-14	425	390
15-19	370	315
20-24	300	280
25-34	485	505
35-44	455	405
45-54	345	360
55-64	255	245
65-69	90	100
70 +	180	245

Employment by the various industries for selected subdivisions of the Study Area is given in Table 22. A large proportion of the population is employed in the primary industries, especially forestry. Accomodation and food services account for a significant segment of the work force, due, in part, to the heavy tourist trade in the Area. Personnel at the Canadian Forces Base - Comox account for the relatively large proportion of the work force engaged in defense and the public service.

Employment in the Comox-Strathcona division is considered to be at a high level (Regional District of Comox-Strathcona, 1974). Figures indicate that the Comox-Strathcona division has an average income amongst workers that is slightly higher than the British Columbian and Canadian averages. Income from farming, however, is significantly lower than the provincial and federal averages for that industry.

Table 22. Employment by major industries for selected subdivisions of Comox-Strathcona census division (adapted from Statistics Canada 1971).

MAJOR GROUPS	Campbell River	Cumberland	Courtenay	Comox	Subdivision C	Total
Agriculture	5	-	20	15	255	295
Forestry	475	100	225	35	460	1295
Fishing & trapping	45	-	5	5	55	110
Mining	95	5	30	5	45	180
Sub-Total	620	105	275	60	820	1880
All manufacturing industries	845	35	195	35	290	1400
Construction industries	185	45	135	45	265	675
Transportation	155	15	95	55	135	455
Communications	185	10	50	30	40	315
All utilities	440	45	205	115	205	1010
All commercial trade	615	75	480	195	515	1880
Finance & real estate	115	5	115	55	65	355
Education & related services	250	30	170	100	290	840
Health & health services	130	40	125	145	160	600
Accommodation & food services	250	30	180	40	175	650
All other services	130	10	180	60	215	715
Sub-Total	3395	340	1930	875	2355	8895
Public service & defence	160	75	635	510	1035	2415
Industry unspecified	375	50	195	110	405	1135
Sub-Total						
TOTAL	4150	530	2820	1450	4425	13375

D.4. Transportation

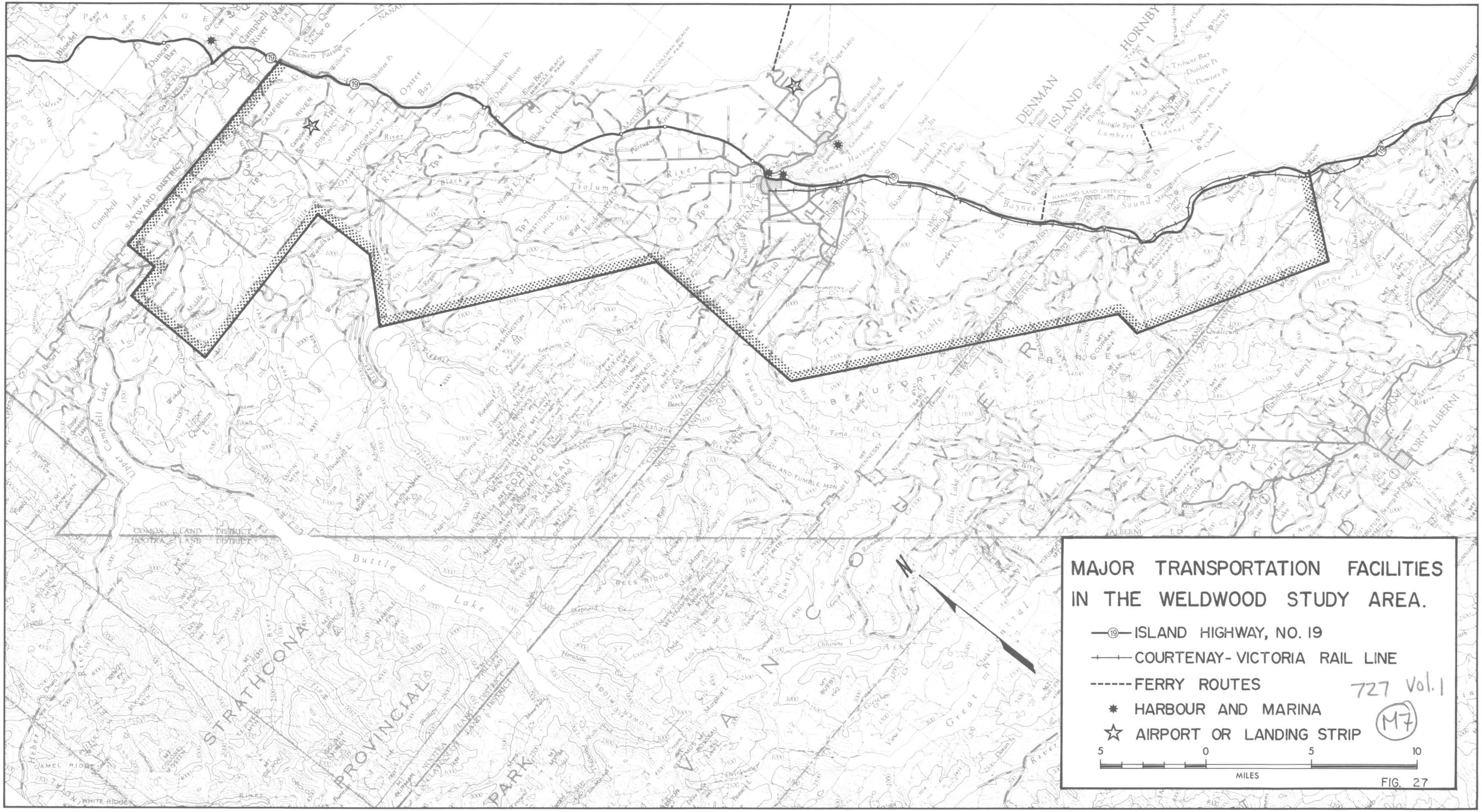
D.4.1. Roads and Highways

Vancouver Island is served by one major north-south highway as well as several less important east-west routes. The Island Highway (Hwy. 19) runs parallel and in close proximity to the east coast, from Victoria to Kelsey Bay, through the most heavily settled region of the island. South of the Study Area, Highway No. 4 extends from Parksville to Port Alberni and finally to Tofino, on the west coast of the island. A second east-west highway (Hwy. 28) which runs from Campbell River to Gold River, and provides access to the northwest end of the island, lies close to the north boundary of the Study Area (Figure 27).

Highway No. 19 has serious limitations as a transportation artery, despite the fact that it is the major highway on the island. The route winds along the coast, passing through numerous towns and villages and although scenic, its traffic capacity is inadequate, especially during the summer tourist season.

Secondary public roads within the Study Area are limited in number. A network of roads, some paved, but for the most part gravelled, serves the populated district in the vicinity of Courtenay, Comox, Cumberland and Royston. North of Courtenay, the farming district is adequately served by good secondary roads. Public roads generally extend only a short distance from the coast. An exception is the route to the Forbidden Plateau ski area at the edge of Strathcona Provincial Park, about 8 miles west of Courtenay.

A network of private forest access roads exists within the coastal lowlands and in some cases extends into all but the highest mountain areas. These roads were built for the timber industry, but with some limitations are open to public use. Roads in active use by the industry are



MAJOR TRANSPORTATION FACILITIES IN THE WELDWOOD STUDY AREA.

