

AN ECOLOGICAL AND LAND USE STUDY OF
BURNS BOG, DELTA, BRITISH COLUMBIA

by

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ABSTRACT

Burns bog is a large sphagnum peat bog occupying approximately 4,000 ha of the Fraser River delta in south-western British Columbia. The area has been extensively disturbed by peat extraction, landfilling and other land-uses. Much of the bog remains in a natural or semi-natural state. As such it represents one of the largest single tracts of underdeveloped land in the Corporation of Delta. Land development and growth in the municipality has been rapid in the past ten years. Because the Burns bog area was not well known and the pressures for development of the area were mounting, this study was initiated in January 1975.

Available existing environmental and land-use information pertaining to the Burns bog area was reviewed and collated. Basic vegetation and wildlife inventories were carried out in the area, and a cover map of extant vegetation was prepared. Several aspects of peatland ecology were investigated. These included the determination of the rate of sphagnum peat accumulation, an estimate of the energy (caloric content) of the peat stored with Burns bog, and net primary productivity.

The bog was found to be floristically interesting and to be quite unlike most of the remaining underdeveloped areas of the Fraser River lowland. Because of its large size, waterlogged character, and location between the Fraser River, Boundary Bay and the foreshore areas of Roberts and Sturgeon banks, Burns bog is believed to be an important natural refuge for many species of birds. The area is an important loafing area for waterfowl, particularly mallard, pintail, and teal, and is a nesting area for a number of raptorial, passerine and other birds. Perhaps one of the more important birds of Burns bog is the greater sandhill crane, which nests in the bog in small numbers.

Burns bog supports a number of mammal species. In addition to a variety of "common" small mammals, the area supports a small number of black bear, and Columbian black-tailed deer which are believed to be isolated populations.

The land-use patterns of lands surrounding the bog area are believed to be of key importance to bird and mammal life in the area. For example many species of birds (ducks, raptors and sandhill cranes) and mammals (Columbian black-tailed deer and eastern cottontail rabbit) feed at the interface between the forested sections of the

bog and the neighbouring agricultural lands. The agricultural character of these peripheral lands appears to influence use of the bog by various wildlife species.

The peat samples analysed were found to be high in nitrogen and minerals, although these nutrients were not believed to be available for plant utilization.

The volume of peat in the bog was crudely estimated to be 108.8 hm^3 . The dry weight of this material was estimated to be 3,949,440 metric tons, and the caloric content of this material was found to be approximately 20,023.76 G. cal. This figure is believed to be the approximate amount of energy stored as peat in the bog.

The sphagnum peat accumulation rate and net primary productivity appeared to be considerably higher at hummock sites as compared to wet depressional areas. The average rate of accumulation of ten samples (six hummock and four wet depression sites) was found to be .43 cm/yr, while the average net primary productivity was $128.8 \text{ g/m}^2/\text{yr}$.

The vegetation and wildlife of the bog are largely determined by the land-use practices surrounding and within the bog. For example, "improving" the drainage of the area for the agricultural reclamation of the peatland, or for other purposes will probably result in the rapid decomposition and subsidence of the drained peat. The increased availability of nutrients, and drier conditions will consequently alter the vegetation and wildlife species distribution in the bog.

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AN ECOLOGICAL AND LAND-USE STUDY OF

BURNS BOG, DELTA, BRITISH COLUMBIA

1. Introduction

Burns bog (Delta Bog, Anrep 1928), (The Great Delta Bog, Osvald, 1933; Rigg and Richardson, 1938), is a large raised sphagnum peat bog occupying approximately 4000 hectares (ha) of the Fraser River delta in south-western British Columbia.

Although extensively disturbed from peat extraction, land filling and other land uses, Burns bog is a large "underdeveloped" area within the Greater Vancouver Regional District (population approximately 1.2 million), and is by far the largest underdeveloped area of the Fraser River lowland. As part of this ever expanding district, and because of its proximity of the Pacific Ocean, Fraser River and the rich agricultural lands of the Lower Fraser delta, numerous proposals for development of the bog have been, and will, continue to be forthcoming.

Because the area was not well known, physically and biologically, this study was initiated in January 1975, to bring together environmental information pertaining to the area as a base for

additional specialized ecological studies which should be done to effectively predict the impact of future developments on the bog area.

To achieve this end, the following objectives were outlined at the outset of the study:

- A. to collate and review existing environmental and land-use information pertaining to the area,
- B. to carry out basic vegetation and wildlife inventories in the area,
- C. to prepare a cover map of extant vegetation of the area and
- D. to investigate certain aspects of the ecology of the bog such as the determination of peat volume, weight and stored energy in Burns bog, and to estimate the rate of sphagnum peat accumulation rate and net primary productivity.

2. Description of the Study Area

2.1 Location

Burns bog ($49^{\circ}08'N$, $123^{\circ}00'W$) is situated in the Corporation of Delta, approximately 20 km. south of Vancouver, British Columbia. The bog occupies an area of approximately 4000 hectares, or roughly 21% of the municipal land area of Delta (Figure 1).

The bog is vaguely elliptical in shape and is bordered by the North Delta escarpment (Panorama ridge) to the east, and Crescent Slough to the west. The combined Canadian National-Burlington Northern Railway trackage and a narrow bank of partially developed agricultural and industrial land south of River Road, marks the bog's northern limit; Highway 499 serves as its southern boundary (Figure 1).

Burns bog is surrounded by land that is used in the following ways: 60% agricultural, 20% residential and 20% industrial and other land-use. Approximately 40% of the surface vegetation of the bog has been disturbed for the extraction of peat moss (mined or cleared).

2.2 Physiography

The study area lies within the Fraser Lowland region of the Coastal Trough physiographic subdivision (Holland, 1964). Burns bog is situated on the Fraser River delta approximately 18 km. east of the western delta-front, and 7 km. north of the southern delta-front (Hoos and Packman, 1974). The average altitude of the surrounding lands is 1-2m above sea level (a.s.l.); however, the central domed section of Burns bog is somewhat higher and reaches an altitude of 5-6m (a.s.l.).

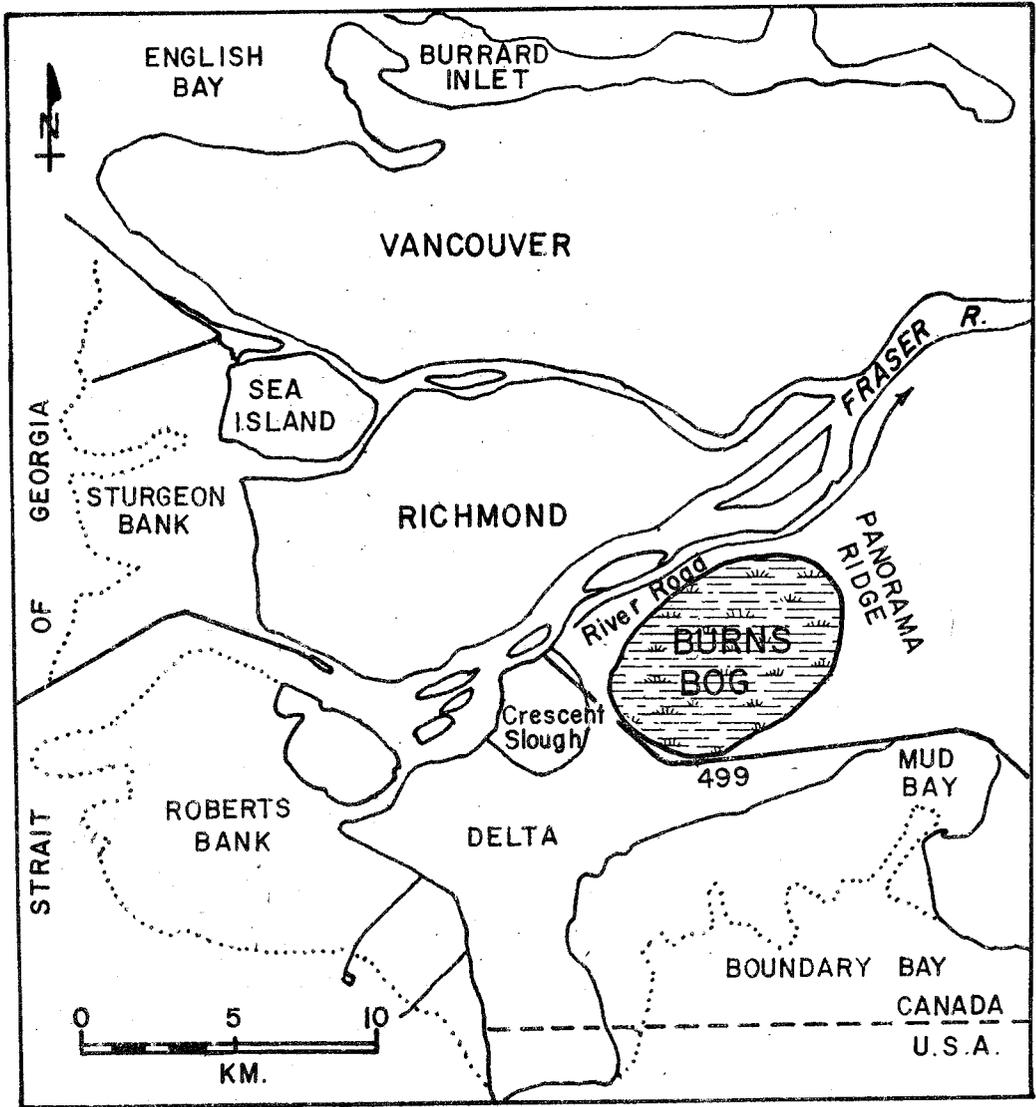


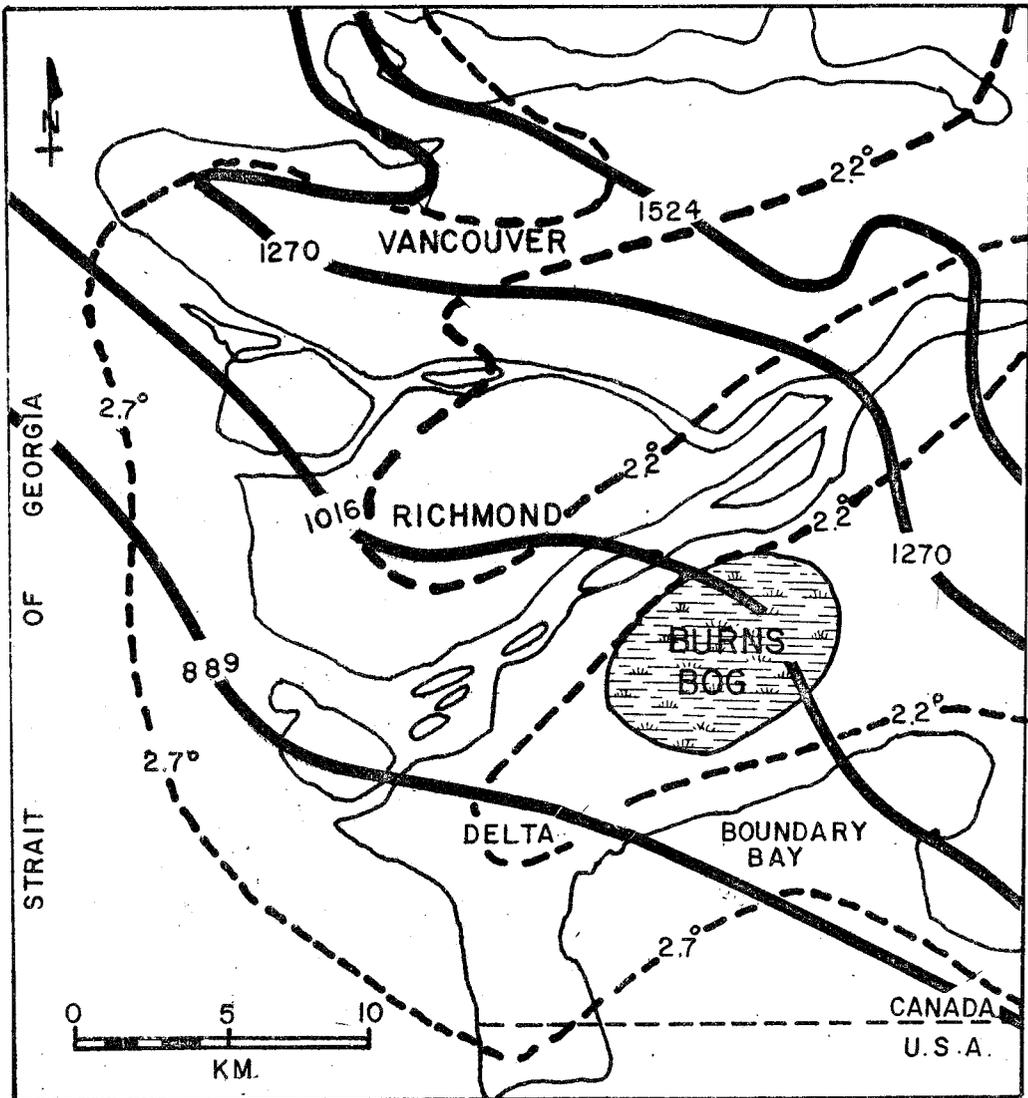
FIGURE 1. MAP OF THE FRASER RIVER DELTA, B.C.
INDICATING THE LOCATION OF BURNS BOG

Lands surrounding the bog to the north, west and east are poorly drained, and are generally "very gently, to gently undulating". (Luttmerding and Sprout, 1969). Directly east of the bog, an upland area, consisting of glacial till and glaciomarine deposits rises to an average elevation of up to 90 meters above the bog. This upland area is called Panorama ridge or the North Delta escarpment.

2.3 Climate

The climate of the Burns bog study area is best described as a modified maritime climate, and falls within the Köppen Mediterranean Type (Csb). (Hoos and Packman, 1974). The area is characterised by mild rainy winters and bright, dry, warm summers. The climate of the study area is modified by its close proximity to the Gulf of Georgia, and distance from the coastal mountains. It appears that the average winter (December 21 to March 21) temperatures tend to be lower with increased distance from the delta-front, and that the annual average precipitation increases from west to east across the delta (Figure 2). Some climatic parameters for the study area have been summarised in Figure 3.

The meteorological recording station nearest the study area is the Ladner station, located approximately 8 km west of



SOURCE: HOOS AND PACKMAN, 1974

— ANN. AVER PRECP. (mm)

- - - JAN. MEAN TEMP (°C)

FIGURE 2. ANNUAL AVERAGE PRECIPITATION, AND JANUARY MEAN TEMPERATURE FOR THE LOWER FRASER DELTA

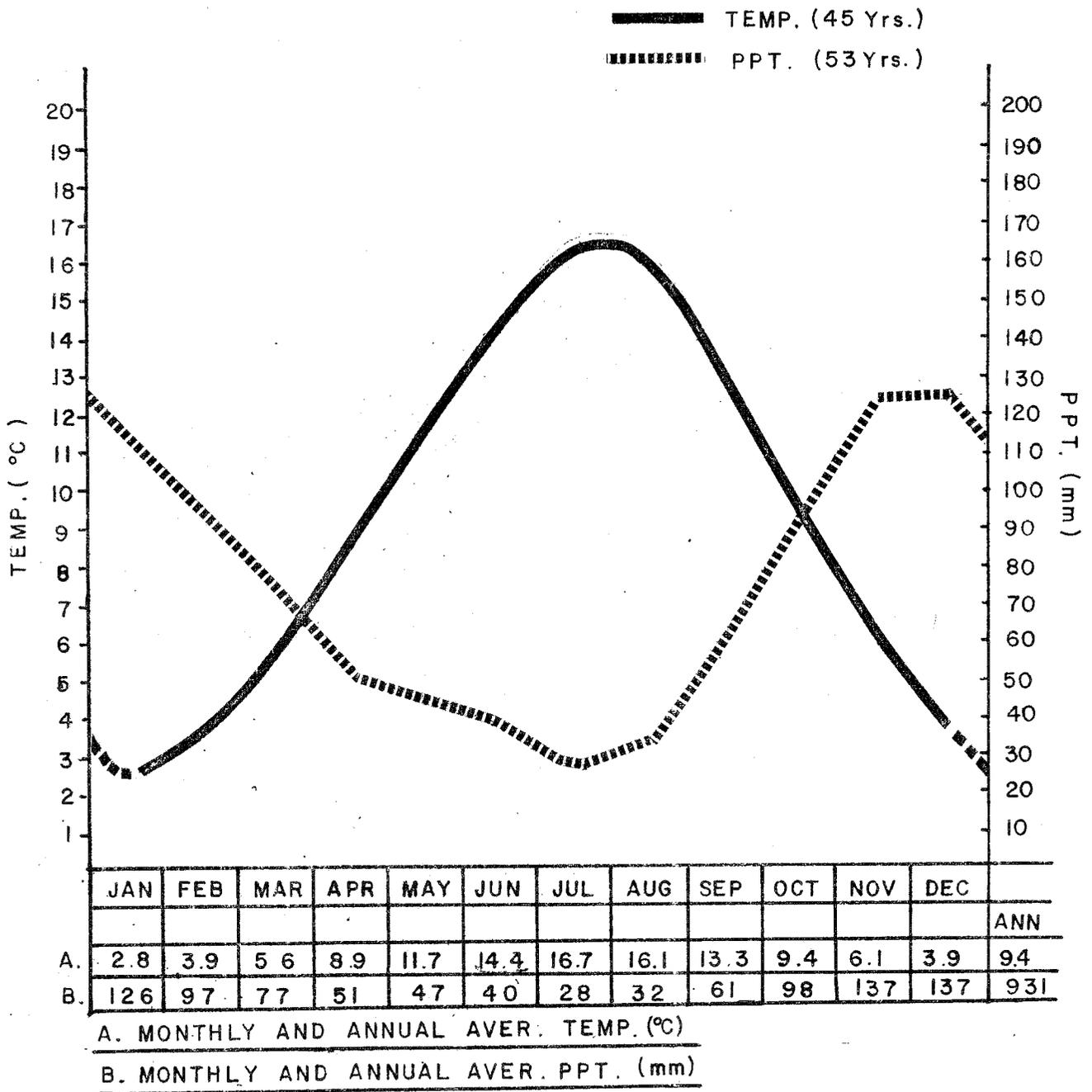


FIGURE 3. MONTHLY AND ANNUAL AVERAGE TEMPERATURE AND PRECIPITATION FOR THE LADNER CLIMATOLOGICAL STATION, DELTA, B. C. (SOURCE B.C.D.A. 1965)

Burns bog. This station records precipitation, temperature and intensity of rainfall. Long term normals of sunshine and wind are recorded at the Vancouver International Airport station, situated 16 km west and north of Burns bog. The record of climate for these stations was assumed to reasonably represent the climate of the study area.

2.4 Temperature

High pressure cells which seasonally establish off the coast of British Columbia provide the Lower Fraser valley with dry, bright, warm summer months (June-August). The forty-five year (1920-1965) average summer temperature for the study area was 15.7°C . (B.C.D.A., 1965). Winter months are generally cool but not cold as the area is close to the sea and protected from cold continental air masses by the Coast mountains. However, the cold continental air does drain down the valley into the area occasionally during the winter months. Long term (53 years) average winter temperatures (December-February) for the area are 3.5°C (ibid.).

General the temperature fluctuations are not extreme. The lowest and highest temperatures recorded in 45 years at the Ladner station were -17.2°C and 35°C , respectively (ibid.).

2.4.2 Precipitation

The average annual precipitation for the Burns bog area is approximately 930+ mm/yr (B.C.D.A., 1965). Because the Ladner station is located 8 km west of Burns bog, and because precipitation increases from the west to the east over the area (Figure 2), the average annual precipitation for the bog may be approaching 1000 mm/yr (Luttmerding and Sprout, 1969).

July is the driest month of the year with an average monthly rainfall of 28 mm. The wettest months are usually November or December, each with a monthly average of 137 mm of rain and snow (Figure 3).

Winter temperatures generally are above freezing, and snow cover rarely persists for more than a few days. A 53 year average annual snowfall of 390.8 mm was recorded at the Ladner station (B.C.D.A., 1965).

2.4.3 Sunshine and Visibility

The Vancouver International Airport climatological station records reveal that the area has approximately 1900 hours of bright sunshine per year (Atmospheric Environment Services, Environment Canada, 1974). Reduced visibility is usually due to industrial smoke and radiation fog. Fog

occurs most commonly in the months from October through February, but its occurrence is unusual during the spring and summer months, from March to August (Hoos and Packman, 1974).

2.4.4 Wind

The prevailing winds over the study area blow in an easterly direction. Surface wind patterns over Burns bog are partly the result of its proximity to Boundary bay, and the Strait of Georgia (Figure 1). Although the major land-sea interface is responsible for the characteristic on and off-shore flow of air, the strongest winds are usually associated with the passage of active storm fronts. These active frontal disturbances usually blow from a northwesterly direction (ibid.). During the winter months, and occasionally in the summer, cold continental air spills over the mountain passes and/or flows west along the Fraser valley bottom resulting in rapid cooling of the delta.

2.4.5 Growing Season

With a growing season length of approximately 230 days, Burns bog is situated in an area with one of the longest frost-free periods and growing seasons in Canada (Luttmerding and Sprout, 1969). The Ladner station rarely

experiences much more than a few degrees of frost. This is manifest in the wide variety of agricultural crops that can be grown in Delta. The dates of spring and fall frosts, and the duration of the frost-free period has been recorded at the New Westminster and Ladner climatological station (Table 2). These dates and periods are believed to adequately represent the Burns bog area, as the stations both are a short distance (approximately 8 km) east and west of the bog respectively.

Table 1. Spring and Autumn Frosts and Duration of Frost-Free Period for the New Westminster and Ladner Climatological Stations (From: Luttmerding and Sprout, 1969).

Station and Altitude	First Autumnal Frost			First Spring Frost		
	Earliest	Latest	Mean	Earliest	Latest	Mean
New Westminster * (16m)	Sept. 25	Dec. 10	Nov. 4	Feb. 19	May 14	Apr. 5
	214 Frost-free days: 57 years record					
Ladner** (3m)	Sept. 3	Dec. 24	Oct. 18	Mar. 7	June 18	Apr. 10
	183 Frost-free days: 38 years record.					

*air drainage excellent

** air drainage poor

3. Collation

3.1 Glacial History

The Fraser River delta is a relatively old delta as it is believed to be the site of early deltas and coastal plains approximately 700 million years ago during the Upper Cretaceous period (Blunden, 1973). The onset of glaciation of the Fraser delta began some 800,000 years ago (Kent et. al., 1971). Glaciers originating in the valleys of the Coast Mountains to the north and east of the area advanced over and retreated from the delta many times. Major ice advances and retreats buried the Burns bog area to a depth of up to 1800m (Blunden, 1973 ; Mathews et.al., 1970).

The last in the series of advances by ice of the Fraser Glaciation was called the Sumas Stade. Ice of the Sumas Stade withdrew from the lower Fraser valley approximately 11,000 years ago (Mathews et.al., 1970; Fulton, 1971) to roughly the present site of Panorama Ridge (Figure 1) leaving the Burns bog and other areas of the delta ice free. The recent geological history of the delta area therefore began approximately 11,000 years ago (Blunden, 1973). Although free of glacial ice, the study area was depressed to approximately 230m below sea level (ibid.). Isostatic rebound of the area, the relatively low sea levels at this time, and the continual

deposition and reworking of alluvium by the Fraser River at its mouth are responsible for the build-up of the delta (Blunden, 1975).

3.2 Bog Development

Mt. Mazama volcanic ash from the Crater Lake in Oregon some 6600 radio-carbon years ago was not found in Burns bog.

