Some Ecological Effects of Beaver upon the Watersheds in the Porcupine Hills, Alberta.

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ABSTRACT.

This ecological investigation of the beaver (<u>Castor canadensis canadensis</u> Kuhl) was part of the Eastern Slopes (Alberta) Watershed Research program conducted during the summers of 1968, 1969, 1970, and 1971.

A soil particle size analysis indicated that soil heavy with clay was used by the beaver for construction purposes in the Porcupine Hills. Examples were given of the beaver controlling erosion with the construction of dams, and also causing erosion to occur. However, in general, the beaver slow down soil erosion and decrease the loss of soil from this region.

The beaver utilized measureable amounts of herbaceous vegetation. However, the utilization of herbs by the beaver requires further investigation. A system of exclosures and enclosures of herbaceous vegetation plots was used to study the utilization of sedges, grasses, and forbs.

The beaver indicated stronger species preference for willow as compared to aspen. The size preference for willow was in the 1.0 to 10.0 centimeters basal diameter classes, while the beaver utilization of aspen indicated a preference for the largest trees with basal diameter greater than 20.0 centimeters.

Willow was the most important plant in the low lying areas with regard to distribution, abundance and to produce sustained yield. The beaver used this plant for food and construction throughout the study area. The distribution of aspen was limited, and this species did not appear to produce more than one crop in the lifetime of a beaver colony. Nine out of 15

woody plant types were sampled by the beaver in this region. A plot-intercept transect technique was used for systematic vegetation sampling of the woody vegetation in six intensively studied watersheds.

The beaver population of the Porcupine Hills region of SW-Alberta is believed to depend upon the chinooks. During the 1971 ground census, a total of 60 active beaver colonies were tallied on the 930 square kilometers large study area. The beaver of the region were not found to store large food caches during fall and winter, however, they are believed to collect feed periodically throughout the winter months. It was observed that the severe winter in 1968-69, reduced by 27 per cent the number of active beaver colonies within the study area.

The Porcupine Hills region had 0.07 beaver colony per square kilometer in 1971, a low density of beaver colonies due to the rough topography of the area. However, the importance of the beaver ponds was somewhat clarified as they provide increased moisture, which lessens the fire damage, and store water for wildlife and cattle in the area.

Meteorological data was collected by the author in collaboration with the Department of Transport.

ACKNOWLEDGEMENTS.

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The completion of this part of the study owes a great deal to Mr. E. Telfer, Canadian Wildlife Service, who was the major field advisor and always offered assistance, suggestions and encouragement. The project was initiated while under the guidance of Dr. S. K. Sikes.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I. INTRODUCTION.

One aspect of the Eastern Slopes (Alberta) Watershed Research program includes the study of the ecological effects of beaver (*Castor canadensis canadensis* Kuhl) upon the watersheds in the Eastern part of the Rocky Mountains. This problem was attacked by studying the following features of beaver habitat: the factors effecting the climate, soil, herbaceous vegetation, woody vegetation, and a survey of the beaver colonies. This investigation should assist in understanding the total effect of beaver upon their environment in the Porcupine Hills. The objectives were as follows:

1. To determine the soil particle size requirements for successful construction of beaver lodges and dams.
2. To study the beaver's use of herbaceous plants during the summer.
3. To describe the associations of the woody vegetation of the beaver habitat in the Porcupine Hills, Alberta.
4. To determine the beaver's preference for certain plant species.
5. To determine if the beaver prefer certain plant sizes, based on basal diameter measurements.
6. To clarify the positive and negative roles of the beaver in the watersheds of the Porcupine Hills.
7. To estimate the beaver population of the Porcupine Hills.
8. To try to extrapolate the beaver's food requirements for the future on the basis of a well managed beaver population in the Porcupine Hills, Alberta.

A literature review of related investigations revealed that the physical factors suitable for beaver habitat were described by MacDonald (1956), Retzer et al. (1956), Novakowski (1965), Rutherford (1954, 1964), Semyonoff (1951), and Zhdanoff (1951). Vegetative characteristics of beaver habitat had been described by Aldous (1938), Knudsen (1962), and Tufts (1967).

Water must be present in sufficient depth and extent to provide protection from enemies, cover the entrance of the lodge and facilitate travel to, and storage of, the food supply (Williams, 1965). Water depths vary with latitude (Bailey 1927, Novakowski 1965, Semyonoff 1953, Symington and Ruttan 1956, Williams 1965, and Yeager and Rutherford 1957). Spring floods adversely affect the permanency of beaver structures by shifting river channels and breaking dams (Rutherford 1964, and Yeager and Rutherford 1957).

Constancy of flow appears to be the factor that insures the permanency of a colony site (MacDonald 1956, and Tufts 1967).

Streams dammed by beaver usually have a flow between 0.2 cubic feet per second (MacDonald, 1956), and 100 cubic feet (Cox, 1940). Stream gradient, as discussed in the literature, differs widely by region. Beaver concentrations are found in the more level areas (Swank, 1949). The limit for permanent beaver occurrance is about eight per cent gradient (Rutherford, 1955). Beaver habitat has been classified by valley grades (Retzer 1955, and Retzer et al. 1956); excellent (0 to 6 per cent); good (7 to 12 per cent); questionable (12 to 15 per cent); unsuitable (greater than 15 per cent).

Suitability of beaver dam sites depends on valley width.

The wider the valley the better the habitat is (Rutherford, 1964). All valleys that are wider than the stream channel are suitable for beaver habitation, and those valleys that were only channel wide were found to be unsuitable (Retzer 1955, and Retzer et al. 1956).

Location and dimensions of beaver dams were found to depend upon the topography (Cox 1940, Swank 1949, and Williams 1965). Beaver choose narrow outlets which permitted easier control of water runoff, Smith (1961) from Tufts (1967).

Soil condition is important for construction material in dams and lodges. Where soil conditions are suitable for burrowing into steep banks, the beaver will live in bank burrows rather than lodges (Hodgdon and Hunt 1955, Nash 1951, Symington and Ruttan 1956). Sandy banks prevent successful burrow digging because of cave-ins (Henderson, 1960). Least desirable soil types for beaver habitat are derived from shale or granitic rock (Retzer et al. 1956, and Rutherford 1955). Rutherford (1964) found that stream bottoms consisting almost entirely of sand and gravel were subject to channel shifting, which adversely affected the permanency of beaver structures.

Little information was available on the composition of the soil that beaver utilize in construction of dams. Several authors have indicated that sandy soil banks are unstable both for burrow digging and construction purposes (Henderson 1960, Rutherford 1955, and Yeager and Rutherford 1957). The soils containing clay mixed with sand and gravel can support bank burrows and are good for dam construction (Moore and Martin, 1949).

The beaver dams in the Porcupine Hills appeared to be stable, thus, an investigation of the composition of soil used for construction should aid in classifying the beaver habitats.

The importance of herbaceous vegetation in the beaver's diet has been neglected by most students of beaver ecology. Nash (1951) thought that herbaceous material, though of considerable importance as beaver food, should not be considered a limiting factor as it is usually present in abundant supply wherever the other requirements of beaver occupancy existed. The variety of foods during the summer includes grasses (Morgan, 1868), mushrooms and sedges (Mills, 1913), cow parsnips, thistles and wild geraniums (Warren, 1927), cat-tail, arrowhead, canary grass, sedges, with others (Semyonoff, 1951), sedges, reeds and water lilies (Retzer et al., 1956), and herbaceous vegetation (Brenner, 1962). MacDonald (1956) found that beaver feeding during the summer months cut small amounts of woody material during this season, but that herbaceous plants constitute the major food source during the warmer months of the year. He made no actual measurements of herbaceous material utilized, but stated that in his study areas in Colorado nearly three-fourths of the food consumed from about mid-spring until the middle of August was herbaceous material. Bradt (1938), Tevis (1950), and Brenner (1962) observed a tendency toward use of aquatic plants in summer. Hodgdon and Hunt (1955) found that aquatic plants were substituted for wood in the wintertime, when the brushpile stored for winter was lost. Even under these circumstances the condition of the beaver appeared normal in early spring.

During the summer months, the succulent parts of the woody plants are utilized, leaves and branches (Tevis, 1950), shoots and willow (Rudersdorf, 1952). The beaver do not store food during the summer and therefore the feeding habits vary and the intake of food is high (Brenner, 1962). Most authors agree that aspen constitutes the major woody plant utilized for food by the beaver (Tevis 1950, Retzer et al. 1956, Hall 1960, and Henderson 1960). Stegeman (1954) felt that the distribution of beaver was governed by the distribution of aspen. Willow was reported to be of equal importance at higher elevations or northern latitudes by Retzer et al. (1956), Rutherford (1964), Novakowski (1965), and Aleksiuk (1968). Some of the other woody plants utilized by the beaver are raspberries and roots (Morgan, 1968), wild rose bushes (Warren, 1927), hazel and Saskatoon berry (Bailey, 1927), birch and conifers (O'Brian, 1938), alder (Rudersdorf, 1952), shrubby cinquefoil (Retzer et al., 1956), red maple, black cherry, hawthorn, and hop hornbeam (Brenner, 1962), red osier dogwood, choke cherry, sweet gale, holly, maple, shadbrush, ash, beech, and others (Tufts, 1967). This author believes that preference for aspen might be due to its availability in newly established colonies, since aspen is a species that establishes itself under stable conditions (Novakowski, 1965), in locations where the topography is right for the establishment of beaver dam and lodge. Buckley (1950) found that availability preceded preference as a major factor in the feeding habits of beaver.

The preferred size of woody plants varied according to the plant species under consideration, and from location to

location. Haseltine (1950) found that availability had an effect on the choice of trees cut. Many authors have reported on the preference for certain diameter classes of aspen without considering availability: two inches (Hall, 1960), one to two inches (Hodgdon and Hunt, 1955), up to three inches (MacDonald, 1956), mostly small trees (Neff, 1956). Gibson (1957) found no size class preference for aspen.

The type of soil and moisture present often determines the vegetative type of any area. The staple food varies with the area (Williams, 1965). Important food in one locality may be scarcely used in another. The type of food eaten would include samples of all deciduous trees, many herbs, most aquatic plants and grasses. The feeding behaviour of the beaver thus indicate an adaptive availability attuned to seasonal availability and to quality.

Carrying capacity of the beaver habitat is influenced by the innate territorial behaviour of the species (Northcott, 1963). The factors that influence the territorial behaviour are population density, the amount of available food, the topography, and occurrence of suitable sites for construction of a beaver colony (Northcott 1963, and Novakowski 1965). Novakowski (1965) stated that the temporary abandonment of a colony by all its members during the summer increased the carrying capacity of the beaver habitat. Townsend (1953) felt that the population pressure may determine the limits of a colony.

Whatever the most important food species is, an adequate food supply for at least one year is required for a beaver

family to settle (Williams, 1965). Food supply available within foraging range was a necessity. The distance over land travelled for cutting trees varies with the topography of the land (personal observation). MacDonald (1956) observed that moderate slopes extended foraging range. Novakowski (1965) found the distance travelled to be rarely more than 100 feet; Stegeman (1954) 250 feet; and Symington and Ruttan (1956) 500 feet.

Degree of utilization of food material from the deciduous trees depends upon many factors. In the presence of abundance, beaver will be more wasteful than when food is scarce (MacDonald 1956, and Rutherford 1964). When a large aspen is felled near water, almost all the bark was removed (Hall, 1960). Several investigators have calculated over all waste due to various causes: Aldous (1938) 64 per cent, MacDonald (1956) 13 per cent, Stegeman (1954) 35 per cent in aspen over eight inches in diameter.

The beaver is a non-hibernating rodent that ranges throughout the province of Alberta (Soper, 1964). It spends the winter in a microenvironment of a lodge and a small area beneath the ice in the front of the lodge in a beaver dam made on a stream or in a lake. Novakowski (1967) stated that the beaver apparently depends entirely on food stored in a cache in the front of the lodge for its nourishment. Thus, the food was limited to the amount in the cache. The food was plentiful during the summer. The energy expenditure was attuned to the environmental food availability in northern beaver (Aleksiuk and Cowan, 1969). The energy expenditure followed the activity

of the thyroid gland, that was high during summer and low during winter (Aleksiuk, 1968). He further stated that the decrease in energy expenditure was an inherent attribute and not merely due to nutritional limitations. An adult beaver in the northern latitudes weighs between 18-23 kilograms (Aleksiuk, 1968 and Pearson, 1960). The relative food intake was similar for northern and southern beaver with maximal requirements of 60 grams per kilogram of body weight per day, from September to November-December, after which period the requirement decreased to 20 grams per kilogram of body weight per day in March, at which time the energy requirements increased again (Aleksiuk, 1968).

The subnivian environment protects the animals against extreme physical conditions (Formozow, 1946). The chinook winds of the Porcupine Hills, causes the protective snow cover to be of less importance due to its irregularity. Thus, the author feels the beaver in this region are subject to a higher stress factor compared to areas not affected by chinooks.

The beaver do come up from beneath the ice and feed during the winter (Semyonoff 1953, Brenner 1962, and Aleksiuk 1968). In the winter, the beaver feed on species surrounding the shoreline and do not travel inland to the main aspen feeding area (Brenner, 1962).

The number of beaver per colony may vary between one individual up to a theoretical maximum of ten, which includes the two parents, four young of the year and four young of last year. Novakowski (1967) estimated 12 beaver per lodge in his study area. Hammond (1943) measured the size of the food cache

and estimated number of individual beaver per colony. His estimates varied from 3.7 beaver in the smallest colonies to 9 beaver in the largest colonies. Denny (1952) calculated an average of 5.0 beaver per colony in Canada, and 5.2 in the United States. Bradt (1947) reported an average of 5.1 in Michigan. The density of beaver colonies was reported by Novakowski (1965) to be 0.7 active lodges per mile in Pine Creek, Wood Buffalo National Park, and by Buckley (1950) to be up to two beaver colonies per mile in North Dakota.

Beaver mortality is due to predation, disease, parasitism, and starvation. Accidents in tree felling may occur (Ellarson and Hickey, 1952). Predation of beaver by wolf and coyote was reported by Packard (1940), and Nash (1951). The black bear was the largest predator on the beaver (Hakala, 1952). Panfil (1964) listed three diseases that affect beaver: tularemia, tuberculosis and pasteurellosis. Tularemia was recorded by Nash (1951) in Manitoba and by Banfield (1954) in Waterton Lakes National Park, Alberta. Nash (1951) states that parasitism cause some deaths, but believes the effect to be negligible. Starvation appears to be insignificant according to the literature. Pearson (1960) felt the beaver suffered from malnutrition in the spring, and Lauckhart (1957) stated that malnutrition and not starvation causes mortality.

HISTORY OF THE PORCUPINE HILLS, ALBERTA.

The Porcupine Hills of Alberta were part of the domain of the Peigan Indians. They became known to the white man in 1792 or earlier, as was disclosed by Johnston (1971). He stated that the region was prospected for gold in the 1860's and exploited for furs during the 1870's. Cattle ranching began about 1881 with the passing of an order-in-council which permitted the leasing of 100,000 acres tracts for 21 years at an annual rental of one cent per acre. The area has remained as rangeland. The homesteaders tried to settle in the region from 1905 to 1915, but the climatic conditions, early frost and heavy snowfall during spring and fall, forced them out.

During the 1880's the rate of stocking the ranges was one head of cattle per 10 acres. This resulted in overgrazing from the beginning since the carrying capacity today has been established at one head of cattle per 20 acres of land. The grazing of cattle by the ranchers within the Porcupine Hills Forestry Preserves has in recent years enraged sportman's associations in Alberta. They feel that the region has a much higher value for recreational purposes and that production of wildlife should have preference. Due to public pressure, the Department of Lands and Forests in Alberta is presently slowly phasing out its cattle ranging leases by reducing number of heads allotted on any tract of forestry preserve in the region (Hume, pers. comm., 1971).

The beaver trapping was closed prior to about 1946, but for how long is not known. After the exploitation of furs in the

region during the 1870's, it is not unreasonable to believe the beaver had become extinct. This furbearer re-established itself during the 1940's and provided trapping again. From 1946 until about 1954-55, beaver trapping in the Porcupine Hills was open under a limited permit basis only (Woodward, pers. comm., 1970). Since about 1954-55, beaver trapping was open during seasons, from November 1 until May 15, on an unlimited basis. The region is divided into registered trapping areas including both lease land and forestry preserve. However, the native people (Indians) from nearby preserves can hunt and trap on all crown land in the region independent of white-man's regulations, that makes game management in this area extremely difficult.

CHAPTER II. DESCRIPTION OF STUDY AREAS.

General description of the Porcupine Hills, Alberta.

The Porcupine Hills study area (Figure 1) located in the foothills of southwestern Alberta (49° 50' N to 50° 08' N and 113° 55' W to 114° 16' W), ranges in elevation from 900 meters (3000 feet) of the prairie region in the East to 2450 meters (8000 feet) at the top of Livingston Range in the West. The beaver colonies may be found up to 1525 meters (5000 feet) altitude in Bob Creek. The higher elevations of Porcupine Hills, which reach 1800 meters (5900 feet) in altitude, have not been glaciated (Stalker, 1965). This formation was laid down in fresh-water lakes or rivers (Stalker, 1959) during the Eocene era, and is closely related to the Willow Creek formation. The area is located in the zone where the Laurentide glaciers from the plain met the Cordilleran glacier from the mountain in the West. The parent material deposited by the glaciers and its lake formations is of great diversity, but the sandstone and shales from the Porcupine Hills itself is well mixed into the parent material. The soils on the top of the Porcupine Hills were developed from strongly calcareous parent material (Pawluk et al. 1968), which is reflected in the soil surrounding the Porcupine Hills. Most of the soils in the valleys and lowlands between the foothill ridges have been derived from decayed rock on the ridges (Moss, 1955). Johnston (1970) classified the soil as Black Chernozems, high in nitrogen and organic matter.

The Porcupine Hills study area of 930 square kilometers (358 square miles) had in 1971 a density of 0.07 beaver colony

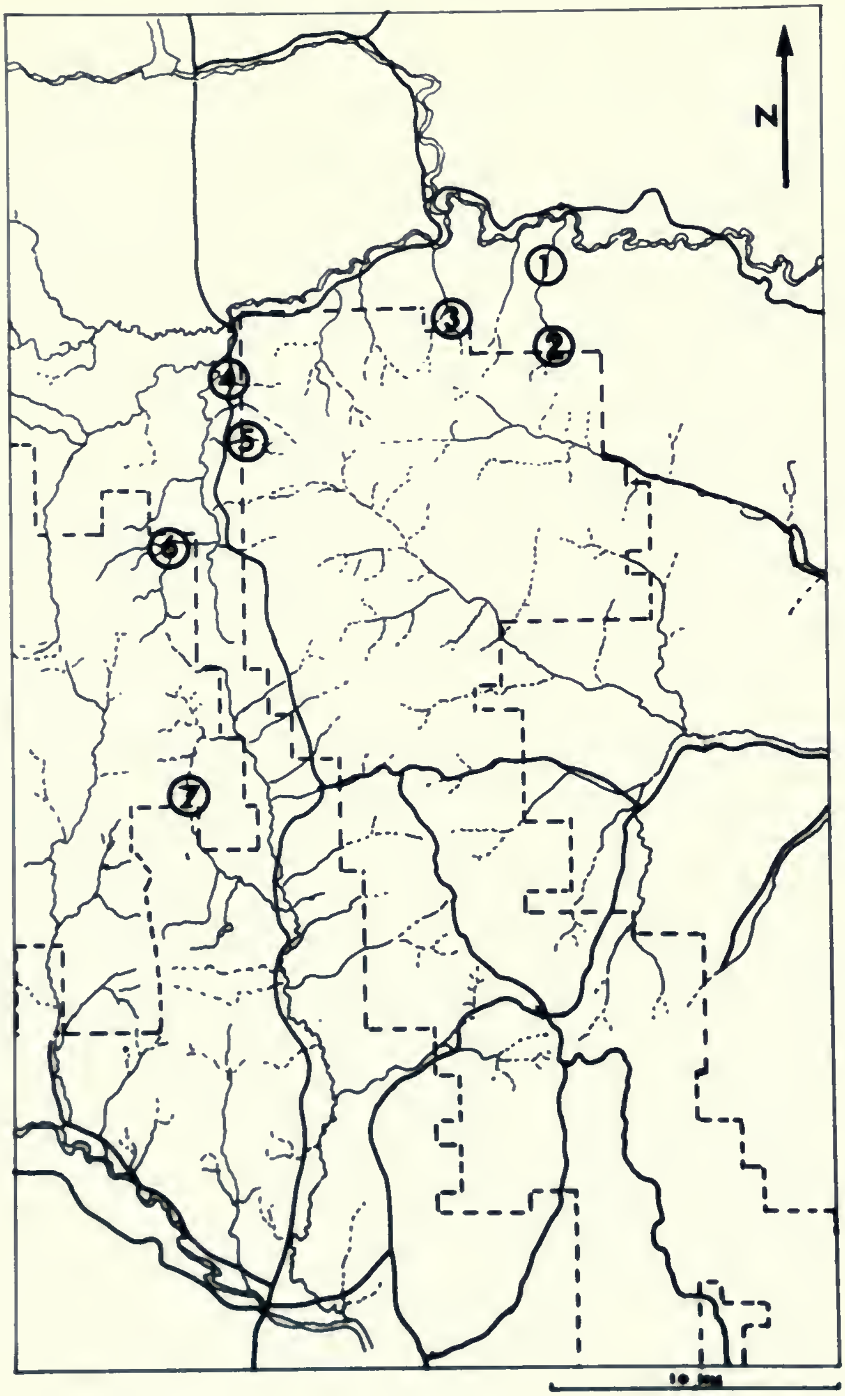

Figure 1. Location of study areas of the Porcupine Hills, Alberta: 1 - Johnson Creek I; 2 - Johnson Creek II; 3 - Streeter Basin; 4 - Camper Creek; 5 - Raspberry Creek; 6 - Hawkeye Creek; and 7 - Black Mountain beaver habitat. (Legend: _____ dirt road, - - - - Provincial Forestry Preserve boundary.)

per square kilometer (0.16 beaver colony per kilometer of stream). Drainage density is 0.45 kilometer of stream per square kilometer (Figure 1), which includes the intermittent streams. This low drainage density indicates an area of coarse texture with large individual elements of the topography (Strahler, 1966). Where there are wide open valleys of low gradient and adequate waterflow, beaver colonies may be found. MacDonald (1956) found in his study area a water flow of 0.2 cubic feet per second (.0057 cubic meters per second) was adequate for beaver colony establishment.

The Porcupine Hills study area, located in the Parkland region and partly in the Boreal-Cordilleran Transition zone (Moss, 1955), is cooler and more moist due to its higher elevation as opposed to the adjacent lowlands to the East. The area is located in the rain shadow of the Rocky Mountains to the West. A high number of semi-permanent springs in the area cause little flow in the creeks during summer. Yearly drought was due to two factors, long, dry summers causing a high evapotranspiration rate, and the layered sandstone formations causing streams to become intermittent even during relative high waterflow as in Burke and Sharples Creek.

The vegetation of the Porcupine Hills is varied. The higher elevations have softwood forests which include lodgepole pine (Pinus contorta), limber pine (Pinus flexilis), Engelman spruce (Picea engelmanni), white spruce (Picea glauca), and Douglas fir (Pseudotsuga taxifolia). The major hardwood species are dispersed among the conifers and in the low lying areas there are black poplar (Populus balsamifera), aspen (Populus tremuloides),

willow (*Salix* spp.), birch (*Betula glandulosa*, *Betula occidentalis*), wolf willow (*Elaeagnus commutata*) and Saskatoon berry (*Amelanchier alnifolia*). The shrubs of the higher elevations are juniper (*Juniperus horizontalis*, *Juniperus scopulorum*) and Labrador tea (*Ledum groenlandicum*). Rose (*Rosa acicularis*) and members of the honeysuckle family (Caprifoliaceae) are the two shrub types that best characterize the aspen parkland of the Porcupine Hills. Other important shrub species are shrubby cinquefoil (*Potentilla fruticosa*), gooseberry (*Ribes oxycanthoides*), raspberry (*Rubus strigosus*) and buffalo-berry (*Shepherdia canadensis*). Johnston et al. (1971) described the native open grassland of the Porcupine Hills region as that of the Fescue Grassland Association (as reported by Moss and Campbell, 1947). The author's investigation of the grassland of the lowlying areas of the northern Porcupine Hills, found fescue (*Festuca* spp., in particular *Festuca scabrella*) to be important, however, timothy (*Phleum pratense*), wheatgrass (*Agropyron* spp.) and sedge (*Carex* spp.) are the most common genera of the region at the present (Sverre, 1970). The northern grassland of the study area may be classified as mixed vigorous herbland, while the southern part by the Oldman River is typical short grass prairie.

The slope and aspect are important when considering the distribution of the vegetation of the Porcupine Hills region. Pawluk et al. (1968), found both slope and aspect to be very significant factors in the pedogenic development of the soil, since the vegetative cover can reflect various degrees of soil development. Lodgepole pine, white spruce, and Douglas fir

are commonly found on the cooler, shadier northerly and easterly facing slopes. The limber pine, the 'porcupine quills' of the Porcupine Hills, are able to withstand the direct sun on the dryer southerly facing slopes, and form an open community with the grass covered slopes. Due to lack of moisture, the limber pine is generally dwarfed on these slopes. The open grassland communities in the Porcupine Hills region are unique in Canada, and represent the northern limit of the Grassland Biome in Canada.

The mean annual precipitation for Streeter Basin, Porcupine Hills, was 56.7 centimeters (22.30 inches) from 1968 to 1970, (Figure 2), and of this an average of 40.4 centimeters (15.90 inches) fell (71 per cent) between April 1 and September 30, Water Survey of Canada (1968, 1969, 1970). The yearly mean temperature was 2.3^{o}C (36.1^{o}F) at Streeter Basin research station (Figure 3). The semi-arid to sub-humid climate of the area produces the best range land in Alberta, both for wildlife production and cattle grazing. The Porcupine Hills are located in the 'chinook' belt, (a warm dry wind from the west coast in winter that melts the snow and dries up the country, and extends the grazing of the rangeland throughout the winter months). If the 'chinooks' do not arrive, it is considered by the ranchers to be a hard winter and supplementary feed must be provided for the cattle.