FIG. 27

restricted to evening and weekend travel while those not in active use allow free public access. Logging roads may be subject to closure due to fire hazard, however. The condition of these roads varies from good to impassable, depending on the time interval since last active use and the importance of the road for ongoing forestry activities. Privately published maps are available showing most logging roads. Public use of these roads is generally of a recreational nature with hunters and sports fisherman being the most active users.

D.4.2. Railways

A C.P.R. rail line (originally the Esquimault-Nanaimo line) connects Victoria and Courtenay, following the east coast of the island (Figure 27). Passenger service has been temporarily suspended between Parksville and Courtenay pending decisions on several new bridges. Freight Service, however, is still available. Small branch lines also provide freight service to Sooke, Cowichan Lake and Port Alberni.

D.4.3. Bus Service

Bus service is available linking Courtenay to Nanaimo and Victoria in the south and to Campbell River in the north, with connections to Kelsey Bay, Port Hardy and Gold River. Buses providing service to the mainland are available from the ferry terminals at Kelsey Bay, Nanaimo and Victoria.

D.4.4. Air Facilities

Comox airport handles daily scheduled flights to and from Vancouver, as well as Canadian Forces military traffic. This airport is equipped to handle the largest existing passenger aircraft, while landing strips at Campbell River and Nanaimo are suitable for small aircrafts only. Campbell River is also headquarters for float plane service (Figure 27).

D.4.5. Ferry Service

A ferry operating between Comox and Powell River connects the Study Area to the mainland. Additionally, service between Vancouver and Vancouver Island is available at Nanaimo and Victoria. Ferries connect Kelsey Bay to Prince Rupert, and small local ferries are also available between Buckley Bay & Denman Island and between Denman Island & Hornby Island (Figure 27).

D.4.6. Marine Service

Rental boats suitable for sport fishing are available in the Courtenay-Comox and Campbell River areas. Marina and harbour facilities are also available in these centres (Figure 27).

D.5. Historical Sites

As early as 1836, the Hudson's Bay Company had noted Indian reports of coal deposits along the unsettled southeast coast of Vancouver Island. In succeeding years, development of these coal measures provided the impetus for settlement in the Nanaimo and Comox areas (Ormsby 1971).

Although the Hudson's Bay Company undertook the initial mining ventures, the central figure in Vancouver Island's coal industry was Robert Dunsmuir, who later became one of the wealthiest and most influential men in the province. Dunsmuir founded Canadian Collieries (Dunsmuir) Company, the principal company with coal interest on the island.

The first mine in the Comox coalfield was opened in 1875, but operated for only two years. Larger mines, eventually eight in all, began operating in 1888. The last large mine to operate in the region was located in an isolated coalfield on the Tsable River and ceased operation in 1966.

The Town of Cumberland became the prosperous centre of the mining district. Chinese mine labourers founded a separate community known as "Jap Town" on the edge of Cumberland. This was a colourful, if seemingly mysterious addition to the region. Jap Town has since been destroyed by fire and most of the residents have moved elsewhere.

Farmers and loggers later moved into the district, broadening its economic base. Union Bay prospered as the harbour and rail terminus for coal shipments. It is interesting to note that sailing ships loaded coal at Union Bay as recently as 1947 (Kelly pers. comm.).

The history of the region is closely related to the development of the coal industry. Remnants of abandoned collieries (Photo 7) reflect

Photo 7. The entrance to the old colliery located at Comox Lake

the profound influence that the industry has had on the area. At present, little historical importance is given to such reminders of the past, possibly because of their relatively recent use.

D.6. Archaeological Sites

The native Indians of Vancouver Island are the Coast Salish ethnic group, originally speaking the now extinct Pentlach dialect. Settlements were concentrated along the coast, but the population within the Study Area is considered to have been less dense than in many other areas of Vancouver Island (Duff 1969).

Twenty-four sites of archaeological interest, most of which are shell middens, are known to exist within the Study Area (Table 23; B.C. Archaeological Sites Advisory Board, pers. comm.). All of the sites are coastal and most are located near the mouths of streams (Figure 28). The Tsable, Oyster and Puntledge Rivers, and Rosewall Creek have the largest concentrations of sites; all of these are of Indian origin. These sites are the subject of ongoing investigations by the British Columbia Archaeological Sites Advisory Board and by researchers at provincial universities.

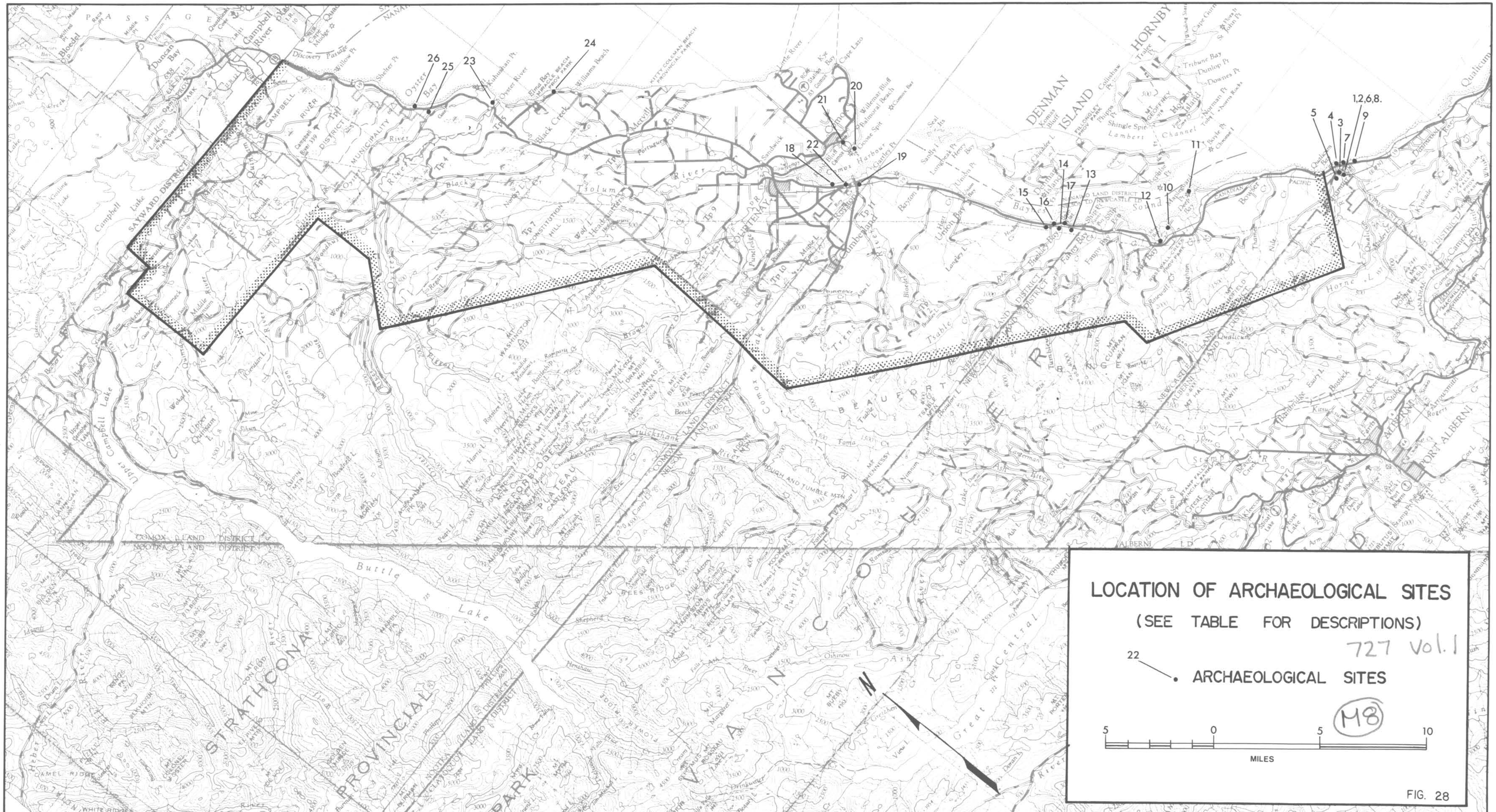
Because of the coastal location of all sites known to date, it is extremely unlikely that any will be affected by proposed coal mining activity within the Study Area.