"Numerous borings made in the bog have failed to show any volcanic ash, though it is present in the bogs showing a lake origin in the city of Vancouver, B.C., only a few miles distant."
(Rigg and Richardson, 1938).

As no ash was found it is assumed that the area was below sea level at the time of ash fall and the bog originated some time after 6700 years ago. It is believed that the development of Burns bog began approximately 5000 to 6000 years ago (Matthews, pers. comm.). At this time the bog was probably a large shallow water lake or basin developed on the recent alluvium of the Fraser river delta. Early workers in the area also state that "undoubtedly there was standing water in the depression during its development" (Rigg and Richardson, 1938). Their profiles indicate that the mineral substrate below the organic deposit is undulating and irregular. Boreholes done by Engineering Drillers Ltd. in 1970 confirm Rigg and Richardson's findings, viz., that the bog is developed on angular sand which reaches a depth of at least 30m. Additional drilling log data reveal

a layer of clay-silt and silty sand of variable thickness, usually less than 10m above the angular sand (B.C. Hydro, 1974). The presence of this clay silt layer is another reason for the belief that Burns bog began as a water-filled depression. "A bog mire ecosystem takes a position between terrestrial and limnic (lake) types . . . Lake sediments are always found below the peat layers of the mire." (Malmer, 1975).

Coring of the bog indicated that the open-water basin was first invaded by various sedges, and floating aquatic plants (Rigg and Richardson, 1938). The remains of vegetation found to occur at the greatest depth in the core are assumed to represent the earliest type of vegetation to "invade" the bog basin. In this way peat stratigraphy functions as a record of plant succession, and indicates patterns of bog development. The record is a function of the variable rates of decomposition/preservation of organic materials in that profile.

Stratigraphic studies of post-glacial bog development in Great Britain indicate that the typical segment of bog development on coastal and estuary sites is generally as follows:

All species of the genus Sphagnum have remarkable cation exchange capacity. Hydrogen ions are exchanged for cations in solution of surrounding waters (Williams and Thompson, 1936). The absorption of cations, and possibly the secretion of organic acid molecules by the plant (Clymo, 1964) result in the lowering of the pH of the water or sphagnum soil deposit.

The acidity of the peat deposit, waterlogged nature of the deposit and relatively low temperature of the bog compared to other terrestrial ecosystems slows down bacterial decomposition (Latter et.al., 1967; Clymo, 1965) and results in the accumulation of peat. Plants such as sphagnum, heaths and others, growing in bogs are tolerant of this low nutrition, low pH regime.

Natural afforestation usually follows centripetal development in peatlands. The trees near the centre of the bog in the wettest sections are generally stunted, while the trees have a more developed growth form at the edges of the deposit (Moore and Bellamy, 1974). The general species distribution and approximate growth appearance of some trees in Burns bog is presented in the following schematic diagram (Figure 4).

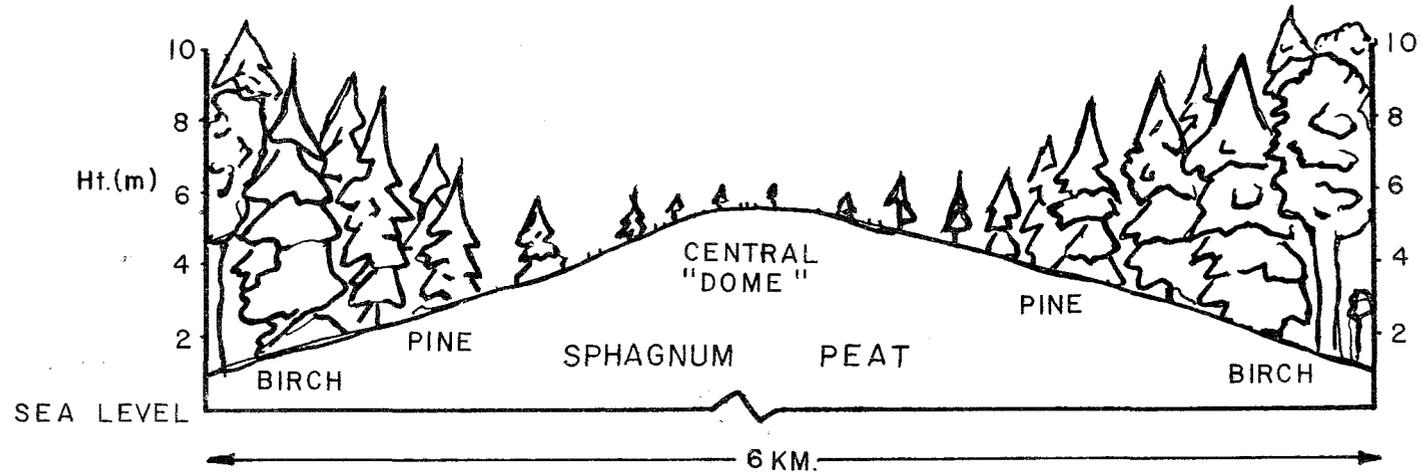


FIGURE 4. SCHEMATIC CROSS-SECTION OF BURNS BOG

3.3 Soils

The two dominant soil types of the Burns bog area have been classified by Luttmerring and Sprout, 1969, as follows:

Soil Order:	Organic	
Great Group:	Fibrisol	Mesisol
Soil Subgroup:	Sphagno-Fibrisol	Typic Mesisol
Soil Series:	Triggs	Lumbum

The Triggs and Lumbum series have a deep (greater than 133 cm) organic deposit as their parent material. The Triggs soils are the deepest, and occupy the central portion of the bog. The Lumbum series occurs in an irregular concentric band around the Triggs series (Figure 5).

Two minor intrusions of the Annis and the Lulu series have been mapped in the north-eastern section of the bog (ibid.). The Annis soils are of the Rego Gleysol soil sub-group --- Gleysolic Order, and the Lulu series has been classified as a Terric Mesisol of the Organic Soil Order. The Annacis series, a Typic Humisol, also of the Organic Order, is found at the extreme south-west boundary of the bog (ibid.) (Figure 5).

The Triggs and Lumbum soil series will be examined in greatest detail, as the two groups represent roughly

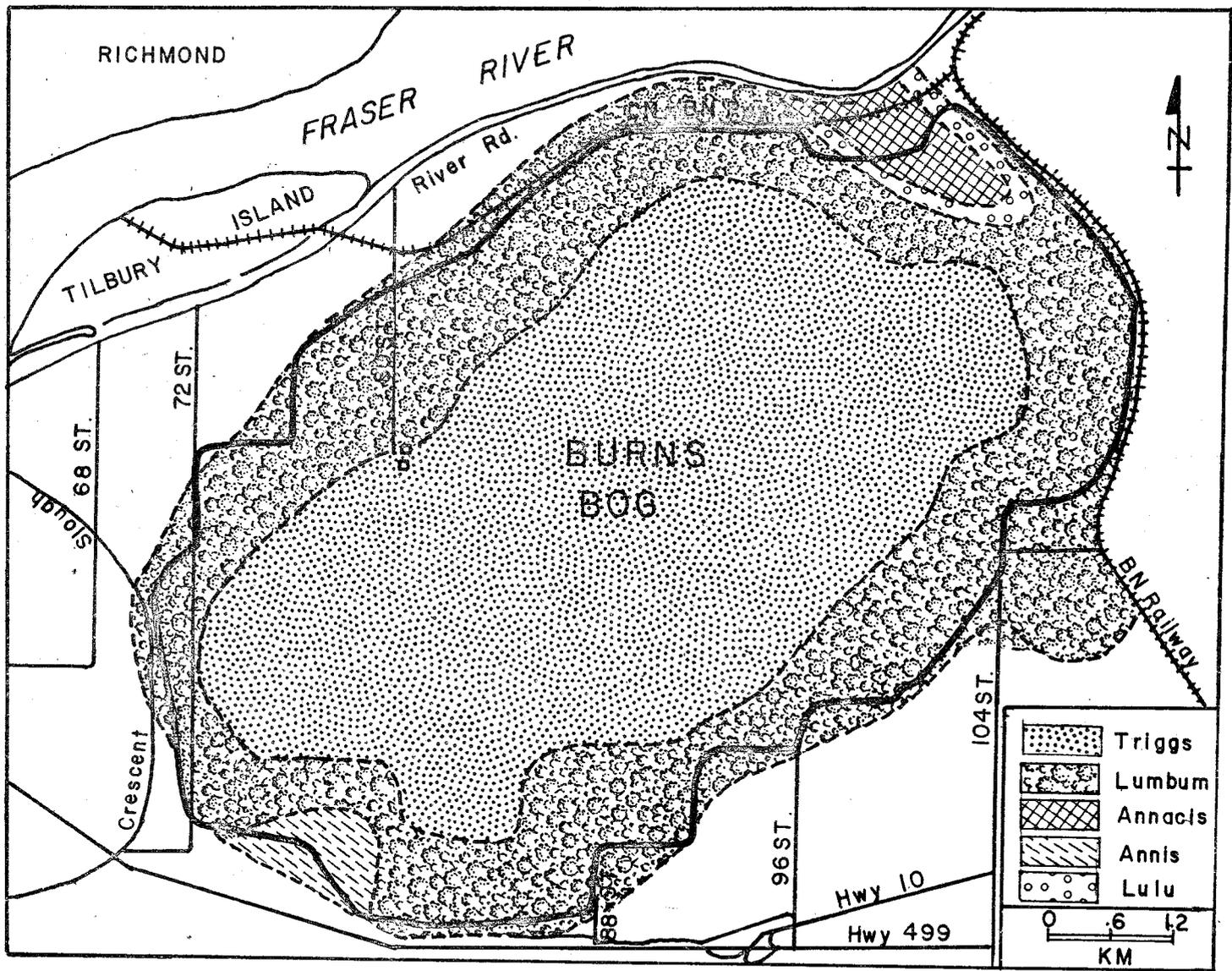


FIGURE 5. SOIL MAP OF BURNS BOG
 (SOURCE : LUTTMERDING AND SPROUT, 1969)

3800 ha, or 95+% of Burns bog. The characteristics of these two soils is outlined in Table 2.

Table 2: The characteristics of the Triggs and Lumbum soil Series

PROPERTY	TRIGGS SERIES	LUMBUM SERIES
Topography	Level to very gently sloping.	Flat to very gently undulating.
Elevation	304-610 cm at dome	152 - 213
Water Table	At or near surface for most of year.	At or near surface winter, spring and early summer.
Water holding capacity.	Extremely high.	Very high.
Soil reaction.	Extremely acid.	Extremely acid.
Surface horizon.	Undecomposed sphagnum mosses.	Undecomposed sphagnum mosses.
Subsurface horizon.	Unhumified sphagnum peat.	Partially humified sphagnum peat.

(Source: Luttmerding and Sprout, 1969).

Luttmerding and Sprout, 1969, described the Lumbum and Triggs soils from typical profiles taken at the north end of Matthews Rd. (96 st.) and the east-central of Burns bog respectively, (Tables 3 and 4).

Table 3: Soil Profile Data: Lumbum soil series.

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Of	0-22.9	Yellowish-red (5YR 4/6, moist) or dark reddish brown (5YR 3/4, rubbed, moist) fibric moss. Weakly stratified and spongy. Abundant roots. pH 3.3. Gradual to clear boundary:
Om1	22.9-40.6	Dark reddish brown (2.5YR 2/4, moist) or very dusky red (2.5YR 2/2, moist) mesic material, mainly moss and shrub remains. About 40% fibre when rubbed. Weakly stratified and slightly compact. Common roots. pH 3.4. Gradual boundary:
Om2	40.6-73.7	Dark reddish brown (2.5YR 3/4-5YR 3/2, moist) or very dusky red to dark reddish brown (2.5YR 2.5/3, rubbed, moist) mesic material, mainly a mixture of sedge, moss and shrub remains. About 30% fibre when rubbed. Weakly stratified and somewhat slippery. Occasional living roots. pH 3.3. Gradual boundary:
Om3	73.7-96.5	Dark reddish brown (5YR 3/3, moist) or very dark brown (10YR 2/2, rubbed, moist) mesic material, mainly sedge and shrub remains. About 20% fibre. Weakly stratified and somewhat slippery. Common dead roots, mostly vertical. pH 3.6. Gradual boundary
Om4	96.5-127.0	Very dark brown (10YR 2/2, moist and rubbed, moist) mesic material. About 10 to 20% fibre. Massive. Slippery when wet. Common dead roots, mainly vertical, pH 4.2. Diffuse boundary
Om5	127.0-165+	Very dark brown to dark yellowish brown (10YR 2.5/2.5, moist) or dark reddish brown (5YR 3/2, rubbed, moist) mesic material, mainly sedge remains. About 20% fibre when rubbed. Massive. Slippery when moist. pH 4.5:

(Luttmerding and Sprout, 1969)

Table 4: Soil Profile Data: Triggs soil series.

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Of1	0-20.3	Light-brown (7.5YR 6/4, dry), yellowish-brown to yellowish-red (5YR 5/5, moist) or reddish-brown (5YR 4.5/4, rubbed, moist fibric material, mainly sphagnum moss.. Eighty to 90% fibre. Soft and spongy. Common roots. pH 4.0. Gradual boundary:
Of2	20.3-33.0	Yellowish-red (5YR 4/6, moist) or dark reddish brown (5YR 3/4, rubbed, moist) fibric material, mainly sphagnum moss. About 75% fibre. Stratified and slightly compact. Occasional roots. pH 3.7. Clear boundary:
Of3	33.3-63.4	Dark reddish brown (5YR 3/4, moist and 2.5YR 2.5/4, rubbed, moist) fibric material mostly sphagnum and some hypnum moss. Fifty to 60% fibre. Massive to weakly stratified. Several thin, black banks, containing charcoal. Occasional dead tree roots. pH 3.6. Diffuse boundary:
Of4	63.4-86.4	Dark reddish brown (5YR 3/4, moist and 5YR 3/3, rubbed, moist) fibric material, mainly sphagnum moss. Fifty to 60% fibre. Massive to weakly stratified. Occasional dead tree roots. pH 3.8. Gradual boundary:
Of5	86.4-119.4	Yellowish-red (5YR 4/7, moist) or dark reddish brown (5YR 3/4, rubbed, moist) fibric material, mainly sphagnum moss. Eighty to 90% fibre. Weakly stratified. Occasional dead tree roots. pH 4.1. Gradual boundary:

Table 4, continued

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Of6	119.4-165.1	Dusky-red to dark reddish brown (2.5YR 3/2 - 5YR 3/4, moist) or dark reddish brown (5YR 3/3, rubbed, moist) fibric material, mainly sphagnum moss. About 50% fibre. Massive and slightly slippery. Occasional dead tree roots. pH 4.2.

(Luttmerding and Sprout, 1969)

The results of Luttmerding and Sprout's Chemical Analysis on the Triggs and Lumbum Soil Series are presented in Table 5.

Table 5: Chemical Analysis of the Lumbum and Triggs Soils

Horizon	Depth (cm)	Textur ^e	Organic matter %	Total N %	C/N Ratio	Phosphorous		Available and organically complexed		Available S ppm	Exchangeable cations and exchange capacity Milli Equivalents/100 gram				Cation exchange capacity	Bas ^e saturation %	
						P1 ppm	P2 ppm	Cu ppm	Zn ppm		Ca	Mg	K	Na			
Triggs	Of1	0-20.3	fibric	100.0	0.63	106.1	17.2	-	33.1	5.5	73.5	12.6	5.39	2.16	0.78	158.5	13.0
	Of2	20.3-33	fibric	100.0	0.92	74.6	7.2	7.2	6.0	4.8	54.2	5.30	7.71	0.39	0.46	163.2	8.5
	Of3	33-63.5	fibric	100.0	0.80	84.8	2.4	2.4	10.6	3.6	17.7	3.55	7.33	0.09	0.57	172.6	6.7
	Of4	63.5-86.4	fibric	100.0	0.68	100.1	7.8	10.4	29.3	3.9	7.8	5.73	9.90	0.16	0.89	178.5	9.4
	Of5	86.4-119.4	fibric	100.0	0.70	84.5	5.0	5.0	18.6	3.7	18.6	-	-	-	-	-	-
	Of6	119.9-165.1	fibric	100.0	1.04	70.7	1.3	7.8	15.6	3.9	35.0	-	-	-	-	-	-
Lumbum	Of	0-22.9	fibric	100.0	1.28	54.5	35.1	40.0	13.6	6.5	104.9	5.43	16.30	0.69	0.77	178.5	13.0
	Om1	22.9-40.6	mesic	100.0	1.25	59.8	8.8	13.2	-	-	62.8	2.87	10.77	0.19	1.04	173.9	14.3
	Om2	40.6-73.7	mesic	100.0	1.16	66.3	9.7	17.0	10.3	3.6	100.1	2.91	9.47	0.17	0.97	164.7	8.2
	Om3	73.7-96.5	mesic	100.0	1.13	65.6	0	0	8.4	3.3	144.2	-	-	-	-	-	-
	Om4	96.5-127	mesic	100.0	2.27	31.3	0	0	9.7	5.5	255.5	-	-	-	-	-	-
	Om5	127-165.1	mesic	100.0	1.87	32.9	14.4	18.0	22.5	18.0	-	-	-	-	-	-	-

(Luttmerding and Sprout, 1969)

3.4 Hydrology

The two major soil series in the Burns bog area are saturated for most of the year, where no artificial drainage has been installed (Luttmerding and Sprout, 1969). The water within the Lumbum and Triggs soils is, however, unevenly distributed. The central section of the bog which is primarily assigned to the Triggs series has an irregular surface resulting from extensive peat excavation activities and natural hummocky sphagnum growth. Most of the wet depressions, natural or man-made, are water-filled on a year-round basis, although certain cutting "lakes" dry during the late summer months. Natural wet depressions vary in size from small pools less than 1m in diameter, to fairly deep (2m) pools which were found to be over 40m in diameter. Peat cutting lakes generally are several hectares in size, and appear as regular water filled trenches with walls formed by unmined peat and debris. The tops of hummocks and mounds of peat debris remaining after mining were found to be relatively "dry", (i.e., free water low and sometimes absent) at all times of the year (Biggs and Hebda, 1976).

3.4.1 Water Input

At present the main source of the water of the bog is precipitation. However, some water probably entered the bog as runoff from Panorama ridge prior to the construction of the Burlington

Northern Railway and the major sewer line which parallels the railway. Water for use in the hydraulic peat mining is occasionally pumped into the bog from Dow Chemical Ltd., through an above-ground pipeline system which runs west of 80th street (Figure 6). The rate of flow of water from this source into the bog ranges from 0 to 4546 litres per minute. The water is taken from the Fraser River and then is used as cooling water for the Dow Chemical plant. The temperature of this water is approximately 25^oC when it leaves Dow Chemical, but it is believed to cool considerably as it passes through the 4.5 km of 20 cm diameter pipe to the extraction site in the central bog. The cooling water is reported to contain no biocides (Entech Environmental Consultants Ltd., 1974).

3.4.2 Surface Water Outflow

The bog has the following four large drainage areas (Figure 6), (Tempest, 1971):

1. River Road area,
2. Big Slough-Beharrel Area,
3. Crescent Slough South Area,
4. Crescent Slough North Area.

Three of these drainage areas (Areas 1, 3 & 4 above) drain into the Fraser River while Area 2 drains directly south into Boundary Bay.

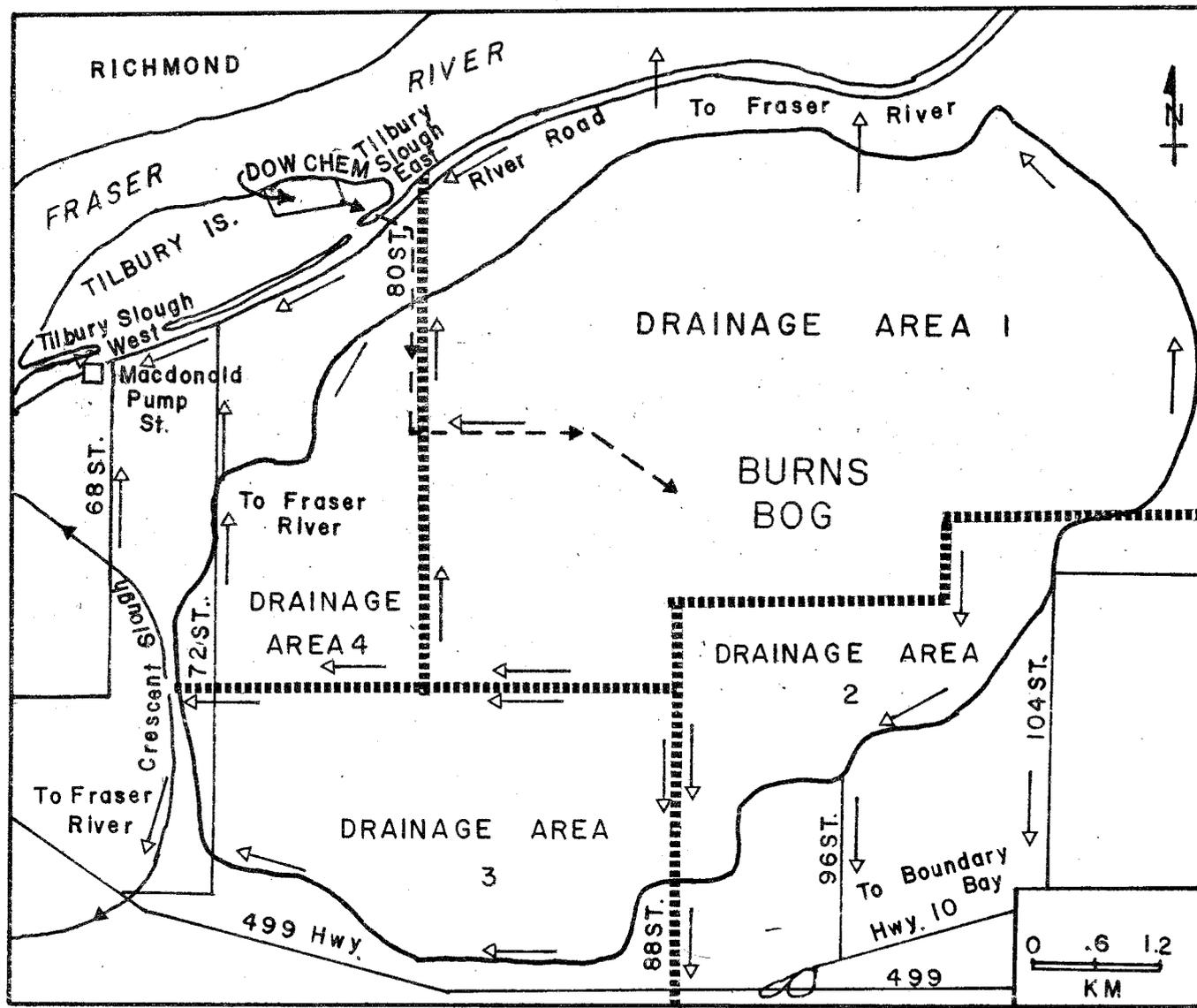


FIGURE 6. DRAINAGE AREAS OF BURNS BOG
(SOURCE: TEMPEST, 1971)

An integrated system of open drainage ditches, culverts and pump stations drain the peripheral lands, also road and railway construction within the bog impede drainage out of the bog.

The flow in all ditches surrounding the bog is very slow and no flow estimates were available (Voute, pers. comm.).

Drainage Area 1 - River Road Area

This drainage area is the largest, and drains approximately 2126 ha, or 52.8% of the northeastern section of the bog. The Burlington-Northern railway marks the eastern boundary of the area and 80th Street and River Road serve as its west and northern boundaries. The southern boundary was arbitrarily mapped by inspection of the contours of the bog (Tempest, 1971), (Figure 6).