The beaver (Castor canadensis canadensis Kuhl) are plentiful in the area, but only a few muskrats (Ondatra zibethicus spatulatus (Osgood)) have been observed. The major native ungulates are mule deer (Odocoileus hemionus hemionus (Rafinesque)), wapiti (Cervus canadensis nelsoni Bailey), moose (Alces alces),

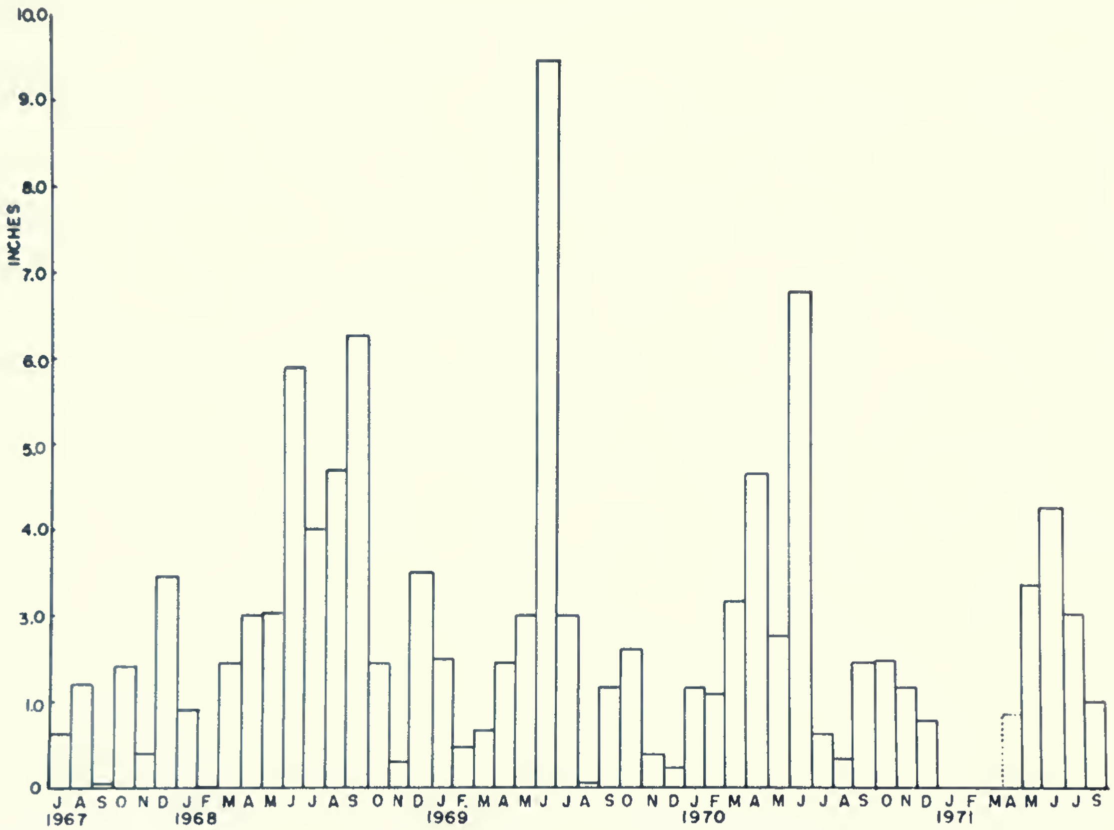

Figure 2. Histogram of monthly precipitation in inches at Streeter Basin, Alberta, (site 7) Water Survey of Canada (1967, 1968, 1969, 1970, and 1971) (Stippled line indicates incomplete data.)

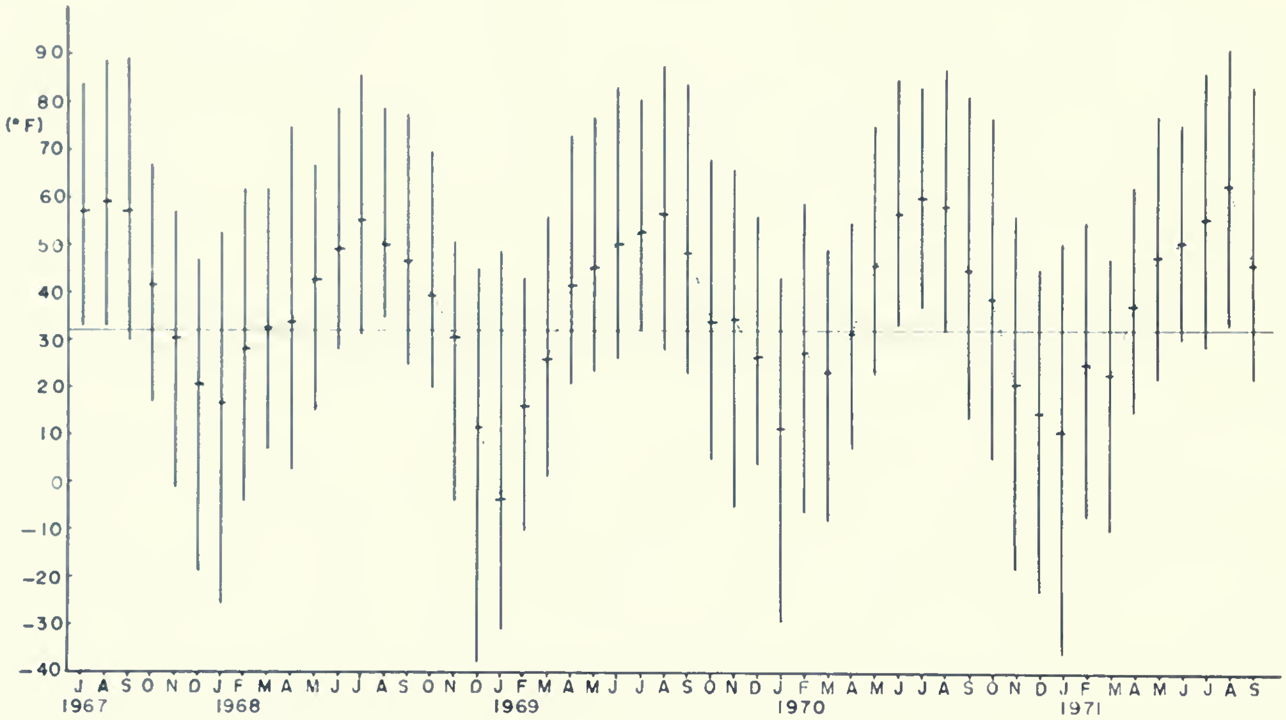

Figure 3. Mean monthly air temperatures plotted together with maximum and minimum monthly values in degree Fahrenheit. The data from site 7, Streeter Basin, Alberta. Water Survey of Canada (1967, 1968, 1969, 1970, and 1971)

and white-tailed deer (*Odocoileus virginianus ochrourus* Bailey) which only during the last few years have extended their range westward to include the Porcupine Hills. The study area has been considered the last stronghold of the mule deer population of Alberta. Black bears (*Euarctos americanus*) are common throughout the area, both black and brown color phases appeared to be of equal importance. Columbian ground squirrels (*Citellus columbianus columbianus* (Ord)) occupy the Porcupine Hills and westward, and meet on the eastern boundary of the range with Richardson ground squirrel (*Citellus richardsonii richardsonii* (Sabine)) and striped ground squirrel (*Citellus tredecemlineatus tredecemlineatus* (Mitchill)) which are respectively distributed over the treeless plains to the east and the aspen grove belt across the province. The Columbian ground squirrel is an important herbivore that is presently extending its range eastward. The same species is one of the most important prey species for the carnivores and birds of prey during the early part of the summer. Other observed species are chipmunk (*Eutamias minimus* and *Eutamias amoenus*), red squirrel (*Tamiasciurus hudsonicus richardsonii* (Bachman)) and Richardson pocket gopher (*Thomomys talpoides talpoides* (Richardson)). The Richardson pocket gopher is extending its range eastward into the Porcupine Hills study area, to the great dismay of the area ranchers. The white-footed mouse (*Peromyscus maniculatus*), meadow mouse (*Microtus pennsylvanicus*), red-backed vole (*Clethrionomys gapperi galei* (Merriam)), and jumping mouse (*Zapus princeps*) have been caught in traps.

The following mammalian predators are know to be present:

cougar (*Felis concolor missoulensis* Goldman), lynx (*Lynx canadensis canadensis* Kerr.), long-tailed weasel (*Mustela frenata longicauda* Bonaparte), Hudson Bay mink (*Mustela vison lacustris* (Preble)), American badger (*Taxidea taxus taxus* (Schreber)), northern plains skunk (*Mephitis mephitis hudsonica* Richardson), and finally the most common predator, the coyote (*Canis latrans latrans* Say.).

According to Fyfe (Pers. comm. 1970) the Porcupine Hills provide the best nesting area for predatory birds in SW-Alberta. A list of avian species observed in the Porcupine Hills is recorded in the appendix III.

Johnson Creek I.

The beaver colony under study is located at 50° 08' 00" N and 114° 00' 30" W (Figures 1 and 4). The creek is 6.5 kilometers long and drains North-East from Porcupine Hills into Willow Creek with the study area located 2 kilometers above the mouth. The study basin, located in long grass prairie type of habitat, has unbroken native grassland to the East, while on the West side the plow has broken the land and hay fields have been developed. Presently, beavers are occupying only the lower region that is mapped (Figure 4) at 1250 meters (4100 feet) elevation, but beaver 'scars' on trees along the creek tell of previous occupancy for several miles above the present colony. There was adequate water supply in the creek for beaver establishment during the 4 years of study. The surrounding field is used for wintering of bulls, which prevents the regrowth of the young willow (*Salix* spp.) by overbrowsing and destruction of the habitat in general.

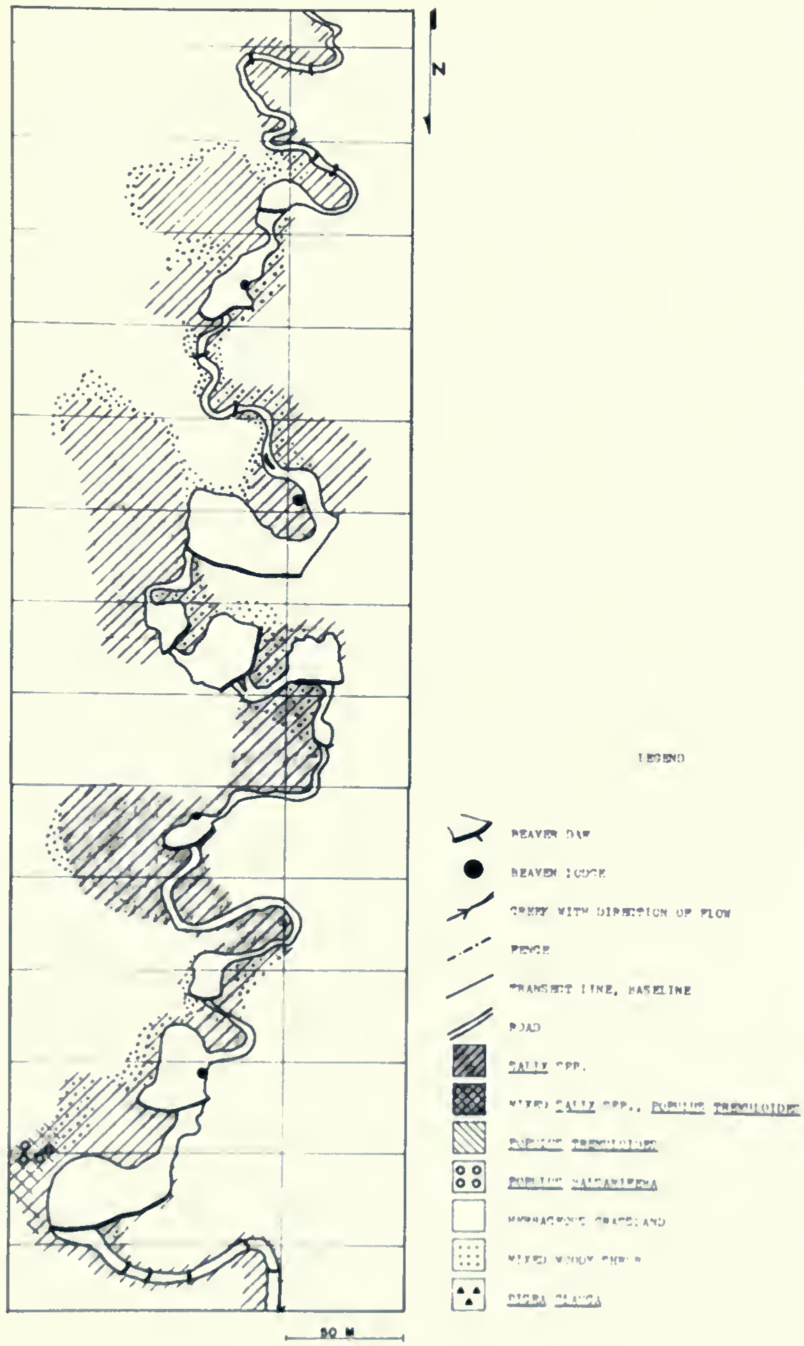

Figure 4. Johnson Creek I habitat map.

Willow is growing along the stream banks (Figure 5) and around the beaver dams and is providing the main food reserve for the beaver. Small stands of aspen (Populus tremuloides) have been completely utilized by the beaver. Wolf-willow (Elaeagnus commutata) and Saskatoon berry (Amelanchier alnifolia) are the second most important woody plants. The gradient of the stream is 3 per cent (2 degrees).

The plot-intercept study area covers 990 ares (24.5 acres) (Figure 4) of which 390 ares (9.6 acres) were broken grassland, thus only 600 ares (14.8 acres) were actually sampled for woody plants. Fourteen transect lines were laid out at right angles to the baseline. The transect lines were spaced 40 meters apart. The baseline (560 meters) followed the main direction of the creek (S 20° N) and is drawn on the map (Figure 4). The width of the mapped area is 170 meters which is the maximum length of any transect line. One hundred and nineteen plots of three quadrat sizes were sampled in this area of 600 ares, thus the ground coverage values were: quadrat size 4 x 4 square meters - 3.17 per cent; quadrat size 2 x 2 square meters - 0.78 per cent; quadrat size 1 x 1 square meter - 0.20 per cent.

Johnson Creek II.

This potential beaver habitat is located at 50° 06' 25" N and 114° 00' 30" W (Figure 1). The study area is located on the same watershed as Johnson Creek I, but 3 kilometers higher up the creek at an elevation of 1340 meters (4400 feet). The aspect of the creek is due North, and the overall slope of the mapped section of the creek is 4 per cent (3 degrees). The study area

Figure 5. The willow habitat at Johnson Creek I.

Figure 6. The mixed willow and aspen habitat at Johnson Creek II.

is situated on the edge of the deciduous forest of the Porcupine Hills adjacent to an aspen stand (Figure 7) to the West, while on the East a hayfield is located. The main vegetation growth immediately adjacent to the creek is overmature willow (Salix spp.) (Figure 6), but an aspen stand is easily accessible. No sign of beaver ever utilizing this site could be found. The plot-intercept study area covers 180 ares (4.4 acres).

The direction of the 200 meters long baseline was S 20° E with a permanent stake put into the ground at the northern end of the study area (Figure 7). The first of five transect lines was located 30 meters (from random tables) from the permanent stake, and thereafter the transect lines were spaced 40 meters apart. Each transect line was 90 meters long. Thirty-seven plots of 3 quadrat sizes were surveyed. The ground coverage values were: quadrat size 4 x 4 square meters - 3.29 per cent; quadrat size 2 x 2 square meters - 0.82 per cent; quadrat size 1 x 1 square meter - 0.21 per cent.

Streeter Basin.

The abandoned beaver colony under study is located at 50° 07' 00" N and 114° 03' 30" W (Figure 1). The Streeter Creek is 5 kilometers long and drains North into South Willow Creek. The average gradient of the creek is 10 per cent (7 degrees) with a 5 per cent (3 degrees) slope at the site of the beaver dams. There was a mean discharge of 0.27 cubic feet per second over a three year period, this was adequate watersupply in the creek for beaver establishment during the study (Figure 8). The altitude is 1326 meters (4350 feet) at this typical aspen-parkland habitat

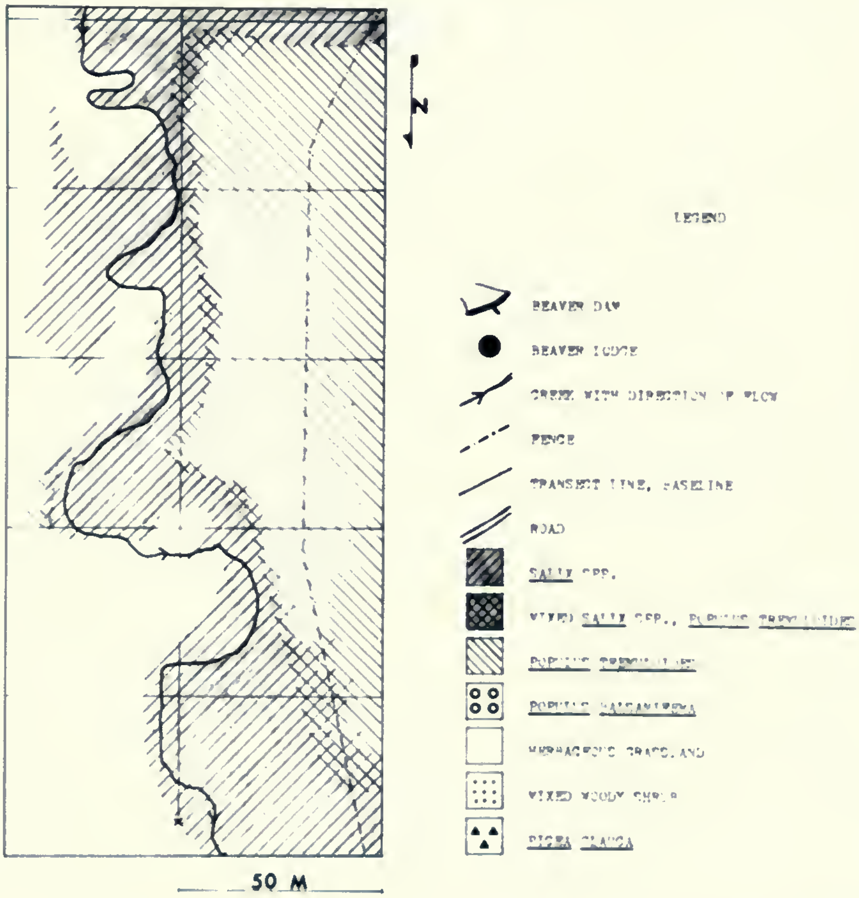

Figure 7. Johnson Creek II habitat map.

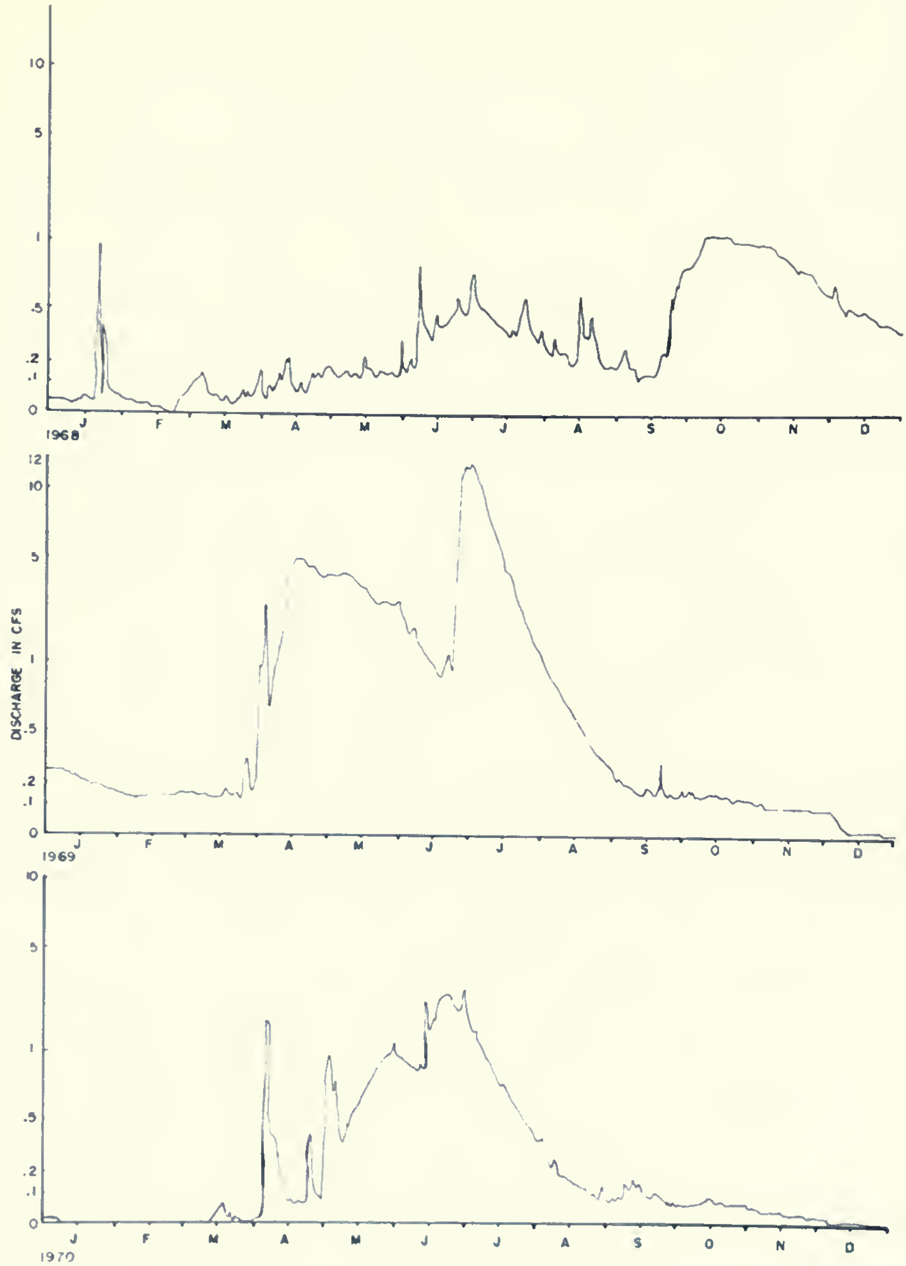

Figure 8. A continuous hydrograph of the discharge of water in cubic feet per seconds (CFS) at Streeter Creek main stream, Water Resources of Canada (1968, 1969, and 1970).

(Figure 9) with rose (Rosa spp.) underbrush type interrupted by sedge (Carex spp.), wheat grass (Agropyron spp.) and timothy (Phleum pratense) type grassland adjacent to the beaver dams (Figure 10). The sedge, wheatgrass and timothy type of grassland appears to be able to withstand heavy grazing. This area is grazed by cattle each year between October and April. The willow (Salix spp., mostly Salix banksiane) provides the major re-growth of woody vegetation after the beaver has removed the aspen (Populus tremuloides) (Figure 9). Most of the willow is presently overmature within the study area. The beaver dam complex under study was abandoned during 1967 and has not been re-occupied. The skeleton of one adult beaver was found in the estuary of the dam during the summer of 1969, probably the beaver of 1967 (cause of death might have been natural).

The Streeter Basin is the major research basin of the Porcupine Hills as 15 other agencies are involved or have been involved in co-operative watershed research here. It is probably one of the best studied watersheds in Alberta, with background information on soil, bedrock, climatic, vegetative, meteorological and hydrological data collected since 1964.

The Streeter Basin study area covers 450 ares (11.1 acres) (Figure 9) which were sampled for woody vegetation by the plot-intercept study. Twelve transect lines, spaced 30 meters apart, were laid out at right angles to the 373 meters long baseline. The baseline direction was N 20° W, and the first transect line was 13 meters from the stake (from table of random numbers). The maximum length of a transect line was 154 meters and the shortest was 34 meters (Figure 9). Data from two hundred and twenty-five

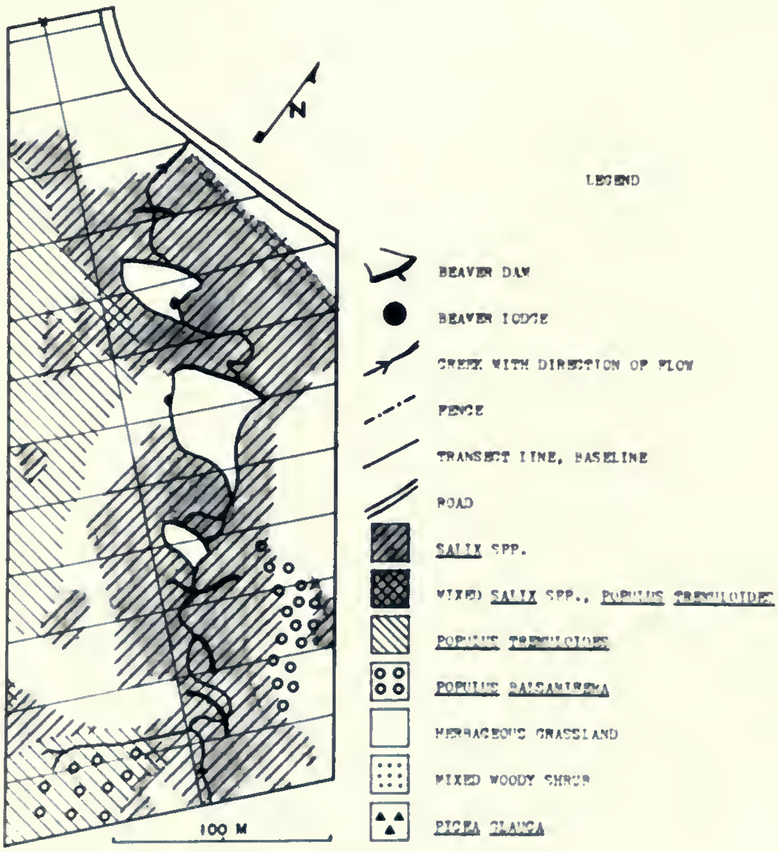

Figure 9. Streeter Basin habitat map.

Figure 10. The beaver habitat in Streeter Basin. Mostly overmature willow was left after clearing of aspen by the beaver.