Table 23. Description of archaeological sites designated in Figure 28.

SITE NO.	LOCATION	TYPE	FINDS	POSSIBILITY OF FUTURE DISTURBANCE
1	40°24'50" N 124°35'40" W	Occupational deposit mostly non-shell	Artifacts and skeletal material	Big Qualicum River is eroding site
2	49°23'55" N 124°36'30" W	Double trench (intermittent)		
3	49°24'30" N 124°36'40" W	Shell midden		
4	49°24' N 124°36'50" W	Bench weir	Stakes	Sea erosion and human removal
5	49°24'00" N 124°36'50" W	Shell midden		
6	49°23'40" N 124°36'20" W	Midden and three square mounds		May be bulldozed
7	49°24'50" W 124°36'40" W	River weir		
8	49°23'40" N 124°36'50" W	Shell midden	Artifacts	Pothunting
9	49°23'30" N 124°35'40" W	Shell midden		Unlikely
10	49°27'50" N 124°46'40" W	Shell midden		
11	49°27'50" N 124°28'30" W	Shell midden and trench	Bone barbs, slate knives, stone club	Development of auto courts
12	49°27'50" W 124°46'15" N	Midden and pits	Artifacts	
13	49°30'35" N 124°49'50" W	Shell midden	Artifacts	Pothunting
14	49°31'15" N 124°50'25" W	Shell midden	Two wetstones, dog bones	Gravel pit
15	49°31'55" N 124°51'30" W	Shell midden		Pothunting

Table 23. Continued.

SITE NO.	LOCATION	TYPE	FINDS	POSSIBILITY OF FUTURE DISTURBANCE
16	49°31'15" N 124°50'40" W	Shell midden	Bone fragment, basalt core tool	Log storage area
17	49°30'55" N 124°50'10" W	Shell midden	Artifacts	Highway development
18	49°30'55" N 124°58'20" W	Shell midden	Skeletal material	Subdivisions
19	Royston, B.C.	Petroglyph rock	500 lb rock with inscriptions	Present owner of land is trying to give rock away
20	49°39'55" N 124°53'55" W	Shell midden		Wave erosion and pothunting
21	49°39'35" N 124°55'05" W		Stone bowls, chipped points	Very little
22	49°39'00" N 124°55'05" W	Shell midden		Totally disturbed
23	49°52'15" N 125°07'05" W	Small shell midden		None
24	49°50'10" N 125°03'20" W	Shell midden		Unlikely
25	49°53'50" N 125°09'30" W	Shell midden		Logging and roads
26	50°55'20" N 125°11'15" W		Arrow points, harpoon heads, stone sinkers	Area to be subdivided



LOCATION OF ARCHAEOLOGICAL SITES
(SEE TABLE FOR DESCRIPTIONS)

FIG. 28

E. RECLAMATION

E.1. Introduction

There is a voluminous literature pertaining to reclamation and revegetation of disturbed land, particularly arising from research in the Eastern United States and Europe. In recent years a number of studies and revegetation trials have also been undertaken in the East Slopes of Alberta, many of which will be useful in planning reclamation programs in the Study Area (Etter 1971; Selner 1973; Lesko Etter and Dillon 1974; Macyk 1972, 1973, 1974; Stephenson 1974; Regier 1974). It should be noted that while studies done elsewhere are useful in providing background information they are of limited applicability since the ecological and physiographic conditions differ greatly as will the types of environmental constraints encountered. Consequently, this report only describes the extent of reclamation research occurring within British Columbia.

E.2. Reclamation Legislation

Section III of the Mines Regulation Act, of the Province of British Columbia and Section 8 of the Coal Mines Regulation Act deal specifically with legislative requirements for reclamation of mined land in the province. In part, the Coal Mines Regulation Act states that:

> It is the duty of every owner, agent, or manager of a surface mine to institute and carry out a programme for the protection and reclamation of the surface of the land and watercourses affected thereby, and, on the discontinuance or abandonment of a surface mine, to undertake and complete the programme to leave the land and watercourses in a condition satisfactory to the minister; and such a programme shall be submitted to and approved by the minister as hereinafter provided.

Prior to beginning a surface mining operation, the mining company is required to submit a proposed reclamation program to the Department of Mines and Petroleum Resources for review by a multi-jurisdictional committee. If approved, the plan is given to cabinet which has the power to grant a mining permit through an Order in Council. The practice has been to grant temporary three-year permits contingent on payment of a security deposit. During this period, the mining company is required to conduct reclamation research necessary for the preparation of a detailed reclamation plan. Upon acceptance of this plan, a permanent permit is then granted. For a detailed interpretation of the Act, the reader is referred to Thirgood (1970a).

E.3. Reclamation Research in British Columbia

Reclamation research in British Columbia is still in its infancy with virtually all of it occurring within the past five years. Most of this research is associated with development of the extensive coal deposits in the southeastern part of the province.

Kaiser Resources Ltd., in particular, has been actively involved in reclamation research in the Elk River valley (Thirgood, 1970b). These operations are occurring between 5000 and 6500 feet elevation however, and will be of limited applicability to conditions on Vancouver Island. Fording River Coal Co. has also conducted research in the East Kootenays including growth-chamber experiments, fertilization trials and attempts at water quality control (Thirgood, 1971a). A great deal of industry-related reclamation research is currently underway at the University of British Columbia, Faculty of Forestry, under the direction of Dr. J.V. Thirgood.

Much less is known about reclamation in coastal regions. Thirgood (1971b, 1971c) describes revegetation trials taking place at an open pit molybdenum mine, north of Prince Rupert on Alice Arm. He (1971b) reports that "at the end of the first year it was established that unweathered waste rock newly dumped, can support vegetation growth, that a grass vegetation can be established by seeding and, most significantly, that with fertilizer additives, at least under humid coastal conditions, there is no initial advantage to be gained from the stockpiling and later incorporation of organic materials such as muskeg into the surface layers".

There is no information available on the reclamation of mined land on Vancouver Island. However, some information of a related nature, including reforestation, is available from logging companies. Additional useful information can be gained from examination of abandoned mine workings in the area. Slack piles examined during the course of this study indicated that generally, unassisted revegetation was successfully occurring (Photos 8 and 9). Due to the high humidity, low elevation and relatively longer growing season, reclamation should pose fewer problems in the Study Area than at higher elevations in the interior.