Surface water, including runoff water from the Western Peat Moss Ladner dewatering plant runs north into a major deep (3m) collector ditch south of River Road. At high tide the water in the ditch runs west along River Road to the MacDonald pump station. The water is then pumped under the road into Tilbury Slough and eventually reaches the Fraser River. At low tide the water flows through a culvert under River Road into the Fraser River at the east end of Tilbury Slough (Figure 6).

Drainage Area 2 - Big Slough-Beharrel Area

This area drains approximately 569 ha, or 14.7%, of the south-eastern corner of Burns bog. The area's western boundary is 80th Street and the northern limit is the arbitrary line between it and Area No. 1 (Figure 6). Flow from the bog and neighbouring agricultural lands crosses Highway 499 through various culverts and ditches, eventually leading to either the Big Slough or Beharrel pump stations. These stations pump water over the sea dyke and into Mud Bay-Boundary Bay.

Drainage Area 3 - Crescent Slough South Area

The City of Vancouver landfill site is located within this drainage area, and for this reason a number of preliminary hydrological studies of surface water leachate movement were available. A system of interceptor and collector drainage ditches have been excavated around the 405 ha site to reduce pollution of the groundwater in the remainder of the bog, and adjacent farmlands.

Water movement from the site and the southwestern corner of the bog enters Crescent Slough and flows a distance of approximately 8 km to the Fraser River. The section of Crescent Slough responsible for transporting this water is not connected to the northern section. The bog water and

landfill leachate therefore enters the Fraser River west of Deas Island, near Ladner Marsh (Voute, per comm.).

The northern boundary of this area is 64th Avenue. The southern boundary is a drainage ditch and the southern margin of the City of Vancouver property, and 88th Street serves as the eastern boundary of the drainage area. This area drains approximately 818 ha or 20.5% of the bog.

Drainage Area 4 - Crescent Slough North Area

This drainage area is the smallest of the four as it drains approximately 436 ha or 10.9% of the northwestern corner of Burns bog. The boundaries are 64th Avenue to the south, River Road to the north, and 80th Street to the east.

The drainage from this area, like Area 1, enters the deep ditch south of River Road and is eventually pumped through the MacDonald pump station into the Fraser River via Tilbury Slough.

The volume of water leaving the bog through the various ditches of the four drainage areas is not known, however, because the bog soils retain water extremely well, the drainage system previously outlined has not appreciably reduced the water level in the bog (Voute, pers. comm.).

3.5 Land-Use

3.5.1 Past Land-Use

Although the early land-use of the area is not well documented the presence of charcoal throughout the profile of the bog (Hebda, pers. comm.), and charred stumps in various parts of the bog, indicate that fire has played an important role in the history of the Burns bog area. The area may have first been fired by the Coastal Salish Indians who inhabited the general area, to promote increased berry crops in the bog. Fire could have also been used to clear parts of the area for agriculture (Armstrong, 1956). Increment boring and counting of annual growth rings of certain trees reveal that most trees now standing in the bog are less than 75 years old (Hebda and Biggs, manuscript in progress).

Over the years various attempts to clear and manage the periphery of the bog have been initiated by agriculturalists hoping to bring portions of the shallower peat deposit into production. "The shallow margins have been reclaimed and other parts of the bog have recently been burned." (Osvald, 1933). The drainage of the east Delta area was, and still is, very poor (Paton et al, 1973). For example, an attempt at drainage was made by Blake, who in the 1920's, cleared a large section in the south-central portion of the bog for oats and pasture. This area has subsequently regrown to typical

Pine Woodland vegetation since the sale of the Blakeburn Estate to Pineland Peat Co. and Western Peat Moss Ltd.

The boundaries of the bog were more or less limited by the construction of roadways and clearing and drainage of parts of the bog for agriculture or development. Highway 499, and the clearing of the Ingledow-Arnott transmission line right-of-way marks the southern boundary of the bog. The northern border has been pushed back somewhat by the industrial and other developments south of River Road. Various encroaching land-uses from all directions have reduced the size of the bog from an early estimate of 4856 ha (Rigg and Richardson, 1938) to its present size of approximately 4000 ha (Biggs and Hebda, 1976).

3.5.2 Present Land-Use

(i) Land Ownership

Burns bog is approximately 85% privately owned. The largest single land owner is Western Peat Moss Ltd. This company controls approximately 2500 ha or 63% of the bog. The major land owners and the present land-use of the bog is outlined in Table 6. A present land-use map is presented in Figure 7.

Table 6: Land Ownership and Land-use, Burns Bog

Land Owner(s)	Area (ha)	Land-use	% of total bog
Western Peat Moss Ltd.	2491.0	Peat extraction & processing.	62.9
City of Vancouver	404.7	Sanitary land-fill.	10.2
Gibson/Paine	131.4	Idle, natural bog.	3.3
Pineland Peat Ltd.	64.7	Peat extraction.	1.6
The Corporation of Delta	62.7	Delta nature reserve.	1.6
The Corporation of Delta	25.9	Delta animal shelter.	0.7
CKLG Broadcasting station	22.3	Radio towers.	0.6
Various peripheral land holdings, i.e., B.C. Development Corp., Sundbury Mills, etc.	760 (approx.)	Agricultural, industrial, etc.	19.1
Total	approx. 3,972.00		100.0

(ii) Peat Extraction

The most widespread and significant present land-use in the bog is the extraction (mining) of commercial horticultural peat moss. Over 1600 ha, or approximately 40%, of Burns bog has been disturbed by peat extraction and related processing and transportation activities.

Peat mining was initiated in the bog prior to 1940. At that time peat extraction was a considerably slower process

and involved "hand cutting" methods. A large quantity of the peat mined from the bog at this time was used for the United States government war effort, as packing for armaments and ammunition (Carncross, pers. comm.).

The bog was purchased by Western Peat Moss Ltd. in 1946, and the slow hand cutting and ditching continued until the hydraulic peat mining techniques were applied by the company in 1965.

At present the basic steps in the hydraulic method of peat excavation employed in Burns bog are as follows (Johnstone, pers. comm.).

1. The surface vegetation and trees are cleared from the cutting site; then a trench is excavated in the peat deposit with a bulldozer or backhoe.
2. Surface water usually flows into the excavation, and an external source of water from the Dow Chemical plant is pumped at the cutting site through two high pressure monitors.
3. These monitors are directed into the peat deposit and effectively "blast" the unhumified and humified peat away from all roots and produce a "slurry" of peat and water.

4. The slurry collects in a sump and then is pumped from the cutting site through an above ground pipeline to the Ladner dewatering plant on 80th. Street.

5. Excess water is removed, then the peat is trucked to the gas-fired drying operation on 72nd. Avenue in the eastern portion of the bog.

6. At this location the peat is further dried to 50% moisture content then bagged for horticultural purposes or artificial soil mixtures. Most of this material is trucked to California, Nevada and Arizona markets.

This method, barring breakdowns, is employed 24 hours per day, seven days per week. Five men work at the extraction site on each eight hour shift.

Some peat is also extracted by "scratching" off the top 8 cm of the peat deposit. This technique is occasionally used in the "drier" eastern section of the bog.

Western Peat Moss Ltd. has plans to discontinue both of these processes and initiate a hoverbarge system in 1976. This system will enable them to extract shallower (less than 3 m) peat deposit, and operate more efficiently.

Approximate 2,650,000 bales of peat (1 bale \approx 36.4 Kg., 50% dry weight) have been removed from Burns bog since 1941, and the bog is believed to have twenty to thirty years of mineable peat left (Dunfield pers. comm.).

iii. Sanitary Landfill

The Burns bog landfill, owned and operated by the City of Vancouver is the largest, sanitary landfill in British Columbia, (City of Vancouver brief 1973). Filling was begun in 1966 and to date 41 ha. of the 405 ha. site has been used. The site is believed to have a future twenty years of life. (Bunel and MacKay, 1973). All refuse entering the site is weighed. Approximately 250,000 tons are deposited at the site per annum. (City of Vancouver, 1973A).

The landfill site serves:

1. The City of Vancouver,
2. Refuse contractors from the Corporation of Delta,
3. Refuse contractors,
4. The University of British Columbia and endowment lands and
5. Commercial refuse haulers and private citizens.

The landfill has a strict set of operational guidelines. These guidelines restrict all burning of refuse and the dumping of

certain materials. The landfill has been designed in three successive stages. At each level, approximately 1 m of refuse is dumped at specified "working faces" of the site, then spread and compacted to roughly 60 cm by a bulldozer. The compacted material is covered with a 15 cm thick layer of sand. This process is repeated until a final design height of approximately 6.5 meters is reached. Once this height is reached a final 60 cm thick covering of comparatively impervious clay-silt mixture is applied. To date approximately 28 ha have been covered, levelled and graded. It is intended that 12 ha of this area will be planted to a crop such as clover once the surface has been properly prepared (City of Vancouver, 1975).

The City of Vancouver has implemented various measures to control fire, vectors, and blowing debris however the major concern has been the pollution of ground and surface water by garbage leachates from the site.

The water quality at the bog site is jointly monitored by the City of Vancouver and the Pollution Control Branch of the B.C. Government. The City of Vancouver initiated its Leachate Monitoring Study in 1966. At present water quality at the site is tested quarterly, in the spring and fall by the City of Vancouver, and in the summer and winter by the Pollution Control Branch (Danner, pers. comm.).

Several standard water quality tests are made at 15 test locations, (7 control, and 8 monitoring sites) near and within the landfill site.

Pollution of water from the landfill is believed to come about in the following manner:

"Precipitation falling on the surface of the fill....will infiltrate into the fill. As the water percolates under the force of gravity downward through the refuse mass, it supplies moisture for biological and chemical decomposition, and on its path leaches products of these processes out of the decomposing refuse. The percolate laden with suspended and dissolved products of decomposition, which have the character of pollutants, is referred to as 'leachate'. The leachate moves along existing gradients downward and laterally until it reaches the groundwater or enters surface waters. Another way in which leaching can occur is by direct contact of refuse with groundwater when a fill is placed or subsides below the groundwater table." (Bunnel and MacKay, 1973).

In a brief presented at the public enquiry into municipal type waste discharge on land conducted by the B.C. Government Pollution Control Branch (P.C.B.) 1973, the City of Vancouver concluded that "contaminant concentrations, as measured at the monitoring

locations, are not generally higher than native water conditions measured at the control locations." However, the water quality parameters of zinc, iron manganese, chlorides, pH, organic nitrogen, ammonia nitrogen total residue, soluble and suspended residues, C.O.D. and coliforms were described as higher in the test monitoring sites than the control sites. (City of Vancouver, 1973B). In a 1975 technical report the City of Vancouver stated that contaminant concentrations generally fall within the P.C.B. guidelines - "our leachate parameters are either within the specified limit, or consistent with background levels, except for iron and manganese".

It was further pointed out that iron and manganese are not toxic elements and do not constitute a threat to the environment at the concentration observed. (City of Vancouver, 1975).

Golder, Brawner & Associates Ltd. 1973 study included an analysis of flow patterns through the landfill site and underlying peat. Their study revealed "that approximately 95% of the landfill seepages rises to the ground surface within ten feet of the toe of the landfill. It was concluded that nearly all of the discharged leachate produced by the landfill was intercepted by the peripheral ditching system and transported to the Fraser River" (City of Vancouver, 1975).

iv. Utility Corridors

Various kinds of transportation, service and communication corridors are restricted to the periphery of Burns bog. These land uses have been divided into the following major categories:

1. Roads and Railways,
2. Radio towers
3. Service corridors.

These land uses represent about 60 ha or 1.5% of Burns bog.

The Burlington Northern (B.N.) Railway and the combined trackage of the Canadian National, and the Burlington Northern Railway marks the respective eastern and northern boundaries of the bog.

The eastern section of the railway line is constructed on mineral soil at the base of Panorama ridge. A portion of the combined BN-CN trackage is built over peat and services the Tilbury Island area directly north, and west of the bog. Although the area between this trackage and River Road (Figure 7) is peatland, it was not considered part of the bog as much of it is being preloaded with sand for industry or has been modified by clearing for residential, agricultural or industrial land uses.

Similarly, the construction roads such as Burns drive and Highway 499 have effectively reduced the size of Burns bog, by cutting off areas of peatland from the bog proper. The only road to completely cross the bog is 72nd. Street. However, this road is gated and use of it is restricted by B.C. Hydro.

The only road to enter the central portion of the bog is 80th. Street (Tasker Rd.). This road is the access road for the Western Peat Moss Ladner Plant. Various trails, walkways (boardwalk), and all-terrain vehicle tracks have been cleared and constructed to provide peat excavation crews with relatively dry access to the peat cutting sites in the central section of the bog. Wood wastes are used extensively for trails & access roads.

A small gauge railway, once used for the transport of raw peat to the 72nd. Avenue plant, still exists in the east-central section of the bog. The only other areas with a defined trails system are located in the Delta Nature Reserve, and Duncan's Trap Shooting Club (104th. Street and 64th. Avenue). Although these trails are not extensive, they do provide access to approximately 90 ha of the eastern and southern section of the bog.

The radio station CKLG-AM has erected four 50 K.W. radio broadcasting towers on a 22.3 ha site at 7225 80th. Street. These towers and a small field building are within the Pine Woodland vegetation zone although the entire area has been cleared of all trees (McIntosh pers. comm.)

The following British Columbia Hydro transmission lines and gas lines are located within the Burns bog area.

1. A 230 K.V. Hydro transmission line and a 61 cm (24") diameter gas pipeline share a 50 m wide corridor which runs in an east-west direction across the northern portion of the bog.

2. A 30 cm (12") gas line runs in a north-south direction from the B.C. Hydro's Tilbury Island plant to the Ladner area through a 20 m wide cleared corridor between 72nd. and 80th. Street, in the western section of the bog.

3. The southern and south-south eastern margin of the bog is marked by the clearing created for the 230 K.V. Ingledow-Arnott transmission line

v. Recreation and Education

At present two 16 member gun clubs have hunting rights to approximately 850 ha of the bog (Figure 7). Most hunting and trap shooting activities are limited to the south central bog and in the peat cutting lakes. However, some pheasant shooting is carried out west of 80th. Street, and along the north-western boundary of the bog (Johnstone pers. comm.)

The Delta Nature Reserve occupies approximately 60 ha at the eastern border of the bog (Figure 7). This area is owned by

the Corporation of Delta. A network of nature-trails has been constructed and the area serves as a recreational area and outdoor classroom for Delta students. In the summer of 1971 a group of students mapped and worked on many of the trails. The result of their efforts, and others interested in the reserve, was the preparation of a preliminary plant, and animal inventory (McKenzie et. al., 1971).

vi. Peripheral lands

Various other surrounding land-uses not on peatlands, but considered to have important impact effects on the bog are as follows:

Agricultural land-use

Although most of Burns bog is not included in the Agricultural Land Reserve, about 50% of the surrounding lands are. These lands are west and south of the bog. Agricultural land use is wide spread in the adjacent southern and western lands. The main agricultural pursuits are dairying and the production of vegetable cash crops.

Industrial and Residential Land Use

Light industry south of River road and north of the combined CN-BN railway tracks constitutes the major land use of the northern section of the bog. In this area marine repair and sales, cedar mills, and manufacturing activities are common. Presently, the property directly north of the bog between 72nd. and 80th. Street has been assembled for industrial

development. The first construction plant for the Tilbury Island Industrial Park was initiated in the autumn of 1975 and development will eventually remove approximately 300 ha from agricultural production.

Residential land-use is concentrated on Panorama ridge. This housing development is not within the peatlands, however the bog's eastern border is used to some extent as a recreational area by residents of this development, particularly in the Delta Nature Reserve.

3.5.3 Proposed Land-Use

Delta is one of the fastest growing municipalities in Canada. The population of Delta will more than triple in the 10 year period 1966-76 (GVRD, 1974). With this fact in mind, and considering that Burns bog represents a very large, underdeveloped area of this municipality, it is not surprising that a number of land-use proposals have surfaced over the years. Only the major proposals for the bog proper and peripheral lands will be discussed here.

i. Green belt

The Greater Vancouver Regional District in their Livable Region 1976/1986 publication (1974) site Burns bog as one of Delta's

principal open space assets. In this and a previous GVRD open space document (Pearson, 1973) recreation conservation and wildlife management opportunities of the bog were recognised. (GVRD, 1974).

A specific wildlife management proposal for use of the extensive open-cast cutting areas left in the peat deposit following mining was first put forth in 1971 by Dr. B. A. Leach, Director of the Douglas College, Institute of Environmental Studies. In this proposal entitled, "A proposal for the multiple use of peat cuttings in Burns bog for sewage disposal and wildlife management - Information booklet No. 14", concern was expressed at the plans for the disposal of sewage into the Fraser river from the new Annacis Island treatment plant. In an effort to avoid further degradation of the Fraser river water quality, and increase the primary productivity of the cutting areas of the Bog, it was proposed that instead of dumping the treated sewage directly into the river from the Annacis Island plant, that the sewage be pumped into the cuttings, on the assumption that the sewage would fertilize the rather sterile exhausted cuttings. The outflowing water from the operation in the winter months would be directed into the river. However, it was believed that the peat/meadow system would serve to purify the water through filtration. This proposal and a subsequent elaboration of the

first proposal (Information booklet, No. 15), outlined a detailed water level maintenance, and crop rotation system which would provide suitable habitat and abundant food resources for a number of waterfowl and the wildlife species. "The growing of corn and other grain crops in an area such as Burns bog, lying between the two main migratory bird resting areas on the B.C. coast - Boundary Bay and Roberts-Sturgeon Bank, would undoubtedly have spectacular results. Parts of the crop could be flooded, providing feeding opportunities for Canada geese, and dabbling ducks. Part of the crop could be left on dry soil to provide feeding opportunities for deer and pheasants. The remainder could be harvested from areas required for sewage filtration. These flooded areas would then provide feeding opportunities for diving ducks and shore-birds, and loafing areas for geese and dabbling ducks adjacent to the standing grain. (Leach, 1974A). In addition to this fairly elaborate system of lagoons, marshes and meadows for wastewater filtration of wildlife management, it was suggested that the filtered outflowing water may be directed into a system of ponds which could be used as coarse fish (i.e. carp) hatcheries. These fish could then be used for fertilizer or animal food.

ii. Transportation routes

The main road link between Highway 499 and Surrey is the River road. Associated Engineering Services Ltd. in a road development

study for the Corporation of Delta in 1973, proposed that River road be rerouted parallel to the existing road but on the south side of the combined Canadian National - Burlington Northern railway tracks (Figure 7). The "new" River road will service the Tilbury Industrial Park and connect with the proposed Annacis Island river crossing and associated access roads from the south may cross the bog at 104th. Street (Figure 7) or near the Burlington Northern Railway tracks. (C.B.A. Engineering Ltd. and F.F. Slaney Co. Ltd., 1974).

iii. Sandfill and Residential Development

Although no formal proposals for the development of the deep peatland sections of the bog have been published, informal discussions about the future use of Burns bog with a senior property consultant of Western Peat Moss Ltd. revealed the possibility of the sandfilling and development of the central section of the bog (Leach pers. comm.). The plan called for the excavation of a large portion of the central bog to create a 30 m deep lake. The sand from the bottom of this lake would be used to preload and settle the surrounding peatland prior to the construction of a shopping centre complex to be located on the west side of the bog and the remainder of the 240 ha site would be used for a residential housing development.

iv. Agricultural Reclamation

A possibility not to be ruled out, but as yet not formally proposed, is the reclamation of the shallower portions of the bog (Lumbum Soil Series) for agricultural purposes. At present these soils are very poorly drained and have low nutrient availability, however, "with a controlled drainage system adequate fertilizer application and possibly liming the area surrounding Burns bog would be quite suitable for agricultural developments." (Maas, 1975 written comm.) Considering the possible alienation of the northern portion of the bog, the main reclamation activities would have to be restricted to the southern boundary and the bog between, 88th. Street and 104th. Street and the peatland west of 72nd. Street (Figure 7).

3.6 Energy Flow and Storage

As in other terrestrial and aquatic ecosystems, solar energy is entrained into the mire ecosystem by the process of photosynthesis. Mire is defined here as a wetland ecosystem where peat accumulates and peat refers to "the completely decomposed remains of plant and animal life accumulating at that site of growth under extremely wet conditions." (Moore and Bellamy, 1974). Ecosystem is defined as the interaction between the incident energy, the abiotic and the biotic components of a given area over a stated interval of time (ibid).

The net result of this entrainment is the production of organic material by the photosynthetic organisms. In peat producing ecosystems, however, the organic material produced by the photosynthetic process is not entirely broken down by the decomposer elements of the system (i.e. fungi, bacteria and other micro organisms). These organisms are impaired by the extremely wet, low pH conditions characteristic of such ecosystems.

"Thus when we consider the energy balance sheet for mire ecosystems we find that not all of the energy entering the system is liberated by the respiration of the component organisms, nor is the remainder entirely to be accounted for in the process of succession and the accumulation of living material in the system. A component of the energy remains stored up in the peat, locked away until the restraining factor of excessive wetness is removed resulting in the energy becoming available to decomposers once more." (Moore and Bellamy, 1974).

The storage of energy in Burns bog, of course, is not limited to sphagnum. All other organisms growing out of, and/or feeding on the plants contribute to the total energy budget. Sphagnum, however, is considered to be the most important energy storing component of the mire ecosystem.

A general model of energy flow in a mire ecosystem is presented below:

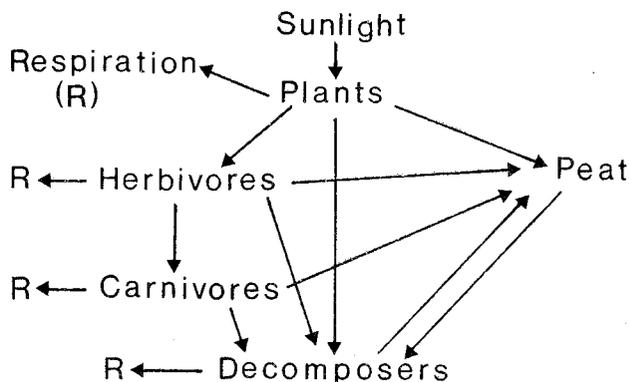


Figure 8 - Energy Flow in a Sphagnum Peatland (after Moore and Bellamy, 1974).

3.7 Nutrient Cycling

Minerals in precipitation and air-borne particulate matter are the main source of minerals in ombrotrophic bogs (Malmer, 1975; Allen, 1964). Burns bog is believed to be an ombrotrophic bog as it is relatively independent of runoff water from neighbouring lands. Therefore the nutrient supply in peatlands, in general and ombrotrophic bogs in particular, is very poor. The cycling of nutrients in these systems is inhibited by excessive water, acidic conditions, and a high cation exchange capacity of the dominant material of the system - sphagnum peat. The decomposers of peatlands do, however, regenerate some nutrients from accumulated organic material even though they are inhibited by the waterlogged, low pH and relatively low temperature conditions of the bog.

The activity of decomposers determines the rate of release of nutrient elements from the accumulated peat, and may be a limiting factor for the growth of some ombrotrophic mire plants. (Moore and Bellamy, 1974).

Burns bog is believed to be similar to other mire ecosystems in that the process of decomposition and ultimately the liberation of nutrient elements into the ecosystem by decomposers is done in two particular layers of the deposit, the aerobic and the anaerobic layers.

Studies of decomposition in United Kingdom revealed that microbial activity decreased with wetness.

Lowering of the pH resulted in changes of the kind of decomposer. For example it was found that at low pH (<4.0) the fungal component of the decomposer system becomes more important than the bacterial components. (Latter et al., 1967).

Similarly, most bacteria and soil herbivores are best able to function under aerobic conditions. Most decomposition was found to take place in the surface aerated layers of the peat deposit (Clymo, 1965).