Figure 11. The beaver habitat of Camper Creek. Mark the deposition of sediment in the beaver pond.

plots of three quadrat sizes was collected. On transect line numbers 1-6, which represents 171 ares, one hundred and forty-seven plots were selected (147 plots out of 225 plots), because in the beginning of the experiment a complete count of all the plots along a transect line was made, however, due to lack of time only every third plot was included in the analysis. Thus, on transect line numbers 7-12, only 78 plots were selected on the 279 ares these transect lines represent. Ground coverage values for transect line numbers 1-6 were: quadrat size 4 x 4 square meters - 13.76 per cent; quadrat size 2 x 2 square meters - 3.44 per cent; quadrat size 1 x 1 square meter - 0.86 per cent. Ground coverage values for transect line numbers 7-12 were: quadrat size 4 x 4 square meters - 4.47 per cent; quadrat size 2 x 2 square meters - 1.12 per cent; quadrat size 1 x 1 square meter - 0.28 per cent. All measurements from this watershed were calculated into number of plants per unit area for each of the ground coverage values obtained, and the mean numbers were used for comparison.

Camper Creek.

The beaver colony under study is located at 50° 06' 00" N and 114° 10' 00" W (Figure 1). The Camper Creek, 2.5 kilometers long, drains into Nelson Creek. The aspect of the creek is West-facing, with an average slope of 13 per cent (8 degrees). The gradient of the creek where dams were constructed was 7 per cent (5 degrees). The mapped beaver habitat (Figure 12) is located at an altitude of 1326 meters (4350 feet) of typical aspen-parkland habitat. The aspen (Populus tremuloides) appeared

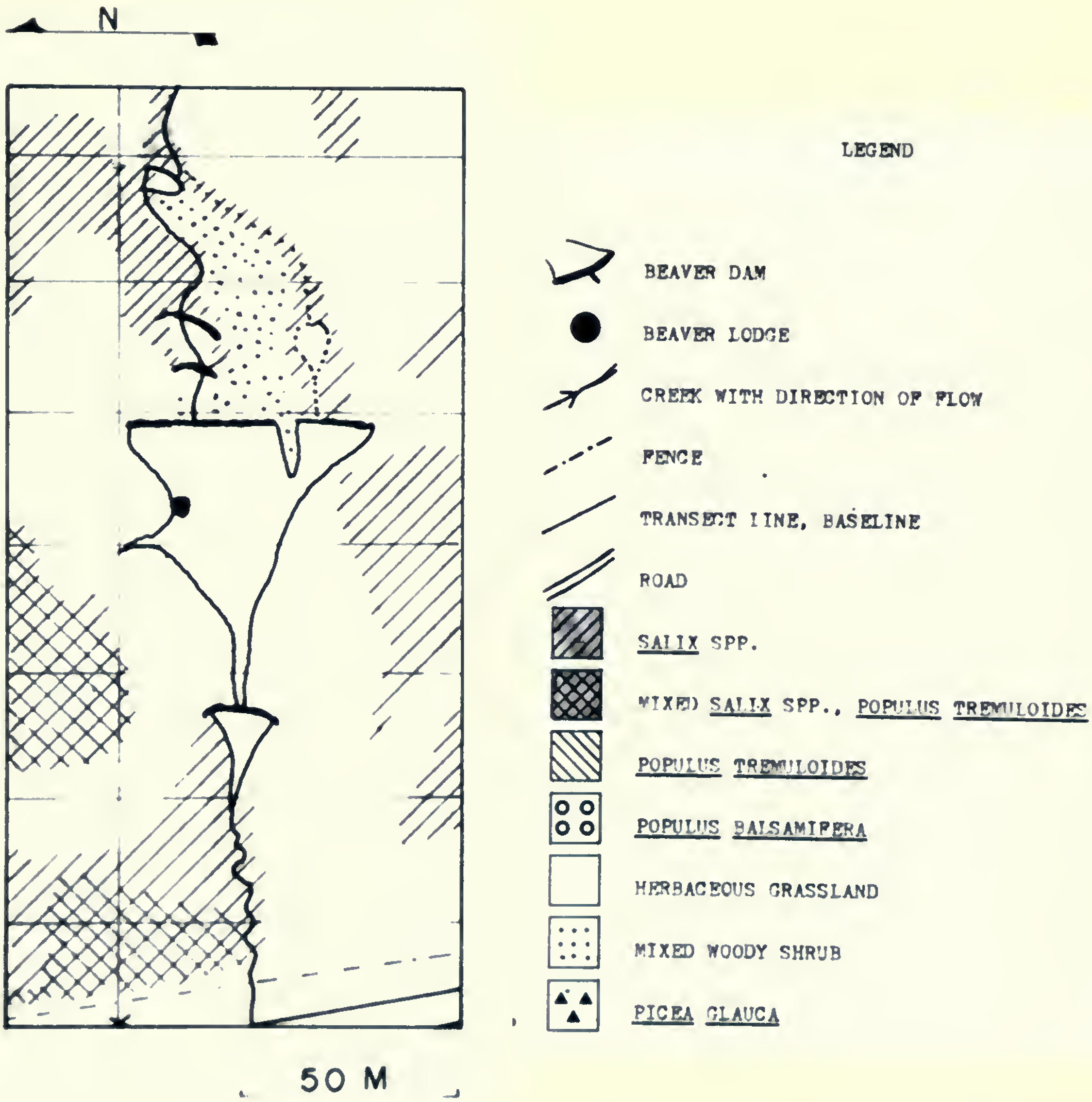

Figure 12. Camper Creek habitat map.

to be readily available (Figures 11 and 12), and the willow (*Salix* spp.) was younger and of smaller diameter than in Streeter Basin. The shrubs were mainly rose (*Rosa* spp.) and wolf willow (*Elaeagnus commutata*). The grassland type of habitat was largely composed of rough fescue (*Festuca scabrella*), timothy (*Phleum pratense*) and sedge (*Carex* spp.). The area is grazed by cattle during the summer months. There appeared to be sufficient flow of water in the creek during the summer to allow permanent beaver occupancy. The beaver colony was abandoned by the beaver during the spring of 1970, only one year after the plot intercept study was completed at this location.

Camper Creek study area covers 183 ares (4.5 acres) (Figure 12), which were sampled for woody vegetation by the plot-intercept method. Seven transect lines, spaced 30 meters apart, were laid out at right angles to the 204 meters long baseline. The baseline direction was W 90° N, and the first transect line was 24 meters from the permanent stake. The length of each transect line was 90 meters. Data from fifty-eight plots were collected for the plot-intercept study. The ground coverage values were: quadrat size 4 x 4 square meters - 5.07 per cent; quadrat size 2 x 2 square meters - 1.27 per cent; quadrat size 1 x 1 square meter - 0.32 per cent.

Raspberry Creek.

The potential beaver habitat under study is located at 50° 04' 40" N and 114° 09' 40" W (Figure 1). Raspberry Creek study area has an altitude of 1356 meters (4450 feet). The creek is facing West, with an average slope of 12 per cent (8 degrees),

however, the gradient at the mapped area is 4 per cent (3 degrees). The creek drains into Nelson Creek. The habitat is aspen-parkland type (Figure 13), but with a heavy predominance of black poplar (Populus balsamifera) (Figure 14). The black popular and willow (Salix spp.) are overmature at places. Aspen stands (Populus tremuloides) with heavy rose (Rosa spp.) underbrush are killing off the willow. The area is grazed by cattle during the summer months. There appears to be sufficient flow of water in the creek at the mapped site during summer to allow permanent beaver occupancy.

Raspberry Creek study area covers 220 ares (5.4 acres) (Figure 13), which were sampled for woody vegetation by the plot-intercept method. Six transect lines, spaced 40 meters apart, were laid out at right angles to the 243 meters long baseline. The baseline direction was E 90° N, and the first transect line was 9 meters from the permanent wooden stake. The length of each transect line was 88 meters. Data from forty-two plots of different quadrat sizes were collected. The ground coverage values were: quadrat size 4 x 4 square meters - 3.05 per cent; quadrat size 2 x 2 square meters - 0.76 per cent; quadrat size 1 x 1 square meter - 0.19 per cent.

Hawkeye Creek.

The beaver colony under study is located in Breeding Valley at 50° 02' 40" N and 114° 11' 40" W (Figure 1). The Hawkeye Creek is 5 kilometers long and drains mainly North and then East into Nelson Creek. The mapped area (Figure 16) is located at an altitude of 1372 meters (4500 feet) with an average gradient of

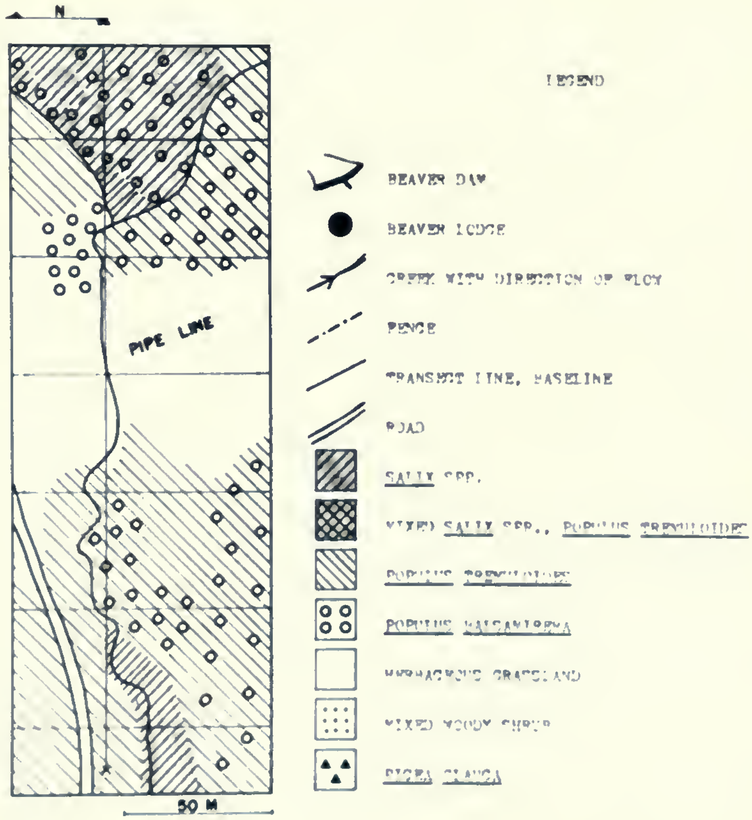

Figure 13. Raspberry Creek habitat map.

Figure 14. The potential beaver habitat of Raspberry Creek.

Figure 15. The main beaver colony at Hawkeye Creek. The aspen was cleared from the valley bottom and this created improved grazing condition.

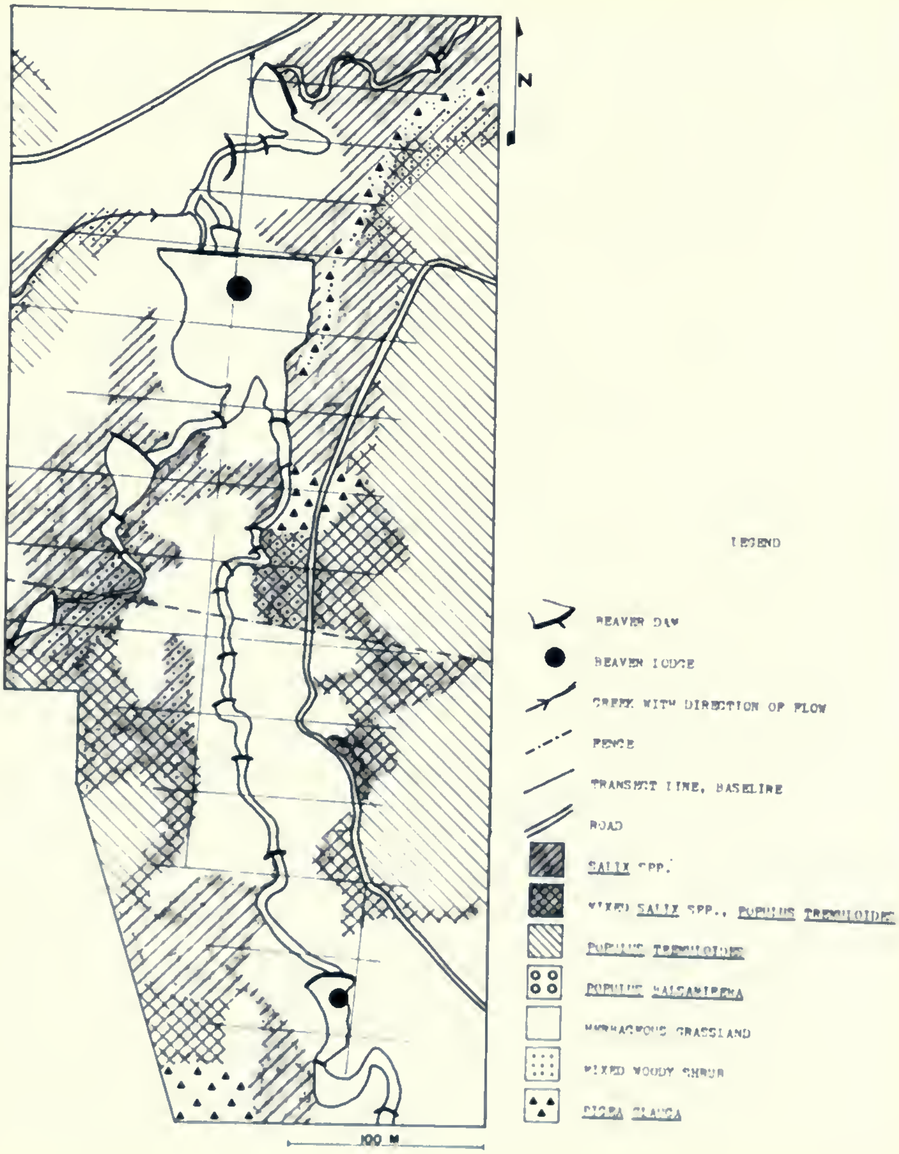

Figure 16. Hawkeye Creek habitat map.

the creek of 13 per cent (9 degrees). The study basin is located in aspen-parkland type of flora, but it is divided up by coniferous stands, and by open weedy grassland on the steeper slopes (Figure 15). Presently, the most important grasses are: sedge (Carex spp.), timothy (Phleum pratense), Parry oat grass (Danthonia parryi), inland blue grass (Poa interior) and of less importance are the genera, Bromus, Festuca and Agropyron. The East facing bank has an average gradient of 7 per cent (5 degrees), and the West facing slope has an average gradient of 34 per cent (22 degrees). No part of this study area has been broken for agriculture, but grass seeds have been distributed to create better grazing for the cattle. The location of this beaver colony is a classic example of good beaver habitat, a wide flat valley bottom of low gradient where a beaver meadow has been forming through the ages (Figure 15). The habitat of predominant willow (Salix spp.) adjacent to the creek is able to withstand continous utilization by the beaver. Birch (Betula glandulosa) provides extra woody material in this area. The white spruce (Picea glauca) is the only conifer present. The active beaver colony is located at the northern end of the area mapped and has been occupied throughout the four years of study (Figure 16). It does not appear that this colony is depleting its food resource. The study area on the South side of the fence is located within the Provincial Forestry Preserve, while on the North side of the fence is leased land. Both sides of the fence are grazed by cattle during summer months, but the northern area receives the heaviest grazing pressure as it often serves as a bull and horse pasture during the winter months. The Hawkeye

Creek usually has sufficient flowing water to keep the beaver dams filled, however, during dry years no water flows in the creek, and the beaver dams provide the only water available for cattle and wildlife in the area.

The plot-intercept study area covers 585 ares (14.5 acres) of the total mapped area of 1,304 ares (32.2 acres) (Figure 16). Fourteen transect lines were laid out at right angles to the baseline. The baseline (503 meters) follows the main direction of the creek (S 30^{o} W), as drawn on map (figure 16). The first 4 transect lines were spaced 30 meters apart and the other 10 transect lines were spaced 40 meters apart. The 3 initial transect lines of 100 meters with complete coverage of all plots per transect line (ie. 25 plots per 100 meters) represented 88 ares out of the 585 ares. Seventy-five of the 180 plots were located on the 3 first transect lines. On the next 11 transect lines, every third plot was tallied, and they were spaced 40 meters apart. This was done to improve the efficiency due to the time allotted for the project. Thus, on transect line numbers 4 to 14, 105 plots of three quadrat sizes were investigated and the number of woody stems present and or utilized was recorded. These 11 transect lines represented 497 ares. The ground coverage values for transect line numbers 1-3: quadrat size 4 x 4 square meters - 13.64 per cent; quadrat size 2 x 2 square meters - 3.41 per cent; quadrat size 1 x 1 square meter - 0.85 per cent. The ground coverage values for transect line numbers 4-14: quadrat size 4 x 4 square meters - 3.38 per cent; quadrat size 2 x 2 square meters - 0.84 per cent; quadrat size 1 x 1 square meter - 0.21 per cent.

Black Mountain.

Black Mountain beaver colony is located at 49° 55' N and 114° 10' W (Figure 1). The runoff from the beaver-enlarged natural pond is draining northward into Black Creek. The elevation of the pond is 1420 meters (4650 feet). The pond located in Breeding Valley (Figure 17) is perhaps the most important watering station for the northern part of Valdron Ranch Ltd.

The habitat at Black Mountain beaver colony is native grassland on the southfacing slopes (Figure 18), while on the northfacing slopes and in the coulees, the aspen (*Populus tremuloides*) and willow (*Salix* spp.) constitute the major hardwood species. Tongues of soft wood, mainly Douglas fir (*Pseudotsuga menziesii*) and white spruce (*Picea glauca*) extend from the surrounding hilltops, down along the coulees almost to the beaver pond.

The Cordilleran glacier from the mountains in the West deposited the parent material, and rounded off the hills. The rolling hills, best characterize the fertile county that is covered with Black Chernozems soil (Johnston, 1970).

The Black Mountain pond covers 96.4 ares (Figure 17), is shallow, and no runoff occurs during the summer. There is no creek entering the pond. Evaporation causes the water to drop from 1.0 to 1.5 feet during the summer. It is not known if there are any springs within the pond but this is anticipated since water loss appears to be slight. Runoff water from surrounding hills during fall and spring is believed to give the major influx of water.

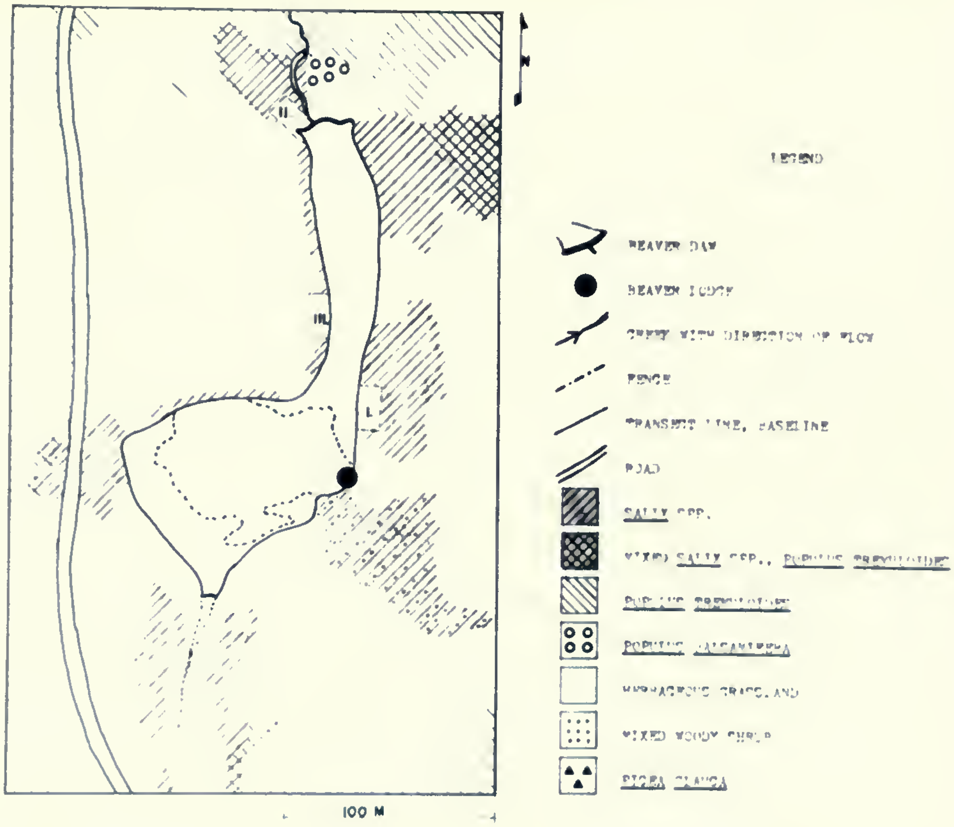

Figure 17. Black Mountain beaver habitat. (Study areas I, II, and III are marked on the map.)

The beaver habitat appeared rather marginal with old willow (mainly Salix bebbiana) supplying the major food resource (Figure 18). Aspen was available, but its distance from the pond might have been the factor limiting its use by the beaver. Two stands of aspen were utilized, one stand was located approximately 50 meters from the pond, the other aspen stand was in excess of 70 meters away from the edge of the water. However, some young aspen trees were dispersed throughout the willow stands.

The beaver colony has been active for several years and it is presently occupied by one adult pair and the young of the year. Two families of muskrat inhabited the beaver pond, but it is not believed these animals influenced the study as they kept to areas of the pond other than where the enclosures were located. During July and August, 1971, 9 American widgeons, 3 Barrow's goldeneye, 10 Greenwing teal, and 16 Mallards occupied the beaver pond. The major predators were coyote, skunk, red-winged hawk, and golden eagle.

The major herbivores were moose, elk, mule deer and cattle. The cattle grazed the whole range in the period from August 1, to September 30, and salt blocks were put out to disperse the herd of several hundred animals throughout the grassland. Due to the lack of watering holes, the cattle congregated at the beaver pond and stripped the vegetation immediately around it, thus removing the herbaceous vegetation most accessible to the beaver.

Figure 18. Black Mountain beaver pond. (The fenced in areas represent study area I (furthest away) and study area III (closest).)

Figure 19. The meteorological instrumentation at site 7 in Streeter Basin. (The following instruments were present, from left; class A evaporation pan, hydrothermograph, precipitation intensity recorder, standard rain gauge, anometer, and finally the activity recorder.)

CHAPTER III. METHODS AND MATERIALS.

Hydrometeorological instrumentation of Streeter Basin, Alberta.

Measurements of evaporation during the summer months were made by the author throughout the study at site 7 in Streeter Basin (Figure 19). A Standard Class A pan was employed.

Precipitation was measured daily during the summer by Vertical M.S.C. Standard Rain Gauge. A M.S.C. 'Tipping Bucket' rain gauge was used in determining the intensity of the precipitation for both rain and snow (Figure 19). Air temperature and moisture were recorded on an utomatic Hydrothermograph that was checked once a week (Figure 19).

All meteorological instruments were provided and maintained by Meteorological Branch, Department of Transport, Government of Canada.

All hydrometeorological data from Streeter Basin, Alberta, have been assembled in 'Compilation of Hydrometeorological Record Streeter Creek Basin', Water Survey Canada, Department of the Environment, in volumes number 3 to 7, representing the years 1967 to 1971.

Soil temperature data was available for the period January 1967 to October 1968, at which time the project was terminated. The temperatures were obtained by 10 thermistors (Y.S.I. #44003) located from the soil-humus interface down to 72 inches (1.8 meters). Readings were made once a week with a locally built meter with an accuracy of 0.1^{o} C. The soil temperature in an East-facing aspen stand, site number 4, Streeter Basin, had been plotted to indicate the changes that occurred throughout the

year from the soil-humus layer down to 24 inches (0.6 meter).

Stream flow throughout the year was measured in Streeter Basin, of which only the data from the main stream was employed in this study, to represent the fluctuation of waterflow in the creeks through the Porcupine Hills study area. The stream flow, discharged in cubic feet per second, was plotted with distorted scale to emphasize the fluctuations over a three year period (1968-70). The discharge was measured continuously with Stevens recorder. "The main stem stream gauge control is a 3.5 foot head H-type flume complete with a negator drive recorder. The flume throat section is metal with a prefabricated, rigidly attached well. The approach section is constructed of penetreated woody and has a side sloping floor to facilitate the passing of bed load sediment material at low flows." (Water Survey of Canada, 1970).

No other study area was instrumented for meteorological studies. However, the meteorological data obtained from the Porcupine Hills Ranger Station, Department of Lands and Forests, was compared with the data from Streeter Basin to determine if there were any significant differences between the two locations. None was observed for the temperature, as the yearly mean temperature was 35.8^{o} F, only 0.3^{o} F less than in Streeter Basin. One inch less moisture fell at this site, which was located 60 kilometers apart at 75 meters higher elevation.

Slope measurements were made by a slope measuring instrument, called type: PM - 5/PC66 Suunto Instrument, made in Helsinki, Finland. The instrument reads the angle of any slope directly both in percentage and in degrees.

Soil particle size analysis.

The soil samples were taken from the actual beaver dams, as this soil analysis was to be of soil used only for construction by the beaver. This soil from the dams might be somewhat diluted from silt carried by the streams with the smallest particles, however, the samples were made of the most recent beaver deposited soil to eliminate this problem. The soil samples were collected systematically from active beaver dams of the Porcupine Hills.

The soil samples were collected in plastic dishes due to the high water content in the samples. The plastic dishes were kept without a lid until all excess water had evaporated (Figure 20). Thereafter, the samples were air-dried in paper bags. The evaporation of excess water prevented any loss of clay material in the drying process.

A unique feature of the hydrometer methods was the fact that the personal element was reduced to a minimum. The success of the experiment depended upon a complete dispersion of the soil, which could only be accomplished when the paddle on the stirring rod or shaft was in good condition.