Photo 8. Natural revegetation of the Comox Lake slack pile.

Photo 9. A view of slack piles located at Bevan, showing the extent of natural revegetation.

PART 2

DEFICIENCIES AND RESEARCH REQUIREMENTS

PART II. DEFICIENCIES AND RESEARCH REQUIREMENTS

A. INTRODUCTION

In the preceding sections, available environmental information pertinent to the Vancouver Island Coal Properties is reviewed and summarized. The subject areas dealt with are those considered necessary for assessment of environmental impact. In this section, the adequacy of this information is discussed and recommendations as to original research necessary to fill any deficiencies are presented.

Generally, there is a large amount of data of an overview nature that relates to the Weldwood Study Area. In almost all subject areas, however, site-specific information is lacking.

The research program outlined is of necessity, general in nature and is designed to provide base-line information for the entire area encompassed by the Coal Properties. Details of the program should remain flexible until operational plans for development of the Weldwood leases become finalized. It is recognized that the program may be modified by circumstances such as:

(a) changes in the mining schedule, location or methods,

(b) the need for special environmental studies (e.g. toxicity studies, monitoring studies, revegetation studies) or

(c) deficiency statements from governmental departments.

When mining areas are delineated, the following general program will provide a basis for detailing the site-specific studies necessary to satisfy all environmental regulations.

B. CLIMATE

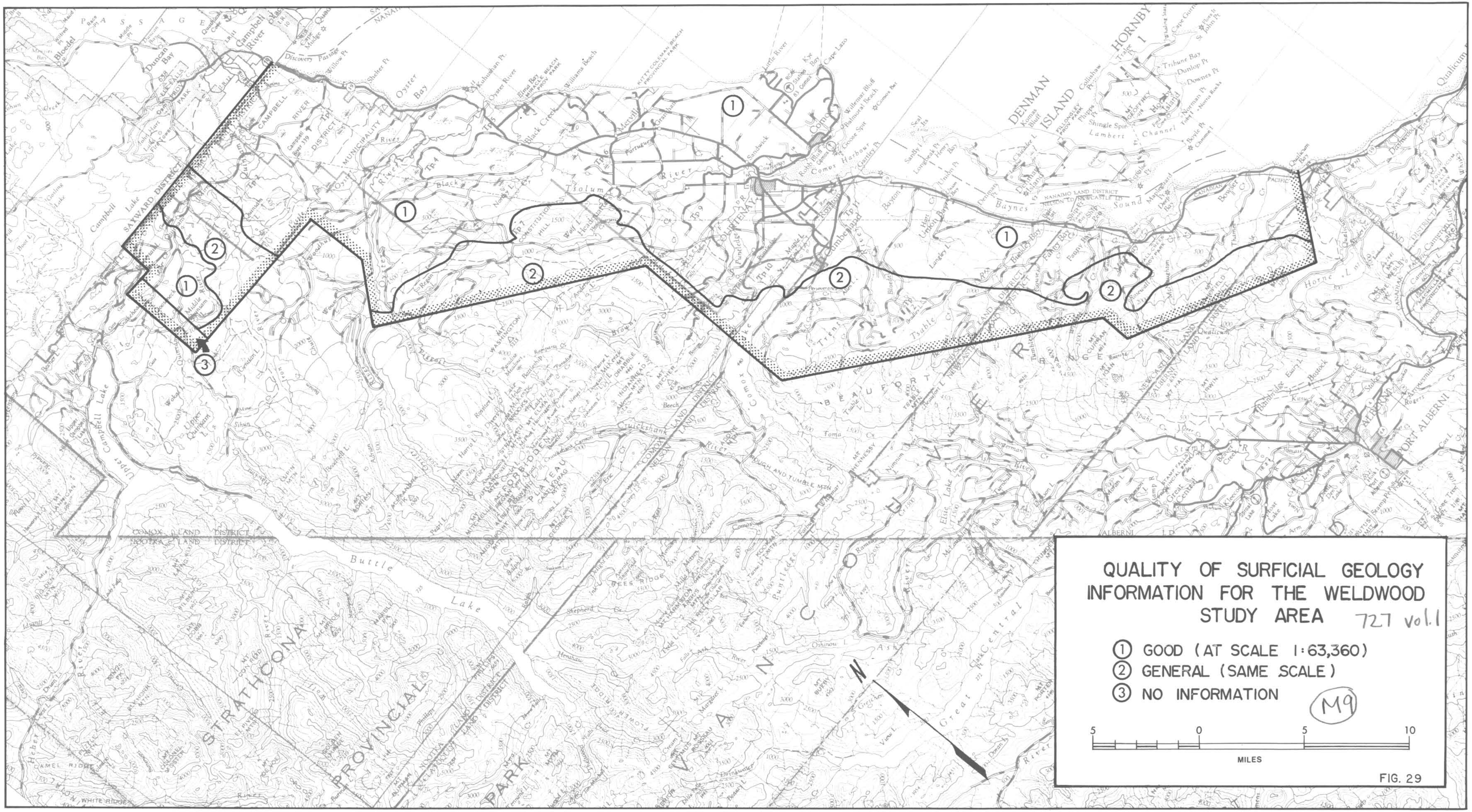
Climatological data are generally sufficient for assessing environmental impact. The Study Area is well represented with continual and seasonable climatological stations operated by government agencies, private companies or research stations. Additional information will be required, however, in regard to snow depths on ungulate winter range.

C. SURFICIAL GEOLOGY, PEDOLOGY AND HYDROGEOLOGY

Because of their inter-related nature, surficial geology, pedology and hydrogeology aspects have not been separated and are here considered as a unit.