Anaerobic decomposers such as yeasts and various bacteria operate at depth, in the bog and in the absence of oxygen. Yeasts

utilise a fermentation reaction to incompletely oxidise the organic material under these conditions. Certain anaerobic, bacterial decomposers make use of the oxygen which is usually combined with sulphate or sulphide ions in the anaerobic layer of the bog, to effect a breakdown of the organic material by an oxidation-reduction reaction. (Moore and Bellamy, 1974).

The major findings of experiments on the decomposition of peat can be summarized as follows:

1. The rate of decomposition decreases as one passes deeper into the deposit. The reason given is this fact appears to be related to the observation that fewer decomposer organisms can function under the reducing conditions of the anaerobic layer (Clymo, 1970).
2. The rate of decomposition is rapid in the initial stages, but becomes slower as time progresses. (Waksman and Stevens, 1929).
3. The decomposition rate is found to vary depending upon the species of sphagnum responsible for the formation of the peat (Clymo, 1965).

The main organisms responsible for decomposition in peatlands are listed below (Clymo, 1965; Latter et al., 1967; Cragg, 1961).

Aerobic layer

Fungi
Aerobic Bacteria
Soil Microfauna

Nematodes
Collembola
Mites
Spiders
Fly Larvae

Anaerobic layer

Yeasts
Anaerobic Bacteria

When the overall nutrient budget of the ombrotrophic mire ecosystem is examined, it appears that the physical and chemical inhibition of the decomposers of the system results in an accumulation of peat and corresponding accumulation of nutrients "trapped" in the peat. "The nutrients are effectively removed from circulation and the process of peat formation must therefore be regarded as a drain upon the nutrient economy of the system." (Moore and Bellamy, 1974).

Another important reason why nutrients are retained in peat is a result of the high cation exchange capacity of organic soils. The cation exchange (C.E.C.) has been defined as "the sum total

of exchangeable cations a soil can absorb." (Hausenbuiller, 1972). The average C.E.C. of a number of samples from Burns bog was found to be 169.9 milliequivalents/100 grams (Luttmerding and Sprout, 1969). This value indicates that a high percentage of nutrients entering, or liberated from the system will be retained in the organic deposits.

Various other factors are thought to be directly or indirectly responsible for the liberation of nutrients from peat reservoirs. Included here are the land-use practices of burning, and drainage of the peat deposit.

Fire,, particularly surface fires, aid decomposers in the breakdown of charred plant and organic material remains (Odum, 1972). A laboratory burning experiment of heather, showed that mineral nutrients are readily dissolved from residual ash. It was also suggested that dissolved nutrients would drain to the substrate below but would probably be absorbed by sphagnum (Allen, 1964).

The lowering of the water table through drainage effectively lifts one of the major restrictions to aerobic decomposition. This practice therefore seems to accelerate the cycling of nutrients in the mire ecosystem. (Maas, 1972).

Available nitrogen, phosphorus and potassium are generally considered low for organic soils. (ibid). Certain bog species, such as all species of the genus Sphagnum are capable of growth in this low nutrient environment. Other bog species have adapted to the low nitrogen regime of the mire ecosystem in two main ways.

Unlike many other terrestrial ecosystems bacteria responsible for the cycling of nitrogen in peatlands are greatly reduced. Nitrifying and aerobic nitrogen fixing bacteria were found to be almost completely absent from four peat soils in England (Latter et al., 1961).

High water content, low pH, and relatively low temperatures of the soils were cited as the main restrictions to the growth of these bacteria (ibid).

One strategy that has evolved in bog species to enhance their nitrogen input is by the symbiotic fixation of nitrogen. The following plant species are believed to fix nitrogen in this way sweet gale (Myrica gale), red alder (Alnus rubra). Blue green algae present in wet depressions of the bog may also fix nitrogen. (Bond, 1951, 1956). Many bog plants, particularly those vascular species growing in peat from ombrotrophic mires exhibit xeromorphy, as an adaptation to low nutrient availability (Saebo, 1970). The general characteristics of these bog species

are reduced leaf size, strongly cutinised epidermal walls, and occasionally pubescent leaves. (ibid; Esau, 1960). Saebo's review of xeromorphy indicates that low nitrogen availability caused by excessive wetness of peat may be a significant factor influencing the adaptation. However nutrient deficiencies other than a low nitrogen level of peat may relate to xeromorphy. Phosphorus availability also appears to be reduced with increasing wetness in bogs, (Saebo, 1965). For this reason xeromorphy may be related to a low soil phosphorus availability as well as to a low nitrogen availability. (Saebo, 1970). Typical xeromorphs of Burns bog include Andromeda polifolia, Empetrum nigrum, Ledum groenlandicum and others (Osvald, 1933; Beamish et al., 1968; Biggs and Hebda, 1976).

The sundew (Drosera spp) and other carnivorous plants exhibit another interesting mechanism for increasing their mineral input. This method involves the trapping and digestion of insects and other small animals by the plant. This carnivorous habit has been viewed as an advantage to the individual plant, however its importance to the cycling of nutrients in the mire ecosystem is not known. (Moore and Bellamy, 1974).

Mycorrhiza, is the association of fungal mycelia within the root tissues of pine and some heaths. This mutualistic association is believed to be another strategy of bog species to increase the uptake of nutrients from the peat soils, and surface water (Cairns, 1973).

4. BASIC INVENTORY AND ECOLOGICAL RESEARCH

4.1 Vegetation

Several individuals or groups have studied the vegetation of Burns bog (Rigg and Richardson, 1938; Beamish, Krajina and Bednar, 1968; Beamish, 1969; McKenzie et al., 1971; Butler and Footit, 1974; and Biggs and Hebda, 1976). In an effort to provide a detailed account of the vegetation of the entire bog, the author and R. J. Hebda, a graduate student in the Department of Botany, U.B.C., collaborated to achieve this end. The result will be the publication of a vegetation paper and extant vegetation map of Burns bog (Hebda and Biggs 1976; manuscript in progress).

4.1.1 Methods

All available vegetation studies and vegetation maps of the area were reviewed prior to the spring and summer, 1975, field season.

A controlled black and white aerial photo mosaic (scale 1": 800'), flown on June 12, 1974 by Pacific Surveys Corporation for Western Peat Moss Ltd. was used to prepare a vegetation base map. Clear acetate was placed over the mosaic. Each unit marked on the acetate and those areas which were difficult to classify from the mosaic were subsequently visited on two reconnaissance level vegetation surveys (after Kuchler, 1968).

Once a preliminary vegetation map was produced, field investigations were begun. The verification of the air photo interpretation and quantitative analysis of the vegetation units was initiated in June, 1975. A total of sixty, ten by ten meter quadrats (6000 m^2) were analysed in representative areas of major vegetation units. The majority of the quadrats were placed along transect lines designed to cross vegetation units. To maximize sampling effort, quadrats were placed at 50 or 100 meter intervals along lines depending upon the rate of vegetation change through the unit. Single 100 m^2 quadrats were placed on many sites where the plant assemblages were difficult to determine from air photos, or in areas where verification of the air photo interpretation was necessary.

Within each 100 m^2 quadrat, cover estimates were made and counts of each shrub and tree species within the quadrat were made. Five 1 m^2 plots were set out along the transect line at one meter intervals within the larger quadrat. The shrub, herb, bryophyte and lichen cover was estimated in most of these plots, (Figure 9).

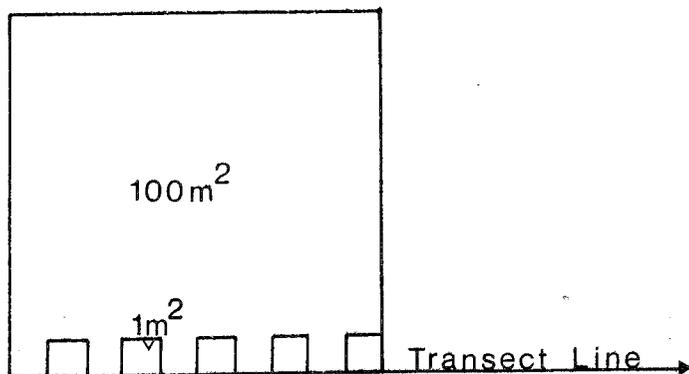


Figure 9 - Arrangement of 100 m^2 and 1 m^2 quadrats Used for Vegetation Analysis in Burns Bog.

In addition to the recording of vegetation data, various other ecological investigations were done in a number of quadrats. Peat depth was determined with a stainless steel probe, and tree ages were determined by increment boring, or counting of annual rings of felled trees within the quadrat, tree height, and diameter breast height measurements were also made in certain zones.

Qualitative analysis was done for certain sites within major vegetation units, to verify classification and determine the cover of shrubs and tree species. The rationale and cover groups used for these qualitative assessments is presented in Table 7 below:

Table 7
Cover Categories used in
Vegetation Analysis of Burns Bog

CATEGORY	% COVER
Dominant	50 - 100
Very Common	25 - 50
Common	5 - 25
Occasional	1 - 5
Present	1

Vegetation information from quantitative and qualitative sampling was analysed by grouping all quadrats according to species composition and

cover. Vegetative descriptions were made from the analysis of those data, and a penultimate vegetation map was prepared.

Upon the completion of this map, additional recent black and white air photographs of the area (scale 1":500'), provided by the British Columbia Land Assessment Department in Ladner, were examined. Revisions were made to the map and ground truthing of the revised areas was done.

The final step in the method was the preparation of a cover map of extant vegetation of Burns bog, (Figure 10).

Voucher specimens of plant species found in the bog were collected throughout the spring and summer field season 1975. These specimens will be deposited in the University of British Columbia herbarium.

4.1.2 Results

The vegetation of Burns bog was classified into eight main categories, or vegetation zones, based primarily on dominant overstory or cover plant species (Figure 9). The eight vegetation zones areas are presented below:

1. Heathland
2. Pine Woodland
3. Birch Woodland
4. Spirea Brushland
5. Mixed Coniferous Woodland
6. Salmonberry Brushland
7. Alder Woodland
8. Vegetationless Peatland

FIGURE 10

BURNS BOG VEGETATION
COVER MAP 1976

IN MAP POCKET
(Back Cover)

A species list of all plants found to occur in the bog has been prepared (Appendix 1).

Vegetation Zone Descriptions: (Hobda and Biggs, 1976, manuscript in progress.)

i Heathland

The Heathland vegetation zone covers approximately 2100 ha. of the wet central section of Burns bog. Even though much of this zone has been excavated for peat moss, most peat cutting areas which showed evidence of regeneration to "typical" Heathland vegetation were included within this zone. Peat cutting areas have been designated on the cover map as areas within dashed lines (Figure 10). Various small outliers of this vegetation type were found to be surrounded by Pine Woodland vegetation.

The Heathland vegetation zone is characterized by:

1. An open, extremely wet area with scattered dwarfed coniferous trees.
2. A heath (Ericaceae) dominant shrub layer.
3. An irregular surface, resulting from natural hummock formation, or from the mining of peat moss.

Trees:

The Heathland zone has no significant tree overstory. The few trees that do exist in the extremely wet conditions are generally dwarfed and stunted. The dominant tree species is lodgepole pine (Pinus contorta). Most specimens were found to be less than 4 m. in

height, and many are less than 2 m. A number of dwarf lodgepole pine were cut to determine the approximate age. No tree in the zone was found to be older than 70 years and all exhibited extremely slow growth rates, ie. a 46 year old dwarf pine 1.5 m. in height had a trunk 3.8 cm. in diameter. Large pines up to 10 m do occur in this zone but are generally restricted to the margins of drainage ditches, roads and trails which have been constructed in the zone.

A few dwarfed specimens of Western hemlock (Tsuga heterophylla) and the occasional stunted birch (Betula occidentalis) were also found to occur in the Heathland zone. These trees were not common, but when found usually occurred on sphagnum hummocks.

Shrubs and Woody Plants:

Various species of heaths (Ericaceae) form the shrub layer of the Heathland vegetation zone. The two dominant heaths are Labrador tea (Ledum groenlandicum) and bog blueberry (Vaccinium uliginosum). Labrado tea, velvet-leaf blueberry (V. myrtiloides) and occasional specimens of salal (Gaultheria shallon) are found throughout the zone particularly on hummocks and drier sites. Specimens of Labrador tea were generally found to range from 0.4 to 1.0 meters in height. Bog blueberry commonly grows with Labrador tea but was frequently found at the margins of wet depressions and hummocks, or along ridges of peat which remained following the peat mining activities. Crowberry (Empetrum nigrum), bog rosemary (Andromeda

polifolia), bog laurel (Kalmia polifolia), bog cranberry (Vaccinium oxycoccus) and sweet gale (Myrica gale) were also frequently found in this transitional area between the wet depressions and drier hummocks.

Herbs:

The wet depressions within the zone are dominated by beakrush (Rhynchospora alba) and cottongrass (Eriophorum chamissionis). Other of sticky tofieldia (Tofieldia glutinosa), and three-way sedge (Dulichium arundinaceum). Two species of sundew (Drosera rotundifolia) and D. anglica were found to exist in many of the shallower portions of the natural wet depressions throughout the zone. Depressions which were deeper (approximately 20 cm or more) usually contained specimens of the yellow-water-lily (Nuphar polysepalum).

Bryophytes:

Various species of sphagnum are the dominant ground cover of the Heathland zone. Sphagnum angustifolium was found to be one of the first invaders of the water-filled depressions, and was commonly found in association with the yellow water-lily. Sphagnum fuscum and Sphagnum capillaceum were the mosses believed to be responsible.

for most hummock formation in the zone. Sphagnum papillosum was also found to be an important hummock forming species and was most commonly observed. Small patches of this moss occur with other sphagnum species on hummocks and "drier sites" within the zone. Sphagnum tenellum was also found but appeared to occur only in shallow depressions in the central section of the bog.

Other non sphagnum moss species were found within the heathland zone. For example Polytrichum juniperinum and Aulacomium androgynum were frequently observed on mesic sites such as well established sphagnum hummocks and dry peat debris. Rhytidiadelphus triquetrus R. loreus, Pleurozium schreberi, Dicranum howellii and others were often found on drier sites at the bases of dwarfed pine or woody stems of Labrador tea.

Liverworts were observed in association with Sphagnum angustifolium and generally found within or near water filled depressions. The two most common liverworts were Gymnocolia inflata and Mylia anomala.

Lichens:

Cladonia mitis was commonly found growing on the tops of hummocks. Various other lichen species such as Usnea sp. and Hypogymnia enteromorpha occur as epiphytes on pine and heaths, while dry exposed peat supports Cladonia subsquamosa, and other cladonia species.

ii Pine Woodland

The Pine Woodland | vegetation zone surrounds the central Heathland

in a broad, irregular, concentric band. The Pine Woodland occupies approximately 1140 ha and is characterized by a dense overstory of lodgepole pine and Labrador tea dominant understory.

Trees:

Lodgepole pine completely dominates the overstory. These trees are generally greater than 4 m high and range from approximately 12 cm diameter breast height (d.b.h.) to about 30 cm d.b.h. The canopy is generally closed but was found to be partially open to open depending upon the age of the stand and depth of peat. Growth rate of pine within this zone was found to be much greater than trees of the same species on the Heathland zone, as the supporting peat deposit is considerably drier in the Pine Woodlands. The age of most trees within the zone is generally between 20 and 70 years.

A few scattered western hemlock & birch were found to occur in the zone particularly at the interface between the Mixed Coniferous Woodland zone and the Birch Woodland vegetation zone. Sitka spruce (Picea sitchensis) and mountain ash (Sorbus aucuparia), and red alder (Alnus rubra) also occur within the zone usually as isolated individual trees.

Shrubs:

The shrub layer is well developed throughout the zone. The dominant shrub in all but the western section is Labrador tea. This

plant thrives on the somewhat drier sphagnum understory and reaches a height of 1.5 to 2 meters in many areas. In the western section of the bog, specifically west of 72nd Street salal replaces Labrador tea in the understory and reaches a similar height.

Other important plants of the shrub-layer include the velvet-leaf blueberry, spirea (Spiraea douglasii) oval-leaf huckleberry (Vaccinium ovalifolium), red huckleberry (V. parvifolium), cascade blueberry (V. deliciosum) and bracken fern (Pteridium aquilinum). These species are frequently found in association with Labrador tea, but can also be found as a complete ground-cover or in clumped distribution if the overstory has recently been removed by clearing or burning.

At the transition between the Pine Woodland and Heathland various shrubs and woody plants characteristic of the Heathland zone were commonly found in the overstory. These species include sweet gale, bog blueberry and bog laurel.

Herbs:

The herb layer is not well developed in this zone, however the following species were most commonly found to occur: bunchberry (Cornus canadensis), northern starflower (Trientalis arctica) and cloudberry (Rubus chamaemorus).

Bog cranberry, beakrush, cottongrass, sundew and a few other

Heathland herbs and woody plants were commonly observed in the wetter portions of the Pine Woodland zone.

Bryophytes:

Sphagnum mosses primarily Sphagnum capillaceum forms an extensive moss mat and hummock ground cover S. fuscum, S. tenellum and S. papillosum also were found but were much less common. Numerous other moss species occur on the sphagnum hummocks at the bases of woody vegetation and on rotting wood. The most common of these mosses are as follows: Dicranum howelli, Polytrichum juniperinum, Pleurozium schreberi, Rhytidiadelphus triquetrus R. loreus, Hypnum circinale, Aulacomium androgynum, Eurychium oregonum and Plagiothecium undulatum.

Liverworts were not found to be as common in the Pine Woodland as in the Heathland zone. However, Scapania bolanderi was found occasionally on wet rotting wood and Myliā anomala was found on west sites usually in association with Sphagnum capillaceum.

Lichens:

Lichens in the Pine Woodland zone were most frequently found as epiphytes rather than ground cover. Lodgepole pine branches and stems were encrusted with Platysmatia glauca, Hypogymnia spp. and Evernia prunaetri, and Usnea spp. was festooned from many branches. Cladonia chlorophaea and C. transcendens although uncommon were

found growing on dry hummocks and rotting wood throughout the zone.

iii Birch Woodland and Spirea Brushland

The vegetation of these two zones surround the Pine woodland zone and essentially marks the boundary between the bog and surrounding agricultural lands. Although the two zones do occur, and were mapped as separate entities, they are described together in this section as they share many of the same species and may be a continuum.

Trees:

In most areas birch is the dominant tree species and occurs in a closed canopy, a clumped distribution or as single individuals in an open canopy stand. The Spirea Brushland has no tree species. Within the Birch Woodland a few scattered lodgepole pine, sitka spruce, trembling aspen (Populus tremuloides), black cottonwood (P. trichocarpa) hawthorn (Crataegus douglasii) and escaped holly (Ilex aquifolium) can be found.

Shrubs:

The shrub layer in both zones is completely dominated by spirea. The Birch Woodland does however have some Labrador tea, salal, and salmonberry (Rubus spectabilis) in the shrub layer, particularly if the canopy is closed, and/or near the Pine Woodland zone. Spirea formed in dense thickets is the only plant found to occur in the Spirea Brushland.

Herbs:

Herbs are not common in the Birch Woodland, and do not exist in the Spirea Brushland vegetation zone. A few weedy herbs and non-bog species such as chickweed (Stellaria spp.), hemp nettle (Galeopsis tetrahit), fireweed (Epilobium angustifolium), and common vetch are occasionally found in the Birch Woodland. Natives such as mannagrass (Glyceria grandis) bunchberry, starflower and blue skullcap (Scutellaria laterifolia) were also collected. Perhaps the most frequent component of the shrub layer of the Birch woodland zone is bracken fern. This plant grows luxuriantly in partially cleared (disturbed) sites or open canopy Birch stands.

Bryophytes:

Mosses are greatly reduced in the Birch Woodland although, specimens of all species listed in the previous two zones were recorded. No living mosses were found below the dense Spirea Brushland cover, even though the substrate of the zone is sphagnum peat.

Similarly liverworts were inconspicuous in both zones although they are probably most widespread in the Birch Woodland zone.

Lichens:

Cladonia transcendens was the only lichen found. This species was recorded for the Birch Woodland. No lichen species

were found in the Spirea Brushland Vegetation zone.

iv Mixed Coniferous Woodland

The Mixed Coniferous Woodland vegetation zone is located at the periphery of the bog and restricted to two main areas. The first, and largest mixed coniferous woodland is located in the Eastern section of the bog. A smaller area of this zone is located at the bog's western edge, west of 72nd Street (Figure 10). In total the zone covers approximately 75 ha.

Trees:

The Mixed Coniferous Woodland vegetation zone was found to have thirteen coniferous and deciduous tree species and be the most floristically diverse vegetation zone within the bog.

No one tree species dominates the zone, however, western red cedar (Thuja plicata) was found to be very common, and western hemlock, sitka spruce, birch, and lodgepole pine were recorded in most quadrats. A few western yew (Taxus brevifolia) were also observed in the Mixed Coniferous Woodland.

In addition to the diverse assemblage of coniferous species the following deciduous species were occasionally found in a clumped distribution, or as individuals reasonably evenly distributed throughout

the zone; red alder, vine maple (Acer circinatum), big-leaf maple (A. macrophyllum) trembling aspen, cascara (Rhamnus purshiana) and crabapple (Pyrus fusca).

Shrubs:

The shrub canopy is fairly well developed in this vegetation zone. In many places shrub cover approaches 100%. However, the numerous water filled depressions which characterize this zone are usually free of shrubs. Salmonberry (Rubus spectabilis), spirea, and ovalleaf blueberry were most commonly found in the area. Occasionally the evergreen blueberry (Rubus lacinatus) is found in the shrub layer as is red huckleberry. The shrubs found to be present in the mixed coniferous woodland are velvet-leaf blueberry, red elderberry, thimbleberry (Rubus parviflorus) and the high bush cranberry (Viburnum edule).

Herbs:

Skunk cabbage (Lysichitum americanum) is the most common herbaceous plant found in the zone. This plant frequently occurs in wet depressions in the peat deposit. False-lily-of-the-valley (Maianthemum dilatata) is occasionally found as ground cover in many areas of the zone. Also present in the herb layer were skullcap, starwort (Stellaria calycantha), and bedstraw (Galium aparine and G. oreganum). Certain "non-bog" species were found as isolated individuals in the zone, of these velvet-grass, timothy (Phleum pratense), fireweed, and clover (Trifolium repens) were the most obvious.

Bryophytes:

Mosses and liverworts are well developed in this zone.

The following members of the moss sub-class Bryidae are common on many logs, stumps, tree trunks and branches in the zone:

Plagiothecium undulatum, Eurhyncium oregonum, Dicranum howellii,
Hylocomillum splendens, Rhizomnium glabrescens, Rhytidiadelphus,
R. loreus, Isothecium stolonifera, Neckera menziesli. Most species of sphagnum previously listed for other zones were common on the forest floor.

The liverwort Porella navicularis and other leafy liverworts were commonly found on suitable rotting wood substrate, and in wet depressions.

Lichens:

Although no detailed investigation of the lichen of the zone was carried out, Usnea spp. and Cladina spp were recorded as epiphytes and ground on the peat substrate.

v. Salmonberry Brushland

This rather interesting vegetation zone is dominated by a dense growth of shrubs which were approximately 2-3 meters high. Some trees were found, however, most were deciduous species. The herb layer was greatly reduced. With a coverage of 22 ha, this zone

was the smallest to be described.

Trees:

The most common tree in the shrub-dominant Salmonberry Brushland zone was the red alder. The only coniferous species recorded were western red cedar sitka spruce, and western hemlock. Crabapple and willow (Salix lasiandra) were occasionally found within the zone. Also mountain ash and a few black cottonwood were present at the margin of the zone.