To calculate the total amount of combined sand, silt, and clay as determined by the hydrometer method, the procedure was as follows for the U.S. Department of Agriculture soil particle classification. The corrected hydrometer reading at the end of 40 seconds is divided by the amount of absolute dry soil taken and multiplied by 100. This result is the percentage of material still in suspension at the end of 40 seconds. This percentage is subtracted from 100, and the result is the

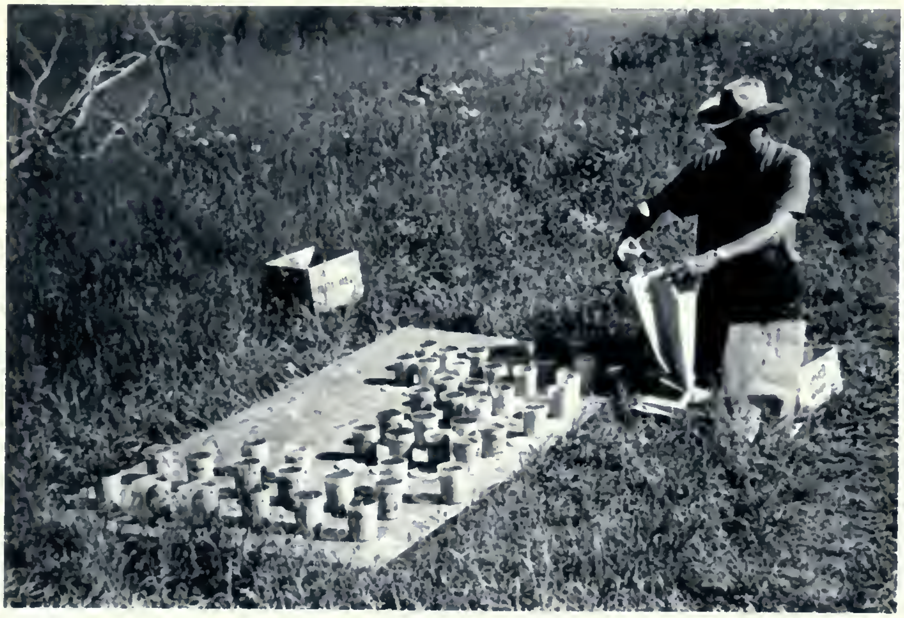

Figure 20. Drying of soil samples from the Porcupine Hills beaver dams.

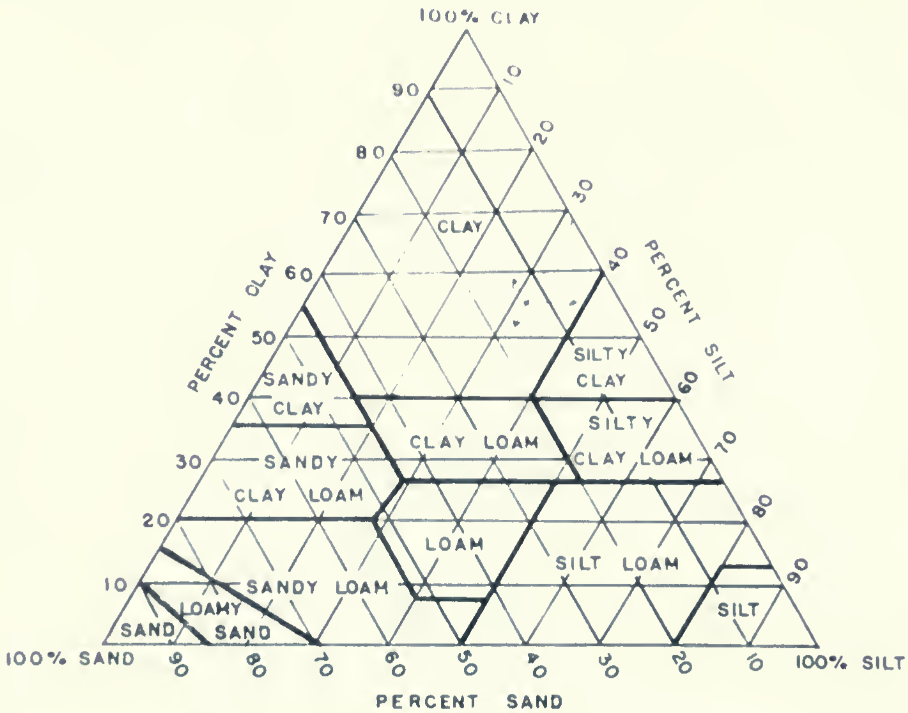

Figure 21. Textural triangle showing the percentages of sand, silt, and clay in the textural classes (Foth and Jacobs, 1964).

percentage of material that settled out at the end of 40 seconds, which is supposed to represent all the sand in the soil (2.00 - 0.05 millimters). The corrected hydrometer reading at the end of 2 hours is also divided by the weight of the soil and multiplied by 100. The result is percentage of material still in suspension at the end of 2 hours, and is considered to be the clay (below 0.002 millimeter). The percentage of silt (0.05 - 0.002 millimeter) is obtained by difference, by subtracting the combined percentage of clay and sand from 100.

When percentages of sand, silt and clay are known, the class names (Table 2) follow the textural triangle (Foth and Jacobs, 1964). In Figure 21 the percentage of clay is a line parallel to the bottom of the triangle. Percentage of silt is a line parallel to the left side of the triangle. The area in which intersection of the two lines occurs gives the class name or texture of the soil. As a check, the percentage of sand is a line parallel to the right side of the triangle. If the three lines intersect at the same place, the class name has been correctly determined.

Beaver utilization of herbaceous vegetation.

Since the whole beaver pond at Black Mountain study area could be observed from one point, it was decided to use this colony for the study of summer food utilization by the beaver. The beavers were observed during the afternoons over a period of two weeks. Observations were made of the beaver utilizing the grassland for grazing.

By help of enclosures and exlosures, I attempted to study the amount of herbs that was removed by the beaver. From August 2, 1971, the area was grazed by several hundred head of cattle. Thus, the study is concerned with the beaver and ungulates (mainly cattle, but also moose, elk, and mule deer) grazing pressure upon the native grassland. Due to lack of time, only the month of August was committed to the study.

From my primary observation, there were three grassland areas which the beaver frequented. The two areas (I and II) were associated with the willow stands and the trails the beaver followed for food (Figures 22 and 23). One area (III) was open grassland with little or no willow present (Figures 18 and 24). The willow along the edge of the water was mainly dead; there were only a few green shoots.

Area I (Figure 22) had Columbian ground squirrels (Citellus columbianus columbianus (Ord)) present and extra care was taken to include them in the study. Since the study area was located at a low elevation, with extremely high midday temperatures, the ground squirrel activity tended to decrease during midday. The adult ground squirrels were hibernating before the end of August, and only the younger individuals were active for shorter periods during the latter half of August (Telfer, pers. comm., 1971). Thus, the Columbian ground squirrel activity would be less than when the animals were fully active.

Each study area had 200 square meters (3 ares) enclosed with a 4 feet tall 3 wire fence of barbed wire, but open toward the pond for the beaver to enter (Figures 22, 23, 24). The barbed wire fence served to exclude ungulates. The fence was

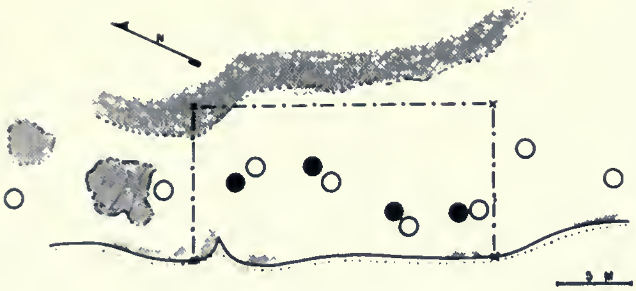

Figure 22. Study area I, Black Mountain.

Figure 23. Study area II, Black Mountain.

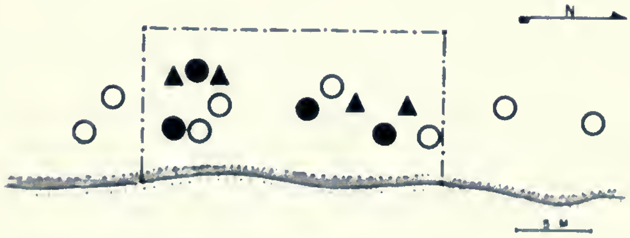

Figure 24. Study area III, Black Mountain.

flagged on each wire between each fence post and wire-support post to stop the deer from going between the wires or jumping across the fence (Telfer, pers. comm., 1971).

Forty study plots were established. Each study area had four plots of each type. Four types of study plots were defined: A - small mesh netting cones to exclude the beaver within the fenced-in area; B - large mesh netting cones on the inside of the fence to allow the Columbian ground squirrel to utilize the vegetation within the cones, but excluded the beaver - (Large mesh netting cones were only used in area III); C - uncovered study plots within the fence to allow the beaver to 'graze' on the plots; D - uncovered study plots outside the fence to allow the ungulates and beaver to utilize the vegetation. All study plots were circular with a radius of 0.564 meter, covering 1 square meter. The centre of each plot was marked with a marked wooden stick.

The experiment is based upon the hypothesis that all the animals move at random and utilize all plant equally. Another hypothesis is that during high grazing pressure by ungulates on the outside of the fence, the beaver would utilize the vegetation inside the fence, otherwise it would be impossible to determine the effects of 2 beaver upon several hundred ares of herbland. The selection of plots was subject to human errors, however, emphasis was made to select three (four for area III) plots of as similar plant density and composition as possible.

The study plots were set up on July 30, 1971, and on August 2, 1971, several hundred head of cattle were released in the area. The experiment terminated on September 1, 1971, on

which day the study plots were clipped with sheep-shears at ground level (Figure 25). The clipped vegetation included all green, live vegetation. The fresh top layer of plants killed the same year, was also included in the sample. The clipping itself was done by help of 0.564 meter sticks which were placed around the stake, and 'pie' slices of the 1 meter square area were cut out until the whole study plot was covered (Figure 26).

The clipped vegetation was stored in paper bags, air-dried in the laboratory at Brock University, and then separated by genera and species. The separation was impossible for the dried grasses, but the broad leafed plants could be identified. However, all pieces of grass and broad leafed plants that were hard to separate were lumped into a category of 'unidentified herbs' (Table 2). After the plants had been sorted, the identified plants or groups of plants were oven-dried for 48 hours at 100° C (Cox, 1967) and weighed to the nearest one tenth of a gram.

Plot-intercept transect study.

The May to September periods of 1969-71, inclusive, were spent in the field obtaining data on the utilization of vegetation by the beaver. One method (plot-intercept transect) was employed in measuring the presence or absence of woody stems only to characterize the utilization, preference and association of the woody plant species. While recording the data, tallies were also made of the condition of each woody stem, whether dead or alive, and whether or not browsed by

Figure 25. Cutting of herbaceous vegetation at plot 1C in study area II, Black Mountain.

Figure 26. Plot 2D, area II, has been cleared for herbaceous vegetation. Mark the heavily grazed surroundings.

animals other than beaver. See Sverre (1970) for field forms used in the collection of the plot-intercept data.

A habitat map was made of each study area before the experimental plots were laid out. The habitat maps were drawn from data obtained by pacing distances and directions from compass lines, which were spaced 40 paces apart. For the final habitat maps see Figures 4, 7, 9, 12, 13, and 16, where vegetation types, beaver activity, and the baseline and transect systems were laid out.

An objective method of sampling was reached based on a systematic sampling technique where the samples were taken at regular intervals. Through personal communication with the statistician of Lethbridge University (Wignall, pers. comm., 1969), in Alberta, a method was developed where random selection of the plots was achieved at the same time as the plots were systematically selected throughout the study area. The method required that the distance between the first transect line and the baseline stake (a permanently established stake that marks the beginning of the baseline) be selected from a table of random numbers, within the allowable limits of the distance between the transect lines. Thus, a method had been developed where systematically selected data could be employed in statistical analysis.

The layout of the sampling grid (Figure 27) was drawn on the maps (Figures 4, 7, 9, 12, 13, and 16). Firstly, the baseline was laid out longitudinal by the aid of steel tape and compass through the study area. Secondly, the transect lines were spaced evenly and at right angles to the baseline.

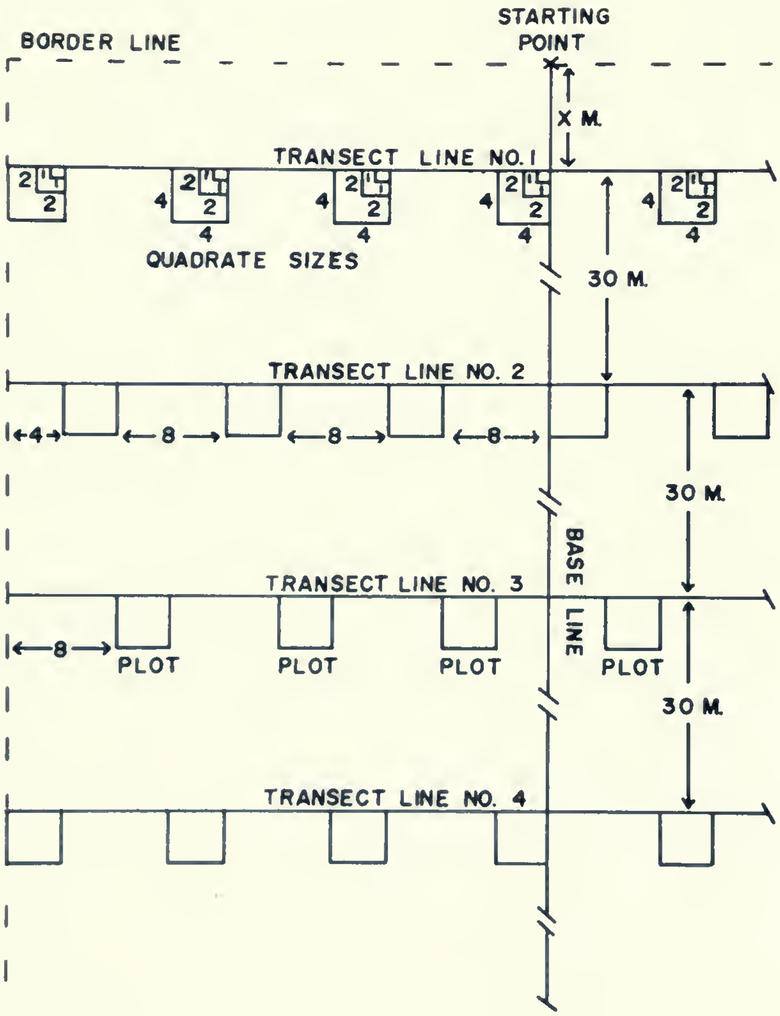

Figure 27. Layout of plot-intercept transect lines and plots.

Thirdly, the plots were laid out on the south side of the transect line with 8 meters between each plot. The plots on the transect lines were moved 4 meters so that every fourth transect line would have the plots spaced identically in relation to the starting point of the transect line (Figure 27). Each plot was composed of 3 different-sized quadrats which were nested with the smaller ones in the corner of the larger (Phillips, 1959). The smallest, 1 square meter, sampled all trees and shrubs with a basal diameter less than 1.0 centimeter. The medium sized quadrat of 4 square meters sampled all trees and shrubs with a basal diameter from 1.0 centimeter to 5.0 centimeters. The largest quadrat of 16 square meters sampled trees with a basal diameter greater than 5.0 centimeters. The trees of the largest quadrat size were tallied in 5 columns of 5 centimeters basal diameter intervals from 5.1 centimeters to greater than 25.1 centimeters. The two smaller quadrat sizes were tallied in one column each.

The cut woody plants were tallied on separate sheets, but with the same basal diameter classes as for uncut vegetation. All identifiable stumps with bark were counted. Each basal diameter class was sub-divided into 6 sub-classes to determine utilization according to amount of bark, branches and stem that was removed. The code used to define each of the sub-classes used for classifying the degree of beaver utilized woody vegetation is given in Table 1.

Any woody plant that had its base half way inside the border line of the quadrat, was included in the tally, otherwise it was excluded (Figure 28).

Figure 28. Plot-intercept sampling of woody vegetation in tall grass on quadrat size 1 x 1 square meter, at Johnson Creek I.

Figure 29. Beaver with aspen during midday at Black Mountain beaver pond.

Table 1.

DEGREE OF UTILIZATION OF WOODY VEGETATION.

Per cent utilized	Classification
0%	The plant had been cut and left on the site, or hanging in nearby trees.
0% - 25%	Part of the down stem had been removed from the site; For example, a few branches and some bark.
25% - 50%	The top had been removed together with a few branches and some bark off the stem.
50% - 75%	The main stem had been left with the bark on together with the larger branches.
75% - 100%	The whole plant had been utilized with the exception of up to 2/3 of the main stem that might be partly barked.
100%	The complete cutting had been removed from the site.

Six watersheds were included in the study, of which four have or have had beaver activity recently, and two sites represented potential beaver habitat. The study areas, listed in order from east to west, to study the vegetative change from the prairie to aspen-parkland, were: Johnson Creek I, Johnson Creek II, Streeter Basin, Camper Creek, Raspberry Creek, and Hawkeye Creek. A total of 2218 ares (54 acres) of stream bank habitat were sampled with a total of 661 plots (1983 quadrats of different sizes). Ground coverage values for each study area has been calculated separately. (See the section on description of study areas.)

At the beginning of the plot intercept study, every plot per transect line was counted and the transect lines were spaced only 30 meters apart. It was soon apparent that to complete the project the ground coverage value had to be lowered. Therefore, every third plot on the transect line was tallied and the distance between the transect lines was increased to 40 meters. This change was done without much decrease in the accuracy of the sampling of the habitat, as indicated by plotting the initial data on an efficiency curve (Figure 30).

Due to the difficulties in identifying the different seedling species within the honeysuckle family, it was decided to lump all species of the Caprifoliaceae.

The importance value, which is the sum of three relative indexes (density, dominance, and frequency), reflects these somewhat different measures of the importance of the species in the community. Separate calculations were made of the live

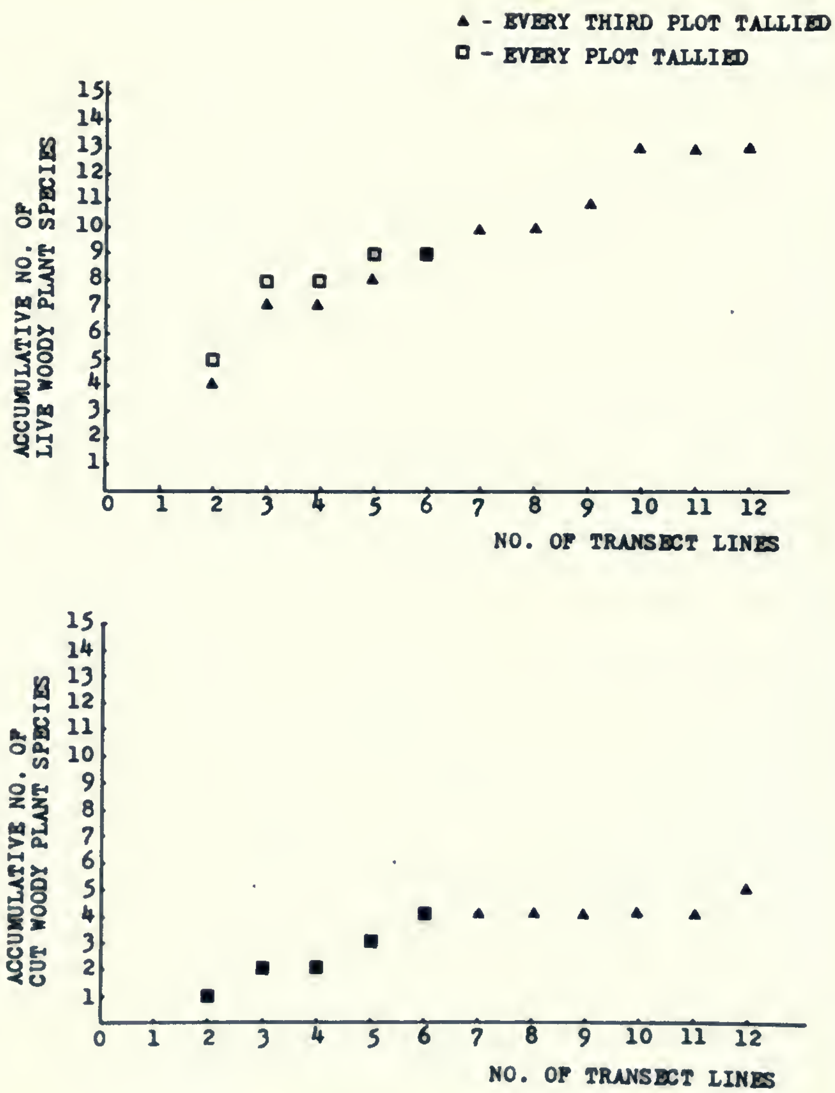

Figure 30. Efficiency curve of plot-intercept transect study in Streeter Basin. (The accumulative no. of live (above) and cut (below) woody plant species versus no. of transect lines.)

woody plants for each quadrat size. The author believes that for community description of any habitat there is a need to consider the relative components that make up each story of the vegetation. The comparable values thus obtained would then be: underbrush story, shrub, and finally the top canopy of the trees themselves. The importance value was determined according to the following formulas (Cox, 1967):

$$\text{density} = \frac{\text{number of individuals}}{\text{area sampled}}$$

$$\text{dominance} = \frac{\text{total of basal area}}{\text{area sampled}}$$

$$\text{frequency} = \frac{\text{number of plots in which species occurs}}{\text{total number of plots sampled}}$$

$$\text{relative density} = \frac{\text{density for a species}}{\text{total density for all species}} \times 100$$

$$\text{relative dominance} = \frac{\text{dominance for a species}}{\text{total dominance for all species}} \times 100$$

$$\text{relative frequency} = \frac{\text{frequency value for a species}}{\text{total of frequency values for all species}} \times 100$$

$$\text{importance value} = \text{relative density} + \text{relative dominance} + \text{relative frequency}$$

These formulas were followed closely, and any elaboration should not be necessary. However, for the dominance value the midpoint of each diameter class was used to calculate the basal area for all the individual plants of one species that had been

tallied.

Importance values were also calculated for beaver utilized vegetation, to merely determine the relative historical aspect of the relationship between the utilized species at different locations.

Computation sample in determining preference.

A X^2-test with Yates correction factor (Strickberger, 1968), was used in determining the preference or dislike the beaver had for the different plant species utilized by the beavers. The null hypothesis was that there was no preference for any species or diameter class - complete random utilization. The rejection of the null hypothesis followed if the mean figures under consideration were found to differ in sufficient degree at the 0.05 level of significance.

Calculations of expected number of utilized stems ($\bar{X}u$): sum of cut values for all plant species x sum of available stems for one species / sum of available values for all plant species = $\bar{X}u$. Calculations of expected number of available stems ($\bar{X}a$): sum of available values for all plant species x sum of cut values for one species / sum of cut values for all plant species = $\bar{X}a$.

Xa - sum of available values for one species

Xu - sum of cut values for one species.

$$X^2 = \frac{(|Xa - Xa| - \frac{1}{2})^2}{\bar{X}a} + \frac{(|Xu - Xu| - \frac{1}{2})^2}{\bar{X}u}$$

Species preference Johnson Creek I.

Values calculated for Salix spp.:

$Xa = 146.5 \quad \bar{X}a = 639.45 \quad Xu = 43.5 \quad \bar{X}u = 9.96$

Null hypothesis: No preference is evident, $Xu = \bar{X}u$

Alternative hypothesis: There is a preference for the Salix spp., $Xu > \bar{X}u$, or there is a dislike for the Salix spp., $Xu < \bar{X}u$.

$$X^2 = \frac{(|146.5 - 639.45| - 0.5)^2}{639.45} + \frac{(|43.5 - 9.96| - 0.5)^2}{9.96}$$

$$X^2 = 488.84$$

$$X^2_{.001,\ 1df} = 10.83$$

Since $X^2_{1df} = 488.84 > X^2_{.001,\ 1df} = 10.83$, the null hypothesis is rejected at the 0.1 per cent level of significance and 1 degree of freedom. The alternative hypothesis is accepted where $Xu > \bar{X}u$, there is a preference for Salix spp. at 0.1 per cent level of significance and 1 degree of freedom.

Computation sample in determining biomass.

An estimate of the total biomass for the aspen and willow in each diameter class was made with the help of Telfer's prediction equations based on basal stem diameter. Since most of the data obtained in the Porcupine Hills falls outside the range of sizes used to establish the equation (Telfer, 1969), a check was made by using Young's biomass equations (Young, 1964) on the larger diameter classes. His data was based on diameter at breast height stem diameter and the height of the tree. Comparing the calculations from Young (1964), the result

was relatively close for aspen. In the 15 to 20 centimeters diameter class the 'Young's' result was 8 per cent larger than 'Telfer's', however, in the larger than 25 centimeters class, the 'Telfer's' result was 9.5 per cent larger than 'Young's'. Extra caution should be employed in comparing this data from Eastern Canada with that of SW-Alberta, but since no research of this type has yet been made in the West, a comparison was made based on estimated numbers. Young (1964) had no calculations for Salix spp. The computation samples of biomass are tabulated in Tables 21 and 22.

Beaver colony survey.

A census of beaver colonies was made by the enumeration of 'active lodges' within the prescribed study area of the Porcupine Hills. This count of occupied beaver colonies gave an index of the density.

The beaver colony census was done on the ground during the summer, with the major tally in the end of August of every year. Beaver colonies were tallied as occupied when "mudding activity" (Novakowski, 1965), was observed on dam or lodge or both. In the cases where there was more than one lodge with fresh mud, it was only counted as one colony. Beaver have been observed to deposit approximately 4 liters of fresh mud on a second unoccupied lodge within the same colony (MacDonald, 1956).

A classification of the most important woody plants representing each colony was made at the time of the survey by observation. This will aid in classifying the overall average beaver habitat present in the foothills of the Rocky Mountains, SW-Alberta.

CHAPTER IV. ANALYSIS OF DATA.

Soil particle size analysis.

From Table 2, the observation can be made that all soil used for construction by the beaver had a large percentage of clay. The clay soil is needed by the beaver to construct stable beaver dams, as the clay is a necessary binding material for the trees, sticks and branches used in constructing the dam. The soil settling in the beaver ponds, often heavy with clay, is scooped up and laid on the top and face of the beaver dam, then sticks are laid down followed by more clay again. The sticks protruding on the outer face of the dam serve as energy breakers and thereby reduce the eroding effect of the overflow water.

Beaver are reported to be agents in controlling sedimentation (Bates, 1963). This was illustrated in the Camper Creek case, where there was a very heavy clay sedimentation (Table 2) in the beaver pond with the result that the beaver abandoned the colony during the spring of 1970 (Figure 11). The special feature of the Camper Creek site was that runoff erosion from the gravel highway just above the beaver pond ran into the beaver pond during spring runoff and during heavy precipitation. The highly turbid runoff water from the highway deposited silt and clay in the beaver pond. The beaver dam decreased water velocity and thereby deposited the suspended soil within the dam.