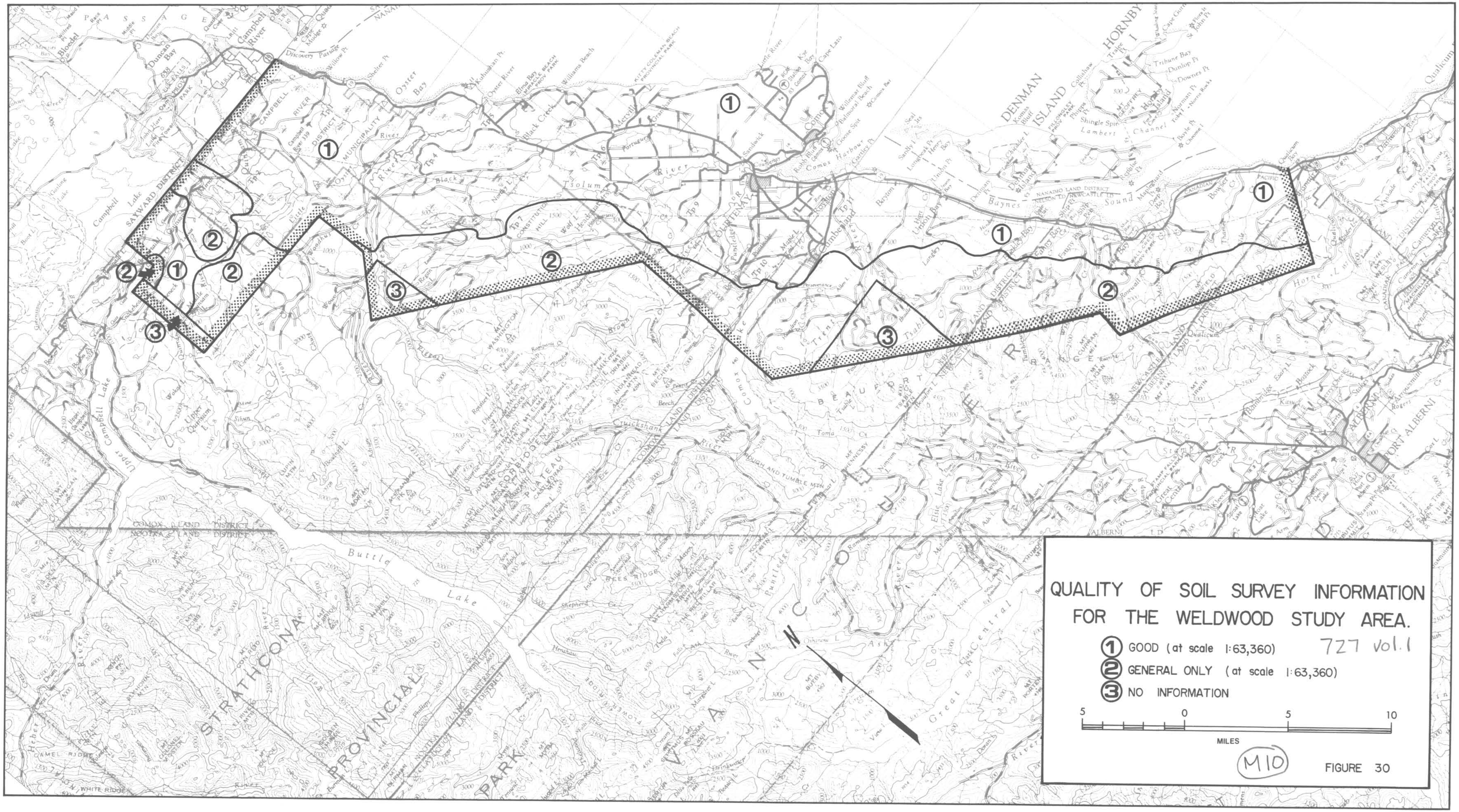
The review of existing information on surficial geology and pedology has indicated that while several maps and reports encompass the Study Area, all are at a relatively small scale (i.e. 1:63,360) (Figures 29 and 30). Information at this scale, while adequate for a general overview, will not be sufficient for site-specific impact assessments. The scale reguired largely depends on the particular site but should be at least several times larger than that of the existing maps. The hydrogeological information is also small-scale (i.e. 1:126,720) (Figure 31) and is insufficient for site-specific assessments.

The methodology of site-specific studies should include an assimilation of exploration mapping, coring, log and test results with air-photo analysis and a field investigation of deficiencies. This will identify surficial deposits, groundwater aquifers, recharge and discharge areas, sand and gravel resources and soil units. Hydraulic characteristics of aquifers and groundwater quality with respect to the impact



QUALITY OF SURFICIAL GEOLOGY INFORMATION FOR THE WELDWOOD STUDY AREA

FIG. 29



QUALITY OF SOIL SURVEY INFORMATION FOR THE WELDWOOD STUDY AREA.

FIGURE 30

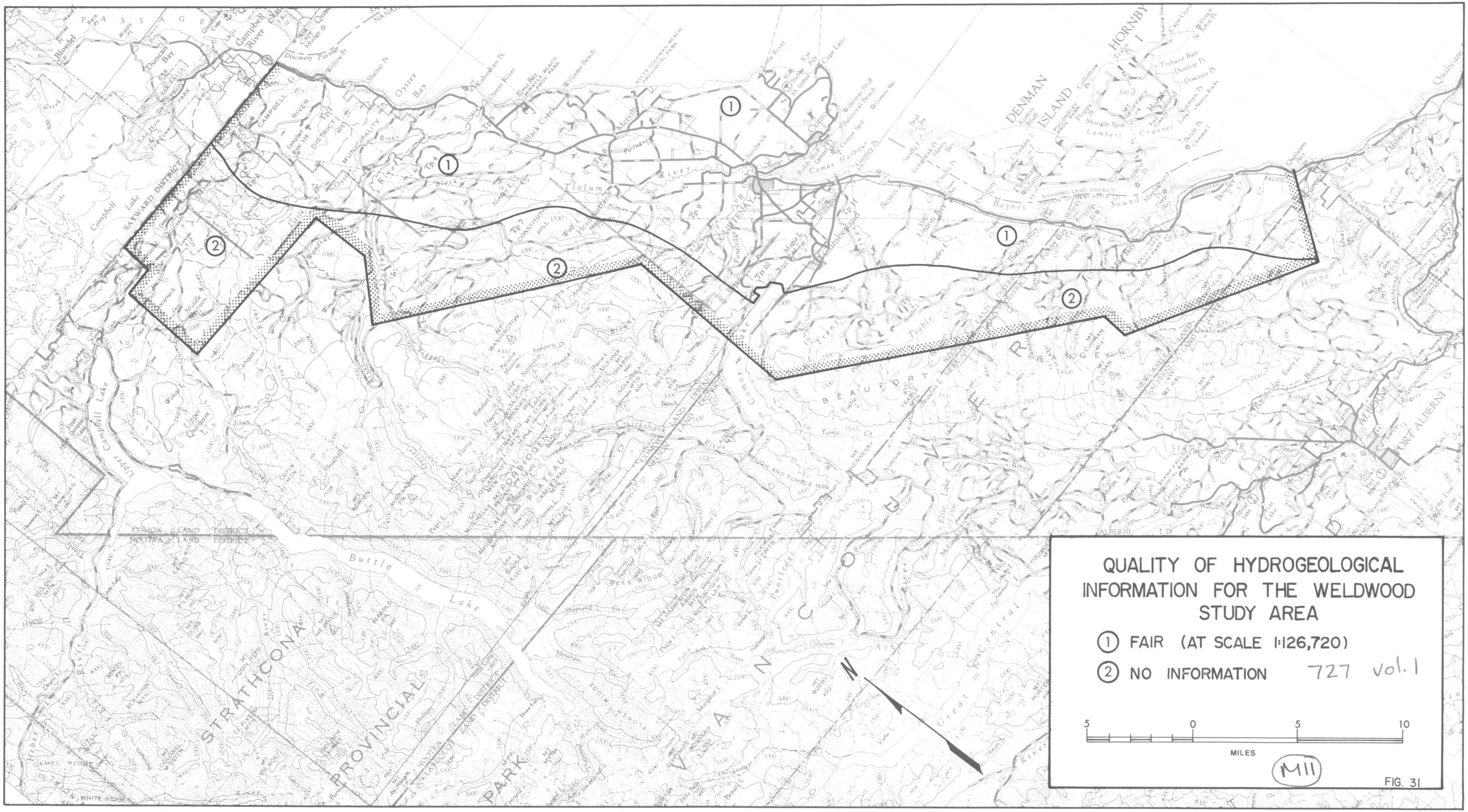

QUALITY OF HYDROGEOLOGICAL INFORMATION FOR THE WELDWOOD STUDY AREA
① FAIR (AT SCALE 1:126,720)
② NO INFORMATION
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FIG. 31

assessment may be derived from the hydrogeological study of the site.