Shrubs:

Salmonberry dominates the zone having up to 100% cover in places. Red huckleberry, spirea, salal, and red osier dogwood (Cornus stolonifera) were common in areas not completely overrun by salmonberry. Other shrubs found to occur were thimbleberry, prickly current (Ribes lacustre) Himalayan blackberry, oval leaf blueberry, red elderberry and false azalea. (Menziesia ferruginea)

Herbs:

Like the previous two zones skunk cabbage was commonly found to occur in wet depressions in this zone. False-lily-of-the-valley, skullcap, and the occasional clump of Juncus spp. were also present on the ground cover.

Bryophytes:

Nearly all species of bryophytes observed in the neigh-

boring mixed coniferous woodland zone were recorded for this zone. However, the cover was reduced considerably.

Lichens:

No lichens were recorded for the zone. However, they are probably present.

vi. Alder Woodland

This vegetation zone, located in the eastern section of the bog, has probably resulted from the clearing of the area in the past. The canopy is closed and the herb and shrub layer was reduced. The total area represents 16 ha. (Figure 10).

Trees:

Red alder dominates the zone. Most trees are approximately 10 m high and have a 25-35 cm d.b.h. Crabapple and cascara were commonly found to occur. The tree assemblage also includes the occasional sitka spruce, western red cedar, birch, vine maple, mountain ash and hemlock.

Shrubs:

No one shrub species dominated the zone. However, salmonberry was found to be very common. Red huckleberry, high bush craberry, red elderberry and false azalea were found on occasion. Also present in the shrub layer were salal, prickly currant, spirea and oval-leaf blueberry.

Herbs:

The most common herbaceous plant was skunk cabbage. *Montia* (*Montia saprica*) and starwort were also found in the herb layer.

Bryophytes:

The following bryophytes were recorded in the Alder Woodland zone: *Rhytidiadelphus triquetrus*, *R. loreus*, *Eurhyncium oreganum*, *Rhizomnium glabresceus*, *Hylocomium splendens*, *Neckera menzessi*, *Isoihecium stolonifera* and others. Liverworts were not recorded in this zone.

Lichens:

The lichens of the zone were not recorded.

vii Vegetationless Peatland

This vegetation zone was mapped because it represents a very large portion of Burns bog. Covering over 344 ha, this zone is the result of extensive peat excavation. The area in summer is usually dry "caked" peat material, virtually devoid of all plant life. In the winter most of this area is flooded and becomes a large shallow, peat cutting lake.

The vegetation that did exist prior to clearing and excavation activities probably resembled that of the Heathland zone.

At present, however, only a very few specimens of beak-rush and the infrequent small area of growing sphagnum (Sphagnum angustifolium) were found to exist.

4.1.3 Discussion

The qualitative, and quantitative analysis of the vegetation of Burns bog and the subsequent mapping of the area revealed that, generally, the species diversity and growth of plants increased from the centre of the bog to the perimeter, corresponding to the increasing "dryness" of the peat substrate.

The eastern portion of the bog particularly the Alder Woodland, Mixed Coniferous Woodland, and Salmonberry Brushland vegetation zones are unlike other peripheral areas of the bog. Although these vegetation zones have generally developed on deep sphagnum peat, and some may have been encouraged by past clearing practices, these zones are anomalous. Even though physically connected to Burns bog, these zones may represent another "separate" peatland with a distinctive development history.

The majore disturbances and developements on, or through the various vegetation zones in the bog are believed to have had the following impacts on the vegetation of the bog:

1. Peripheral drainage ditch excavation, has dried the sphagnum deposit to some extent. The net result of this action has been the development of the Birch-Woodland and Spirea Brushland vegetation zones.
2. The clearing of the outer sections of the Pine Woodland zone has resulted in the development of Spirea Brushland or an open canopy Birch Woodland Zone with a bracken fern/salal dominant understory.
3. Peat excavation has created large open cast areas. The recently mined areas which completely dry during the summer months do not support plant life. Other areas particularly water filled cutting areas older than 20 years (mined ca. 1945-1950), have regrown to certain Heathland species.
4. Landfilling and sandfilling of the bog has irreversibly altered the water table in the sphagnum deposit and compacted the peat substrate. It is expected that non-bog plant species will develop on and immediately around these areas because of the alteration of the water table (drying).
5. Fire - the short-run, obvious effect of the burning of the

vegetation of the bog is the complete removal of most of the overstory, shrub herbaceous layers and, possibly, the peat deposit to the water table. However, it does appear that if the drainage is unchanged the area will revegetate to an assemblage similar to that of the zone prior to the fire.

The removal of peat and ultimate creation of open water areas probably "retards" the succession of the Heathland. Numerous pine and other tree and shrub species were commonly found in the unmined portions of this zone. For this reason, and because there are few remaining natural pools in the deposit, it is believed that Burns bog would become completely forested, without these disturbances of peat mining and other land uses that alter the normal succession rate (ie. fire and clearing).

This belief was first formalized by Osvald (1933)... "Very likely the whole bog would quickly develop into pine forest if the trees were not killed off by fire."

4.2 Wildlife

An assessment of the wildlife utilization of Burns bog and neighbouring areas was based on field surveys by the author, published and unpublished reports by the various resource management agencies (B.C. Fish and Wildlife Branch, and the

Canadian Wildlife Service), and the records of biologists and naturalists with field experience in the area.

4.2.1 Methods

i Birds:

The bog area was classified into four main wildlife habitat types based on reconnaissance level vegetation mapping (Figure 11).

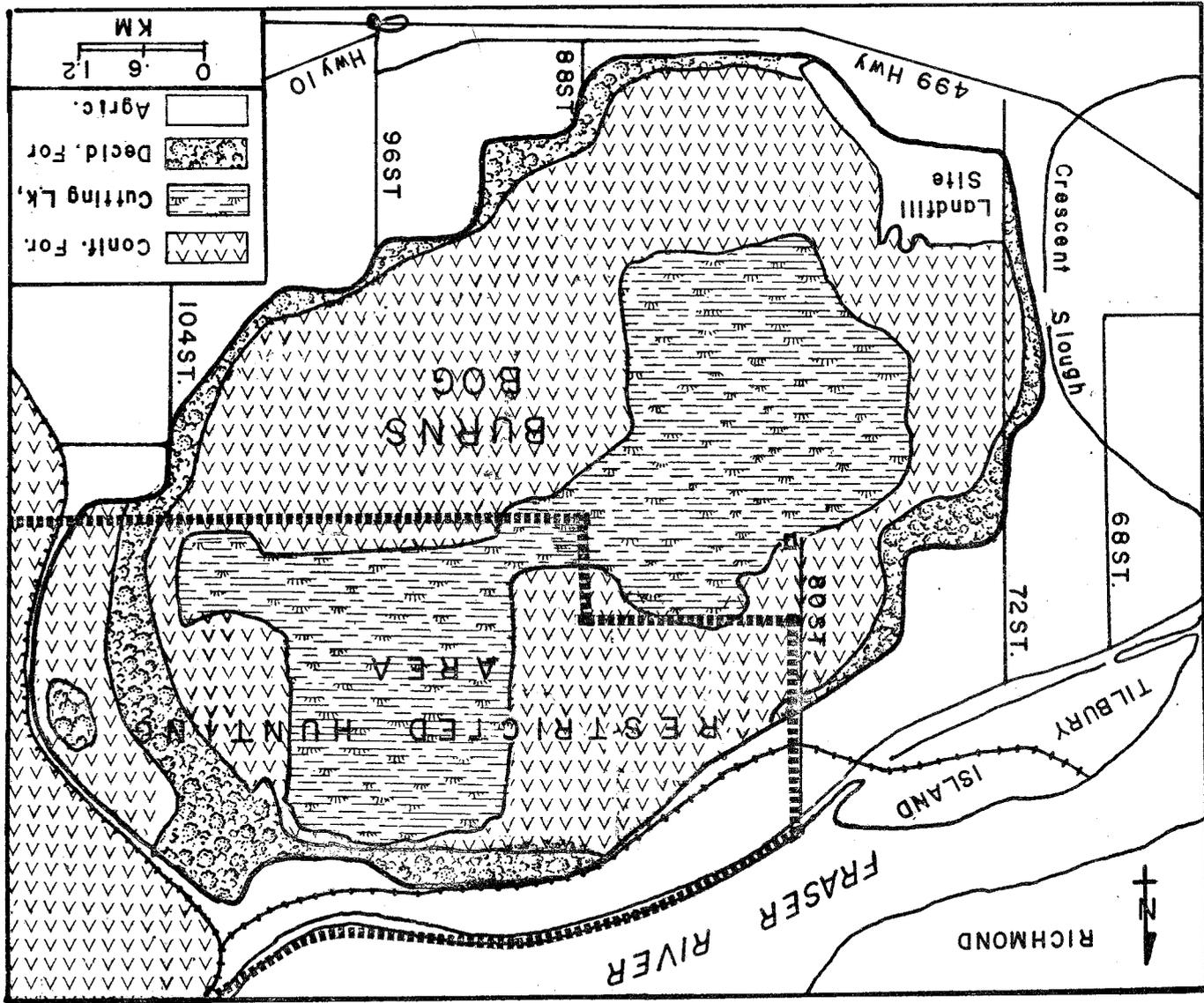
Habitat 1 Coniferous forest: includes all of the Pine woodland zone, the dwarf pine vegetation of the Heathland zone, and the mixed coniferous woodland zone.

Habitat 2 Open water cutting "lakes", or flooded peat cutting areas located in the Heathland zone.

Habitat 3 Deciduous forest: irregular stands of Alder, Birch Woodland, and Spirea Brushland vegetation generally located between the Pine Woodland zone and the neighbouring agricultural land.

Habitat 4 Agricultural land: characteristic flat, cleared agricultural fields with occasional large trees and shrubs along sloughs and road rights of way. (Although not considered part of the bog per se, this habitat was assumed to be important "back-up" habitat for the bog wildlife.

FIGURE II. WILDLIFE HABITAT MAP, AND BOUNDARY OF THE RESTRICTED HUNTING AREA IN BURNS BOG



A preliminary bird list was prepared from thirty field surveys by the author (Nov. 1974 to Dec. 1975), and the published bird records for the area. This list was examined and revised by individuals with known ornithological experience in and around the Burns bog. Ultimately a revised bird species list indicating habitat use, status and bird abundance was prepared. This list is presented in Appendix 2.

ii Mammals

Published accounts of the mammals of the Burns bog area, consultation and field observations were utilized to gain information regarding the present use of the bog area by mammals. A species list of mammals is presented in Appendix 3.

iii Amphibians and Reptiles

Little or no information was found available on the amphibians and reptiles of the bog, however, during the course of both the vegetation and wildlife field investigations all sightings of these animals were recorded and a species list was prepared (Appendix 4).

4.2.2. Results

i Birds

Burns bog is located a short distance north of Boundry Bay and east of the extensive tidal marshes of Roberts and Sturgeon banks (Figure 1).

In a regional context these areas in particular, and the Fraser River delta in general, are very important for migratory birds. "The Fraser River delta is one of the most valuable migratory and wintering areas on the entire Pacific coast of North America." (Halladay and Harris 1972). They estimate that approximately two million waterfowl, five million shorebirds, and thousands of passerine and other birds annually migrate through the Fraser River delta. Because of moderate climate and relative abundance of food resources, the area is also important as a wintering area for many waterfowl, passerine and raptorial bird species.

A total of 145 species of birds were found to utilize Burns bog and neighbouring agricultural areas (Appendix 2). Of this total, 60 species, or 41% are resident birds, or birds which nest within the bog, and can be found there on a year-round basis. Sixty-one species, or 42% are seasonal birds, and 24 species, or 17% use the bog occasionally or were found to be transients. The transient birds are defined here as birds which stop to rest and or feed during seasonal migrations.

Waterfowl: Even though Burns bog has a limited food supply for waterfowl, mallard (Anas platyrhynchos), pintail (A. acuta), green-winged teal (A. crecca) and other duck species utilize the open water cutting "lakes" and wet regrowth Heathland sites for resting and staging areas during the autumn and winter months. Approximately 1200 ha of the bog is utilized by waterfowl.

The Canada Land Inventory (C.L.I.) has classified the Burns bog area, and most areas of the delta as 3 M. This classification has been defined as "not important for waterfowl production, but important as migration or wintering areas."

Complete waterfowl survey information for the Burns bog area does not exist. The area was occasionally included on regular Canadian Wildlife Service (C.W.S.) aerial waterfowl surveys of the Fraser delta. However, because of the vastness of the bog area and apparent irregular use of the bog by waterfowl, the C.W.S. data did not provide adequate detail. In an attempt to upgrade the waterfowl survey information, a programme of waterfowl hunter surveys was initiated in 1973.

Two sixteen member waterfowl hunting clubs have hunting rights, and utilize approximately 850 ha of the central water-filled cutting "lakes" of Burns bog (Figure 11). The combined bag record of these two clubs is as follows: (Barnard 1976 unpublished)

<u>Season</u>	<u>No. of Birds Killed</u>
1973/1974	1586
1974/1975	1499
1975/1976	2407

It should be recognized that these totals represent preferred waterfowl species (ie. mallard, pintail and some teal) which utilize less than one-half of the available cutting lakes in the bog. The remainder of the bog is a restricted area and the discharge of

firearms is prohibited by municipal by-law (Figure 11). These kill statistics, therefore, were considered to be a minimum and serve only to indicate that a large number of dabbling ducks, probably well over 10,000 utilize the bog during the winter months.

A study of the neighboring Delta Industrial Park site north of the bog indicated that dabbling ducks used these agricultural lands as loafing and flooding areas (Entech Environmental Consultants Ltd., 1974). Flocks of 200-600 mallard, pintail and American wigeon (Anas americana) were observed by the author feeding on rotting potatoes left on the neighboring fields in February of 1975 and March of 1976. Other individuals have observed two to five thousand mallard and pintail circling and landing in the bog at dusk. (Johnstone, pers. comm.)

A total of 19 species of waterfowl were found to utilize Burns bog primarily in the autumn and winter months (September-March), (Appendix 2). Although a few records of waterfowl nesting in the bog do exist, the area is considered to be far more important to waterfowl as a resting and a staging area.

In July of 1975 a total of 66 adult Canada geese (Branta canadensis) raised at the Serpentine Fen, as part of the B.C. Fish and Wildlife Branch, Douglas College and Ducks Unlimited Canada Fraser Valley goose re-stocking programme were released in the central Heathland vegetation zone. Of this total only 25-30 birds

were believed to be alive the following September. Parasitism was thought to be responsible for the die-off (Burgess, pers. comm.), a group of geese which could have been the remainder of the released birds were observed at the northern boundary of the bog in early October 1975. The movements or success of these birds since October is not known.

Upland Game Birds:

Ruffed grouse (Bonasa umbellus) and the ring-necked pheasant (Phasianus colohicus) are both residents of the Burns bog area. The preferred habitat of the ruffed grouse is the mixed woodland area in the eastern section of the bog, while the ring-necked pheasant was frequently observed in and around the spirea thickets and hedgerow vegetation around the bog's perimeter.

Raptorial Birds:

Ten species of hawks and seven species of owls were recorded for the area. Of this group ten raptorial species were found to be residents and the remainder were classified as wintering or migratory birds (Appendix 2).

The red-tailed hawk (Buteo jamaicensis), and marsh hawk (Circus cyaneus) were found to be the most common raptors in the area. Red-tailed hawks utilize large black cottonwood trees at the bog's northern boundary as a nesting area, while marsh hawks were commonly observed hunting in the open Heathland zone or the

agricultural land areas surrounding the bog.

The most common owl occurring in the area appears to be the screech owl (Otus asio). This bird nests in the large conifers on the eastern border of the bog below Panorama ridge. A long-eared owl (Asio otus), roost has been recorded for Burns bog (Campbell et.al., 1972). However, this owl is considered a rare resident in the bog (ibid).

In general it appears that the Burns bog area is locally important as a nesting, and roosting area, and because it remains relatively undeveloped and many of the large trees remain, it appears to serve as a natural refuge for raptorial birds. With the exception of the marsh hawk, few raptors were observed hunting in the bog area proper. Most of these birds are believed to feed in the surrounding agricultural areas, and then return to the bog to roost.

Greater Sandhill Cranes:

One breeding pair and one juvenile, greater sandhill cranes (Grus canadensis tabida) were observed feeding on the Reynolds property, a farm located immediately west of Burns bog, September 15, 1975. These birds were found to nest in the western section of the bog (Heathland vegetation zone), and are believed to be the only pair to use the bog as a nesting area (Luscher, pers. comm.)

Mr. Lusher has been recording sandhill cranes sightings in the bog for over thirty years. His records indicate that the sandhill crane breeding population in the bog has dropped from a high of eight breeding pairs in 1945, to the single breeding pair which remain.

Counts of cranes in the area are confused by the fact that sandhill cranes which nest in the Pitt polder area, some 24 km. east-north east of the Burns bog area, apparently travel between the Reynolds property and the Pitt area on occasion. "On September 15 (1974) at 1:00 p.m., we visited Mr. Reynolds' farm in Ladner, where we saw a flock of twenty cranes, including three young. A resident pair with one young was feeding in an adjoining field. The visiting flock, we were told, had arrived a few weeks before, and at one time twenty-four cranes were seen, including eight young. This flock would seem to be the missing cranes from the Pitt area". (Robinson, 1974).

The greater sandhill crane has been given the status of rare summer resident (Campbell et al. 1972 and 1974). These birds are considered endangered resulting from destruction of suitable nesting habitat along the southern edge of the species range (Godfrey, 1970).

Locally greater sandhill cranes have only been reported for the Pitt polder and the Burns bog areas (Campbell et al., 1972).

A review of the habitat requirements for this species indicated that greater sandhill cranes prefer to nest in expansive wet areas that are isolated from human activity. Cranes feed in the cultivated fields usually located near the wetland nesting/roosting sites, (Howard, 1976). Howard summarizes the review by stressing the conservation of greater sandhill crane habitat. "...breeding populations are small and isolated. As such, they should be protected and preserved whenever possible. Due to limiting habitat requirements and a very low reproductive potential, they respond to wetland improvements at a very slow rate. Wetland acquisition and management programmes have made an impressive start in some areas in bringing the greater sandhill crane back from a seriously low number (ibid.)."

Shorebirds:

A total of eight species of shorebirds were tallied for the area. (Appendix 2) The only resident member of this group is the killdeer (Charadrius vociferus). "Three birds were seen in the peat cuttings performing defense behaviour on June 25 and 26, 1974, although no nests were located" (Butler and Footit, 1974).

Butler and Footit also observed 15 migrating western sandpipers (Calidris mauri) in the south-west corner of the bog.

Common snipe (Capella gallingago) were occasionally observed during the regular counts in the open heathland area of

the bog during January and February 1975. (Entech Environmental Consultants Ltd., 1975).

Spotted sandpiper (*Actitis macularia*), greater and lesser yellowlegs (*Tringa melanoleuca* and *T. flavipes*), black-bellied plover (*Pluvialis squatarola*) and dunlin (*Calidris alpina*) were recorded for the agricultural area surrounding the bog, however, their use of the treed and open cutting areas of the bog as a staging or wintering area is not known.

Shorebirds were frequently observed on the central peat cutting areas of the bog when a strong south-easterly wind blows during the winter months. (Johnstone, pers. comm.)

Gulls:

With sixty-five to seventy thousand gulls, the Vancouver area has the second largest wintering population on the west coast of North America; in this respect it is next to the San Francisco Bay area. (Drent et al, 1971). Swarms of glaucous-winged gulls (*Larus glaucescens*) daily feed in the City of Vancouver landfill site. A total of 9 species were recorded for the bog area (Appendix 2).

Glaucous-winged gulls are by far the most common gulls in the Vancouver area and at the landfill site. An average of 7000 glaucous-winged gulls were counted at the landfill October 12,

1969 (ibid.). Approximately 5000 glaucous-winged gulls and 600 new gulls were recorded by the author at the landfill site 28 June, 1975.

Other gull species were frequently observed at the landfill site and flying over the bog. Butler and Footit recorded 100 to 125 California gulls (Larus californicus) and 12 adult ring-billed gulls (Larus delawarensis) in the area July 10, 1974. Other less common species recorded for the landfill site include the western gull (Larus occidentalis) and glaucous gull (Larus hyperboreus). (Campbell et al. 1972).

The remaining three species, Bonaparte's gull (Larus philadelphia) Thayer's gull (Larus thayeri) and the herring gull (Larus argentatus) were observed on the agricultural areas north of the bog, or on the Fraser River, approximately 1 km. north of the bog. Their use of the landfill site and other areas of Burns bog is not known.

Passerine and Other Birds:

For the purposes of this discussion, the remainder of the bird species which were found to occur in the Burns bog area were grouped into this broad, arbitrary classification. Although this group comprises the major portion of the species to utilize the area, little or no information regarding status, abundance, or habitat selection was found available.

Thirty-three of the 87 known species of this group are believed to nest within or at the boundaries of the bog. (Appendix 2). The remaining 54 species are thought to be wintering or transient birds. The few available sighting records did however, indicate that many members of this group utilized the Pine and Birch Woodlands, spirea thickets and the eastern Mixed Coniferous, Birch and Alder Woodland areas. The Heathland vegetation zone, was not heavily utilized by the group.

ii Mammals

A total of 20 mammal species were found to occur in Burns bog (Appendix 3). Although no specific mammal survey was carried out in the area, all mammal sightings and signs (tracks scat and browse) were recorded as part of the wildlife and vegetation field investigations.

The only recent mammal survey beyond the reconnaissance level, done in the area was initiated at the north-central border of the bog in the winter of 1974/75. A small mammal live trapping programme in the Birch-Spirea vegetation zone indicated the presence of, deer mice (Peromyscus maniculatus) long-tailed voles (Microtus longicaudus), Townsend's vole (Microtus townsendii) and eastern cottontail rabbit (Sylvilagus floridans) (Entech Environmental Consultants Ltd., 1975).

Investigations within the bog during the spring and summer of 1975 revealed the presence of coyote (Canis latrans), Columbian black-tailed deer (Odocoileus hemionus), black bear (Ursus americanus), Douglas squirrel (Tamiasciurus douglasii), muskrat (Ondatra zibethica), beaver (Castor canadensis) and raccoon (Procyon lotor).

On a preliminary survey of Burns bog by the British Columbia Fish and Wildlife Branch in the summer of 1974, one specimen of a shrew mole (Neurotrichus gibbsi) and a snowshoe hare (Lepus americanus) were found dead in the Heathland vegetation zone near the Western Peat Moss Ltd. Ladner plant. These animals were believed to be killed by a predator (Butler and Footit, 1974).

Five additional mammal species, porcupine (Erethizon dorsatum), red fox (Vulpes fulva), north-western chipmunk (Eutamias amoenus), coast mole (Capanus ovariatus) and the wandering shrew (Sorex vagrans) were found to occur in the Delta Nature Reserve area of Burns bog (McKenzie et al. 1972).

An American opossum (Didelphis marsupialis) has been found dead at the radio tower on 80th Street (MacIntosh pers. comm.) and skunk tracks have been observed in the mud near the Burlington and northern railway tracks east of the bog.

Black Bear:

At least one, possibly two, black bear utilize the Pine wood-

land and Heathland vegetation zone of the bog, as a fresh scat was found in the northern section of this zone in September, 1975. Cursory scat analysis indicated that the animal was feeding on rose hips and blueberries. Workers at the peat plant have seen two black bear in the central and south (Heathland) section of the bog. It is strongly suspected that the bear (s) feed at the Landfill site, however no reliable sightings of bear were available for the Landfill site.