The daily activities of the beaver includes the upkeep of the dam face and channels. These activities cause the soil particles and the deposited material to be re-suspended.

In some instances the beaver does cause erosion, that is

Table 2.

SOIL PARTICLE SIZE ANALYSIS OF SOIL USED BY THE BEAVER TO CONSTRUCT DAMS IN THE PORCUPINE HILLS, ALBERTA.

Location	Sand (%)	Silt (%)	Clay (%)	Class*
Adair Cr.	35.9	36.7	27.4	clay loam-loam
Black Cr.	31.2	39.4	29.4	clay loam
Bob Cr. I	36.8	40.2	23.0	loam
Bob Cr. II	20.5	56.0	23.5	silt loam
Burke Cr.	24.3	40.6	35.1	clay loam
Callum Cr.	41.0	36.4	22.6	loam
Camper Cr.	20.0	24.4	55.7	clay
Chaffen Cr. I	33.6	42.3	24.5	loam
Chaffen Cr. II	36.9	37.2	25.9	loam
Hawkeye Cr.	39.7	36.6	23.7	loam
Johnson Cr. I	31.7	31.2	37.1	clay loam
Johnson Cr. II**	30.1	41.9	28.0	clay loam
Lassie Cr. I	43.7	28.9	27.5	loam
Lassie Cr. II	39.5	33.1	27.4	clay loam-loam
Lyndon Cr. I	23.8	48.9	27.3	clay loam-loam
Lyndon Cr. II	48.8	27.8	23.4	sandy clay loam-loam
Nelson Cr.	35.2	38.0	26.9	clay loam-loam
Playle Cr.	49.5	35.3	15.2	loam-sandy loam
Raspberry Cr.**	47.6	37.0	15.4	loam
Riley Cr.	36.7	48.7	14.6	loam
Sharples Cr., South	18.1	71.6	10.3	silt loam
Sharples Cr., North	42.1	37.5	20.4	loam
Squaw Coulee	33.0	15.5	51.5	clay
Streeter Basin	35.4	32.6	32.0	clay loam
Trout Cr.	37.0	48.9	14.1	loam
Average for all soil samples	34.9	38.7	26.5	loam-clay loam

* The classification follows the texture triangle system in Figure 21, (Foth and Jacobs, 1964).

** This soil sample was from the stream bank and the stream itself. No beaver dam was present.

when its activities create greater turbidity in the outflowing water compared to the water flowing into the beaver pond. However, to obtain the complete picture of the action of a beaver colony and its dams, measurements should be recorded during normal runoff to determine whether there is a net gain of deposited sediment or a net loss of suspended soil from the colony site over a period of a year. During spring and other periods of heavy runoff, the amount of suspended material in the water increases drastically, and so does the sedimentation of the beaver ponds.

The most important aspect of the net action of the beaver depends upon the combined effect of the type of soil present and the slope of the terrain around the beaver colony (Retzer, 1955). In Squaw Coulee (114° 07' W, 50° 06' 30" N), the beaver constructed a dam in a V-shaped valley with the sides sloping at gradients of 24 per cent, the stream itself had only 2 per cent gradient, but the soil was clay (Table 2), and here the beaver activity eroded the valley. As the beaver utilized the adjacent vegetation and undermined the banks, several clay soil land-slips occurred, which filled the beaver pond. The beaver activity at Squaw Coulee lasted only one summer, but in that short time the beaver started the erosion which will take many years to heal. No beaver dam in the Porcupine Hills was located on a valley grade greater than 6 per cent. This type of valley grade was determined excellent by Retzer (1955).

Camper Creek had clay soil and the same stream gradient as Squaw Coulee, however, the slopes of the banks of Camper Creek were only 14 per cent compared to 24 per cent for Squaw Coulee.

The 10 per cent less gradient of the banks stabilized the soil and prevented land-slips from sliding into the pond.

The total picture of beaver as a controller of sediments and erosion in the Porcupine Hills is positive, as the beaver dams slow down the rate of downward movement of sediments and decreases stream flow. In Hawkeye Creek (Figure 15), Nelson Creek, Callum Creek, and other long, wide and flat valleys, the beaver activity has in time built 'beaver flat' by retaining the soil close to its original parent material (Cliff, 1936, Rutherford, 1950). Taylor (1935) stated that beaver create a swamp, marsh, and thereby develop peat soil.

Beaver utilization of herbaceous vegetation.

A general decrease in the oven-dried biomass from the netting cone protected plots to open plots within the fence, and further decrease of the open unprotected plots outside the fence was observed for study areas I and II. Area III also followed this pattern with the exception of plot type C which had the highest biomass values. Table 3 gives the tabulated biomass data from each type of plot from the three study areas in units of gram per 4 square meters. The overall average of oven-dried biomass per type of study plot was calculated from Table 3: A = 262.8 gm/m^2; B = 201.8 gm/m^2; C = 256.2 gm/m^2; D = 192.0 gm/m^2. From this data, the ungulates removed (A - D =) 70.8 gm/m^2 (7.08 kg/are) over a 30 days period. The beaver has used (A - C =) 6.6 gm/m^2 (.66 kg/are) on the average between all the study plots, however, if only the study area adjacent to the beaver lodge was to be considered, the beaver utilized

34.5 gm/m^2. The Columbian ground squirrel at area III removed (A - B =) 39.0 gm/m^2 (3.9 kg/are). The open plots within the fenced area I had higher biomass values than the plots enclosed with cones. This might be due to the initial selection of the plots. Based on random selection of the study plots, the standing crop of the herbaceous vegetation (oven-dried biomass) on September 1, 1971, was 26.3 kg/are, assuming that the grazing was negligible before the study began.

Twenty-eight different genera or species were identified from the air dried clippings in addition to the grasses and the unidentified herbs (Table 3). This identification of the plants after they were air dried and crumpled does not represent all the plant species present, but should represent the relative relationship between the most important species.

The clippings of the plots included many plants without flowers or parts of flowers or unidentifiable parts, thus the high values for the unidentified herbs. The relative percentage of each species per plot type represents in this study the relative biomass of the plants to each other.

From primary observations of the beaver feeding during the months of June and July, recordings were made of the beaver selecting the following three forbs and taken inside the lodge: common dandelion (<u>Taraxacum officinale</u>); purple sticky geranium (<u>Geranium viscosissimum</u>); and stinkweed (<u>Thlaspi arvense</u>). The most utilized food observed was young aspen (<u>Populus tremuloides</u>) (Figure 29), and a few young willow (<u>Salix</u> spp.). Beaver feeding on the herbaceous vegetation could also be general, this was the case on plot 1C on area II, where the

beaver removed all vegetation close to ground level during the first week of August.

Seven mouse nests (unidentified as to species, but of recent construction) were found located on the study plots inside the fence at the time of the termination of the experiment, of which five nests were located within the netting cones, and two nests were located adjacent to the stakes marking the centre of the study plots. It is not known how much vegetation these rodents consumed. To find out the population of rodents, 41 Victor-Museum snap traps were set out at night. The catch was 15 rodents, of which 10 were red-backed voles (Clethrionomys gapperi galei) (2 adults and 8 juveniles), and 5 were white-footed mice (Peromyscus maniculatus) (3 adults and 2 juveniles), 4 traps were missing and several other traps were snapped. Thus, the trap-night success in excess of 37 per cent was observed at Black Mountain beaver habitat. Telfer (pers. comm., 1971), did not observe any abundance of red-backed voles or white-footed mice in his population studies at Streeter Basin this summer. Therefore, the high population of rodents might be due to favourable environmental conditions for these species adjacent to the beaver pond.

No observation of beaver utilizing the aquatic plants in Black Mountain beaver pond was recorded. There are two major species of aquatic plants in the pond, namely Myriophyllum verticillatum (water milfoil) and Potamageton richardonii (clasping-leaf pondweed). Sedges (Carex spp.) inhabited the shoreline around the pond. Tevis (1950) found the aquatic water weed (Anacharis canadensis) and eel grass (Vallisneria

americana) to be the most important food in the summer months.

Systematic plot-intercept sampling of beaver habitat.

Vegetative characteristics of the study areas.

Six study areas in the Porcupine Hills were analyzed for their woody vegetative characteristics by means of a systematic plot-intercept transect study. The distribution of the vegetation in the watersheds under study was from long-grass prairie in the East, to aspen parkland in the West, in its earliest seral stage of coniferous forest. Even though the most careful choice of study area is still somewhat subjective, the data does indicate at least the general trend of the effect of beaver upon the flora. Comparison was made between the watersheds according to beaver activity and location. Note that conifers were represented in each watershed with the exception of Johnson Creek.

Johnson Creek I.

It may be seen from Table 4 that the honeysuckle family (Caprifoliaceae), rose (*Rosa acicularis*), and shrubby cinquefoil (*Potentilla fruticosa*) have the highest density of any plants. The high densities of these plants indicate a typical vegetation of the Alberta plain. The buckbrush (*Symphoricarpos occidentalis*) was the most important species among the Caprifoliaceae, and together with rose they form the characteristic shrub of the region. The abundance of shrubby cinquefoil indicated overgrazing by cattle and horses (Cormack, 1967).

The willow (*Salix* spp.) density was the third highest of the

six areas. Of the three species of Salix represented, S. bebbiana Sarg. was common in all study basins, while the two other species were not found further West, namely S. discolor Muhl and S. monticola Rydb. This location was new for S. monticola Rydb., as it was not reported in Alberta by Moss in 1959.

The density of aspen (Populus tremuloides) was the lowest of any area. Saskatoon berry (Amelanchier alnifolia) and wolf willow (Elaeagnus commutata) reached the highest density in this type of habitat where the overstory was absent.

Ten groups of live woody plants constituted the total variety of shrubs and trees present (Table 4).

Johnson Creek II.

Seven groups of live woody plants constituted the total variety of shrubs and trees (Table 4). This aspen-willow association at the edge of the decidious forest of the Porcupine Hills had a canopy of aspen and willow which eliminated much of the light for the understory vegetation. Species like shrubby cinquefoil (Potentilla fruticosa) and wolf willow (Elaeagnus commutata) were absent, while the raspberry (Rubus strigosus) had high density as a shade tolerant species.

The highest density of aspen (Populus tremuloides) (of any study basin) was observed due to the absence of beaver, while the density of willow (Salix spp., mainly S. bebbiana) was less than any other basin. This stand appeared to be approaching the aspen forest stage, but the aspen was relatively young, approximately 30 years.

Streeter Basin.

Twelve groups of woody plants were represented at this site (Table 4). This area was intensively utilized by the beaver (occupied continuously for 15-20 years prior to the present study according to the local rancher), which had utilized the most palatable foods, and left the less palatable overmature beaked willow (Salix bebbiana) (Figure 10). The beaver activity opened up the habitat and allowed more light to enter, thus favouring an increase in species diversity. Caprifoliaceae, rose (Rosa acicularis), and gooseberry (Ribes oxyacanthoides) constituted the major underbrush cover. Both willow and aspen (Populus tremuloides) had relatively high densities, although not high enough to sustain beaver occupancy from 1968-70, at the time the investigation was made.

Camper Creek.

Eleven groups of woody vegetation were tallied in Camper Creek (Table 4). The high densities for Caprifoliaceae and rose (Rosa acicularis) indicated an open canopy, probably from the beaver activity. The shrubby cinquefoil (Potentilla fruticosa) density indicated again overgrazing by cattle and horses (Cormack, 1967). The second highest density of both aspen (Populus tremuloides) and willow (Salix spp.) of all the study sites indicated a stable beaver habitat. The vegetative survey was completed in the fall of 1969, however, already in the spring of 1970 this colony was abandoned, probably due primarily to silting in of the dam (see soil section).

Raspberry Creek.

Nine groups of woody vegetation were found in this watershed

(Table 4). Again the high density of Caprifoliaceae and rose (Rosa acicularis) indicated an open, yet shaded habitat due to the high densities of raspberry (Rubus strigosus) and gooseberry (Ribes oxyacanthoides). This habitat had not been utilized by beaver. The high density of the balsam poplar (Populus balsamifera) may not constitute the best beaver habitat, but it was a distinguished aspect of the region with balsam poplar present in the creek valleys. The willow (Salix spp.) appeared to be mainly S. bebbiana.

Hawkeye Creek.

Twelve types of woody vegetation were classified in this watershed (Table 4). The species diversity indicated relatively open habitat, probably affected by some overgrazing at one time due to the presence of shrubby cinquefoil (Potentilla fruticosa) (Cormack, 1967). The presence of beaver in this watershed has opened up the habitat (Figure 15), and the rise in ground water level due to beaver dams has caused increased growth and sprouting of willow (Salix spp.). The growth of willow at the main beaver colony was greater than what was utilized by the beaver, thus, the beaver population was below the carrying capacity of the habitat.

Of the three species of Salix identified in Hawkeye Creek, the two species S. bebbiana Sarg and S. petiolaris J. E. Smith, appeared to be common, while the S. novac-angliae And. appeared less frequent. S. petiolaris and S. novac-angliae were only found in Hawkeye Creek. Salix novac-angliae was not reported in Alberta by Moss (1959).

The overall relative density (average for all study areas)

Table 4.

DENSITY (NO. OF STEMS PER ARE) OF LIVE WOODY PLANT SPECIES AT STUDY AREAS OF BEAVER HABITAT IN THE PORCUPINE HILLS, ALBERTA.

Species	Johnson Cr. I	Johnson Cr. II	Streeter Basin	Camper Cr.	Raspberry Cr.	Hawkeye Cr.	Average No. per Are	Relative %
Caprifoliaceae	776.9	121.4	153.8	409.7	392.3	161.0	335.9	28.1
Rosa acicularis	610.6	94.4	111.0	519.4	552.6	113.6	333.6	27.9
Ribes oxyacanthoides	74.9	118.7	116.5	126.9	270.9	48.4	126.1	10.5
Salix spp.	103.0	14.9	79.6	140.0	46.9	292.0	112.7	9.4
Potentilla fruticosa	467.1	-	-	54.4	-	32.1	92.3	7.7
Rubus strigosus	-	116.0	56.7	12.0	205.7	25.4	69.3	5.8
Populus tremuloides	4.0	84.9	38.3	77.8	14.5	14.2	39.0	3.3
Amelanchier alnifolia	89.2	24.3	17.7	22.3	63.4	9.1	37.7	3.2
Elaeagnus commutata	94.3	-	-	59.3	-	-	25.6	2.1
Populus balsamifera	-	-	2.9	6.9	52.7	1.2	10.6	.9
Betula spp.	-	-	2.5	-	-	57.9	10.1	.8
Cornus stolonifera	6.1	-	.2	-	-	-	1.1	.1
Shepherdia canadensis	5.2	-	-	-	-	-	.9	.1
Crataegus sp.	-	-	.7	-	-	-	.1	Tr.
Juniperus spp.	-	-	-	-	-	1.5	.3	Tr.
Picea glauca	-	-	.2	.4	.2	2.0	.5	Tr.

for Salix spp. was 9.4 per cent and for Populus tremuloides it was 3.3 per cent of the total vegetation.

Importance values.

The comparison of the importance values for the six study areas gives a good indication of the relative species association in each study basin, as well as in the whole study area. The numerous less important species were ignored. The importance values were calculated to compare the live woody vegetation by quadrat size. This was done because a general decrease in the species diversity could be seen with comparison of larger and larger basal diameter classes (Tables 5, 6, and 7). Thus, the quadrat sizes 1 x 1 square meter, 2 x 2 square meters, and 4 x 4 square meters represent respectively the shrub layer, understory, and finally the overstory layers.

The average importance values for 1 x 1 square meter quadrats (Table 5), indicate that Rosa acicularis and Caprifoliaceae make up more than half the values of the shrub community. Thus, these two plant species groups that had high values in all the study areas, were characteristic for the shrubby vegetation in low lying areas of the northern Porcupine Hills. High values in this quadrat size for the main woody species that the beaver utilized, namely Salix spp. and Populus tremuloides, represented healthy young stands that may be improving the beaver habitat by extending their range. Salix had the highest importance value of any genera in Hawkeye Creek, which indicated a high growth potential and excellent condition for beaver occupancy. Comparing all importance values of the study basins, the Salix and Populus tremuloides rated only numbers 5 and 6

Table 5. IMPORTANCE VALUES FOR 1 x 1 m^2 QUADRAT SIZE - LIVE WOODY VEGETATION.

Species	Johnson Cr. I	Johnson Cr. II	Streeter Basin	Camper Cr.	Raspberry Cr.	Hawkeye Cr.	Average
Rosa acicularis	.918	.524	.690	1.029	1.047	.544	.792
Caprifoliaceae	.918	.620	.770	.760	.767	.705	.757
Ribes oxyacanthoides	.096	.566	.633	.274	.464	.289	.387
Rubus strigosus	-	.718	.351	.027	.421	.115	.272
Salix spp.	.122	.032	.304	.200	.046	.900	.267
Populus tremuloides	.014	.406	.140	.258	.014	.039	.145
Potentilla fruticosa	.552	-	-	.136	-	.127	.136
Amelanchier alnifolia	.161	.134	.095	.126	.140	.071	.121
Elaeagnus commutata	.139	-	-	.170	-	-	.052
Betula spp.	-	-	.017	-	-	.184	.034
Populus balsamifera	-	-	-	.020	.100	-	.020
Cornus stolonifera	.015	-	-	-	-	-	.003
Picea glauca	-	-	-	-	-	.015	.003
Juniperus spp.	-	-	-	-	-	.009	.002
Shepherdia canadensis	.010	-	-	-	-	-	.002

among the 15 species groups of plants listed. The total importance value of these two species represented 0.41 out of 3.00 (14 per cent of the total woody vegetation). A change in species composition in each watershed was observed, that was a sign of uneven distribution of plant species as a result of changes in the specific species requirements from study basin to study basin.

The average importance values for 2 x 2 square meters (Table 6), gave the genus Salix the highest rating, with twice the value of Populus tremuloides. These two species groups have an overall importance value of 2.32 out of 3.00 (77 per cent of the total woody vegetation), that indicated a habitat in favour of beaver colonization. The species diversity decreased in all study areas, from 15 species groups of woody plants in the shrub layer to 14 types in the understory layer. Elaeagnus commutata and Amelanchier alnifolia were the chief understory species after aspen and willow.

The average importance values for 4 x 4 square meters quadrats (Table 7), again gave the genus Salix the highest rating in all watersheds as well as the overall, with greater than four times the value of Populus tremuloides. A drastic decrease of plant species (from understory to overstory layers) was noted compared to the 2 x 2 square meters quadrats (basal diameter from 1.1 centimeters to 5.0 centimeters). Only four species of plants, 3 genera, were represented among the woody plants greater than 5.1 centimeters in basal diameter. Three species utilized by the beaver were in the family Salicaceae.

Importance values were calculated for beaver cut stems of

Table 6. IMPORTANCE VALUES FOR 2 x 2 m^2 QUADRAT SIZE - LIVE WOODY VEGETATION.

Species	Johnson Cr. I	Johnson Cr. II	Streeter Basin	Camper Cr.	Raspberry Cr.	Hawkeye Cr.	Average
Salix spp.	1.720	.999	1.168	1.743	1.493	2.109	1.539
Populus tremuloides	.034	2.001	1.280	.492	.531	.326	.777
Elaeagnus commutata	.713	-	-	.582	-	-	.216
Amelanchier alnifolia	.306	-	.172	.091	.649	.036	.209
Betula spp.	-	-	.050	-	-	.432	.080
Populus balsamifera	-	-	.127	-	.271	.061	.077
Rosa acicularis	.143	-	.014	-	-	.014	.029
Caprifoliaceae	-	-	.104	-	-	-	.017
Ribes oxyacanthoides	-	-	.045	-	.056	-	.017
Potentilla fruticosa	-	-	-	.064	-	-	.011
Picea glauca	-	-	.014	.028	-	.022	.011
Cornus stolonifera	.062	-	-	-	-	-	.010
Shepherdia canadensis	.022	-	.014	-	-	-	.006
Alnus tenuifolia	-	-	.014	-	-	-	.002

Table 7. IMPORTANCE VALUES FOR 4 x 4 m^2 QUADRAT SIZE - LIVE WOODY VEGETATION.

Species	Johnson Cr. I	Johnson Cr. II	Streeter Basin	Camper Cr.	Raspberry Cr.	Hawkeye Cr.	Average
Salix spp.	2.942	2.272	2.583	2.500	1.226	1.841	2.227
Populus tremuloides	.058	.728	.237	.500	.759	.934	.536
Populus balsamifera	-	-	.180	-	.983	.037	.200
Picea glauca	-	-	-	-	.030	.188	.036

Table 8. IMPORTANCE VALUES FOR CUT STEMS OF WOODY VEGETATION.

Quadrat size (m^2)	Species	Camper Cr.	Hawkeye Cr.	Johnson Cr. I	Streeter Basin	Average
1^2	*Salix* spp.	1.673	2.934	1.773	3.000	2.345
	Populus tremuloides	1.327	.066	-	-	.348
	Rosa acicularis	-	-	.945	-	.236
	Cornus stolonifera	-	-	.282	-	.071
2^2	*Salix* spp.	2.422	2.813	2.686	2.063	2.496
	Populus tremuloides	.265	.106	.057	.587	.254
	Elaeagnus commutata	.313	-	-	-	.078
	Cornus stolonifera	-	-	.257	-	.064
	Populus balsamifera	-	.039	-	.145	.046
	Amelanchier alnifolia	-	-	-	.145	.036
	Betula spp.	-	.043	-	.060	.026
4^2	*Salix* spp.	.600	2.063	2.634	1.448	1.683
	Populus tremuloides	2.400	.780	.366	1.552	1.275
	Alnus tenuifolia	-	.120	-	-	.030
	Populus balsamifera	-	.036	-	-	.009

woody vegetation in the four watersheds, merely to determine the relative historical aspect of utilization at different locations. No direct comparison can be made between the importance values of live woody vegetation and the cut vegetation since different numbers of species and watersheds were used in calculating the relative indices. Salix was the most utilized genus (Table 8), while the Populus tremuloides was used comparably only in the (4 x 4 square meters) overstory layer. Willow and aspen were the major species utilized, while the other species were merely tasted. It appears in the largest size class (4 x 4 square meters) that the importance value for cut Salix was smaller than for live woody plants of same diameter class, this might indicate a dislike. The importance values for Populus tremuloides were largest in cut stems compared to live woody stems, this might indicate a preference in this size class.

Woody plant utilization.

The woody plant utilization in each study basin is given in Tables 9-12. The numbers of cut stems, in the different diameter classes per are, were calculated together with the relative percentage utilized for each species and diameter classes. The relative utilization is presented by three classes: 100 per cent utilization, partially utilized, and 100 per cent wasted. This should give an objective of the trend in utilization of cut stems per diameter class. The partially utilized values were a summary of 4 utilization classes (Table 1), namely the classes that lay between 100 per cent utilized and 100 per

cent wasted. The relative percentage of utilization per diameter class has been graphed for Salix and aspen (Populus tremuloides) (Figure 31). These graphs only represent relative utilization of Salix and aspen and not what is available.

Johnson Creek I (Table 9).

Of the four species utilized in Johnson Creek study area, the Salix provided 82.5 per cent of the stems cut. The Populus tremuloides which only constituted 1.8 per cent of the stems cut, did not contain enough values to draw any conclusion to any specific class preference, however, the data might indicate the greatest utilization for the 10.1-15.0 centimeters diameter class (Figure 31A). The Cornus stolonifera was utilized almost 4 times that of the aspen, and even the prickly Rosa acicularis was utilized more frequent than the aspen. Not enough stems were cut to establish any definite trend in the utilization of these two species. Aspen was almost absent in this study area. One aspen stand was observed that had been almost completely eliminated by the beaver. Any re-sprouting of aspen at this site might have been killed by continuous use, and also the potentiality of the site itself might indicate low regeneration of aspen. There was an indication that aspen was utilized more heavily at the larger diameter classes in Figure A.

The willow was utilized heaviest in the 1-5 centimeters diameter class (Table 9) (Figure 31A). The relative waste or utilization per diameter class indicated no significant difference among the willow in Johnson Creek.

Streeter Basin (Table 10).

Five types of woody stems were utilized by the beaver in

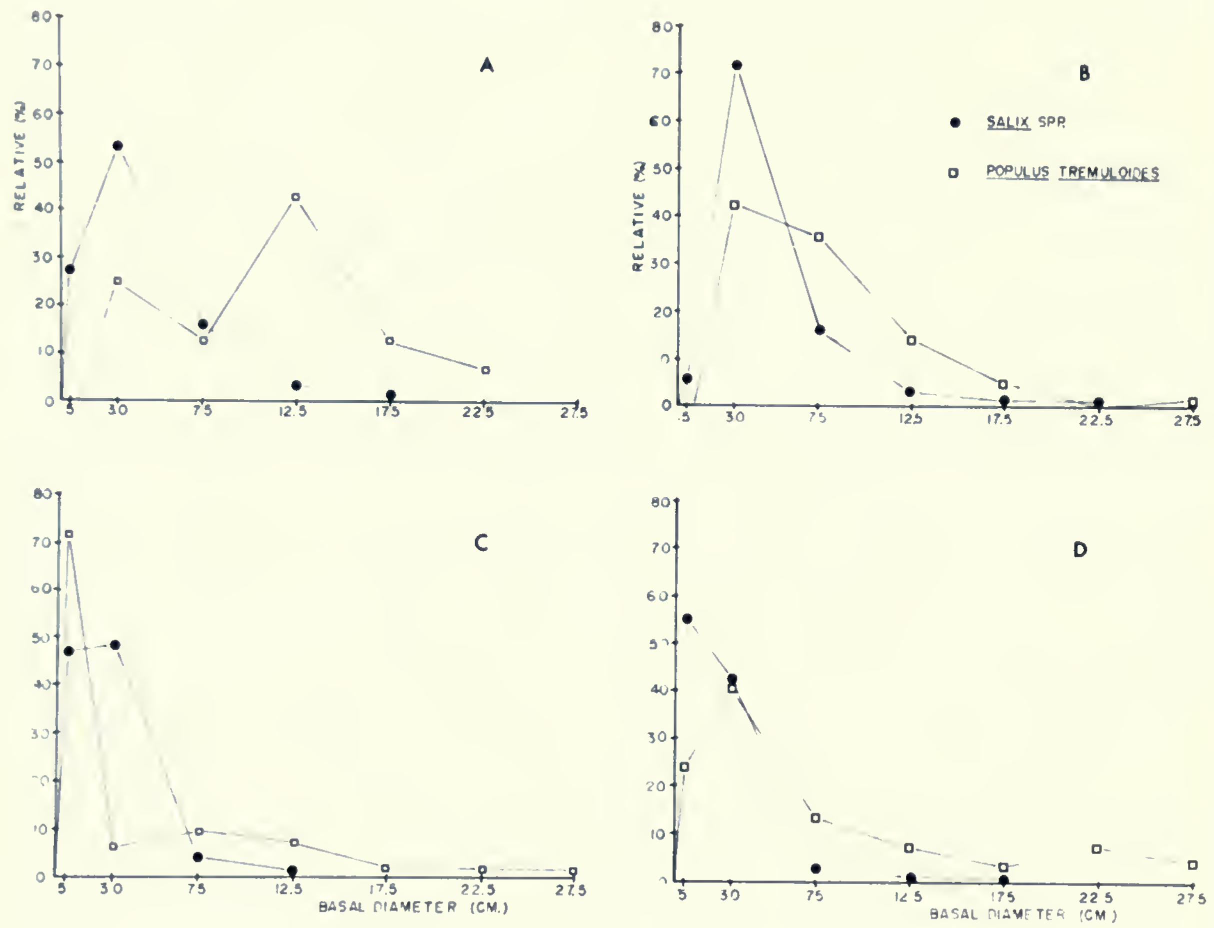

Figure 31. The relative utilization by beaver of *Salix* spp. and *Populus tremuloides* in each of the four watersheds: A - Johnson Creek I; B - Streeter Basin; C - Camper Creek; D - Hawkeye Creek. (The basal diameter values represent class midpoints, and the total area under each curve equals 100 per cent.)