Potential problems resulting from site development have been identified from the existing information (Table 24). These problems include erosion of fine-grained materials with impact on streams; poorly drained soils which impact on construction and revegetation; and possible pollution of sub-Vashon Drift aquifers with major impact on regional groundwater flow systems. In addition, groundwater flow systems fed by super-Vashon aquifers may be locally important. It is stressed, however, that the degree of impact of these problems will depend on the specific site and that none or all may be active.

D. SURFACE HYDROLOGY

A hydrometeorologic analyses of sufficient depth will need to be carried out for each of the watersheds to be affected, in order to determine watershed run-off characteristics, stream flow characteristics as well as probable peak daily flood flows. Baseline data for such analysis is already available for most of the major streams in the Study Area.

E. FISHERIES

Two main points emerge from a review of existing information on aquatic habitats in the region encompassed by the Weldwood leases on Vancouver Island. The first is that a considerable amount of general information is available on the substantial fish and shellfish resources of the area. The second point is that detailed data describing the specific sites which may be disturbed and the effects of the disturbance

Table 24 Summary: Potential site development problems relating to surficial geology, pedology and hydrogeology aspects.

ASPECT	DESCRIPTION	POTENTIAL PROBLEM	IMPACT
SURFICIAL GEOLOGY	SALISH, CAPILANO; Fine grained, lacustrine and marine, silts and sands QUADRA; Fine grained sands	Erosion	Gullying, sheet erosion, slumping of cut slopes; Stream siltation
PEDOLOGY	PUNTLEDGE, FAIRBRIDGE; Fine textured soils on fine grained marine sediments	Erosion	Stream siltation
	CASSIDY alluvial soils ARROWSMITH organic soils PARKSVILLE, TOLMIE, COWICHAN gleysolic soils	Poor drainage; water table near surface; Low bearing strength; High compressibility; Possible salinity especially where associated with groundwater discharge areas.	Construction; Revegetation
HYDROGEOLOGY	SUB-VASHON DRIFT AQUIFERS; Quadra and Mapleguard sands	Pollution	Regional groundwater flow systems

on aquatic habitats in the area are lacking. In this section the potential fisheries-related problems which have been identified to date are outlined. Any program of aquatic studies should be directed in a site-specific and problem-oriented manner at those lakes, streams and marine areas most likely to be affected by the proposed mining activities. The program would involve detailed studies of physical, chemical and living components of aquatic ecosystems which would form the basis for first, a prediction of potential impact and the development of mitigative measures and second, a monitoring of the actual impact as it occurs.

During the first year of investigation, fisheries studies should be concentrated in areas where early development is anticipated.

Union Point. An especially sensitive area due to the variety of productive habitats (estuary, intertidal and subtidal zones) and sources of potential disturbance (wharf construction, docking facility, removal of intertidal portions of existing coal waste piles). Strong opposition from the Oyster Growers' Association can be expected.

Comox Lake Area. Location of several coal waste piles from past mining operations. Mining of these waste piles may affect water quality, particularly at the Comox Lake and Perseverance Creek sites.

Tsable River. Old mining site may be re-opened. There is a past record of poor mining practices and detrimental effects to stream and fish populations (Walker and MacLeod 1970).

The fisheries portion of the environmental program should include detailed studies of fish, invertebrates (principally shellfish) and aspects of water quality. These are briefly discussed below.

E.1 Fish

The Weldwood leases lie within a region of exceptional fisheries importance. It is likely that one of the most sensitive issues with respect to the proposed mining will be the federal, provincial and public concern over this valuable resource.

Our proposal includes investigations of the densities, relative abundance, seasonal distribution and life histories of the important species in the vicinity of proposed developments. In some instances, it may be necessary to maintain fish weirs in order to determine actual numbers of fish using particular streams. Initial research efforts should take place in those areas where development might first occur:

(a) Tsable River,

(b) the lower reaches of Hart (Washer) Creek which flows through Union Bay slack pile,

(c) the marine area around the Union Bay slack pile and proposed wharf site,

(d) Comox Lake, and other slack pile sites where a conflict with fish populations may exist.

In each of these cases, the fish utilization of the water body, or specific site likely to be affected, must be quantified so that appropriate mitigative measures can be defined and subsequent changes, if any can be readily detected and rectified. All of the freshwater areas listed above are important spawning and rearing areas for several species of commercial and/or sport fish.

E.2. Invertebrates

Invertebrates are important as food for both fish and humans. Of particular concern are the commercially important shellfish found in Baynes Sound (off Union Point). Fully 42% of all registered oyster leases in British Columbia are located in this sound. There are also several public reserves in the vicinity for the recreational exploitation of clams and oysters.

The principal research effort would involve baseline and monitoring studies in the marine waters at Union Point. Invertebrates traditionally have served as indicators of change in aquatic environments. Of special concern are the adverse effects of siltation and industrial pollution on shellfish beds in the vicinity of the intertidal mining operation.

Additional invertebrate studies should be conducted at sites of potential disturbance at freshwater locations. Benthic (bottom-dwelling) invertebrate communities in fresh water are especially sensitive to disturbance and monitoring studies often provide an early warning of detrimental changes.

E.3. Water Quality

Water quality is a third important factor which is likely to be affected by mining activities. For example, siltation of salmon and trout spawning and rearing areas is a priority concern. The program should concentrate on those chemical and physical conditions most likely to be affected to the detriment of aquatic habitats. Emphasis should be placed on the following biologically relevant parameters:

(a) temperature

(b) dissolved oxygen

(c) turbidity and suspended sediments

(d) standard water analysis (including pH, conductivity, major ions and macronutrients)

(e) C^{14} primary productivity (standing water only).

As in the case of the fish and invertebrate studies, it is important to quantify naturally occurring fluctuations in water quality conditions before development occurs in order to determine if subsequent fluctuations exceed these levels.

In conclusion, it should be recognized that the timing of the fisheries studies is most important. In order to gather the basic data necessary to document fish utilization in areas subject to disturbance, the seasonal pattern must be examined. A small stream, for example, which is dry during the summer months may serve later in the year as an important overwintering site for juvenile salmonids (Bustard 1973). Since information on salmon spawning can be obtained only in the autumn and early winter months, we recommend that the fisheries studies commence this autumn; otherwise, these data, which in some cases will constitute the most important part of the fisheries investigation, will not be available for another full year.

F. WILDLIFE

While the biology and life history of most of the major species is fairly well understood, information is lacking on their abundance, distribution and seasonal movement patterns within the Study Area. Prior to development, studies should be undertaken to obtain such baseline information and to determine the relationships between each species and its biotic and abiotic environment.

F.1. Habitat

A major impact of coal development is usually the loss of habitat associated with mining and road construction. This is particularly true when strip-mining methods are used. It is therefore necessary to determine the functional relationships between wildlife and particular habitat types.

While forest inventory maps, which are available from the Department of Forestry and individual logging companies, will be sufficient for mapping overstory components, it will also be necessary to classify and delineate habitats according to understory characteristics. Since the history of timber harvesting has apparently had a major effect on wildlife, age of forest or seral stage must also be considered.

F.2. Waterfowl

In view of its importance as a wintering area, additional information is required on the numbers of waterfowl using the Baynes Sound - Union Bay area. This will aid in assessing the degree of impact that the Union Bay facility will have on wintering waterfowl. Factors to be considered in this regard are effects of oil spillage, coal siltation and water quality alteration on feeding habitat and nesting areas of these birds. While marshes and lakes in the northern part of the Study Area are apparently extensively used by nesting waterfowl (Bailey, pers. comm.), quantitative information is lacking. Research requirements in this regard include an inventory of nesting habitat in areas likely to be effected by development, supported by data on productivity (brood counts).