Columbian Black-tailed Deer:

Deer are commonly observed at the agricultural-bog interface browsing on salal, and other shrubs commonly found at the bog's edge. Tracks were observed by the author at the northern boundary of the bog, near 72nd and 80th street, on every field investigation. A group of twelve deer were seen near the Birch-Spirea zone in the spring of 1974 by Mr. J. Savage, a resident of the area.

The animals therefore appear to feed at the bog's perimeter and venture out onto the agricultural lands to some extent. When not feeding they are believed to retreat into the confines of the Pine woodland vegetation, or the mixed woodland areas. "The lodge-pole pine forest just west of the Pineland Peat Company in south Burns bog is heavily used as evidenced by the many game trails." (Butler and Footit, 1974).

iii Amphibians and Reptiles

The biology of the amphibians and reptiles of the Burns bog area and the Lower Fraser River in general is not well known. How-

ever the Pacific tree toad (Hyla regilla) was frequently heard in the bog during the Spring and Summer of 1975.

Other amphibians and reptiles are believed to be common in the area, particularly in and around drainage ditches which surround the bog. A list of the 4 species of Amphibians and Reptiles believed to occur in the area has been prepared from available literature (Carl, 1966, Northcote, 1974, Hoos and Packman, 1974). This list is presented in Appendix 4.

4.2.3 Discussion

i Birds:

Waterfowl

The Burns bog area was probably of little or no value as waterfowl habitat prior to the extraction of peat moss from the bog. The cutting lakes and certain wet areas regrowing to typical Heathland plant species are presently important in attracting waterfowl into the area. These "lakes" are now used by roughly 10,000+ birds during the fall and winter months as resting and watering areas.

Examination of the crop contents of several birds and numerous field observations of waterfowl flying between the bog and neighbouring agricultural fields indicates that these fields are of key importance in the use of the bog by waterfowl. The birds feed on vegetation or cereal crops in these fields then fly into the bog.

Another important factor related to waterfowl use of the bog is the weather/sea conditions south and west of the area. "Waterfowl fly daily into the flooded peat cuttings which are mainly used as loafing areas, especially if Boundary Bay and Roberts bank are covered by tidal waters made choppy by high winds", (Leach, 1972).

Raptorial birds

The bog's large size, and underdeveloped nature provides a natural refuge for several species of raptorial birds. Ten raptorial bird species nest in the bog. Roosting and nesting activities appear to generally be confined to the large deciduous trees at the bog's periphery.

Most resident species feed in the agricultural areas surrounding the area.

Greater Sandhill Crane

One pair of sandhill cranes nested in the bog in 1974/1975. These birds generally feed on the Reynolds farm property immediately east of the bog. The bog population has gradually been declining. This could be largely due to habitat destruction; doubtless too the birds require isolation from human activity, which is probably on the increase.

Shorebirds

Shorebirds use of the bog appears to be related to local weather conditions. The greatest use of the area is during the winter months when a strong south-easterly wind blows.

Gulls

An average of 6,000 gulls use the City of Vancouver sanitary landfill site as a food resource daily. Gulls are generally restricted to this area. However, several hundreds were observed loafing on neighbouring agricultural land west of the site during most months of 1975.

Passerine and Other Bird Species

The Eastern section of the bog, particularly the Mixed Coniferous, Alder and Birch Woodland vegetation zones were found to be the center of most nesting and feeding habitats for this group of birds.

It is interesting to note that the northwestern crow (Corvus caurinus) numbers have more than tripled in the area since the start-up of the landfill site in 1966 (Butler and Footit, 1974).

ii Mammals

Most of the twenty mammal species recorded for the bog can probably be found in other underdeveloped naturally vegetated areas of Delta. The peripheral vegetation zones (ie. Pine, Birch, Mixed Coniferous and Alder Woodlands are believed to contain most of the mammals within the area, although undoubtedly various species venture into the Heathland zone on occasion.

Several mammal species including deer, coyote, and eastern cottontail rabbit have been observed at the interface between the forested sections of the bog and the surrounding agricultural lands.

It is assumed that alteration of the rural nature of these lands would be as detrimental to the populations as the development of the central portion of the bog.

The Columbian black-tailed deer and the black bear appear to be isolated populations as the bog is effectively surrounded by urbanized land, or land not usually considered suitable habitat.

The deer could probably move out of, and into the area through corridors of forested land to the east; however, the black bear population in the bog appears to be disjunct. Suburbia has isolated the bear which were probably once common in the bog and east of the area on Panorama ridge and Surrey prior to development. It is however interesting to note that both groups appear to be managing reasonably well as there is ample natural food supply. The bog should be able to maintain a bear and deer population as long as the area remains in its present underdeveloped state.

iii Amphibians and Reptiles

The use of Burns bog by these animals is not known. However, a total of four species were recorded for the area.

4.3 Nitrogen and Ash Analyses

The percent total nitrogen and percent ash of seven sphagnum peat samples from various depths of the three major vegetation

zones of the bog near 80th Street (Tasker Road). The samples were analyzed to indicate the relative amount and distribution of these substances in the peat.

4.3.1 Methods

Peat samples were removed from various depths of the Heathland Pine and Birch Woodland vegetation zones of Burns bog, November 15, 1975. The seven samples were completely air dried and then ground in a Wiley Mill to pass through a 40 mesh grid.

Nitrogen and ash analysis was done by Mr. I. Derics of the Department of Plant Science U.B.C. The percent total nitrogen was determined by the Kjeldahl method, and the percent ash was calculated after burning of all organic material of each sample at 600°C in a muffle furnace.

4.3.2 Results

The results of the analyses outlined above and the description of the sampling sites and peat samples is presented in Table 8.

4.3.3 Discussion

i Nitrogen

The percent total nitrogen from seven samples taken at various depths, in the three main vegetation zones of the bog (Table 8) compared favourably with the findings of Luttmerding and Sprout (Table 5).

Table 8

Description and Analysis of
Sphagnum peat samples from Burns Bog

AREA	VEGETATION ZONE	RANGE OF SAMPLE DEPTH (cm)	DESCRIPTION OF SAMPLE	% ASH	% TOTAL N	CALORIC CONTENT (K cal/g)
BB1a	Heathland	0 - 10	Living and unhumified <u>Sphagnum angustifolium</u>	3.7	0.68	4.7
BB1b	Healthland	11 - 25	Slightly humified sphagnum peat	3.2	0.89	4.9
BB1c	Heathland	26 - 50+	Humified sphagnum peat	2.4	1.21	5.6
BB2a	Pine Woodland	0 - 5	Mixture of unhumified spagnum (50%) & slightly humified peat	6.6	1.07	4.8
BB2b	Pine Woodland	6 - 40	Humified peat (muck)	3.4	1.14	5.7
BB3a	Birch Woodland	0 - 10	Birch leaf & humified sphagnum peat	8.0	1.48	4.6
BB3b	Birch Woodland	11 - 14	Humified peat (muck)	2.0	1.89	5.2

The total nitrogen appears to increase with depth in the peat deposit, and distance from the central section of the bog. In other words, the percent total nitrogen of samples from 10 cm or more below the surface was higher than samples from the surface in all three vegetation zones. The percent total N was highest in the Birch vegetation zone, second in the Pine woodland and lowest in the Heathland zone.

The lowest value of percent total N from the Burns bog samples was .68%, this value was considered "high" by Luttmerding and Sprout (1969). (They consider all values greater than .40% high.) This indicates that there is a substantial amount of nitrogen held in the peat of the bog. However, this nutrient is believed to be unavailable to plants.

This belief is shared by other investigators. "Although the level of total nitrogen in an organic soil may be ten times as high as in a mineral soil its ability to release available nitrogen for plant growth is low." (Maas, 1972).

ii Ash

The remaining mineral content of the Burns bog peat samples was expressed as percent ash (Table 8).

The results of this investigation indicated that the top 10 cm of the deposit in all three zones contained the most minerals.

The percent ash at the surface was found to be highest in the Birch Woodland (8.0%). The Pine Woodland zone had an intermediate value at 6.6% and the Heathland vegetation zone had the lowest value of percent ash at 3.7%.

The values for percent ash from the surface of the deposit were probably invalid, as the dust from an adjacent farm, or 80th Street, may have been analysed with the surface deposit from the Birch and Pine Woodland samples, thus artificially raising the values of the samples BB3a and BB2a (Table 8).

4.4 Peat Depth Determinations

In order to approximate the amount of energy stored, or "trapped" as peat in Burns bog, a model of the area was constructed based upon field investigations and existing data such as a commercial peat inventory of the bog by J.T. Donald and Co., Ltd. (1964) for Western Peat Moss Ltd. (1964) and other reports.

Various field techniques for determining the depth of the organic deposit leading to the estimation of the volume, and energy stored as peat in Burns bog were initiated during the summer and early autumn of 1975.

4.4.1 Methods

A peat probe consisting of connecting stainless steel rods

(1.5 cm diameter and 1 m length) was pushed into the organic deposit at numerous locations within the bog, until the underlying mineral substrate was reached. The probe was then removed and the depth of peat recorded. The organic-inorganic soil boundary was detectable at the connections between sections of the probe.

Another attempt to determine peat depth within Burns bog by a hammer seismic procedure was initiated and carried out during the autumn of 1975. This procedure was investigated because, if successful, the technique might have some application in other peatlands where a rapid non-labour intensive estimate of peat inventory is required. The U.B.C. enhancement seismograph was used on three field trials in the central Heathland zone and the Spirea Brushland zones of the bog. The theory and methodology of the seismic refraction employed for these trials is described by Wm. G. McDowall (1973) in the 1975 U.B.C. Geophysics 400 - Applied Geophysics Laboratory manual. This information will not be elaborated here, as the results of this brief investigation were not used in estimating the volume of peat in the bog. The use of the method in the bog could not be evaluated because of insufficient data and field testing.

4.4.2 Results

The results of the peat depth, determinations from the peat probing method are presented in figure 12.

No reliable results were obtained from the hammer seismic determinations.

4.4.3 Discussion

The most reliable peat depth data were from coring and logs of the test holes carried out by various consulting engineering firms and agencies such as B.C. Hydro or the Greater Vancouver Sewage and drainage district.

The accuracy of peat probing is reduced because the interface between the peat and silt-clay-peat boundary is not well defined. For this reason errors of up to 1 m were unavoidable.

The hammer seismic technique may have some application for the determination of peat depth, however, the three trials of this method were inconclusive.

Trials with the hammer seismic method in Burns bog did, however reveal the following:

- a) The velocity of sound (as generated by striking a 7 cm thick aluminum block with a 9 kg sledge hammer) in sphagnum peat ranges from 335.3 m/sec. to 365.8 m/sec. in the Heathland zone.

- b) The velocity of sound increased approximately threefold in the underlying mineral layer.

- c) The method as applied could not account for undulations or irregularities at the peat-mineral soil interface.

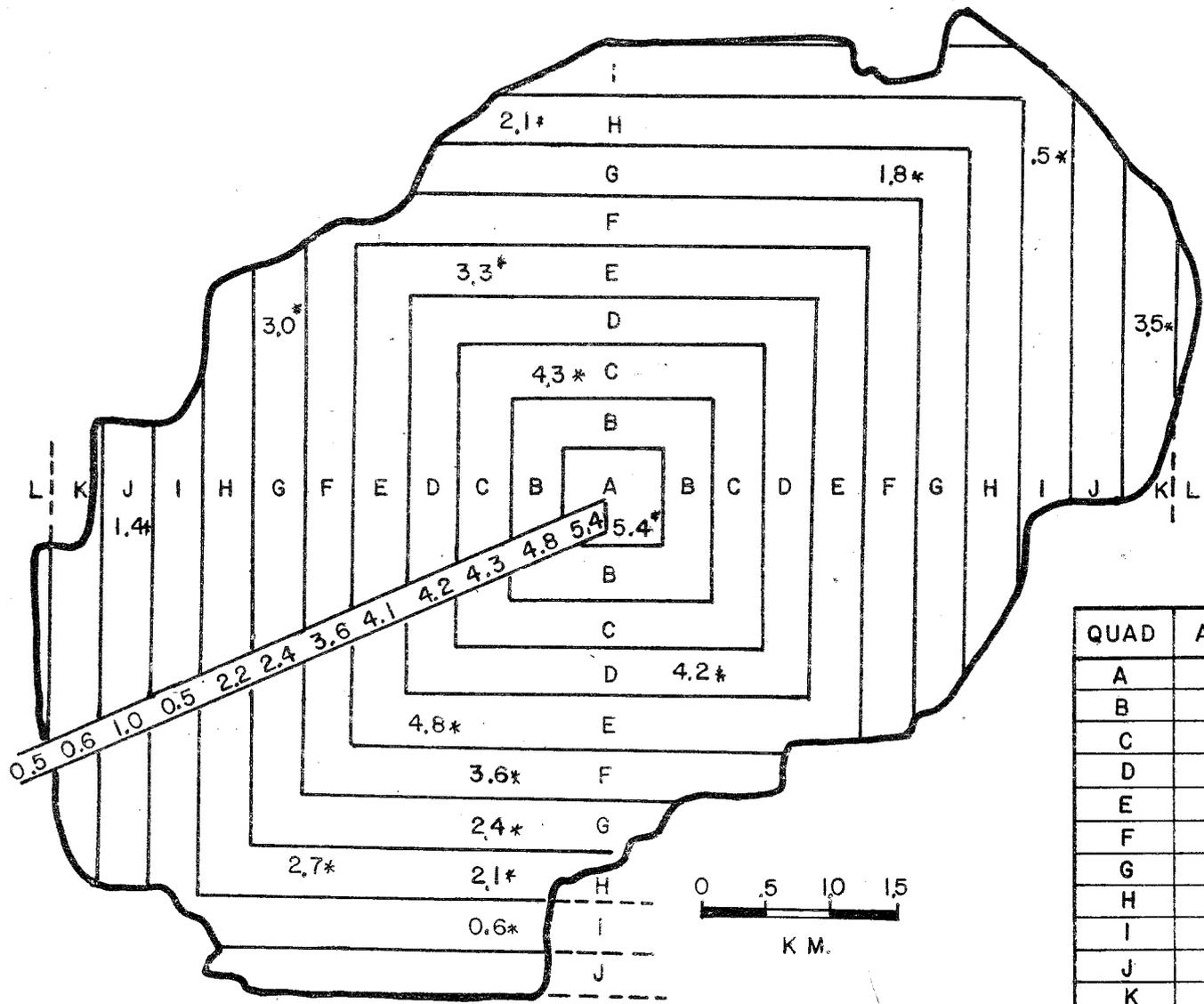
The hammer seismic method has been previously tested in the Burnaby lake (peat) area by B.C. Hydro, approximately 14 years ago (Armstrong, pers. comm.). These trials like the Burns bog trials were unsuccessful as peat depth determined by the Seismic technique and the test log data were not compatible.

4.5 Bog Volume, Weight and Stored Energy Determinations

4.5.1 Methods

The peat depth data from probing activities, plus the scattered depth determinations from published and unpublished sources, (Rigg & Richardson , 1938; Engineering Drillers Ltd., 1970; B. C. Hydro, 1974; J. T. Donald & Co. Ltd., 1964; Golder, Brawner & Associates Ltd. 1973) were plotted on a map of the bog. Concentric quadrats were drawn on the scale map, and then the surface area of each quadrat (Figure 12) was calculated using a grid-dot system.

The approximate peat depth of each quadrat was plotted on the map, if it was known. For a number of quadrats no



* KNOWN PEAT DEPTH LOCATION

QUAD	AREA (ha.)	DEPTH (m)	VOL. (hm ³)
A	54.4	5.4	2.9
B	163.2	4.8	7.8
C	272.0	4.3	11.7
D	380.8	4.2	15.9
E	486.2	4.1	19.9
F	537.2	3.6	19.3
G	523.6	2.4	12.6
H	537.2	2.2	11.8
I	462.4	0.5	2.3
J	326.4	1.0	3.3
K	176.8	0.6	1.1
L	40.8	0.5	0.2
TOTAL	3961.0	\bar{x} 2.8	108.8

FIGURE 12. MODEL USED TO ESTIMATE THE VOLUME OF PEAT WITHIN BURNS BOG

1hm³ = Cubic hectometre = 1,000,000m³

data regarding depth were available. The approximate peat depth was estimated by extrapolation on the assumption that the depth of peat within Burns bog decreases from the deepest central section to the outside.

The volume of peat in each quadrat was determined by multiplying the surface area by the average estimated, peat depth of the quadrat. The total bog volume was then calculated by the addition of each separate quadrat volume. (Figure 12).

Once the volume of the bog was estimated the average oven dry weight of ten 100 cm^2 samples of humified and unhumified peat was used to roughly estimate the weight of peat in the bog (Table 9).

The final step was to apply the average caloric content of seven humified and unhumified peat samples from the Heathland (3 samples), Pines Woodland (2 samples) and Birch Woodland vegetation zone (2 samples). See Table 8 for the total sphagnum peat weight estimation. The caloric content of the seven samples was determined by the Department of Animal Science U.B.C. laboratories in a Gallenkamp adiabatic bomb calorimeter. This value was multiplied by the total weight of peat in the bog to give a crude estimation of the amount of energy stored as peat in Burns bog.

Table 9
Oven Dry Weights
of 100cm² Samples of Peat
from Burns Bog

SAMPLE NUMBER	MICROHABITAT DESCRIPTION	DESCRIPTION OF MATERIAL	OVEN DRY OF 100 CM SAMPLE (9)
BB1	Hummock Top	<u>Sphagnum fuscum</u>	69.9
BB2	Wet Depression	sphagnum muck	15.8
BB3	Hummock	<u>S. capillaceum</u>	53.3
BB4	Hummock Edge	<u>S. capillaceum</u>	40.4
BB5	Hummock Top	<u>S. capillaceum</u>	38.5
BB6	Wet Depression	sphagnum & muck	30.8
BB7	Low Hummock	<u>S. fuscum</u>	25.1
BB8	Wet Depression	sphagnum muck	17.2
BB9	Hummock Top	<u>S. capillaceum</u>	66.7
BB10	Wet Depression	<u>S. angustifolium</u> & unident. organic material	15.2
			\bar{x} 36.3

4.5.2 Results

Bog Volume:

The total volume of peat, ie. sphagnum, heath and sedge peat in Burns bog is estimated to be 108.8 hm^3 , (Figure 12).

(Note: 1 hm^3 or cubic hectometer, cubic hectare, = $1,000,000 \text{ m}^3$)

Total Peat Weight:

The average oven dry weight of 1 cubic meter (m^3) of peat (humified and unhumified) was estimated to be 36.3 kg. (The ten samples ranged in weight from 15.2 kg/m^3 to 66.7 kg/m^3) (Table 9).

When the average estimated weight of 1 m^3 was multiplied with the bog volume estimate the product was found to be 3,949,440 metric tons oven dry peat material in Burns bog.

Stored Energy:

The seven samples of peat ranged in caloric content from 4.7/ k cal/gr to 5.7 k cal/gr (Table 8). The lowest value was from unhumified Sphagnum angustifolium collected on a hummock top in the Heathland zone. The average caloric content was found to be 5.07 k cal/gr.

The total caloric content of the peat material in Burns bog was calculated to be 20,023.7 G cal (1 G cal, giga calorie = 10^9 calories).

4.5.3 Discussion

Bog Volume, Weight and Stored Energy:

Any estimations of the volume of weight of peat within an area as immense as Burns bog cannot be much more than a very crude approximation.

Significant errors can arise because of the assumptions on which the area, depth and volume calculations were made.

The bog surface is not uniform, nor is the bottom regular with a well defined peat-mineral layer interface as assumed. In addition, peat depth in Burns bog is not necessarily deepest in the bog centre, nor does it always decrease toward the periphery.

The average caloric value of peat determined from the seven samples is possibly another potential source of error in the calculation of the total energy stored as peat in the bog. The figure of 5.07 k cal/gr does however compare favourably with caloric content of swamp peat (hummock) taken from a depth of 10 cm. The average caloric value of these samples was found to be 4.99 k cal/gr (Gorham and Sanger, 1967). The caloric value of unhumified Sphagnum palustre was found to be 4.7 k cal/gr (Bellamy & Rieley, 1967).

The caloric content of the peat was found to increase with depth in all three (Heathland, Pine and Birch Woodland) vegetation zones (Table 8). The increased caloric content is believed to be related to the humified, or advanced state of decomposition of the organic deposit at depth, under anaerobic conditions, (ibid., Salmi, 1954).

The estimation of 20,023.7 G cal for the total caloric content of Burns bog is considered to be a conservative estimate, as the peat depth is in many sections of the bog much greater than the depth estimate used in the calculations. The average total bog caloric content would also be substantially increased if a higher caloric of peat were used. (For example the average total bog caloric content would also be substantially increased if a higher caloric of humified peat was found to be 5.5 k cal/gr. If this value were to be substituted for the 5.07 k cal/g value used in the estimation, the caloric content of the total bog would increase 1698.2 G cal to 21,721.9 G cal.)

The estimate is however, believed to serve as a valid indication that Burns bog is an impressive energy "sink", and this fact will hopefully be carefully considered when eventual land-use decisions are made for the area.

4.6 Sphagnum Accumulation Rate and Net Primary Productivity Estimates

The standing biomass of sphagnum in revegetated areas of Burns

bog was estimated as an indication of net primary productivity. Standing biomass (standing crop) here is defined as the weight of living sphagnum material produced. Because sphagnum continuously grows year round, and there are no apparent features about this plant that can be used to indicate living from dead material, or one season's growth from another. To overcome this problem the total regrowth of 28 to 31 years of sphagnum was sampled and biomass estimated from "back calculation" as outlined below:

4.6.1 Methods:

Ten samples of sphagnum peat were removed from the central Heathland zone of the bog March 9, 1976. Samples of hummock, hummock edge and wet depression areas were removed by cutting 10 x 10 cm blocks of peat down to the humified horizon. All samples were collected from areas which had been mined by Western Peat Moss Ltd. in 1945 and 1948.

The regenerating mined areas were chosen as sampling sites because the humified horizon represented a known date, which could serve as a time marker for the calculation of rates of peat accumulation and standing biomass.

The amount of growth of each sample was recorded in the field, then all the non sphagnum species and roots were removed as

the samples air dried. Each sample was allowed to air dry for three days, oven dry at 26.6° C for one day then were finally completely oven dried at 48.2°C for two days.

The samples were then weighed and phytomass calculations were made by dividing the weight of 1 m² of material by the period of regrowth, ie. 28 or 31 years.

4.6.2 Results

The rate of sphagnum accumulation and crude net primary productivity estimates, based on standing phytomass calculations are presented on Table 10.

Peat Accumulation:

Wet depressional areas characterised by Sphagnum aungustifolium were found to have the slowest accumulation rate. The average annual peat accumulation rate of these four sites was .12 cm/yr.

The hummock tops however, exhibited a higher rate of accumulation. The dominant mosses on hummocks in the test area were Sphagnum fuscum and S. capillaceum. The average annual rate of peat accumulation on hummocks (6 samples) was found to be .63 cm/yr.

The average accumulation rate of the 10 samples was .43 cm/yr.

Table 10
Sphagnum Accumulation Rate And
Net Primary Productivity Estimates For
Regenerating Peat Cuttings in Burns Bog

SAMPLE NO.	MICROHABITAT DESCRIPTION	YEARS OF REGROWTH	FIELD DEPTH OF REGROWTH (CM)	RATE OF ACCUMULATION (CM/YR)	NET PRIMARY PRODUCTIVITY (G /M2/YR)
BB1	Hummock Top	28	19	.68	214.3
BB2	Wet Depression	28	4	.14	56.5
BB3	Hummock	28	21	.75	190.2
BB4	Hummock Edge	28	12.5	.45	144.4
BB5	Hummock Top	28	20.	.71	137.4
BB6	Wet Depression	28	5	.18	110.0
BB7	Low Hummock	31	12	.38	81.1
BB8	Wet Depression	28	2	.07	61.4
BB9	Hummock Top	28	23	.82	238.1
BB10	Wet Depression	28	2	.07	54.3

* See Table 9 For Description of Material

Net Primary Productivity:

A corresponding wide range in primary productivity estimates was also found for the wet depressional and "drier" hummock sites (Table 10).