Table 9.

WOODY STEM UTILIZATION PER ARE BY THE BEAVER AT JOHNSON CREEK I.

Species	Diameter class (cm.)	No. utilized per are	% of utilization*	100% utilization (%)**	Partially utilized (%)	100% wasted (%)
<u>Salix</u> spp.	1.0	11.7	22.2	64.3	35.7	-
	1.1- 5.0	23.1	43.8	71.3	28.7	-
	5.1-10.0	7.0	13.3	65.9	32.6	1.5
	10.1-15.0	1.5	2.8	75.0	21.4	3.6
	15.1-25.0	.2	.4	75.0	25.0	-
	25.1	-	-	-	-	-
<u>Populus tremuloides</u>	1.0	-	-	-	-	-
	1.1- 5.0	.2	.4	100.0	-	-
	5.1-10.0	.1	.2	50.0	-	50.0
	10.1-15.0	.4	.8	57.1	28.6	14.3
	15.1-20.0	.1	.2	50.0	50.0	-
	20.1-25.0	-	-	-	-	-
	25.1	.1	.2	100.0	-	-
<u>Cornus stolonifera</u>	1.0	1.7	3.2	50.0	50.0	-
	1.1- 5.0	1.7	3.2	87.5	-	12.5
<u>Rosa acicularis</u>	1.0	5.0	9.5	100.0	-	-

* utilization calculated in relative percentage of all species and diameter classes.

** utilization for each diameter class calculated in relative % of degree of utilization.

Table 10.

WOODY STEM UTILIZATION PER ARE BY THE BEAVER AT STREETER BASIN.

Species	Diameter class (cm.)	No. utilized per are	% of utilization*	100% utilization (%)**	Partially utilized (%)	100% wasted (%)
Salix spp.	1.0	.4	3.0	100.0	-	-
	1.1- 5.0	5.6	42.4	82.0	16.0	2.0
	5.1-10.0	1.2	9.1	71.0	27.0	2.0
	10.1-15.0	.4	3.0	73.0	27.0	-
	15.1-20.0	.2	1.5	-	100.0	-
	20.1-25.0	.1	.8	-	100.0	-
	25.1	-	-	-	-	-
Populus tremuloides	1.0	-	-	-	-	-
	1.1- 5.0	1.7	12.9	100.0	-	-
	5.1-10.0	1.5	11.4	100.0	-	-
	10.1-15.0	.6	4.5	87.0	13.0	-
	15.1-20.0	.2	1.5	17.0	83.0	-
	20.1-25.0	-	-	-	-	-
	25.1	.1	.8	-	100.0	-
Populus balsamifera	1.1- 5.0	.7	5.3	100.0	-	-
Amelanchier alnifolia	1.1- 5.0	.4	3.0	100.0	-	-
Betula spp.	1.1- 5.0	.1	.8	100.0	-	-

* utilization calculated in relative percentage of all species and diameter classes.

** utilization for each diameter class calculated in relative % of degree of utilization.

Streeter Basin, of which <u>Salix</u> and <u>Populus</u> <u>tremuloides</u> made up 90.9 per cent. The other three utilized species, P. <u>balsamifera</u>, <u>Amelanchier</u> <u>alnifolia</u>, and <u>Betula</u> spp., were all in the 1-5 centimeters basal diameter class and 100 per cent utilized. Of the 5.6 stems/are that were utilized in the 1-5 centimeters diameter clas of the genus <u>Salix</u>, 71.7 per cent of all the stems were in the 1-5 centimeters diameter class. The 5.6 stems per are that were utilized in the 1-5 centimeters diameter class of the genus <u>Salix</u> represented 42.4 per cent of all stems cut, or 71.7 per cent of all <u>Salix</u> that was utilized (Figure 31B). This might indicate that the beaver found this diameter class the most palatable and best suited for construction. It may also indicate that this diameter class was most readily available. An increase in wastage of the cut woody stems was apparent for both willow and aspen with increasing basal diameter class. The lack of cut aspen stumps in the less than 1 centimeter basal diameter class, may be due to the fact that the beaver had abandoned the site 2 years prior to the completion of this study. The stumps may have rotted and deteriorated to such a degree that they were not tallied. There was heavy use of aspen in the diameter classes from 1 to 10 centimeters (Table 10) (Figure 31 B). The graph (Figure 31B) indicated that willow was utilized more heavily at the smaller diameter class than was the aspen.

<u>Camper Creek (Table 11)</u>.

Only three genera were represented in the beaver diet at Camper Creek. The <u>Salix</u> and <u>Populus</u> <u>tremuloides</u> made up 95.9 per cent of all the woody stems utilized (Table 11). The very heavy

Table 11.

WOODY STEM UTILIZATION PER ARE BY THE BEAVER AT CAMPER CREEK.

Species	Diameter class (cm.)	No. utilized per are	% of utilization*	100% utilization (%)**	Partially utilized (%)	100% wasted (%)
Salix spp.	1.0	12.0	28.8	100.0	-	-
	1.1- 5.0	12.5	30.0	82.8	17.2	-
	5.1-10.0	1.1	2.6	60.0	40.0	-
	10.1-15.0	.1	.2	-	-	100.0
Populus tremuloides	1.0	10.3	24.7	100.0	-	-
	1.1-5.0	.9	2.2	100.0	-	-
	5.1-10.0	1.3	3.1	91.7	8.3	-
	10.1-15.0	1.0	2.4	77.8	22.2	-
	15.1-20.0	.3	.7	66.7	-	33.3
	20.1-25.0	.2	.5	50.0	50.0	-
	25.1-	.3	.7	-	66.7	33.3
Elaeagnus commutata	1.1-5.0	1.7	4.1	100.0	-	-

* utilization calculated in relative percentage of all species and diameter classes.

** utilization for each diameter class calculated in relative % of degree of utilization.

utilization of both willow and aspen in the smaller basal diameter classes (Figure 31C) indicated that the beaver cut down the seedlings at a faster rate than they grow back. The small seedlings contain less bark and energy than larger plants, thus, when the seedlings were utilized, the potential for increasing the biomass to the beaver was removed. An increase in wasted cut stems is apparent for both willow and aspen with increased basal diameter class.

Hawkeye Creek (Table 12).

This watershed appeared to be similar to Camper Creek, in regard to the utilization of the woody vegetation. Of the five species groups of woody stems tasted by the beaver, the *Salix* accounted for 97.4 per cent of all plants utilized. The *Populus tremuloides* only accounted for 1.7 per cent of all stems (Table 12). These percentages were deceiving as the willow genus was to a large extent composed of the shrub-like species, S. *petiolaris*, with a basal diameter of less than 1 centimeter (Figure 31D), while the aspen was composed of larger trees with greater biomass. However, the fact remains that the willow was more frequently utilized than the aspen. The high number of willow stems of the species S. *petiolaris* provided a high rate of sprouting and re-growth, thus, the beaver population at this site stayed below the carrying capacity of the range. A definite trend for willow was observed (Table 12), that the diameter class increased was followed by an increase in the relative waste. The willow was utilized more heavily in the smallest diameter class than was aspen (Figure 31D).

Table 12.

WOODY STEM UTILIZATION PER ARE BY THE BEAVER AT HAWKEYE CREEK.

Species	Diameter class (cm.)	No. utilized per are	% of utilization*	100% utilization (%)**	Partially utilized (%)	100% wasted (%)
Salix spp.	1.0	68.1	53.3	60.3	39.7	-
	1.1- 5.0	52.2	40.8	76.5	23.5	-
	5.1-10.0	3.4	2.7	49.5	50.5	-
	10.1-15.0	.7	.5	41.2	52.9	5.9
	15.1-20.0	.1	.1	-	100.0	-
Populus tremuloides	1.0	.4	.3	100.0	-	-
	1.1- 5.0	.9	.7	71.4	28.6	-
	5.1-10.0	.3	.2	88.9	11.1	-
	10.1-15.0	.1	.1	100.0	-	-
	15.1-20.0	.1	.1	100.0	-	-
	20.1-25.0	.2	.2	60.0	20.0	20.0
	25.1	.1	.1	66.7	33.0	-
Populus balsamifera	1.1- 5.0	.4	.3	50.0	50.0	-
	5.1-10.0	-	-	-	-	-
	10.1-15.0	.03	Trace	100.0	-	-
Alnus tenuifolia	5.1-10.0	.4	.3	62.5	37.5	-
Betula spp.	1.1- 5.0	.4	.3	33.3	66.7	-

* utilization calculated in relative percentage of all species and diameter classes.

** utilization for each diameter class calculated in relative % of degree of utilization.

In Table 13, the present status of the beaver habitat in four study basins was recorded, a comparison of available and cut woody stems per are of the species utilized by the beaver. From this (Table 13), the condition of the vegetation at the beaver occupied sites may be determined. The average use of *Salix* was 1/4 of all stems available, while that of *Populus tremuloides* had 1/7 of all stems cut down. The other species were not considered to be of the same importance as the above two species.

From Figure 32, the overall average relative percentage of utilization and availability of *Salix* and *Populus tremuloides* indicates that the beaver utilized these two types according to the density that was there at the time. The relative values of cut and available stems were calculated in Table 13. It is hypothesized that these calculations indicate a preference if the relative cut value was greater than the relative available value, and that dislike was evident if the cut value was smaller than the available value. If the above hypothesis was right, then a preference by the beaver was indicated for *Salix* spp., *Populus tremuloides*, *Cornus stoonifera*, *Alnus tenuifolia*, and *P. balsamifera*. A dislike would be expected for *Rosa acicularis*, *Elaeagnus commutata*, *Amelanchier alnifolia*, and *Betula* spp.

The combined waste of *Salix* spp. and *Populus tremuloides* in the four watersheds was calculated from Tables 9 to 12, inclusive: 100 per cent utilized - 69.5 per cent of all stems cut; partly utilized - 30.2 per cent; and 100 per cent wasted - only 0.3 per cent. Thus, if 50 per cent of the stems in the partly utilized class was utilized and 50 per cent wasted, then

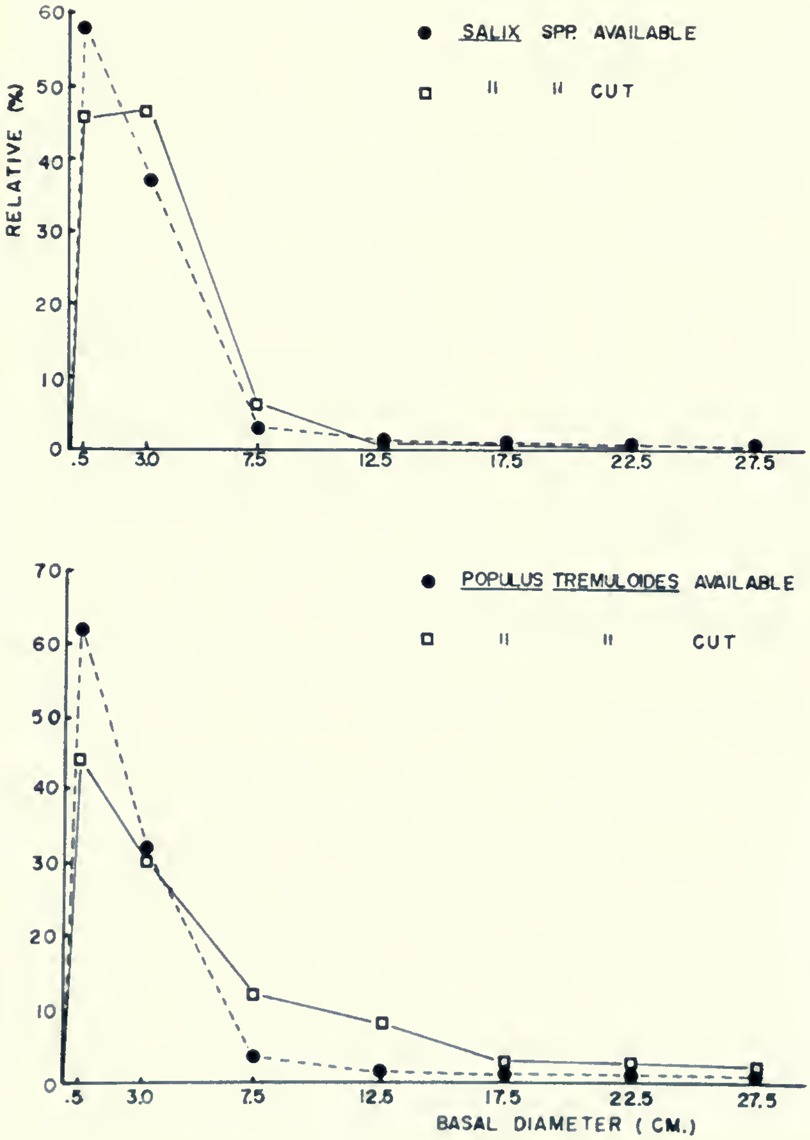

Figure 32. The overall relative percentage of utilization (cut stems) and availability (sum of live and cut stems) versus diameter class of Salix spp. (above) and Populus tremuloides (below). (The basal diameter values represent class midpoints, and the total area under each curve equals 100 per cent. Utilization equals no. of cut stems, and availability represents the sum of live and cut stems.)

Table 13.

THE PRESENT STATUS OF THE BEAVER HABITAT, A COMPARISON OF AVAILABLE AND CUT WOODY STEMS PER ARE OF THE SPECIES UTILIZED BY BEAVER AT DIFFERENT STUDY AREAS IN THE PORCUPINE HILLS, ALBERTA.

Species		Johnson Cr. I	Streeter Basin	Camper Cr.	Hawkeye Cr.	Average No. Per Are	Relative % Cut	Relative % Available
Salix spp.	Available	146.5	87.3	165.7	416.5	204.0		30.3
	Cut	43.5	7.7	25.7	124.5	50.4	85.6	
Populus tremuloides	Available	4.9	42.3	92.1	16.3	38.9		5.8
	Cut	.9	4.0	14.3	2.1	5.3	9.0	
Rosa acicularis	Available	615.9	131.3	488.9	110.9	336.8		50.0
	Cut	5.0	-	-	-	1.3	2.2	
Cornus stolonifera	Available	9.5	.2	-	-	2.4		.4
	Cut	3.4	-	-	-	.9	1.5	
Elaeagnus commutata	Available	94.3	-	61.0	-	38.8		5.8
	Cut	-	-	1.7	-	.4	.7	
Populus balsamifera	Available	-	3.6	6.9	1.6	3.0		.4
	Cut	-	.7	-	.4	.3	.5	
Amelanchier alnifolia	Available	89.2	18.1	22.3	9.1	34.7		5.1
	Cut	-	.4	-	-	.1	.2	
Betula spp.	Available	-	2.6	-	58.3	15.2		2.3
	Cut	-	.1	-	.4	.1	.2	
Alnus tenuifolia	Available	-	-	-	.4	.1		.01
	Cut	-	-	-	.4	.1	.2	

the total waste of the above two genera was only 15.4 per cent.

Species and class preference.

From Tables 14 to 17, inclusive, species and basal diameter class preferences were calculated for four study basins (Johnson Creek I, Streeter Basin, Camper Creek and Hawkeye Creek). Preference for *Salix* spp. was observed in 3 out of 4 watersheds. The Streeter Basin data did not indicate any preference for one species. A preference for the aspen (*Populus tremuloides*) was only observed in the Johnson Creek I beaver habitat, the data from the other basins indicated no preference, but dislike for aspen in Hawkeye Creek proved to be the case (Table 17). The only other species that the beaver showed any preference for was dogwood (*Cornus stolonifera*) in Hawkeye Creek. Alder (*Alnus tenuifolia*) in Hawkeye Creek was 100 per cent utilized, that might indicate a preference, however, it could not be proven statistically. Dislike was indicated for rose (*Rosa acicularis*) in Johnson Creek I (Table 14), Saskatoon berry (*Amelanchier alnifolia*) in Streeter Basin (Table 15), wolf willow (*Elaeagnus commutata*) in Camper Creek (Table 16), and for birch (*Betula* spp., mainly B. *glandulosa*) in Hawkeye Creek (Table 17).

These species preferences were summarized in Table 18, where the weighted values indicated the overall species preference or dislike for plant types that the beaver utilized. The weighted result indicated an overall preference for *Salix*, alder, aspen, and dogwood. *Populus balsamifera* was intermediate. Strong dislike was shown for Saskatoon berry, birch, wolf willow, and rose.

Table 14.

SPECIES AND BASAL DIAMETER CLASS PREFERENCE IN A 600.5 ARES SAMPLE OF BEAVER HABITAT AT JOHNSON CR. I.
THE DATA HAS BEEN CALCULATED BY NUMBER OF STEMS PER ARE.

Species		Diameter class (cm.) < 1.0	1.1- 5.0	5.1-10.0	10.1-15.0	15.1-20.0	20.1-25.0	25.1 >	Total
Salix spp.*	Available	69.2	63.9	10.5	2.2	.4	.2	.1	146.5
	Cut	11.7	23.1	7.0	1.5	.2	0	0	43.5
	% cut	16.9	36.1	66.7	68.3	50.0	-	-	29.7
Populus tremuloides***	Available	3.3	.8	.2	.4	.1	0	.1	4.9
	Cut	0	.2	.1	.4	.1	0	.1	.9
	% cut	0	25.0	50.0	100.0	100.0	-	100.0	18.4
Cornus stolonifera*	Available	6.7	2.8	-	-	-	-	-	9.5
	Cut	1.7	1.7	-	-	-	-	-	3.4
	% cut	25.4	60.7	-	-	-	-	-	35.8
Rosa acicularis+	Available	612.8	2.8	-	-	-	-	-	615.6
	Cut	5.0	0	-	-	-	-	-	5.0
	% cut	.8	-	-	-	-	-	-	.8

* Preference at .1% level of significance.
** Preference at 1% level of significance.
*** Preference at 5% level of significance.

\+ Dislike at .1% level of significance.
++ Dislike at 1% level of significance.
+++ Dislike at 5% level of significance.

Table 15.

SPECIES AND BASAL DIAMETER CLASS PREFERENCE IN A 448.8 ARES SAMPLE OF BEAVER HABITAT AT STREETER BASIN.
THE DATA HAS BEEN CALCULATED BY NUMBER OF STEMS PER ARE.

Species		Diameter class (cm.)							
		< 1.0	1.1- 5.0	5.1-10.0	10.1-15.0	15.1-20.0	20.1-25.0	25.1 >	Total
Salix spp.	Available	53.2	27.7	2.6	1.7	1.3	.7	.4	87.6
	Cut	.4	5.6	1.2	.4	.2	.1	-	7.9
	% cut	.8	20.2	46.2	23.5	15.4	14.3	0	9.0
Populus tremuloides	Available	13.2	26.4	1.6	.7	.3	.1	.1	42.4
	Cut	-	1.7	1.5	.6	.2	-	.1	4.1
	% cut	0	6.4	93.8	85.7	66.7	0	100.0	9.7
Amelanchier alnifolia+	Available	15.5	2.6	-	-	-	-	-	18.1
	Cut	-	.4	-	-	-	-	-	.4
	% cut	0	15.4	-	-	-	-	-	2.2
Betula spp.	Available	1.7	.9	-	-	-	-	-	2.6
	Cut	-	.1	-	-	-	-	-	.1
	% cut	0	11.1	-	-	-	-	-	3.8
Populus balsamifera	Available	-	3.3	.1	.1	.1	-	.2	3.8
	Cut	-	.7	-	-	-	-	-	.7
	% cut	-	21.2	0	0	0	-	0	18.4

* Preference at .1% level of significance.
** Preference at 1% level of significance.
*** Preference at 5% level of significance.

\+ Dislike at .1% level of significance.
++ Dislike at 1% level of significance.
+++ Dislike at 5% level of significance.

Table 16.

SPECIES AND BASAL DIAMETER CLASS PREFERENCE IN A 182.3 ARES SAMPLE OF BEAVER HABITAT AT CAMPER CR.
THE DATA HAS BEEN CALCULATED BY NUMBER OF STEMS PER ARE.

Species		Diameter class (cm.) < 1.0	1.1- 5.0	5.1-10.0	10.1-15.0	15.1-20.0	20.1-25.0	25.1 >	Total
Salix spp.***	Available	75.4	85.1	4.3	.4	.3	.2	-	165.7
	Cut	12.0	12.5	1.1	.1	-	-	-	25.7
	% cut	15.9	14.7	25.6	25.0	-	-	-	15.5
Populus tremuloides	Available	73.7	14.3	2.2	1.0	.3	.2	.3	92.0
	Cut	10.3	.9	1.3	1.0	.3	.2	.3	14.3
	% cut	14.0	6.3	59.1	100.0	100.0	100.0	100.0	15.5
Elaeagnus commutata+	Available	39.4	21.6	-	-	-	-	-	61.0
	Cut	-	1.7	-	-	-	-	-	1.7
	% cut	0	7.9	-	-	-	-	-	2.8

* Preference at .1% level of significance.
** Preference at 1% level of significance.
*** Preference at 5% level of significance.

\+ Dislike at .1% level of significance.
++ Dislike at 1% level of significance.
+++ Dislike at 5% level of significance.

Table 17.

SPECIES AND BASAL DIAMETER CLASS PREFERENCE IN A 548.8 ARES SAMPLE OF BEAVER HABITAT AT HAWKEYE CR.
THE DATA HAS BEEN CALCULATED BY NUMBER OF STEMS PER ARE.

Species		Diameter class (cm.) < 1.0	1.1- 5.0	5.1-10.0	10.1-15.0	15.1-20.0	20.1-25.0	25.1 >	Total
Salix spp.**	Available	274.8	132.8	6.9	1.7	.2	-	-	416.4
	Cut	68.1	52.2	3.4	.7	.1	-	-	124.5
	% cut	24.8	39.3	49.3	41.2	50.0	-	-	29.9
Populus tremuloides++	Available	6.3	7.9	1.1	.2	.2	.4	.3	16.4
	Cut	.4	.9	.3	.1	.1	.2	.1	2.1
	% cut	6.3	11.4	27.3	50.0	50.0	50.0	33.3	12.8
Betula spp.+	Available	41.8	16.5	-	-	-	-	-	58.3
	Cut	-	.4	-	-	-	-	-	.4
	% cut	0	2.4	-	-	-	-	-	.7
Populus balsamifera	Available	-	1.6	-	-	-	-	-	1.6
	Cut	-	.4	-	-	-	-	-	.4
	% cut	-	25.0	-	-	-	-	-	25.0
Alnus tenuifolia	Available	-	-	.4	-	-	-	-	.4
	Cut	-	-	.4	-	-	-	-	.4
	% cut	-	-	100.0	-	-	-	-	100.0

* Preference at .1% level of significance.
** Preference at 1% level of significance.
*** Preference at 5% level of significance.

\+ Dislike at .1% level of significance.
++ Dislike at 1% level of significance.
+++ Dislike at 5% level of significance.

Table 18.

SUMMARY OF BEAVER PREFERENCES FOR CERTAIN PLANT SPECIES USED AS FOOD BY THE BEAVER IN THE PORCUPINE HILLS, ALBERTA. PREFERENCE (P) AND DISLIKE (D) ARE DETERMINED BY THE X^2-TEST, AT 5% AND HIGHER LEVELS OF SIGNIFICANCE FOR 1 DEGREE OF FREEDOM.

	Beaver habitats				
Species	Johnson Cr. I.	Streeter Basin	Camper Cr.	Hawkeye Cr.	Average for all areas.
Salix spp.	P.1%	U	P5%	P1%	P.1%
Alnus tenuifolia	-	-	-	U	P.1%
Populus tremuloides	P5%	U	U	D1%	P1%
Cornus stolonifera	P.1%	-	-	-	P5%
Populus balsamifera	-	U	-	U	U
Amelanchier alnifolia	-	D.1%	-	-	D.1%
Betula spp.	-	U	-	D.1%	D.1%
Elaeagnus commutata	-	-	D.1%	-	D.1%
Rosa acicularis	D.1%	-	-	-	D.1%

U - undecided

Table 19.

SUMMARY OF BEAVER PREFERENCES FOR DIFFERENT DIAMETER CLASSES OF WILLOWS (SALIX SPP.) AND ASPEN (POPULUS TREMULOIDES) IN THE FOUR MAIN STUDY AREAS OF THE PORCUPINE HILLS, ALBERTA. PREFERENCE (P) AND DISLIKE (D) ARE DETERMINED BY THE X^2-TEST AT 5% AND HIGHER LEVELS OF SIGNIFICANCE FOR 1 DEGREE OF FREEDOM.