F.3. Upland Birds

Blue grouse is the most common and economically important gallinaceous species in the Study Area. While ruffed grouse do occur, they are not considered an important resource.

Since 1944, university operated research stations have more or less continuously studied blue grouse populations within the Study Area. The resulting information should prove adequate for assessing impact.

F.4. Ungulates

Although two studies of black-tailed deer are currently underway near the Study Area, no data are available that pertain to the Study Area itself. Similarly, while elk are reportedly distributed throughout the Study Area, quantitative data are completely lacking. Detailed research on both of these species will be necessary to satisfy the concern that can be expected from hunters and sportsmen groups. The following seem to be the most pressing research needs:

(a) delineation of key winter ranges
(b) determination of seasonal distribution and movement patterns
(c) determination of seasonal habitat preferences
(d) assessment of the effects of snow cover, forest succession, hunting and human activity on abundance and distribution.

On Vancouver Island, snow conditions and ungulate productivity may show marked variations from one year to the next; consequently, it is recommended that the proposed research program extend over a minimum of two years and preferably three years. Provisions should also be made in any research program for monitoring populations during the operational phase of the development.

F.5. Furbearers

Although the Study Area is not commercially important in terms of fur production, it does contain several species of aesthetic and scientific interest. The abundance and distribution of the principal furbearing mammals should be investigated in conjunction with the previously outlined ungulate studies. Since research on cougars is currently underway immediately south of the Study Area, detailed studies of this species will not be necessary.

F.6. Rare or Unique Species

Particular attention should be placed on documenting the use of the Study Area by species such as the peregrine falcon, osprey, turkey vulture, bald eagle, golden eagle and Vancouver Island wolf. Of major concern would be determining whether any of these species use the Area for breeding or nesting.

G. SCENIC ELEMENTS

It is important to be able to quantify the aesthetic value of an area, and through this judge the degree of modification or scenic destruction that development will bring.

When mining plans are finalized, a survey should be instituted to classify the recreational and amenity potential of the land (and the landscape) about to be developed. This need only be conducted in specific localities that will undergo such radical scenic transitions as open pit mining or construction of a preparation plant. Methods for conducting scenic inventories have been reviewed by Hamill (1971).

H. DEMOGRAPHY

Major development schemes such as mining bring with them considerable alteration in the socio-economic base of a community. This is largely caused by the influx of people needed to maintain the development.

Socio-economic investigations should centre upon the determination of regional influence with respect to labour shifts, unemployment and income generation. Related areas such as integration of imported labour into present communities, the effects likely to be felt on the social facilities ultrastructure and housing are also important factors to consider. Research in these areas will only be possible when the development plans become more definite and the anticipated number of workers is known.

Other social aspects are not deemed to require further research. However, close contact with archaeological surveys and other external research programs is recommended.

I. RECLAMATION

The long-term, environmental impact of mining is dependent, to a large extent, on how successfully the operator achieves reclamation. Thirgood (1973) states that "reclamation involves three distinct phases:

(i) prior land use planning including an inventory of land and water resources before mining,

(ii) physical operations to achieve a suitable topography, and

(iii) natural or assisted revegetation, and subsequent management of reclaimed land."

Collection of baseline data described in the preceding section will provide a picture of the existing environment prior to development. Physical methods used in contouring, segregating top soil and seed bed preparation are well described in the literature. The only area that will require additional research is revegetation.

Revegetation is dependent upon a number of site-specific factors including topography, surficial geology, soil texture and chemistry, moisture regime and climate. These factors were considered in the previously outlined research requirements. As well, revegetation trials should be conducted to determine species performance, regeneration rates and optimum fertilization rates under controlled, experimental conditions. This program should include at least three years of studies; however, under existing legislation, reclamation research can be coincident with first few years of mine operation.

CONCLUDING SUMMARY

An environmental impact assessment is designed to predict and evaluate the long and short-term effects on the environment of a proposed development. It is basically made up of four components:

I. Description of the Proposed Development - explains the design, setting, construction procedure, operations and maintenance of the proposed development.

II. Description of the Existing Environmental Setting - an inventory of all physical, biotic and social aspects as they exist before the development is implemented. Together with Component I, this forms the basis for Component III.

III. Potential Environmental Impact - identifies the potential long and short-term effects of the proposed development upon the existing environment and assesses the importance and magnitude of these effects.

IV. Recommendations for Minimizing Impact - measures for mitigating any negative effects of the development and for rehabilitating affected areas are described.

In the foregoing report, the present environmental setting of the Vancouver Island Coal Properties has been described on the basis of existing information and preliminary field reconnaissance. As well, subject areas deficient in necessary information have been identified and recommendations for research sufficient to fill these deficiencies have been made. This report is therefore termed a Preliminary Environmental Assessment. As such it serves three purposes:

(1) It serves to aquaint Weldwood of Canada, Ltd, with major areas of environmental concern, early in their planning process

(2) It more closely identifies areas that will require additional original research, thereby avoiding unnecessary time and expense during later stages, and

(3) Much of the information contained herein can later form part of the Environmental Impact Assessment.

In summary, it was found that while much information of a general nature exists, site-specific data were lacking in most cases. Major supplementary research is recommended in the areas of surficial geology, pedology, hydrogeology, fisheries, wildlife and human demography (Table 24). It is emphasized that such research should be of a site-specific nature. For example, the area encompassed by the Coal Properties includes 20 drainage basins with fisheries capability; the costs of conducting detailed aquatic studies on the entire area would prove prohibitive. It is further recommended that the necessary environmental studies begin as soon as proposed areas of development are delineated, in order to provide two to three years of baseline data prior to commencement of operations.

Table 24. Summary of research required to conduct an Environmental Impact Assessment of the Vancouver Island Coal Properties.

SUBJECT AREA	RESEARCH REQUIREMENT No Further Study	 Minor Supplementary Research	 Major Supplementary Research	 Monitor
A. PHYSICAL				
Topography and Physiography	X			
Climate		X		
Surficial Geology			X	
Pedology			X	
Hydrogeology			X	
Surface Hydrology		X		
B. BIOTIC				
Fish			X	
Invertebrates			X	X
Water Quality			X	X
Vegetation (habitat)			X	
Waterfowl		X		
Upland Birds	X			
Ungulates			X	X
Furbearers		X		
Rare or Unique Species		X		X

Table 24. Continued.

	RESEARCH REQUIREMENT			
SUBJECT AREA	No Further Study	Minor Supplementary Research	Major Supplementary Research	Monitor
C. SOCIAL				
Scenic Elements		X		
Land Use		X		
Demography			X	
Transportation	X			
History	X			
Archaeology	X			
D. RECLAMATION				
Revegetation			X	X

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APPENDIX I. Summary of climatic data for selected stations in the Weldwood Study Area.

LOCATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL MEAN
A. TEMPERATURE													
Mean Daily Temperature													
Cape Lazo[1]	36.1	38.3	41.5	46.7	53.6	58.4	62.3	61.6	57.0	49.1	42.1	38.9	48.8
Comox Airport[2]	36.5	38.6	40.8	46.5	53.9	58.5	63.5	62.0	56.2	48.6	41.6	39.1	48.8
Cumberland[1]	34.4	37.3	40.7	46.8	53.3	58.0	62.7	62.5	57.4	49.0	40.8	36.9	48.3
Mean Daily Maximum Temperature													
Cape Lazo[1]	40.2	43.1	47.6	53.8	61.8	66.5	70.9	69.8	64.4	54.8	46.4	42.8	55.2
Comox Airport[2]	41.1	44.0	46.9	55.1	63.2	66.8	73.6	71.2	65.0	55.3	46.9	43.9	56.1
Cumberland[1]	41.3	46.0	50.8	58.8	67.0	70.6	76.0	75.5	70.3	59.3	48.5	43.5	59.0
Mean Daily Minimum Temperature													
Cape Lazo[1]	32.0	33.4	35.3	39.6	45.4	50.3	53.6	53.3	49.5	43.4	37.7	35.0	42.4
Comox Airport[2]	31.8	33.1	33.9	38.0	44.6	50.2	53.4	52.7	47.4	41.9	36.2	34.2	41.4
Cumberland[1]	27.5	28.4	30.6	34.7	39.5	45.3	49.3	49.4	44.4	38.7	33.1	30.3	37.6

[1]Based on 25-30 years data between 1931 and 1960. [2]Based on data from the 10 years period 1951-1960.

APPENDIX I. Continued.

LOCATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL EXTREMES
<u>Maximum Temperature</u>													
Cape Lazo[1]	56	56	64	71	84	86	94	88	84	71	60	59	94
Comox Airport[1]	57	59	62	71	88	90	94	90	98	82	63	60	94
Cumberland[2]	61	69	80	84	97	105	111	100	92	83	70	59	111
<u>Minimum Temperature</u>													
Cape Lazo[1]	1	7	14	25	32	38	43	44	35	29	13	12	1
Comox Airport[1]	-6	3	7	24	27	38	41	40	31	26	14	10	-6
Cumberland[2]	-5	6	5	17	26	29	36	37	28	17	7	3	-5

[1]Based on 20-29 years records. [2]Based on 40-49 years records.

APPENDIX I. Continued.

LOCATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
B. PRECIPITATION													
Mean Total Precipitation													
Campbell R.[1]	8.66	6.67	5.29	2.96	1.93	2.10	1.30	1.89	2.93	5.92	9.32	9.58	58.55
Cape Lazo[2]	6.14	4.46	3.03	2.26	1.45	1.52	0.99	1.32	1.73	4.12	6.16	7.30	40.56
Comox Airport[1]	7.83	5.28	3.99	2.33	1.38	1.67	1.02	1.58	1.92	4.79	7.31	7.63	46.73
Courtenay[2]	8.68	6.18	4.68	2.92	1.76	2.09	1.41	1.62	2.54	5.56	8.43	9.74	55.61
Cumberland[2]	8.53	6.05	5.00	3.06	1.93	2.01	1.57	1.58	2.66	6.24	8.64	10.33	57.60
Cameron L.[2]	8.16	6.12	5.09	3.41	2.51	1.51	1.41	1.35	2.82	6.64	8.54	10.63	58.19
Mean Rainfall													
Campbell R.[1]	7.13	5.87	5.00	2.96	1.93	2.10	1.30	1.89	2.93	5.92	9.00	8.76	54.79
Cape Lazo[2]	5.01	3.95	2.92	2.26	1.45	1.52	0.99	1.32	1.73	4.12	6.03	6.93	38.23
Comox Airport[1]	6.07	4.45	3.72	2.31	1.38	1.67	1.02	1.58	1.92	4.79	7.06	6.83	42.80
Courtenay[2]	7.16	5.27	4.48	2.92	1.76	2.09	1.41	1.62	2.54	5.56	8.20	9.03	52.04
Cumberland[2]	6.45	4.67	4.54	3.06	1.93	2.01	1.57	1.58	2.66	6.23	8.26	9.13	52.09
Cameron L.[2]	6.59	4.97	4.57	3.38	2.51	1.51	1.41	1.35	2.82	6.64	8.22	9.78	53.75

[1]Based on 10-24 years data between 1931-1960. [2]Based on 25-30 years data between 1931 and 1960.

APPENDIX I. Continued.

LOCATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
Mean Snowfall													
Campbell R.[1]	15.3	8.0	2.9	0	0	0	0	0	0	0	3.2	8.2	37.6
Cape Lazo[2]	11.3	5.1	1.1	0	0	0	0	0	0	0	1.3	4.5	23.3
Comox Airport[1]	17.6	8.3	2.7	0.2	0	0	0	0	0	0	2.5	8.0	39.3
Courtenay[2]	15.2	9.1	2.0	0	0	0	0	0	0	0	2.3	7.1	35.7
Cumberland[2]	20.8	13.8	4.6	T	0	0	0	0	0	0.1	3.8	12.0	55.1
Cameron L.[2]	15.7	11.5	5.2	0.3	0	0	0	0	0	T	3.2	8.5	44.4
Maximum Precipitation													ANNUAL
Campbell R.[2]	3.02	3.75	2.81	3.14	1.53	2.00	1.55	1.66	1.65	3.51	3.62	4.13	4.13
Cape Lazo[2]	3.21	2.56	2.35	1.87	0.89	1.12	1.33	2.51	1.33	1.92	2.47	2.61	3.21
Comox Airport[1]	2.75	2.50	2.15	1.61	0.94	1.20	1.07	2.72	1.27	2.34	2.59	4.45	4.45
Courtenay[2]	4.02	3.54	3.02	2.95	1.05	1.29	1.46	2.02	1.94	2.40	3.35	4.05	4.05
Cumberland[2]	3.80	2.30	2.70	1.92	1.77	1.94	2.04	2.89	2.43	3.23	3.60	3.93	3.93
Cameron L.[2]	4.25	3.70	3.35	3.00	2.80	1.50	1.58	1.78	3.30	2.43	3.85	3.90	4.25

[1] Based on 10-24 years data between 1931 and 1960. [2] Based on 25-30 years data between 1931 and 1960.

APPENDIX I. Continued.

TIME	CLOUD COVER (tenths of sky obscured)	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
C. CLOUD COVER[1]													
0430	0-2	22	25	30	29	39	27	38	43	52	33	14	19
	3-7	11	11	11	19	17	13	17	14	10	10	11	8
	8-10	66	65	59	52	46	59	45	43	38	56	75	73
1630	0-2	14	17	17	18	29	29	37	35	40	21	11	12
	3-7	11	11	12	16	17	13	12	19	13	10	9	10
	8-10	75	73	71	66	54	59	51	46	48	70	80	78
D. FOG[2]													
TYPE OF VALUE													
Mean		13	6	1	0	1	0	1	1	9	17	21	30
Highest		198	33	3	0	3	0	3	2	17	41	53	128
Lowest		23	0	0	0	0	0	0	0	0	0	0	0

[1] Percentage frequencies of the specified mean cloud amounts at Comox (all forms) in early morning and afternoon, for the period 1941-1951 (after Kendrew and Kerr 1955).

[2] Fog (visibility ½ mile or less) at Comox for the period 1944 to 1950; mean, highest and lowest numbers of hours (after Kendrew and Kerr 1955).