The average net productivity of the four wet depressional sites was found to be 70.5 g/m²/yr.

The average net primary productivity of the six hummock sites was found to be 167.6 g/m²/yr.

The average of all 10 samples was found to be 128.8 g/m²/yr.

4.63. Discussion

A wide range of sphagnum peat accumulation was evident. (Rates ranged from .07 to .82 cm/yr.)

The average accumulation rate for all 10 samples (4 wet depressions and 6 hummock sites) of .43 cm/yr was found to be more than double the fastest rate of peat accumulation found by Cameron for sphagnum bogs in Northeastern Pennsylvania (.2 cm/yr) (Cameron 1970). The longer growing season of the Burns bog area and the higher annual average precipitation of the area are believed to be the main reasons for the difference between the two accumulation rates.

Because the accumulation process is relatively slow and the peat material compacts as new material is laid down, the precision of this method is reduced. (Moore and Bellamy, 1974).

Numerous other factors confound the calculation, and make the comparison of accumulation rates in other bogs and probably even other sections of Burns bog difficult. The water chemistry was found to be a key determinant of the balance between peat accumulation and decay (Heinselman, 1970). The substrate, micro-climatic effects, species composition, microbiology, and duration of waterlogging are also believed important in altering the rate of peat accumulation.

The standing biomass of sphagnum from the regrowth areas of the exploited Heathland was used as an indication of net primary productivity of the ecosystem.

The rationale behind the use of standing biomass divided by the known growth period for the net primary productivity is as follows:

1. It is extremely difficult to separate the living portion of the sphagnum plant from the dead portion below and virtually impossible to recognize any boundary between the dead plant and peat (Clymo, 1970). The main reasons for this difficulty is

attributable to the growth habit of the plant and the low decomposition state of the bog.

2. ... "good estimates of net primary productivity may be obtained from standing crop data in situations in which organisms are large and living materials accumulate over a period of time without being utilized." (Odum, 1971).

Like the peat accumulation rate the net primary productivity of sphagnum from the regrown heathland was found to be considerably higher on sphagnum hummock tops than in wet depressions (Table 10).

The productivity values for the wet depressional areas are probably invalid because although many of the non-sphagnum species were removed from the four samples, the relatively thin layer of peat may have been formed by other peat forming plants. Such plants as liverworts, yellow water-lily, algae, cottongrass, sundew, beakrush and others were no doubt incorporated into the peat, in these areas along with sphagnum mosses.

The net primary production values of the sphagnum hummock tops and hummock edges however, were believed to serve as a valid

indication that the sphagnum of regenerated Heathland has an extremely low rate of net primary productivity. These values were found to compare favourably with the net annual production rate of *S. fuscum* hummock from a site in Westmorland England. The production here was calculated to be 269 g/m²/yr (Bellamy & Rieley, 1967).

The following table of net primary productivity of various types of vegetation of the world provides an interesting comparison and places the production of the revegetated Heathland of Burns bog into perspective.

TABLE 11
Comparison of the Net Primary Production of
The Regenerating Peat Cuttings in Burns Bog To
Various Other Terrestrial Ecosystems (after. Krebs 1972)

VEGETATION TYPE	NET PRIMARY PRODUCTION (g/m ² /yr)
Arctic Tundra	100.
Regrowth Sphagnum of Burns Bog Heathland	129.
Forested Sphagnum Bog	340.
Southern Taiga Fir Forest	850.
Mangrove	930.
Temperate Steppes	1120.
Subtropical Forests	2450.
Tropical Rainforest	3250.

5. General Ecological and Land-Use Discussion

In the past, and to some extent even today, large tracts of peatlands such as Burns bog have generally been considered wasteland or "problem areas" because the engineering and other drainage costs have been too great to make their development an economically sound venture. For this reason development is not generally widespread in Burns bog.

At present the residents of the lower Fraser River delta are faced with the paradoxical situation of having to develop the few remaining large tracts of the area to meet the needs of a rapidly growing population, yet maintain a desirable living environment.

This study hopefully serves to indicate the vastness of the peat resource of the area, the importance of the bog as a refugium for many plant and animal species, and the complexity of the mire ecosystem. However, this work alone cannot be used to effectively predict the impact of any proposed land-use development in the bog.

As pressure for the development of the area continues to mount, the various agencies responsible for making land-use decisions

should pose the following questions before the land is committed:

1. What are the "costs" of making approximately 5,500 years of organic matter accumulation unavailable by landfilling, or acceleration of the decomposition rate of the peat deposit by draining the area?
2. What will be the demand for sphagnum peat in the future? (Considering recent increases in the demand for soil conditioners and increases in the cost of nitrogen fertilizers and fossil fuels).
3. Will the development further reduce the plant and animal species diversity in the region by destroying another important natural area?
4. Are there other sites as well suited to teaching and scientific research as Burns bog?
5. Is there any provision for multiple land-use in the development proposal?
6. What is, and what will be the importance of the bog as a catchment basin and a buffer zone in the suburban - urban environment?

Perhaps now is the time to start to answer these questions, and rethink the short-term benefits of development of the land base at the expense of its resources. Because it remains in a relatively under-developed state, Burns bog represents not only an exceptionally important natural study area, but a challenge for planners to rationally evaluate the long-term importance of large tracts of under-developed land within "urban" areas.

6. SUMMARY

Burns bog is a large raised sphagnum peat bog occupying approximately 4000 ha of the Fraser River delta in south-western British Columbia. Over 1600 ha or 40% of the bog has been mined for commercial peat moss by the major land owner, Western Peat Moss Ltd.

Even though the area has been extensively disturbed from peat extraction, landfilling and other land-uses, Burns bog represents the largest underdeveloped single tract of land within the Corporation of Delta. Delta has been identified as one of the fastest growing municipalities in Canada (GVRD., 1975). As such it was believed that the bog area will become increasingly important as the Corporation continues to grow and land for various future rural, urban or industrial developments is required.

Although various published and unpublished reports concerning the bog were available, the general ecology of the area was not well known. This study was therefore, initiated to:

- a) Review and collate existing environmental and land-use information pertaining to the site.
- b) Carry out basic vegetation and wildlife inventories.
- c) Prepare a cover map of extant vegetation and
- d) Investigate certain aspects of the ecology of the bog such as

determining the approximate peat accumulation rate and crudely estimate the total calorific value of peat stored in Burns bog.

The study area is located approximately 25 km south of Vancouver, British Columbia, at $49^{\circ} 08'$ N latitude and $1230^{\circ} 00'$ W longitude. The bog is vaguely elliptical in shape and is bordered by Panorama ridge to the east, the combined Canadian National-Burlington Northern Railway trackage to the north, Crescent slough to the west; and Highway 499.

The centre of Burns bog at an average altitude of 5-6 M above sea level (asl) is approximately 3 m. higher than the poorly drained, flat lands surrounding the bog to the north, west to south. Directly east of the bog, Panorama ridge rises to an average elevation of 90 m asl.

The climate of the area is a modified maritime climate characterised by mild rainy winters and bright dry summers. Average winter temperatures are approximately 3.5°C , while the average summer temperature is 15.7°C . The average annual precipitation for the bog is about 1000 mm/yr. July is the driest month (average 2.8 mm) and November or December usually are the wettest, (average 137. mm).

The area receives approximately 1900 hours of bright sunshine per year and the prevailing wind direction is east.

The bog is situated in an area with one of the longest frost-free growing seasons in Canada. (230 day growing season).

Burns bog is believed to be approximately 5000 - 6000 years old, and has developed on recent alluvium through centripetal filling of a shallow water filled basin by aquatic plants, primarily sphagnum mosses.

The bog is dominated by two organic soil series, the Triggs series - a Sphagno-Fibrisol, and the Lumbum series - a Typic mesisol. Both of these soil have a high water holding capacity, high cation exchange capacity and are acidic. (pH 4.0).

These two soils are saturated for most of the year, but water on the surface is unevenly distributed as the hummocks are generally much drier than the wet depressions of the deposit.

Precipitation and water occasionally pumped into the bog for peat mining is the main source of water in the bog. The bog drains extremely slowly. The direction of this water movement is generally northward into the Fraser River, although smaller drainage areas within the bog drain west into crescent slough and ultimately into the river or southward into Boundary Bay.

The bog has had a long history of fire, clearing and peat mining. The main land-use at present is the extraction of commercial peat moss.

Peat extraction is done by hydraulic mining resulting in the creation of large rectangular peat cutting "lakes" which fill with surface water as the peat is being extracted. The material is generally extracted near the centre of the bog and processed at two plants in the area.

The City of Vancouver own and operate a sanitary landfill site in the south-east corner of the bog. At present, about 10% of the 405 ha site has been used. The landfill is believed to have another twenty years of life. Water quality of the remainder of the bog is reported to be unaffected from the leachates entering the surface water from the site.

Various other land-uses such as railroads, road, utility corridors, storage, radio towers, hunting clubs and a nature reserve area are present in the bog area. These are generally restricted to the outer edges of the bog.

The main proposals for development or alteration of the existing character of the bog have been outlined. These include a wildlife management proposal, residential development, agricultural reclamation of the shallower peat soils, the construction of a road through the northern portion of the bog and others.

The study area was classified into eight major vegetation zones.

Air photo interpretation and quantitative and qualitative methods were used to analyse the vegetation. A cover map of extant vegetation was produced. The species diversity and plant growth was found to increase from the centre of the bog to the perimeter. Increased dryness and possibly increased nutrient availability are believed to be responsible for this trend. The vegetation of the Eastern portion of the area does not exhibit the regular zonation characteristic of the remainder of the bog. The land-use practices of drainage and landfilling (sanitary landfill and sandfilling) appeared to have an impact on the vegetation. Various "weedy" and plants species not usually found in the wetter portions of the bog were observed. The regrowth of bog species similar to those prior to perturbation were, however, recorded following the land-use practices of burning, clearing and peat extraction, if artificial drainage measures were not installed.

Avian inventories and consultation with ornithologists with known experience in the Burns bog area accounted for the recording of 145 bird species for the bog area.

The peat cutting "lakes" of Burns bog are utilized by over 10,000 dabbling ducks in the autumn and winter months (September to March). The surrounding agricultural lands appear to provide the main food resource of these birds, and there appears to be a movement of waterfowl from these lands into and out of the bog. Un-

favourable weather and sea conditions on Boundary Bay as well as Roberts and Sturgeon banks appear to make the flooded areas of the bog more attractive to wintering, resident and migratory waterfowl.

The large trees at the perimeter of the bog, the area's large size and underdeveloped character make Burns bog an important natural refuge for a number of raptorial birds. It is believed that the surrounding agricultural lands are extensively used by hawks and owls which nest and roost in the bog.

One nesting pair of greater sandhill crane were found to occur in the Western Heathland section of the area. The cultivated fields directly west of the bog are traditionally used by these birds as a feeding area.

The central "cutting lakes" also appears to serve as a valuable shelter area for numerous shorebirds during the winter months. Their use of these lakes is believed to be related to local wind conditions on Boundary bay, as most shorebirds were found in the bog when a strong south east wind blows.

Over 6,000 glaucous-winged and other gull species feed at the City of Vancouver sanitary landfill site daily.

The mixed coniferous-deciduous woodlands at the eastern edge of the bog is believed to be important nesting and feeding habitat

for most passerine bird species found within the bog.

A total of 20 species of mammals were recorded from sightings and signs.

It is believed that with the exception of the Columbian Blacktailed deer and black bear, most of the remaining species can be found in other naturally vegetated , underdeveloped areas of Delta. The black bear and deer however, are considered to be isolated resident populations. They exist in the bog because it provides suitable cover and food resources. The agricultural nature of the surrounding lands is believed to be of key importance to the survival of deer in the area.

The total percent nitrogen and ash of peat samples at various depths from the peat deposit and the three main vegetation zones was calculated.

The percent total nitrogen increases with depth and distance from the centre of the bog and the percent ash, of the surface 10 cm at least, may similarly increase from the centre of the bog to its perimeter.

Peat depth determinations were done by peat probing at various locations in the area. The use of the hammer seismic technique was attempted as an alternate method of determining peat depth. Based on three preliminary trials, the hammer seismic method was found unsuitable.

The approximate volume, weight and average calorific value of peat from Burns bog was determined in order to crudely estimate the amount of energy stored as peat in the bog.

The volume of peat in the bog is estimated to be 108.8 hm³. The total dry weight of peat is approximately 3,949,440 m. tons. The total caloric content of this weight of sphagnum was calculated to be 20,023.7 G cal.

The rate of accumulation of sphagnum peat from two regenerated heathland sites (following peat mining) was determined, and the average standing biomass was used as an indication of the net primary productivity of these sites.

The rate of sphagnum peat accumulation and productivity varies considerably. The most impressive accumulation and productivity is found at hummocky sites, while the poorest was the wet depressional areas.

The average net primary productivity of sphagnum hummocks is 167.6 g/m²/yr and the wet depressions are correspondingly low at 70.6 g/m²/yr.

7. CONCLUSIONS

1. Considering the rapid growth and land demands of the G.V.R.D. the importance of the bog as a possible wildlife area, agricultural land or similar reversible, "open space" land-use should not be overlooked.
2. The bog contains a substantial volume of peat with a caloric content crudely estimated to be 20,000 G. cal. This resource must be evaluated before any decision is made to make the peat unavailable. ie. landfilling.
3. The peat has a high water holding capacity organic content, and nitrogen content. For these reasons it is a valuable agricultural product. The importance of a local source of this sort of organic material for use other as top dressing or in artificial soil mixtures should be considered.
4. The species diversity and growth of vegetation in the bog appears to be related to the waterlogged, low pH, low decomposition, low available nutrient conditions of the bog.
5. The plant species present in the bog demonstrate interesting adaptations to the bog environment, and floristically the area represents an ecosystem quite unlike the remaining under-

developed areas of the Fraser River delta. Growth of plants in the area appears to be extremely slow and finely tuned to existing environmental conditions.

6. Burns bog is important habitat for a variety of bird species. The use of the area by birds appears to be related to its large size, suitable nesting, loafing and roosting habitat.
7. The area contains an isolated mammal population, whose continued existence is believed to be dependant upon future land-use decisions. That is, habitat destruction will probably displace or effect the demise of resident larger "less-tolerant" mammal species such as the black bear and Columbian black-tailed deer.
8. The land-use patterns of surrounding lands are of key importance to bird and mammal populations within the area, as many species presently utilize the neighbouring agricultural lands as feeding areas (ie. dabbling ducks, sandhill cranes, certain raptorial birds and Columbian black-tailed deer).
9. The rate of sphagnum peat accumulation is considered high compared with peatlands in other areas.
10. The net primary productivity of the revegetated Heathland zone is extremely low compared to other terrestrial ecosystems.

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APPENDIX 1

Burns Bog Plant Species List and Cover Estimates

(after Hebda and Biggs, manuscript in progress).

1.A. TREES

1.B. SHRUBS

1.C. HERBS

1.D. MOSSES

Key to Symbols:

<u>Abundance</u>	<u>Symbol</u>	<u>Cover Value (%)</u>
Dominant	DOM	51 - 100
Very Common	VCM	26 - 50
Common	COM	6 - 25
Occasional	OCC	1 - 5
Present	+	< 1
Absent	-	0

Note: - Vascular plant nomenclature after Hitchcock and Gronquist, 1973.

- Mosses, after Schofield, 1969.

Tree Species	Heathland	Pine Woodland	Birch Woodland	Spirea Brushland	Mixed Conif- erous Woodland	Salmonberry Brushland	Alder Woodland	Vegetation- less Peatland
<u>Picea sitchensis</u> (Sitka spruce)	-	+	+	+	COM	OCC	OCC	-
<u>Pinus contorta</u> (Lodgepole pine)	VCM	DOM	+	OCC	OCC	+	-	-
<u>Taxus brevifolia</u> (Western yew)	-	-	-	-	+	+	+	-
<u>Thuja plicata</u> (Western red cedar)	-	+	-	-	VCM	COM	OCC	-
<u>Tsuga heterophylla</u> (Western hemlock)	+	+	-	-	COM	OCC	+	-
<u>Acer circinatum</u> (Vine maple)	-	-	-	-	OCC	-	OCC	-
<u>Acer macrophyllum</u> (Big-leaf maple)	-	-	-	-	+	-	-	-
<u>Alnus rubra</u> (Red alder)	-	-	-	OCC	-	VCM	DOM	-
<u>Betula occidentalis</u> (Birch)	+	OCC	DOM	COM	COM	COM	OCC	-
<u>Crataegus douglasii</u> (Hawthorne)	-	-	+	-	-	+	-	-
<u>Ilex aquifolium</u> (Holly)	-	-	+	-	+	-	-	-
<u>Populus tremuloides</u> (Trembling aspen)	-	-	+	+	-	+	-	-
<u>Populus trichocarpa</u> (Black cottonwood)	-	-	-	+	-	+	-	-
<u>Pyrus fusca</u> (Crabapple)	-	-	OCC	OCC	OCC	COM	COM	-
<u>Rhamnus purshiana</u> (cascara)	-	-	COM	-	OCC	COM	COM	-

Tree Species	Heathland	Pine Woodland	Birch Woodland	Spirea Brushland	Mixed Conif- erous Woodland	Salmonberry Brushland	Alder Woodland	Vegetation- less Peatland
<u>Salix geyeriana</u> (Willow)	-	-	OCC	+	-	+	-	-
<u>Salix hookeriana</u> (Willow)	-	-	OCC	+	-	+	-	-
<u>Salix lasiandra</u> (Willow)	-	-	OCC	-	-	OCC	OCC	-
<u>Sorbus aucuparia</u> (Mountain ash)	-	-	+	-	+	+	+	-

Shrub Species	Heathland	Pine Woodland	Birch Woodland	Spirea Brushland	Mixed Conif- erous Woodland	Salmonberry Brushland	Alder Woodland	Vegetation- less Peatland
<u>Amelanchier alnifolia</u> (Saskatoon-berry)	-	-	-	-	-	+	-	-
<u>Andromeda polifolia</u> (Bog rosemary)	OCC	+	-	-	-	-	-	-
<u>Cornus stolonifera</u> (Red osier dogwood)	-	-	-	-	OCC	COM	-	-
<u>Empetrum nigrum</u> (Crowberry)	+	-	-	-	-	-	-	-
<u>Gautheria shallon</u> (Salal)	COM	VCM	OCC	COM	DOM	COM	+	-
<u>Kalmia polifolia</u> (Bog laurel)	COM	OCC	-	-	-	-	-	-
<u>Ledum groelandicum</u> (Labrador tea)	DOM	DOM	COM	OCC	OCC	-	-	-
<u>Lonicera involucrata</u> (Black twinberry)	-	-	+	-	-	VCM	OCC	-
<u>Menziesia ferruginea</u> (False azalea)	-	-	-	-	COM	OCC	OCC	-
<u>Myrica gale</u> (Sweet gale)	-	-	COM	+	+	+	-	-
<u>Ribes lacustre</u> (Prickly currant)	-	-	-	-	-	+	+	-
<u>Rosa nutka</u> (Nutka rose)	-	-	-	+	-	-	-	-
<u>Rosa pisocarpa</u> (Clustered wild rose)	-	-	-	-	-	+	-	-
<u>Rubus discolor</u> (Himalayan blackberry)	-	-	-	-	-	+	-	-
<u>Rubus lacinatus</u> (Evergreen blackberry)	-	-	-	-	OCC	+	-	-

Shrub Species	Heathland	Pine Woodland	Birch Woodland	Spirea Brushland	Mixed Conif- erous Woodland	Salmonberry Brushland	Alder Woodland	Vegetation- less Peatland
<u>Rubus parviflorus</u> (Thimble-berry)	-	-	-	-	+	+	-	-
<u>Rubus spectabilis</u> (Salmonberry)	-	-	OCC	-	COM	DOM	VCM	-
<u>Rubus ursinus</u> (Pacific blackberry)	-	-	-	-	-	+	-	-
<u>Sambucus racemosa</u> (Red elderberry)	-	-	-	-	-	OCC	OCC	-
<u>Spiraea douglasii</u> (Spirea)	+	COM	DOM	DOM	COM	COM	+	-
<u>Vaccinium deliciosum</u> (Cascade blueberry)	+	-	-	-	+	-	+	-
<u>Vaccinium myrtilloides</u> (Velvet-leaf blueberry)	COM	COM	OCC	+	+	-	-	-
<u>Vaccinium ovalifolium</u> (Oval-leaf blueberry)	-	+	-	-	COM	OCC	+	-
<u>Vaccinium parrifolium</u> (Red huckleberry)	-	-	-	-	OCC	COM	OCC	-
<u>Vaccinium uliginosum</u> (Bog blueberry)	VCM	COM	-	-	-	-	-	-
<u>Viburnum edule</u> (High bush cranberry)	-	-	-	-	+	+	OCC	-

Herb Species	Heathland	Pine Woodland	Birch Woodland	Spirea Brushland	Mixed Conif- erous Woodland	Salmonberry Brushland	Alder Woodland	Vegetation- less Peatland
<u>Cardamine breweri</u> (Brewers bittercress)	-	-	-	+	-	+	-	-
<u>Carex lenticularis</u>	-	+	-	-	+	-	-	-
<u>Carex obnupta</u>	-	+	-	-	-	-	-	-
<u>Carex pauciflora</u>	-	-	-	-	+	-	-	-
<u>Carex phyllomanica</u>	-	-	-	-	+	-	-	-
<u>Carex rostrata</u>	-	-	+	-	-	-	-	-
<u>Circaea alpina</u> (Enchanter's nightshade)	-	-	-	-	+	-	-	-
<u>Cornus canadensis</u> (Bunchberry)	-	+	+	-	+	-	-	-
<u>Drosera anglica</u> (Great sundew)	+	-	-	-	-	-	-	-
<u>Drosera rotundifolia</u> (Sundew)	OCC	+	-	-	-	-	-	-
<u>Dulichium arundinaceum</u> (Dulichium)	+	-	-	-	-	-	-	-
<u>Epilobium angustifolium</u> (Fireweed)	-	-	+	+	+	+	-	-
<u>Epilobium minutum</u> (Small fireweed)	-	-	+	-	-	-	-	-
<u>Eriophorum chamissonis</u> (Cottongrass)	+	+	-	-	-	-	-	-
<u>Galeopsis tetrahit</u> (Hemp nettle)	-	-	+	-	-	-	+	-
<u>Galium aparine</u> (Goose grass)	-	-	-	-	+	-	-	-
<u>Galium oreganum</u> (Bedstraw)	-	-	-	-	+	+	-	-