		Diameter class (cm.)						
Location	Species	< 1.0	1.1- 5.0	5.1-10.0	10.1-15.0	15.1-20.0	20.1-25.0	25.1 >
Johnson Cr. I.	Salix spp.	D.1%	P.1%	P1%	U	U	U	D5%
	Populus tremuloides	U	D5%	P.1%	P1%	P1%	D.1%	P.1%
Streeter Basin	Salix spp.	D.1%	U	P1%	U	U	U	D1%
	Populus tremuloides	U	U	P1%	U	P1%	-	P1%
Camper Cr.	Salix spp.	U	U	U	P5%	D5%	D1%	-
	Populus tremuloides	U	D.1%	P5%	P5%	U	P5%	U
Hawkeye Cr.	Salix spp.	D.1%	P.1%	U	U	P5%	-	-
	Populus tremuloides	U	U	U	P5%	P5%	U	P5%
Average for each diameter class:								
	Salix spp.	D1%	P.1%	P5%	U	U	D5%	D1%
	Populus tremuloides	U	U	U	U	U	P5%	P5%

U - undecided

The diameter class preference was indicated in relative percentage cut per species, Tables 14 to 17, inclusive. The summary of the calculated beaver preferences for different basal diameter classes of Salix and aspen was recorded in Table 19. No preference was evident in the less than 1.0 centimeter diameter class, however, the beaver showed a dislike for this diameter class of the Salix in 3 out of 4 watersheds. This dislike might be a result of this selection of larger stems over seedlings. The 1.1-5.0 centimeters basal diameter class (Table 19), indicated strong preference for Salix in Johnson Creek I and Hawkeye Creek. A dislike was evident for aspen in the same diameter class in Johnson Creek I and Camper Creek. The other larger diameter classes indicated mixed results for the two above species with regard to preference and dislike.

The overall weighted trend in preference (Table 19), for basal diameter varied with the species (Table 19). For Salix the dislike in the less than 1.0 centimeter was evident, followed by preference in the 1.1 to 10.0 centimeters range of basal diameter. This was followed by a dislike for the willow with basal stem greater than 20.1 centimeters. With regard to aspen, no preference or dislike was apparent in the basal diameter classes up to 20.0 centimeters (Table 19). A preference for aspen with 20.1 centimeters to 25.0 centimeters base was evident, however, how far this preference continued for aspen with larger basal diameter could not be shown. The statistical analysis indicates the beaver's preferences for larger basal diameter classes of aspen, even though the sample sizes were small.

Beaver colony survey.

Sixty active colonies were recorded during the 1971 season. The habitat in each beaver colony was classified according to the five major woody species of the region (Table 20). The habitat consisted primarily of willow, as willow was rated first in forty-seven out of the sixty colonies, and ten colonies had willow as their secondary genus. All colonies had willow present (Table 20). Aspen was the second most important species present. Aspen was rated first in only three colonies, seventeen colonies had secondary aspen stands, while the aspen was absent in twenty-three colonies. Black poplar was the primary woody species in four colonies. Conifers was of primary importance at three sites.

A beaver colony survey was made of the Porcupine Hills to better understand the pressure of the beaver population upon the environment. Over the four year period from 1968 to 1971, the population varied between forty to sixty colonies (Figure 33). The number of colonies decreased with 27 per cent during the winter of 1968-69, however, during the 1970 season the number of colonies were the same as in 1968. The 1971 census indicated only a moderate increase from 1970. The potential increase in this beaver population must be high since it was able to correct for a 27 per cent reduction over two summers, the 1969 and 1970 seasons. There was no apparent migration of beaver into the study area, it was therefore probably the two year old beaver, born spring of 1968, that brought the number of colonies up to its previous level in 1970. It is the belief of the author that it was mainly the marginal colonies that suffered the greatest losses.

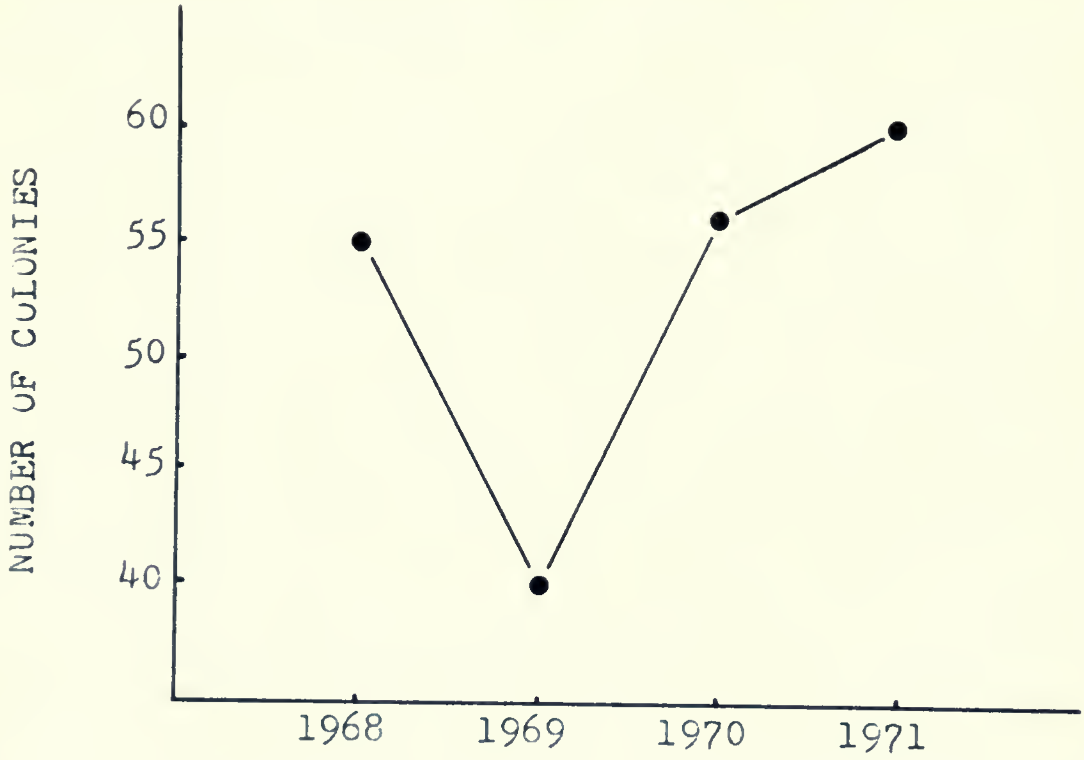

Figure 33. Annual census of beaver colonies, Porcupine Hills study area, 1968 to 1971.

Table 20.

SUMMARY OF HABITAT CLASSIFICATION OF 60 BEAVER COLONIES IN THE PORCUPINE HILLS, SW-ALBERTA.

Importance rating of plants.	Salix spp.	Populus tremuloides	Populus balsamifera	Betula spp.	Conifers
1st	47	3	4	1	3
2nd	10	17	6	5	4
3rd	1	15	9	8	5
4th	2	2	2	3	7
5th	-	-	1	1	2
Absent	0	23	38	42	39

The 27 per cent decrease in number of beaver colonies over the 1968-1969, trapping season was believed to be a result of the severe winter conditions. The low mean temperature for December 1968, was 12° F, (a lower mean temperature than any other December during the investigation, Figure 3). The December average temperature was followed by extremely low mean temperature, -4° F, in January, when the mean temperature was more than 15° F below any other winter month. During those two months, the equivalent of 5 inches of rain fell (Figure 2), that produced 19 inches of snow on the ground at the end of January (Climatological Records of Porcupine Hills Ranger Station, 1968 and 1969). The snow lay on the ground continuously until the end of March 1969. No major chinooks occurred that winter. The water levels appeared rather high in Streeter Creek (Figure 8), which was used to represent the water levels of the region. Although, the soil temperature data was not available for that winter, the data for 1967 and 1968 (Figure 35) indicates that when snow covered the ground (Figure 2), the ground temperature was higher. Thus, for the beaver colonies in the Porcupine Hills study area, as a result of the length of the winter and the extreme cold, the beaver might have been forced to feed above the ice where they might have succumbed to predators or extreme cold. Although, the spring came early during 1969, enabling the trappers and poachers to shoot the beaver instead of trapping them, the annual catch was only average.

The density of the population was low, only 0.07 colony per square kilometer or 0.16 colony per kilometer of stream (as was mentioned in the description of the study areas). The

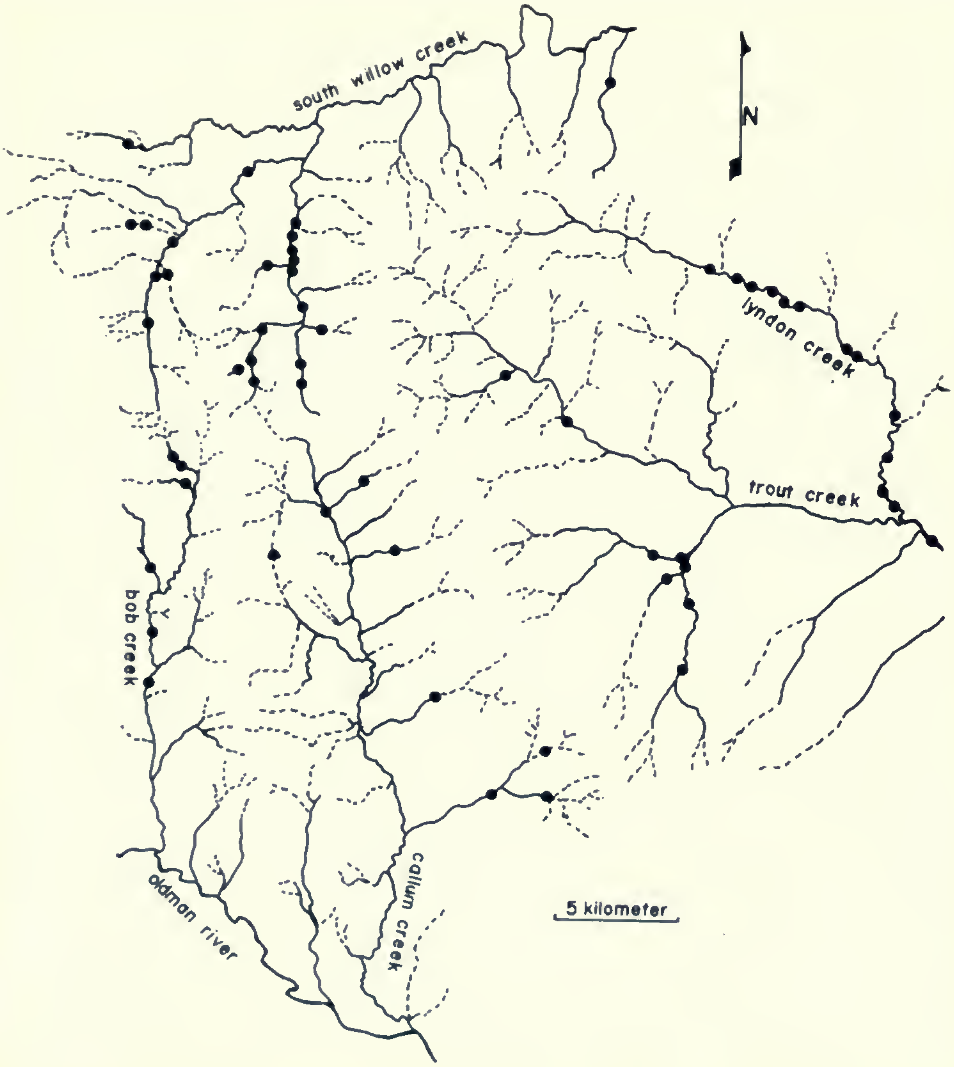

Figure 34. The watersheds of the Porcupine Hills study area with location of active beaver colonies during summer 1971. (Each black dot indicates one active beaver colony.)

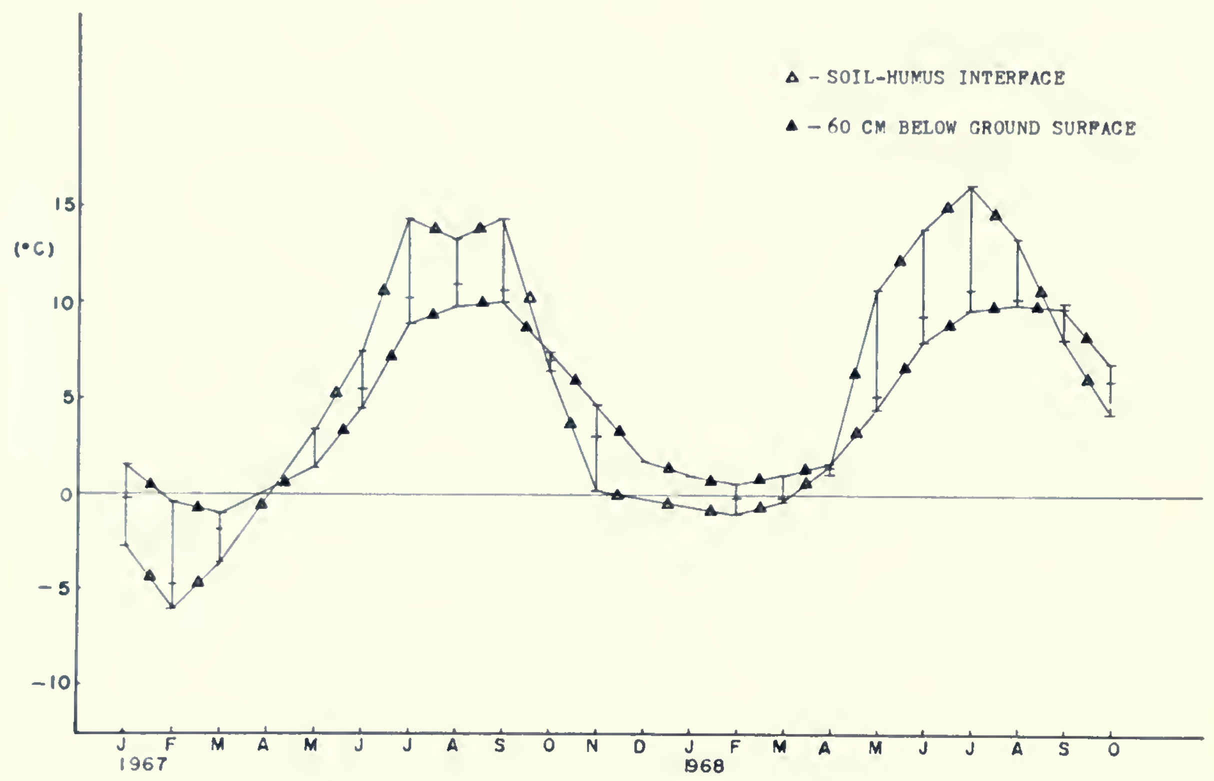

Figure 35. Monthly variation of soil temperature in an east-facing aspen stand in Streeter Basin, Alberta, (site 4), after Water Survey of Canada (1967 and 1968). (Temperature at soil-humus interface was compared to the soil temperature 60 centimeters below the surface.)

rough topography of the foothills causes the establishments of the colonies to be mainly along the main channels (Figure 34).

The heavy grazing pressure of the region causes the willow to be destroyed by scratching cattle. The streams were often very turbid throughout the summer due to cattle spending the hottest part of the day in the cool water. This caused increased silting in of the ponds resulting in abandonment by the beaver.

CHAPTER V. DISCUSSION.

Soil particle size analysis.

The natural condition in the Porcupine Hills is the periodic high precipitation and runoff that causes the increased velocity of water and resultant erosion. The high clay content (Table 2) in this region causes high turbidity during the periodic floods, otherwise the water is low in suspended material.

Beaver activity causes increased turbidity in the watersheds of normal water flow, but this does not necessarily mean increased erosion as outlined on page 66. When turbidity increases, less light penetrates into the water, but the heat absorbing effect and the water temperature increases. Increased water temperature causes increased water loss through evaporation of the water. Increased water temperature causes greater growth rate of the flora and fauna, (Benton and Werner, 1958), that live in close contact with the beaver dams of the Porcupine Hills. The cool creek water is normally only 8-14° C during July and August.

The increased evaporation from beaver ponds also causes higher environmental moisture content (a microclimatic consideration), that increases vegetation growth in this semi-arid region of Alberta.

Beaver utilization of herbaceous vegetation.

If herbivore activity was assumed to be equal in all vegetation plots before the start of the experiment, the net primary production of shoot tissue during a period of time was equal to the increase in standing crop of live tissue, corrected

for the loss of live material by mortality. The mortality factor in this study was the decomposition of spring plants, diseased plants, or plants that simply had completed their life cycle for the year. Any live tissue removed from the study plots were considered to have been utilized by the mammals.

It is understood that the data obtained does not represent the true primary production, since the initial standing crop was not measured in each study area before the initiation of the experiment. Neither were the plots clipped for live vegetation, nor the withering matter removed before the experiment started. The reason for this was that the plots should appear as natural as possible to the herbivores. Plot type A should represent the primary production, protected from herbivores by 3/4 inch netting, plot type B should represent the primary production minus the amount of vegetation utilized by Columbian ground squirrel, protected from large herbivores by 3" x 5" netting. Plot type C should represent the primary production minus the standing crop that was utilized by the beaver and Columbian ground squirrel within the fence. Plot type D should represent the amount of the standing crop that was utilized by the ungulates, beaver and ground squirrel.

The following three major difficulties were encountered. Firstly, how does one count for regrowth of vegetation when grazed by the mammals? Secondly, how much do red-backed voles and white-footed mice eat, and distort the data when they select their nesting sites within the protection of the study plots? Thirdly, when selecting study plots, the density and composition of the plots change throughout the summer, thus, the biomass of

the plots might be equal at the time of selection, but later would be greatly distorted due to different growth potential for the different species involved.

Within the first week of the experiment, study plot 1C on area II was heavily grazed by beaver. Three weeks later the plot was clipped, and due to replacement of new vegetation, the plot indicated only a 29.7 per cent drop in biomass compared to the average of this plot type. The growth of plants in this moist habitat appears to have the possibility to yield several crops per growing season if utilized, and thus distort the utilization data if it is not included in the experiment at the beginning.

No reference has been found to the amount of vegetation a family of red-backed voles or white-footed mice consume per day, therefore no calculation will be attempted of the distorted effect these rodents caused in the experiment.

One feature of this project was the selection of the netting cones for nesting sites by the red-backed voles (*Clethrionomys gapperi galei*) and/or white-footed mice (*Peromyscus maniculatus*). Both species were nesting in the willow grassland habitat (Soper, 1964). The protection offered by the netting cones was twofold, the vegetation was not utilized by larger herbivores, and thereby offered better nesting habitats for the small rodents at the same time as it protected the rodents from predators like skunk, coyote, and avian predators. The fenced-in area in itself offered much better cover for the rodents than outside the fence due to extremely heavy use of the standing crop by the cattle close to the

watering hole. Thus, it is reasonable to believe the rodents would move from the rapidly depleting range into heavier cover, and the heaviest cover was located within the cones.

It is the opinion of the author that the beaver does select certain forbs when feeding on the herbaceous vegetation during the daytime, however, at other times this rodent eats all species both grass and forbs that are available. The degree of herbaceous plants in its diet appeared rather small at this study area, both from actual observations and biomass data collected. It might be that the beaver depends more heavily upon herbaceous vegetation for food when the food supply begins to be depleted.

Systematic plot intercept sampling of beaver habitat.

This study indicates that the beaver in the Porcupine Hills removed the top canopy and increased the floral diversity of species requiring more light, thus playing an important factor in the local plant succession. Willow became more plentiful with beaver activity in a watershed, and so beaver activity also created better browsing for the ungulates of the area. The opening of the canopy produced increased grazing areas, as herbaceous vegetation provided lush feed for the grazers in the low lying areas where the organic soil was accumulated.

Salix novac-angliae was only found in Hawkeye Creek, and S. *monticola* Rydb. was only found in Johnson Creek I. This might indicate a range extension as these plants were not reported by Moss (1959). Of the six species of *Salix* recorded for the area, only S. *bebbiana* appeared common throughout. The other species were only located in certain study areas,

probably due to the different environmental conditions of the study basins. The willow at both Johnson Creek II and Raspberry Creek sites was composed solely of S. bebbiana, a species that appeared to tolerate the low light intensity under the Populus canopy.

Shrubby cinquefoil may be used as an indicator of high grazing pressure (Cormack, 1967); the density values of this plant may be used as an objective indicator of the condition of the range. High values in Johnson Creek I indicated overgrazing over a period of time (Cormack, 1967). This observation correlated well with the deteriorating effect the cattle had upon the browsing of the willow, which in many places was completely killed off due to stripping and breaking of the stems. The lower values of the shrubby cinquefoil in Camper and Hawkeye Creek indicated that the grazing was much lighter than the deteriorating effect caused by grazing in Johnson Creek. This is in agreement with the condition of the range in Camper and Hawkeye Creek.

Hall (1960) stated that die-back of willow at beaver colonies might be due to overbrowsing of the willow by ungulates. Die-back of willow was observed at all colonies intensively investigated, and there appeared to be a definite relationship between die-back of willow and browsing pressure. The number of willow per are that were dead, browsed, and live in the six study basins is shown in Figure 36. The unbrowsed value may be obtained by subtracting the browsed value from the live value. No relationship between the number of dead and browsed plants could be found (Figure 36). Either there was no relationship,

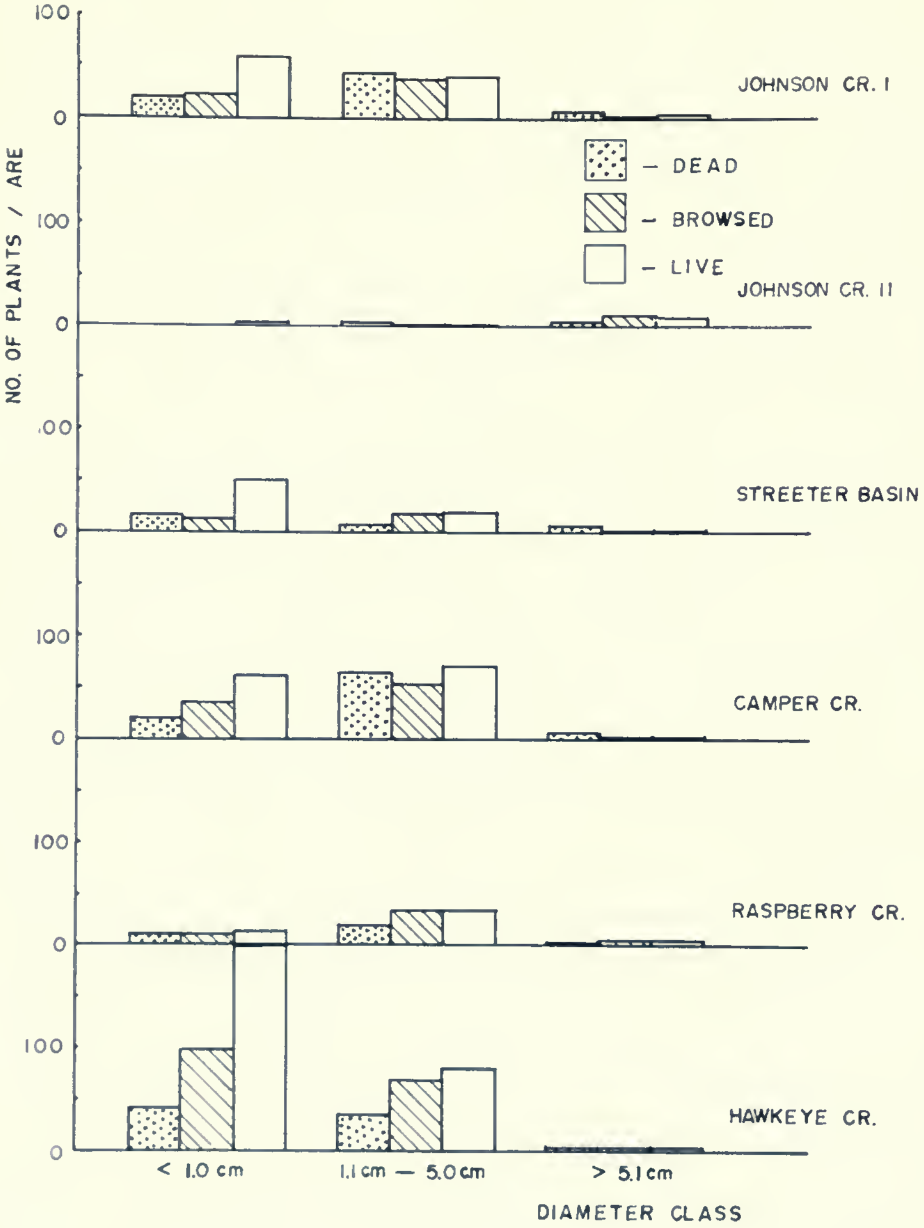

Figure 36. Relationship between actual density of dead, browsed, and live _Salix_ in the six study areas of the Porcupine Hills. (The _Salix_ of each study area was summed to represent the three quadrat sizes.)

or the method of data collection does not lend itself to the analysis attempted. The relationship of the browsing pressure on the different basins is indicated in Figure 36. The number of dead stems in the 1-5 centimeters basal diameter class appeared greatest where heavy grazing occurred. This is also correlated with the high density of shrubby cinquefoil.

Food requirements.

The gathering of food in caches before freeze-up was not observed in the Porcupine Hills. The beaver was observed to chew holes from beneath the ice to remove the saplings of *Populus tremuloides* from the shore, and to transport the saplings back beneath the ice, during the first week of December, 1969. Several localities where the beaver had cut aspen up to 3 feet above ground, indicated winter feeding by the beaver. Aleksiuk (1968) reported a second food gathering period toward the spring in the Mackenzie Delta, N.W.T., prior to break-up. The amount of food needed to meet the energy demand of life processes varied according to different authors, to location and to climatic conditions. Thus, the amount of daily food utilized should be in direct proportion to the beaver's requirements. Novakowski (1965) stated that the adult beaver in Alberta weighs approximately 21 kilograms, and utilizes on the average approximately 43 gm. per kg/day (estimated from Aleksiuk, 1968), thus, every adult beaver needs 904 gm./day or 330 kilograms of food per year. An average colony of 5 beaver would need 1650 kilograms (1000 kilograms dry weight based on 35 per cent moisture, Young (1964), of food per year). The combined biomass available per are in the Porcupine Hills of *Salix* spp. and *Populus tremuloides* was

260 kg/are (dry weight) (Tables 21 and 22), thus, one beaver colony needs approximately 4 ares of the above vegetative types per year to sustain their feed requirements. The above calculations considered all available biomass as food, however, since this was not the case, the author felt that a conservative estimate of 50 per cent of the available biomass may be considered as food. The other 50 per cent of non digestible stems and wasted food and stems was primarily employed in upkeep of dam and lodge. Therefore, an estimated 8 ares (0.2 acres) annually were needed to sustain a beaver family of 5 in the Porcupine Hills region.

Herbaceous material was not included in the above estimate. At the Black Mountain site for the month of August, herbaceous material accounted for 22 grams/day or approximately 2 per cent of one beaver's diet per day. These figures appeared to be insignificant compared to the above woody biomass utilized. However, if the herbaceous beaver habitat at Black Mountain may be considered to be uniform and randomly sampled by the beaver, then utilization of herbaceous plants would be of great importance in the beaver's diet. For example; the beaver pond had 600 meters of shoreline. If the herbs were utilized at an estimated 10 meters inland from the shoreline, the surface area would equal 60 ares. Then the beaver would have consumed 1320 gm. per day (dry weight) of herbaceous plants, a biomass figure which was a little higher than needed for the beaver during the month of August (Aleksiuk, 1968).

Woody plant utilization and species preference.

By basing the utilization and preference values on number

Table 21.

TOTAL AVAILABLE OVEN-DRY BIOMASS PER ARE OF *SALIX* SPP. IN SIX DIFFERENT AREAS OF BEAVER HABITAT IN THE PORCUPINE HILLS, ALBERTA. CALCULATIONS FOLLOW THE PREDICTION EQUATION OF ABOVEGROUND BIOMASS (W IN GRAMS) BASED ON BASAL DIAMETER (D IN MILLIMETERS): LOG W = - 1.519 + 2.325 (LOG D), (TELFER, 1969).

Location	Diameter class (cm.)							Total (kg/are)
	0- 1.0	1.1- 5.0	5.1-10.0	10.1-15.0	15.1-20.0	20.1-25.0	25.1 >	
Johnson Cr. I	.6*	38.0	52.6	36.1	14.4	12.9	10.3	164.9
Johnson Cr. II	.02	.5	25.5	8.2	18.0	-	20.5	72.7
Streeter Basin	.5	16.5	13.0	27.9	46.7	45.1	41.1	190.8
Camper Cr.	.7	50.7	21.5	6.6	10.8	12.9	-	103.2
Raspberry Cr.	.1	16.8	16.5	39.4	32.3	12.9	-	118.0
Hawkeye Cr.	2.5	79.2	34.6	27.9	7.2	-	-	151.4
Total	4.42	201.7	163.7	146.1	129.4	83.8	71.9	801.0

* weight is given in kilo per are (kg/are)

Table 22.

TOTAL AVAILABLE OVEN-DRY BIOMASS PER ARE OF POPULUS TREMULOIDES IN SIX DIFFERENT AREAS OF BEAVER HABITAT IN THE PORCUPINE HILLS, ALBERTA. CALCULATIONS FOLLOW THE PREDICTION EQUATION OF ABOVEGROUND BIOMASS (W IN GRAMS) BASED ON BASAL DIAMETER (D IN MILLIMETERS): LOG W = - 2.920 + 2.715 (LOG D), (TELFER, 1969).

	Diameter class (cm.)							
Location	0- 1.0	1.1- 5.0	5.1-10.5	10.1-15.0	15.1-20.0	20.1-25.0	25.1 >	Total (kg/are)
Johnson Cr. I	.01*	.5	1.3	10.6	6.6	-	22.6	41.6
Johnson Cr. II	.3	.7	10.0	13.3	33.2	-	45.3	102.8
Streeter Basin	.06	14.6	10.6	18.6	19.9	13.1	22.6	99.5
Camper Cr.	.3	7.9	14.6	26.6	19.9	26.2	67.9	163.4
Raspberry Cr.	.01	4.2	12.0	31.9	46.4	39.4	67.9	201.9
Hawkeye Cr.	.03	4.4	7.3	5.3	13.3	52.5	67.9	150.7
Total	.41	32.3	55.8	106.3	139.3	131.2	294.2	759.8

* weight is given in kilo per are (kg/are)

of stems cut, a value was obtained that not only recorded the frequency, but also relative food value. Young and Carpenter (1967) found that the smallest diameter class of young aspen was considered to have the highest nutrient value for the beaver. They further found that in general, the percentage of essential elements was highest in the foliage, and decreased from foliage to the branches, and decreased further in the stem.

Young (1971) estimated the following amounts of the elements in bark as per cent of amounts of elements in complete aspen (*Populus tremuloides*) tree: Al - 59; Mn - 39; Mo - 69; Ca - 67; P - 41; Mg - 43; Zn - 55; Cu - 28; Fe - 53; B - 53; N - 34; and K - 40. These estimates included the whole tree exclusive of leaves, branches, and roots less than 1/4 inch in diameter. He also stated that about half of the elements in the standing tree was located in the bark. From this it could be seen that the beaver utilize the most nutritious part of the tree when eating the bark during the winter.

I observed a beaver in June, 1970, that completely ate a piece of fresh cut aspen approximately 10 centimeters wide and 10 centimeters long. The aspen was plentiful in the area. It was not known whether this was a unique food item, or whether it was eating its regular diet. This was confirmation of Novakowski's (1968) statement, that he considered all parts of the aspen under 5 centimeters to constitute food during the winter. I believe that aspen over 5 centimeters in diameter might be an exception rather than the rule in the Porcupine Hills. However, if the habitat was marginal for occupancy, diameter above this would probably be completely utilized.

It was observed that the intensity with which the beaver utilized the vegetation decreased with the distance away from the water, both in regard to woody stems, and particularly in the case of herbaceous plants.

Salix was the most important food genus of the Porcupine Hills region. A preference for this genus was observed in three out of four study areas. Willows consituted the plant group with the largest biomass (Table 21) both in the smaller basal diameter classes and in total. Willow was highest in overall density of the plants for which the beaver indicated preference. The beaver habitat in this region of Alberta may therefore be determined as very good, since the most preferred genus was also the most abundant.

Populus tremuloides, as a major species, was second in preference in the beaver's food diet. This species provided a biomass (Table 22) of approximately equivalent mass to the *Salix*. However, the aspen stand was mainly composed of mature trees which might be considered less palatable than the young succulent willow stems.

The preference of any particular size class, presented a problem in how to decide if it was related to food and as such palatability and nutrition; or primarily as building material; or to density. Since the preference for willow was for stems below 5 centimeters in basal diameter, it was believed to be chosen due to density, but of course the above considerations for food, palatability, and construction material affected the result.

The preference for aspen 20 centimeters and larger was

harder to explain, because the bark on the older trees tended to be corky and thereby less palatable. Although the preference for any single class was slight, it might be considered that the choice of "non renewable resource" (Hall, 1960), was reflected in the available aspen stand. When depleted, the aspen tended to be replaced by willow and as such probably played a relatively smaller role in the life of a colony compared to the willow. The willow, a fast sprouting and growing plant, was able to produce a sustained yield for beaver in Hawkeye Creek, Streeter Basin, and Johnson Creek valleys. In Johnson Creek valley, there was danger that the cattle use had been too heavy for a sustained yield.

Availability of the sum of the cut and uncut woody stems in this paper was only considered as a historical review of the habitat. It was recorded here as merely the presence of the sum of live uncut and cut stems. A second theoretical hypothesis that relative utilization (cut) and relative availability values may be used in determining preference, was demonstrated in Table 13. When the relative cut value was larger than the relative available value, a species specific preference was evident.

The topographical influence on feeding behaviour by the beaver was best illustrated in Hawkeye Creek. The average gradient of the East bank was 34 per cent and the beaver trails and cuttings could be followed 100 meters up the hillside. The West bank was sloping with 7 per cent average, and here the beaver went only a maximum of 50 meters away from the water. The feeding distance away from the water appeared to depend upon

the gradient of the slope (within the range of the slope gradients recorded), and thereby depending upon the topography.

Although willow and aspen were the most important items cut by beaver, most woody plants are sampled to some extent (Hall, 1960). During this investigation, it was found that 9 out of 15 species were cut by the beaver. No observation was made of any cut coniferous trees. The variety in the diet of the beaver may be very important in providing the different nutrition and vitamins.

Beaver colony survey.

The five colonies intensively investigated with past or present beaver activity, included a total of 314 ares of pond surface, or 62.8 ares of pond surface per colony. This approximate average pond surface area per colony was multiplied by the 60 active colonies located within the study area, to total 3,768 ares. The evaporation loss at Streeter Basin averaged 4 millimeters (0.16 inch) per day (Water Survey of Canada, 1967-71) for the period June 1, to September 30, over the five year period (Figure 37). Considering this as an average loss of evaporated water from the beaver ponds, the total yearly loss of water would be in the magnitude of 1,507 cubic meters per day or 183,878 cubic meters from June to September. The evaporation loss does not consider unoccupied beaver ponds. This evaporation loss of the study area does not consider losses from open water in the creeks outside the areas studied. The study area had roughly 375 kilometers of stream of an estimated width of 1 meter. The theoretical evaporation loss from the

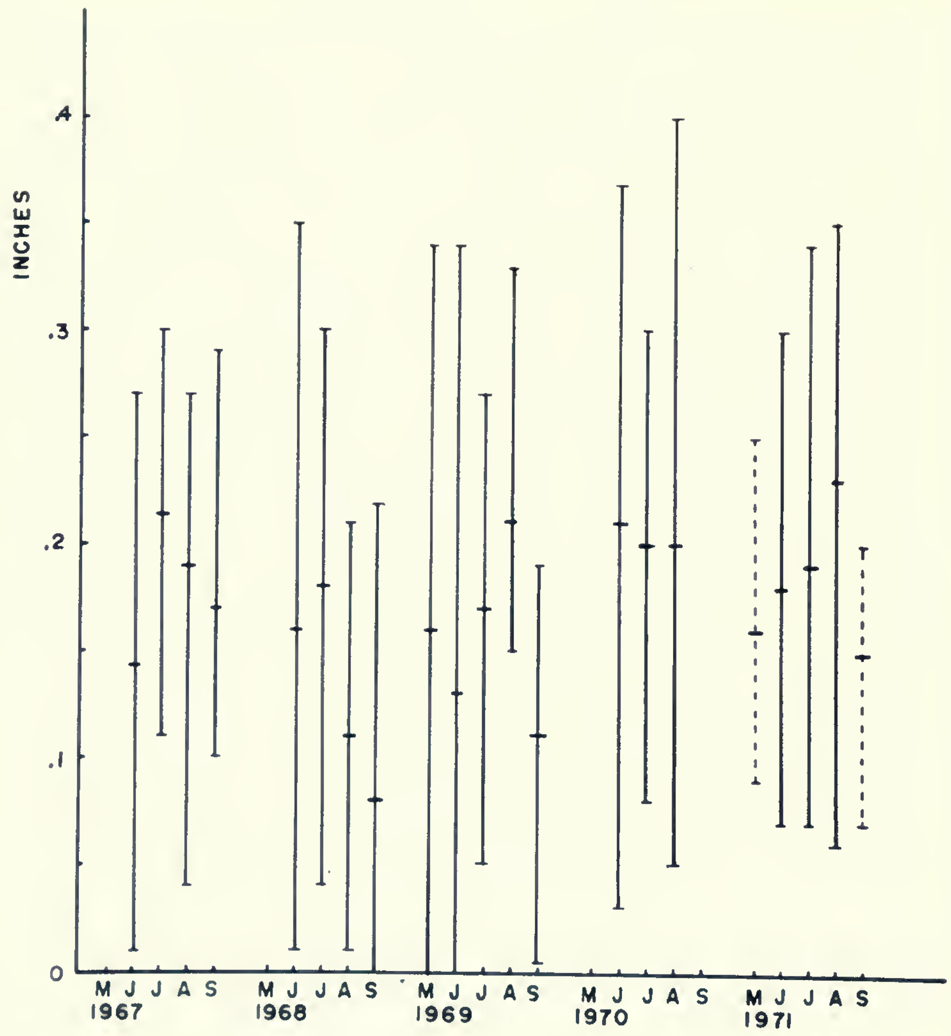

Figure 37. Mean monthly evaporation with maximum and minimum values in inches from May to September, 1967 to 1971, inclusive, at (site 7) Streeter Basin, Alberta. Water Survey of Canada (1967, 1968, 1969, 1970, and 1971). (Insufficient data was indicated by stippled lines. The evaporation was measured with a standard Class A pan.)

streams would be 183,000 cubic meters of water in the period June to September each year. Thus, the evaporation loss of the beaver ponds may be considered to be approximately equal to the loss from the streams. The beaver activity was therefore proven to have increased the humidity in the valleys based on micro-climatic consideration.

The total water holding capacity of all the active beaver dams in the region was estimated to equal 188,400 cubic meters. The rather conservative estimate of 0.5 meter overall depth over the 3,768 ares of pond surface was established after considering that many ponds have great shallow areas as a result of soil settlement. The water holding capacity of the beaver ponds was much larger than the above volume if one consider the water held in the soil behind the dam itself. A beaver pond in general tends to raise the water table over a large area, both above and below the dam itself, (Storr, pers. comm., 1969).

An estimated 300 beaver occupy the beaver colonies in the Porcupine Hills study area. To reach this number, an estimated number of 5 beaver per colony was employed (Denny, 1952). The beaver population appeared to be of average density. The licenced trappers of the region do not presently trap the annual crop of beaver, because of the low prices on the beaver pelts. It is the author's belief, however, that poaching by Indians and unregistered trappers is keeping the population in check.

CHAPTER VI. SUMMARY AND CONCLUSION.

1. The main objective of this study was to examine the ecological effects of beaver upon the watersheds in the Eastern part of the Rocky Mountains. Vegetation, soil, water, and beaver colony numbers were examined. The data was analyzed and extrapolations, as it pertains to the Porcupine Hills study area, was attempted.

2. The soil used by the beaver for construction purposes had large percentage of clay. The clay served as binding material for trees, sticks and branches used in construction of dams and lodges.

3. Heavy deposition of soil in the beaver dams in this region is one of the major reasons for beaver abandonment of colonies.

4. The beaver dams are agents in controlling soil erosion, serve as nutrient pools, and play an important role in the biogeochemical cycles of the Porcupine Hills.

5. The herbaceous vegetation study indicated that the beaver utilizes measurable amounts of herbs. The duration of the study was too short, and more than one season of data is needed before any trends can be established. Dandelion, purple sticky geranium, and stinkweed were observed to be utilized by the beaver.

6. The association of woody vegetation in the low lying areas, where the beaver habitat is located, is mainly aspen and willow in the top canopy. Rose and honeysuckle have the highest values in the understory. Willow was by far the most important group of plants associated with the beaver colonies, followed by aspen. A total of 15 types of woody plants were identified within the study area.

7. The species diversity of the flora was increased by the presence of beaver. The beaver cut down the top canopy and allowed more light to enter the forest floor.

8. Species preference was observed for 4 genera out of 9 plant types utilized by the beaver, namely willow, alder, aspen, and dogwood. Balsam poplar was utilized according to its availability. Dislike was observed for 4 genera, namely Saskatoon berry, birch, wolf willow, and rose.

9. Preference for certain basal diameter classes was observed for willow and aspen, the only two species that were utilized frequently enough to allow for statistical analysis of the data. Preference for basal diameter of willow was observed from 1.0 centimeter up to 10.0 centimeters. Dislike was observed for willow with basal diameter smaller than 1.0 centimeter and larger than 20.0 centimeters. The beaver utilization of aspen indicated no dislike for any basal diameter class, but preference was indicated for trees with basal diameters above 20.0 centimeters. Thus,

the basal diameter size preference for woody stems cut by beaver differs with different plant types in the Porcupine Hills.

10. The actual utilization of each cut stem was generally found to decrease as the basal diameter increased both for willow and aspen. The reason for this is assumed to be due to the palatability of the bark. The older trees had more corky bark and were therefore less palatable.

11. The density of willow was much higher than the density of aspen, however, when comparing the overall biomass of these two species, they were approximately equal within the study area.

12. Sixty active beaver colonies were tallied during the 1971 season. Thus, an estimated 300 beaver are presently inhabiting the area (on the basis of five beaver to a lodge). All the active colonies had willow, while 23 sites had no aspen. Twenty-two of the colonies had balsam poplar, and 21 colonies had conifers within the range of the beaver colony. The beaver in the Porcupine Hills is thereby dependent upon willow, since all colonies had willow present, and this was also the species for which the beaver in this region indicated the strongest preference.

13. Strong climatic evidence was available to explain the sudden decrease in the beaver population during the 1968-69

winter. A 27 per cent decrease was observed in the number of active beaver colonies in the study area. At the same time the minimum temperature dropped to minus 38° F, and there was no chinook in the region during the winter of 1968-69.

14. The evaporation rate from the beaver pond surfaces within the study area was estimated to equal 1,507 cubic meters per day in the period from June to September. This is a considerable daily evaporation loss of water in this semi-arid region of SW-Alberta. The combined surface area of all the streams had a theoretical evaporation loss of water equal in magnitude to that of the beaver pond.

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APPENDIX I.

LIST OF DEFINITIONS.

Available: The sum of uncut and cut woody vegetation - the past condition of the habitat.

Cuttings: "Pieces of herbaceous vegetation, often grass, that have been chewed into short lengths by a mammal." (Benton and Warner, 1958). This refers only to herbaceous vegetation study.

Dislike: Observed utilization per species (X) is less than the expected utilization ($\bar{X}$) for the same species. ($X < \bar{X}$) when tested positively with the X^2-test at the 5% level of significance.

Ground coverage value: This is the per cent of total area that was actually covered by plots in the plot-intercept survey.

Preference: When the utilized number of stems of any species exceeds the expected number ($X > \bar{X}$) relative to all available and utilized plants species. A preference is evident when tested positively with the X^2-test at the 5% level of significance. A preference does not indicate the amount utilized of each cut stem.

Relative: Means a comparison of the whole thing ie., all the diameter classes per species, or all diameter classes for all the species, as specified.

Undecided: When neither preference nor dislike could be proven statistically, the values in question were called undecided.

APPENDIX II.

SCIENTIFIC AND COMMON NAMES OF ALL PLANT SPECIES USED IN THIS REPORT, AFTER MOSS (1959).

Achillea millefolium L.	Common yarrow
Agropyron spp.	Wheat grass
Alnus tenuifolia Nutt.	River alder
Amelanchier alnifolia Nutt.	Saskatoon-berry
Artemisia ludoviciana Nutt.	Prairie sage
Aster spp.	Aster
Betula glandulosa Michx.	Dwarf birch
Betula occidentalis Hook.	Water birch
Bromus spp.	Brome grass
Carex spp.	Sedge
Cirsium arvense (L.) Scop.	Canada thistle
Cornus stolonifera Michx.	Red osier dogwood
Crataegus sp.	Hawthorn
Danthonia parryi Scribn.	Parry oat grass
Elaeagnus commutata Bernh.	Silver-berry, Wolf willow
Epilobium augustifolium L.	Fireweed
Equisetum spp.	Horsetail
Festuca scabrella Torr.	Rough fescue
Fragaria glauca (S. Watts) Rydb.	Strawberry
Galium boreale L.	Northern bedstraw
Geranium viscosissimum Fisch. & Mey.	Purple sticky geranium
Geum macrophyllum Willd.	Yellow avens
Heracleum lanatum Michx.	Cow parsnip

Juniperus horizontalis Moench	Creeping juniper
Juniperus scopulorum Sarg.	Rocky Mountain juniper
Ledum groenlandicum Oeder	Labrador tea
Lomatium sp.	Parsley
Lonicera involucrata (Richards.) Banks	Honeysuckle
Mentha arvensis L. var. *villosa* (Benth.)	Wild mint
Myriophyllum verticellatum L.	Water milfoil
Petasites sagittatus (Pursh) A. Gray	Colts-foot
Phleum pratense L.	Timothy
Picea engelmanii Parry	Engelman spruce
Picea glauca (Moench) Voss	White spruce
Pinus contorta London var. *latifolia* Engelm.	Lodgepole pine
Pinus flexilis James	Limber pine
Poa interior Rydb.	Inland bluegrass
Populus balsamifera L.	Balsam poplar
Populus tremuloides Michx.	Aspen poplar
Populus trichocarpa T. & G.	Black cottonwood
Potamogeton richardsonii (Benn.) Rydb.	Clasping-leaf pondweed
Potentilla fruticosa L.	Shrubby cinquefoil
Pseudotsuga menziesii (Mirb.) Franco	Douglas fir
Ribes oxyacanthoides L.	Gooseberry
Rosa acicularis Lindl.	Rose
Rubus strigosus Michx.	Wild red raspberry
**Salix* bebbiana* Sar.	Beacked willow
**Salix* discolor* Muhl.	Pussy willow

*<u>Salix lasiandra</u> Benth.	Willow
*<u>Salix monticola</u> Rydb.	Willow
*<u>Salix novac-angliae</u> And.	Willow
*<u>Salix petiolaris</u> J. E. Smith	Willow
<u>Shepherdia canadensis</u> (L.) Nutt	Canadian buffalo-berry
<u>Smilacina stellata</u> (L.)Desf.	Star-flowered salmon seal
<u>Solidago</u> spp.	Goldenrod
<u>Symphoricarpos occidentalis</u> Hook.	Buckbrush
<u>Taraxacum officinale</u>	Common dandelion
<u>Thalictrum</u> sp.	Meadow rue
<u>Thlaspi arvense</u> L.	Stinkweed
<u>Urtica gracilis</u> Ait.	Nettle
<u>Vicia americana</u> Muhl.	Wild vetch

* <u>Salix</u> spp. was identified by Dr. G. W. Argus

APPENDIX III.

THE FAUNA OF THE PORCUPINE HILLS, ALBERTA.

A. MAMMALS OF THE STUDY AREA, AFTER SOPER (1964).

Alces alces	Moose
Canis latrans latrans Say	Coyote
Castor canadensis canadensis Kuhl	Beaver
Cervus canadensis nelsoni Bailey	Wapiti
Citellus columbianus columbianus (Ord)	Columbian ground squirrel
Citellus richardsonii richardsonii (Sabine)	Richardson ground squirrel
Citellus tridecemlineatus tridecemlineatus (Mitchill)	Striped ground squirrel
Clethrionomys gapperi galei (Merriam)	Red-backed vole
Euarctos americanus	Black bear
Eutamias amoenus	Chipmunk
Eutamias minimus	Chipmunk
Felis concolor missoulensis Goldman	Cougar
Lynx canadensis canadensis Kerr.	Lynx
Mephitis mephitis hudsonica Richardson	Northern plains skunk
Microtus pennsylvanicus	Meadow vole
Mustela frenata longicauda Bonaparte	Long-tailed weasel
Mustela vison lacustris (Preble)	Hudson Bay mink
Odocoileus hemionus hemionus (Rafinesqe)	Mule deer
Odocoileus virginianus ochrourus Bailey	White-tailed deer

Ondatra zibethicus spatulatus (Osgood)	Muskrat
Peromyscus maniculatus	White footed mouse
Tamiasciurus hudsonicus richardsonii (Beckman)	Red squirrel
Taxidea taxus taxus (Schreber)	American badger
Thomomys talpoides talpoides (Richardson)	Pocket gopher
Zapus princeps	Jumping mouse

B. LIST OF BIRDS OBSERVED IN THE STUDY AREA, AFTER SALT-WILK (1966).

Actitis macularia	Spotted sandpiper
Anas carolinensis	Green-winged teal
Anas platyrhynchos	Mallard
Aquila chrysaetos	Golden eagle
Ardea herodias	Great blue heron
Bombycilla cedrorum	Cedar waxwing
Bombycilla garrula	Bohemian waxwing
Bonasa umbellus	Ruffed grouse
Bucephala islandica	Barrow's goldeneye
Buteo jamaicensis	Red-tailed (Harlan's) hawk
Buteo lagopus	Rough-legged hawk
Buteo regalis	Ferruginous hawk
Buteo swainsoni	Swainson's hawk
Circus cyaneus	Marsh hawk
Contopus sordidulus	Western wood peewee
Corvus brachyrhynchos	Common crow
Corvus corax	Common raven
Dendragapus obsurus	Blue grouse
Dendrocopos pubescens	Downy woodpecker
Dendrocopos villosus	Hairy woodpecker
Dendroica auduboni	Audubon's warbler
Dendroica petechia	Yellow warbler
Empidonax difficilia	Western flycatcher
Empidonax minimus	Least flycatcher
Falco sparverius	Sparrow hawk

Hylocichla fuscescens	Veery
Hylocichla guttata	Hermit thrush
Icterus galbula	Baltimore oriole
Iridoprocne bicolor	Tree swallow
Ixoreus naevius	Varied thrush
Junco oreganus	Oregon junco
Mareca americana	American widgeon
Melospiza georgiana	Swamp sparrow
Mergus merganser	Common merganser
Molothrus ater	Brown-headed cowbird
Myadestes townsendi	Townsend's solitaire
Nucifraga columbiana	Clark's nutcracker
Nuttallornis borealis	Olive-sided flycatcher
Oporornis tolmiei	MacGillivray's warbler
Parus atricapillus	Black-capped chickadee
Passerherbulus caudacutus	Le Conte's sparrow
Passerina amoena	Lazuli bunting
Perisoreus canadensis	Grey (Canada) jay
Pica pica	Black-billed magpie
Pooecetes gramineus	Vesper sparrow
Progne subis	Purple martin
Sayornis phoebe	Eastern phoebe
Selasphorus rufus	Rufous hummingbird
Sialia currucoides	Mountain bluebird
Sphyrapicus varius	Yellow-bellied sapsucker
Spinus pinus	Pine siskin
Spinus tristis	American goldfinch
Spizella passerina	Chipping sparrow

Stelgidopteryx ruficollis	Rough-winged swallow
Sturnella neglecta	Western meadowlark
Sturnus vulgaris	Starling
Totanus flavipes	Lesser yellowlegs
Troglodytes aedon	House wren
Turdus migratorius	Robin
Tyrannus tyrannus	Eastern kingbird
Wilsonia pusilla	Wilson's warbler
Zenaidura macroura	Mourning dove
Zonotrichia albicollis	White-throated sparrow
Zonotrichia leucophrys	White-crowned sparrow

C. LIST OF FISH OBSERVED IN THE STUDY AREA.

Catostomus sp.	Sucker
Prosopium williamsonii	Mountain whitefish
Salmo clarkii	Cutthroat trout
Salmo gairdnerii	Rainbow trout
Salmo trutta	Brown trout
Salvelinus fontinalis	Brook trout