Herb Species	Heathland	Pine Woodland	Birch Woodland	Spirea Brushland	Mixed Coniferous Woodland	Salmonberry Brushland	Alder Woodland	Vegetation-less Peatland
<u>Glyceria grandis</u> (Mannagrass)	-	-	+	-	+	-	-	-
<u>Holcus lanatus</u> (Velvet grass)	-	-	+	+	+	-	-	-
<u>Juncus effusus</u> (Common rush)	-	-	-	-	-	+	-	-
<u>Lactuca muralis</u> (Wall lettuce)	-	-	-	-	-	-	+	-
<u>Lysichitum americanum</u> (Skunk cabbage)	-	-	-	-	COM	COM	VCM	-
<u>Maianthemum dilatatum</u> (False lily-of-the-valley)	-	-	-	-	OCC	OCC	+	-
<u>Montia sibirica</u> (Spring beauty)	-	-	-	-	-	-	OCC	-
<u>Myosotis laxa</u> (Forget-me-not)	-	-	-	-	-	-	+	-
<u>Nuphar polysepalum</u> (Yellow water-lily)	+	-	-	-	-	-	-	-
<u>Oenanthe sarmentosa</u> (Water parsley)	-	-	+	-	+	OCC	-	-
<u>Phleum pratense</u> (Timothy)	-	-	-	-	+	-	-	-
<u>Pteridium aquilinum</u> (Bracken)	-	+	OCC	+	+	-	+	-
<u>Rhynchospora alba</u> (Beakrush)	OCC	+	-	-	-	-	-	-
<u>Rubus chamaemorus</u> (Cloudberry)	+	+	-	-	-	-	-	-
<u>Scirpus acutus</u> (Hardstem bulrush)	-	-	+	-	-	-	-	-

Herb Species	Heathland	Pine Woodland	Birch Woodland	Spirea Brushland	Mixed Conif- erous Woodland	Salmonberry Brushland	Alder Woodland	Vegetation- less Peatland
<u>Scutellaria laterifolia</u> (Blue skullcap)	-	-	+	-	+	OCC	-	-
<u>Solanum dulcamara</u> (Climbing nightshade)	-	-	-	-	+	-	-	-
<u>Stellaria calycantha</u> (Northern starwort)	-	-	+	-	-	+	-	-
<u>Stellaria crispa</u> (Crisped starwort)	-	-	+	-	+	+	+	-
<u>Tiarella trifoliata</u> (Coolwort)	-	-	-	-	+	-	-	-
<u>Tofieldia glutinosa</u> (Sticky tofieldia)	+	-	-	-	-	-	-	-
<u>Tolmiea menziesii</u> (Youth-on-age)	-	-	-	-	+	-	-	-
<u>Trientalis arctica</u> (Northern starflower)	-	-	+	-	+	-	-	-
<u>Trifolium repens</u> (White clover)	-	-	-	-	+	-	-	-
<u>Typha latifolia</u> (Cattail)	-	-	+	-	-	-	-	-
<u>Vaccinium oxycoccos</u> (Swamp cranberry)	COM	+	-	-	-	-	-	-
<u>Viola palustris</u> (Marsh violet)	-	-	-	-	+	+	-	-

Moss Species	Heathland	Pine Woodland	Birch Woodland	Spirea Brushland	Mixed Coniferous Woodland	Salmonberry Brushland	Alder Woodland	Vegetation-less Peatland
<u>Aulacomnium androgynum</u>	+	-	-	-	+	+	-	-
<u>Aulacomnium palustre</u>	-	-	-	-	+	+	-	-
<u>Antitrichia curtispindula</u>	-	-	-	-	-	+	+	-
<u>Brachythecium sp.</u>	-	-	-	-	-	+	-	-
<u>Claopodium crispifolium</u>	-	-	-	-	+	-	+	-
<u>Dicranum fuscescens</u>	-	-	-	-	+	-	-	-
<u>Dicranum howellii</u>	+	+	+	+	+	+	+	-
<u>Dicranum scopdrium</u>	-	+	-	-	-	-	-	-
<u>Drepanocladus uncinatus</u>	-	-	-	-	-	+	-	-
<u>Eurhynchium oreganum</u> (<u>Stokesiella oreganum</u>)	+	+	+	+	+	+	+	-
<u>Eurhynchium praelongum</u>	-	-	-	-	+	+	-	-
<u>Fontinalis antipyretica</u>	-	-	-	-	+	-	-	-
<u>Homalothecium fulgescens</u>	-	-	-	-	-	-	+	-
<u>Hylocomium splendens</u>	-	+	-	-	+	+	+	-
<u>Hypnum circinale</u>	+	+	+	+	+	+	+	-
<u>Isopterygium elegans</u>	-	-	-	-	+	-	+	-
<u>Isothecium stoloniferum</u>	-	-	+	+	+	+	+	-
<u>Leucolepis menziesii</u>	-	-	+	-	+	-	+	-
<u>Mnium spinulosum</u>	-	-	-	-	+	+	-	-
<u>Neckera menziesii</u>	-	-	-	-	+	-	+	-
<u>Orthotrichum consimile</u>	-	-	+	-	+	+	+	-
<u>Orthotrichum pyellii</u>	-	-	-	-	+	+	+	-
<u>Plagiothecium undulatum</u>	-	-	+	-	+	+	+	-
<u>Pleurozium schreberi</u>	+	+	+	-	+	-	+	-

Moss Species	Heathland	Pine Woodland	Birch Woodland	Spirea Brushland	Mixed Coniferous Woodland	Salmonberry Brushland	Alder Woodland	Vegetation-less Peatland
<u>Polytrichum commune</u>	+	+	+	-	+	+	+	-
<u>Polytrichum juniperinum</u>	+	+	+	+	+	+	+	+
<u>Ptilium crista-castrensis</u>	-	-	-	-	+	-	-	-
<u>Rhizomnium glabrescens</u>	-	+	+	-	+	+	+	-
<u>Rhytidiadelphus loreus</u>	+	+	+	+	+	+	+	-
<u>Rhytidiadelphus triquetrus</u>	-	+	+	-	+	+	+	-
<u>Sphagnum angustifolium</u>	COM	OCC	-	-	+	-	-	+
<u>Sphagnum capillaceum</u>	VCM	COM	+	-	+	-	-	-
<u>Sphagnum fuscum</u>	COM	OCC	+	-	+	-	-	-
<u>Sphagnum palustre (type)</u>	COM	OCC	+	-	+	-	-	-
<u>Sphagnum squarrosum</u>	-	+	-	-	+	-	-	-
<u>Sphagnum tenellum</u>	-	+	-	-	-	-	-	-
<u>Tetraphis pellucida</u>	-	-	-	-	+	-	-	-

APPENDIX 2

Bird Species List, Status, Abundance and General Use of Major
Habitat Types in, and around, Burns Bog

Explanation of Terms:

Habitat: See Section 4.2.1.i, and Figure 11

Status: Mutually Exclusive Categories:

Resident - present all year and nests in
the area.

Wintering - present in winter and migration.

Summer - present in spring and summer months.

Transient - present in migrations.

Abundance: Relative Categories:

Common - widespread, occurring in large
numbers.

Uncommon - occurring in small numbers.

Rare - occasionally recorded in general
habitat type.

Note: Nomenclature after the 32 Supplement to the
American Ornithologists Union Checklist of
North American Birds. A.O.U. 1973.

NAME	HABITAT	STATUS	ABUNDANCE
<u>Ardea herodias</u> (Great blue heron)	Agricultural lands, sloughs and ditches	Resident	Uncommon
<u>Branta canadensis</u> (Canada goose)	Cutting lakes, and Agricultural lands	Wintering, some resident	Uncommon
<u>Anas platyrhynchos</u> (Mallard)	"	Wintering and resident	Common
<u>Anas strepera</u> (Gadwall)	"	Wintering	Rare
<u>Anas acuta</u> (Pintail)	"	"	Common
<u>Anas crecca</u> (Green-winged teal)	"	Wintering, some resident	"
<u>Anas discors</u> (Blue-winged teal)	"	"	"
<u>Anas cyanoptera</u> (Cinnamon teal)	"	Resident	Uncommon
<u>Anas penelope</u> (European wigeon)	"	Wintering	Rare

NAME	HABITAT	STATUS	ABUNDANCE
<u>Anas americana</u> (American wigeon)	Agricultural lands and cutting lakes	Resident, wintering	Common
<u>Anas clypeata</u> (Northern shoveler)	"	Wintering	"
<u>Aix sponsa</u> (Wood duck)	Agricultural lands	Resident	Uncommon
<u>Aythya americana</u> (Redhead)	Cutting lakes	Wintering	Rare
<u>Aythya collaris</u> (Ring-necked duck)	Cutting lakes, sloughs	Transient, wintering	"
<u>Aythya valisineria</u> (Canvasback)	Cutting lakes	Wintering	"
<u>Aythya marila</u> (Greater Scaup)	Cutting lakes, sloughs	"	"
<u>Aythya affinis</u> (Lesser scaup)	" "	"	"
<u>Bucephala clangula</u> (Common goldeneye)	" "	"	"

NAME	HABITAT	STATUS	ABUNDANCE
<u>Bucephala albeola</u> (Bufflehead)	Cutting lakes and ditches	Wintering	Rare
<u>Lophodytes cucullatus</u> (Hooded merganser)	Slough	"	"
<u>Accipiter gentilis</u> (Goshawk)	Agricultural lands	"	"
<u>Accipiter striatus</u> (Sharp-shinned hawk)	" "	Resident, wintering	"
<u>Accipiter cooperii</u> (Cooper's hawk)	Deciduous forest	Resident	"
<u>Buteo jamaicensis</u> (Red-tailed hawk)	Coniferous forest, agricultural lands	"	Uncommon
<u>Buteo lagopus</u> (Rough-legged hawk)	Agricultural lands	Wintering	"
<u>Haliaeetus leucocephalus</u> (Bald eagle)	" :	Resident	Rare
<u>Circus cyaneus</u> (Marsh hawk)	Cutting lakes, agricultural lands	"	Uncommon

NAME	HABITAT	STATUS	ABUNDANCE
<u>Falco rusticolis</u> (Gyr falcon)	Agricultural lands (near Boundary Bay)	Transient	Rare
<u>Falco peregrinus</u> (Peregrine falcon)	Agricultural lands	Wintering	"
<u>Falco columbarius</u> (Merlin)	" "	"	"
<u>Falco sparverius</u> (American kestrel)	" "	"	"
<u>Bonasa umbellus</u> (Ruffed grouse)	Deciduous forest	Resident	"
<u>Phasianus colohicus</u> (Ring-necked pheasant)	Agricultural lands	"	Uncommon
<u>Grus canadensis</u> (Sandhill crane)	Cutting lakes, agricultural lands	"	Rare
<u>Rallus limicola</u> (Virginia rail)	Agricultural lands	"	"
<u>Porzana carolina</u> (Sora)	Agricultural lands	Unknown	"
<u>Fulica americana</u> (American coot)	Sloughs, agricultural	Wintering	Uncommon

NAME	HABITAT	STATUS	ABUNDANCE
<u>Charadrius vociferus</u> (Killdeer)	Agricultural lands	Wintering	Uncommon
<u>Pluvialis squatarola</u> (Black-bellied plover)	" "	Transient	Rare
<u>Capella gallinago</u> (Common snipe)	Cutting lakes	Wintering	Uncommon
<u>Actitis macularia</u> (Spotted sandpiper)	Agricultural lands	Wintering	Uncommon
<u>Tringa melanoleuca</u> (Greater yellowlegs)	Cutting lakes ?	Transient	Rare
<u>Tringa flavipes</u> (Lesser yellowlegs)	" "	"	"
<u>Calidris alpina</u> (Dunlin)	" "	"	"
<u>Calidris mauri</u> (Western sandpiper)	" "	"	"
<u>Larus hyperboreus</u> (Glaucous gull)	Landfill site, Fraser River	Wintering	Rare
<u>Larus glaucescens</u> (Glaucous-winged gull)	Landfill sites	Non-breeding Resident	Common
<u>Larus occidentalis</u> (Western gull)	" "	" "	Uncommon.

NAME	HABITAT	STATUS	ABUNDANCE
<u>Larus argentatus</u> (Herring gull)	Landfill site	Wintering	Rare
<u>Larus thayeri</u> (Thayer's gull)	" "	"	"
<u>Larus californicus</u> (California gull)	Landfill site, agricultural land	Transient	Uncommon
<u>Larus delawarensis</u> (Ring-billed gull)	" "	"	"
<u>Larus canus</u> (Mew gull)	" "	Non-breeding Resident	Common
<u>Columba livia</u> (Rock dove)	Agricultural land	Resident	Common
<u>Columba fasciata</u> (Band-tailed pigeon)	Coniferous forest	Wintering	Rare
<u>Zenaida macroura</u> (Mourning dove)	" "	Resident	"
<u>Tyto alba</u> (Barn owl)	Agricultural land	Resident	"
<u>Otus asio</u> (Screech owl)	Coniferous and deciduous forest	"	"

NAME	HABITAT	STATUS	ABUNDANCE
<u>Bubo virginianus</u> (Great horned owl)	Coniferous forest, agricultural lands	Resident	Rare
<u>Nyctea scandiaca</u> (Snowy owl)	Agricultural lands	Wintering (occ.)	"
<u>Asio otus</u> (Long-eared owl)	Deciduous forest, agricultural lands	Resident	"
<u>Asio flammeus</u> (Short-eared owl)	Cutting lakes, agricultural lands	Wintering	"
<u>Aegolius acadicus</u> (Saw-whet owl)	Coniferous forest	Resident	"
<u>Chordeiles minor</u> (common nighthawk)	Agricultural lands	Summer	"
<u>Cypseloides niger</u> (Black swift)	--	Transient	"
<u>Chaetura vauxi</u> (Vaux's swift)	--	"	"
<u>Selasphorus rufus</u> (Rufous hummingbird)	Deciduous forest, Agricultural land	"	"

NAME	HABITAT	STATUS	ABUNDANCE
<u>Megasceryle alcyon</u> (Belted kingfisher)	River Road	Resident	Rare
<u>Colaptes auratus</u> (Common flicker)	Coniferous and deciduous forest	Resident	Uncommon
<u>Dryocopus pileatus</u> (Pileated woodpecker)	Coniferous forest	Resident	"
<u>Dendrocopos pubescens</u> (Downy woodpecker)	Coniferous forest	Resident	"
<u>Dendrocopos villosus</u> (Hairy woodpecker)	Coniferous and deciduous forest	"	Rare
<u>Tyrannus tyrannus</u> (Eastern Kingbird)	Agricultural lands	Summer	"
<u>Empidonax traillii</u> (Willow flycatcher)	Deciduous and Coniferous forest	Summer	Uncommon
<u>Empidonax hammondi</u> (Hammond's flycatcher)	"	"	"
<u>Nuttallornis borealis</u> (Olive-sided flycatcher)	"	"	"

NAME	HABITAT	STATUS	ABUNDANCE
<u>Tachycineta thalassina</u> (Violet-green swallow)	Agricultural land	Summer	Common
<u>Iridoprocne bicolor</u> (Tree swallow)	" "	"	Uncommon
<u>Hirundo rustica</u> (Barn swallow)	" "	"	Common
<u>Petrochelidon</u> <u>pyrrhonota</u> (Cliff swallow)	" "	"	Uncommon
<u>Cyanocitta stelleri</u> (Steller's jay)	Coniferous forest	Resident	Uncommon
<u>Corvus corax</u> (Common raven)	" "	"	Rare
<u>Corvus caurinus</u> (Northwestern Crow)	Coniferous and deciduous forest	"	Common
<u>Parus atricapillus</u> (Black-capped chickadee)	Deciduous and coniferous forest	"	"
<u>Parus rufescens</u> (Chestnut-backed Chickadee)	Coniferous forest	"	Uncommon

NAME	HABITAT	STATUS	ABUNDANCE
<u>Psaltriparus minimus</u> (Bushtit)	Deciduous forest	Resident	Rare
<u>Sitta canadensis</u> (Red-breasted nuthatch)	Coniferous and deciduous forest	"	"
<u>Certhia familiaris</u> (Brown creeper)	" " "	"	"
<u>Troglodytes aedon</u> (House wren)	Agricultural lands	Summer	"
<u>Troglodytes troglodytes</u> (Winter wren)	Coniferous forest	Resident	"
<u>Thryomanes bewickii</u> (Berwick's wren)	Coniferous and deciduous forest	"	"
<u>Telmatodytes palustris</u> (Long-billed marsh wren)	Agricultural land (Sloughs)	"	"
<u>Dumetella carolinensis</u> (Gray catbird)	Deciduous forest	Summer	"
<u>Turdus migratorius</u> (American robin)	Coniferous, deciduous forest & agricultural land	Resident	Common

NAME	HABITAT	STATUS	ABUNDANCE
<u>Ixoreus naevius</u> (Varied thrush)	Deciduous and Coniferous forest	Wintering	Rare
<u>Catharus guttatus</u> (Hermit thrush)	Coniferous forest	Summer	"
<u>Catharus ustulatus</u> (Swainson's thrush)	" "	"	Uncommon
<u>Regulus satrapa</u> (Golden-crowned kinglet)	" "	Resident	"
<u>Regulus calendula</u> (Ruby-crowned kinglet)	" "	Resident	"
<u>Anthus spinoletta</u> (Water pipit)	Agricultural land, sloughs	Transient	"
<u>Bombycilla cedrorum</u> (Cedar waxwing)	Deciduous and coniferous forests	"	"
<u>Bombycilla garrulus</u> (Bohemian waxwing)	" "	"	Rare
<u>Lanius excubitor</u> (Northern shrike)	Agricultural land	Wintering	"

NAME	HABITAT	STATUS	ABUNDANCE
<u>Sturnus vulgaris</u> (Starling)	Agricultural lands	Resident	Common
<u>Acridotheres</u> <u>crisatellus</u> (Crested mynah)	"	"	Rare
<u>Vireo huttoni</u> (Hutton's vireo)	Deciduous forest	"	"
<u>Vireo solitarius</u> (Solitary vireo)	Coniferous forest	Summer	"
<u>Vireo olivaceus</u> (red-eyed vireo)	Deciduous forest	"	"
<u>Vireo gilvus</u> (Warbling vireo)	" "	"	"
<u>Vermivora celata</u> (Orange-crowned warbler)	" "	"	"
<u>Vermivora ruficapilla</u> (Nashville warbler)	" "	Transient	"
<u>Dendroica petechia</u> (Yellow warbler)	" "	Summer	Uncommon

NAME	HABITAT	STATUS	ABUNDANCE
<u>Dendroica coronata</u> (Yellow-rumped warbler)	Coniferous and deciduous forest	Transient	Rare
<u>Dendroica nigrescens</u> (Black-throated gray warbler)	" "	Summer	"
<u>Dendroica townsendii</u> (Townsend's warbler)	Coniferous forest	"	"
<u>Oporornis tolmiei</u> (MacGillivray's warbler)	Agricultural lands and deciduous forests	"	Uncommon
<u>Geothlypis trichas</u> (Common yellowthroat)	Agricultural land	"	"
<u>Willsonia pusilla</u> (Wilson's warbler)	Deciduous forest	"	"
<u>Passer domesticus</u> (House sparrow)	Agricultural lands	Resident	Common
<u>Sturnella neglecta</u> (Western meadowlark)	" "	"	Uncommon
<u>Xanthocephalus</u> <u>xanthocephalus</u> (Yellow-headed blackbird)	Agricultural land (slough)	Summer	Rare
<u>Agelaius phoeniceus</u> (Red-winged blackbird)	" "	"	Uncommon

NAME	HABITAT	STATUS	ABUNDANCE
<u>Icterus galbula</u> (Northern oriole)	Deciduous forest	Summer	Rare
<u>Euphagus carolinus</u> (Rusty blackbird)	Agricultural land	"	Rare
<u>Euphagus cyanocephalus</u> (Brewer's blackbird)	" "	Resident	Common
<u>Molothrus ater</u> (Brown-headed cowbird)	" "	"	Uncommon
<u>Piranga ludoviciana</u> (Western tanager)	Deciduous forest	Summer	Rare
<u>Pheucticus melanocephalus</u> (black-headed grosbeak)	" "	"	"
<u>Hesperiphona vespertina</u> (Evening grosbeak)	Coniferous and deciduous forest	Resident	Uncommon
<u>Carpodacus purpureus</u> (Purple finch)	Agricultural land	Summer	Rare
<u>Carpodacus mexicanus</u> (House finch)	" "	Resident	Uncommon

NAME	HABITAT	STATUS	ABUNDANCE
<u>Spinus pinus</u> (Pine siskin)	Coniferous forest	Resident	Uncommon
<u>Spinus tristis</u> (American goldfinch)	Agricultural land	"	"
<u>Loxia curvirostra</u> (Red crossbill)	Coniferous forest	"	Rare
<u>Pipilo erythrophthalmus</u> (Rufous-sided towhee)	Agricultural land, deciduous forest	"	Uncommon
<u>Junco hyemalis</u> (Dark-eyed junco)	Agricultural land, coniferous and deciduous forest	"	Common
<u>Passerculus sandwichensis</u> (Savannah sparrow)	Agricultural land	"	Uncommon
<u>Spizella arborea</u> (Tree sparrow)	Deciduous forest	Wintering	Rare

NAME	HABITAT	STATUS	ABUNDANCE
<u>Spizella passerina</u> (Chipping sparrow)	Agricultural land	Summer	Rare
<u>Zonotrichia querula</u> (Harris' sparrow)	" "	Wintering	"
<u>Zonotrichia leucophrys</u> (White-crowned sparrow)	" "	Summer	Uncommon
<u>Zonotrichia atricapilla</u> (Golden-crowned sparrow)	" "	Transient	"
<u>Passerella iliaca</u> (Fox sparrow)	" "	Wintering	"
<u>Melospiza lincolni</u> (Lincoln's sparrow)	" "	Transient	Rare
<u>Melospiza melodia</u> (Song sparrow)	Agricultural land and deciduous forest	Resident	Uncommon

APPENDIX 3

Mammal Species List, and General Use of
Major Habitat Types in and Around Burns Bog.

Note: Nomenclature after Cowan and Guiget, 1962.

Mammal Species	General Habitat Type
<u>Didelphis marsupialis</u> (American opossum)	Coniferous and/or deciduous forests
<u>Sorex vagrans</u> (Wandering shrew)	Forested and hedgerow vegetation
<u>Scapanus orarius</u> (Coast mole)	Neighbouring agricultural lands
<u>Neurotrichus gibbsii</u> (Shrew mole)	Forested areas
<u>Lepus americanus</u> (Varying hare)	Forested and hedgerow vegetation
<u>Sylvilagus floridans</u> (Eastern cottontail)	Forested areas and "edge" vegetation
<u>Eutamias amoenus</u> (Northwestern chipmunk)	Coniferous forests and treed areas
<u>Tamiasciurus douglasi</u> (Douglas squirrel)	Coniferous forest
<u>Castor canadensis</u> (American beaver)	Wet deciduous areas at the bog's northern edge
<u>Peromyscus maniculatus</u> (Deer mouse)	Coniferous, deciduous forests, hedgerow and agricultural lands
<u>Microtus townsendii</u> (Townsend vole)	Forest edge and forested areas
<u>Microtus longicaudus</u> (Long-tailed vole)	Hedgerow vegetation and forest edge
<u>Ondatra zibethica</u> (Muskrat)	Drainage ditches surrounding the bog
<u>Erethizon dorsatum</u> (Porcupine)	Deciduous and mixed coniferous forest
<u>Canis latrans</u> (Coyote)	Forested areas and agricultural lands
<u>Vulpes fulva</u> (Red fox)	Forest edge vegetation and forested areas

<u>Mammal Species</u>	<u>General Habitat Type</u>
<u>Ursus americanus</u> (Black bear)	Forested area and open bog
<u>Procyon lotor</u> (Raccoon)	Forested areas and shrubbery
<u>Spilogale gracilis</u> (Spotted skunk)	Forested areas
<u>Odocoileus hemionus columbianus</u> (Columbian blacktail deer)	Forest edge and surrounding agricultural lands

APPENDIX 4

SPECIES LIST OF AMPHIBIANS AND REPTILES

Note: Nomenclature after Carl, 1966

Amphibians

1. Bufo boreas (Northwestern toad)
2. Hyla regilla (Pacific tree toad)

Reptiles

1. Thamnophis sirtalis (Northwestern garter snake)
2. Thamnophis ordinoides (Puget garter snake)