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September 6, 1962.

To:

Mr. H.G. McWilliams,
Director,
Provincial Parks Branch,
Victoria, B.C.

Dear Sir:

The attached report entitled: "Ecological Investigations on Lichens in Wells Gray Provincial Park, With Special Reference to their Importance to Mountain Caribou" is submitted herewith for your approval.

Yours very truly,

R.Y. Edwards
R.Y. Edwards,
Park Officer,
Interpretation and Research,
Provincial Parks Branch.

APPROVED: R. H. Ahrens
i/c - Planning Division

APPROVED in accordance with attached addenda.

H.G. McWilliams
H.G. McWilliams,
Director,
Provincial Parks Branch.

Date: ____________________

- ADDENDA -

a very interesting report - the proposed experimental thinning for lichen production would be an interesting work - but in view of the present abundance of food for existing herds in the Park it may have to be delayed

Ho[illegible]

- ADDENDA -

ECOLOGICAL INVESTIGATIONS ON LICHENS IN WELLS GRAY PROVINCIAL PARK, WITH SPECIAL REFERENCE TO THEIR IMPORTANCE TO MOUNTAIN CARIBOU

by

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- 1962 -

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I. INTRODUCTION

Wells Gray Provincial Park, situated in the southern Cariboo Mountains, is well-known for its mountain caribou population (cf. Edwards, 1954, 1956, 1958; Edwards and Ritcey, 1959, 1960), although the present number of these animals is probably less than 200 (Edwards and Ritcey, 1959). These authors have also outlined the characteristics of the migrations, feeding habits, and range conditions of the Wells Gray caribou.

This caribou's high dependence upon arboreal lichens in wintertime is a remarkable and almost unique fact. It is true that most caribou and reindeer in the world browse tree lichens to some extent, but hardly in any other region do these lichens regularly constitute the principal winter food. Therefore it is understandable that data on ecology and production of epidendric lichens with regard to caribou are scarce in the literature. However, Edwards, Soos and Ritcey (1960) made a quantitative study of these lichens in Wells Gray Park and, following them, Scotter (1962) in northern Saskatchewan.

The aim of the present study is to treat the major ecological factors affecting the abundance and distribution of arboreal lichens in general and in Wells Gray Park in particular. This kind of knowledge is necessary for a proper caribou range management in the area.

In connection with this work a considerable collection was made of lichens, mosses and vascular plants and the ground vegetation in forests and subalpine meadows was sampled.

I wish to express my sincere thanks to Mr. H.G. McWilliams, Director of the Parks Branch, B.C. Department of Recreation and Conservation, and particularly to Mr. R.Y. Edwards who made arrangements for the study to be undertaken.

In Wells Gray Park Mr. Ralph W. Ritcey, Biologist, helped me in many ways. I also acknowledge my wife's assistance during the field work.

II. METHODS

In order to evaluate the amounts of lichen available to caribou on trees Edwards *et al.* (1960) weighted lichens of representative sample trees. This method is undoubtedly the most accurate, but a major disadvantage is the great amount of tedious work required for significant results in large areas.

The determination of abundance of epiphytic lichens by any other fairly accurate method presents more difficulties than that of ground vegetation. This is because the underlying substrate (dead and living twigs, stems) and the microclimate in the forest stand are often very variable, changing within small distances. This variation frequently results in ill-defined open groups of plants rather than in true vegetation composed of distinguishable plant communities.

Early authors, who studied epiphytic vegetation, usually only gave species lists, though some of them indicated which species were dominant, abundant, common, rare, etc.

Many European authors (cf. Barkman, 1958 p. 304) have used definite sample plots of various size and shape. However, their plots were mainly established on single trunks or branches of southern hardwood trees (oaks, beeches, etc.), and were small (e.g. one sq. foot) in size. The pendulous lichens of coniferous forests are mainly concentrated on very thin twigs close to the tree trunks, which is quite a different thing to study.

In North America few studies on epiphytic lichen vegetation have been conducted. In general, most (though not all) European authors 'believe' in recognizing plant communities on trees, rather than in studying abundance of individual species. The North American authors (e.g. Hale, 1955) have recently paid more attention to statistically calculated constancy values of species in various forests. However, Szczawinski (1953) has made a study on epiphytic vegetation on Vancouver Island in a more 'European' style.

In the present study the quality and quantity of lichens available to caribou are the determining factors. Therefore the degree of abundance of each species in different kinds of forests is one of the most interesting facts to be known. Several authors have estimated abundance of epidendric cryptogams, but mainly within tiny sample quadrats or on single trees. Usually special scales (e.g. 1 to 5) for visual estimation of density and cover have been developed. However, the writer considers it unnecessary to apply any special scale, if this is essentially based on cover percentage. The percentage scale (1 to 100) alone is much more descriptive because of its universal use, particularly to a person who is not well-acquainted with other scales. A simpler scale does not actually simplify the figures. In this paper percentages are used as much as possible.

The method developed by the author for this work is as follows:

(1) A circular plot, 1000 sq. m. in area (radius 17.9 m.)

was selected as representative of larger districts rather than at random. It was also presumed that each plot was homogeneous as to its tree stand and site type. However, since very wide areas could not be covered during the short time available, the plots taken do not necessarily represent the average situation in the park. In addition, the number of plots is small (41) and thus not statistically significant. It seems, however, that thanks to the occurrence of large, fairly uniform strips of forests in the park, a random method is not practical in this kind of extensive study. Scattered well-selected sample areas give results useful enough.

(2) In each plot the number of trees was counted. The trees were put in two classes according to their DBH: more and less than 6 inches. The species of trees were recorded, as well as the crown canopy, age, height, and abundance of twigs (below 10 ft.). No convenient and exact method to measure the <u>abundance of lower twigs</u> (<u>Symbol B</u>) was detected. Therefore the following subjective scale was used:

I sparse
II fairly sparse
III moderately present
IV fairly abundant
V very abundant

This scale was used in an absolute sense rather than, for instance, as related to the number of trees. The height of 10 ft., used as the upper limit of observations, is probably too high in most cases being frequently above the caribou's reach. Edwards <u>et al.</u> (1960) suggested that ordinarily the caribou may reach about 8 ft. in Wells

Gray Park in wintertime. The present author measured the fall browsing limit to be 6 - 7 ft. at Azure Lake in the park, where it was clearly seen.

(3) The coverages of both fruticose and foliose lichen groups were estimated on the branches as well as separately on the trunks between the heights of about 2 ft. (the base is without any significant lichens) and 10 ft. from the ground on all trees within the whole sample plot. The totals of each of these two lichen groups were thought to be 100 per cent, since they form two vertical vegetational layers. (The here omitted crustose layer is the third one.) The four figures obtained (see Appendix III), indicate the relative abundance of lichenous parts of trunks and twigs and the distribution of fruticose and foliose layers in these parts.

(4) After the total coverages of the lichen layers, the proportion (cover) was estimated for each lichen species, both twigs and trunks now being included. These figures indicate the relations of species, being independent of the total amount of lichen.

(5) Then a 'range index' (RI) was calculated according to the formula

$$RI = (B \cdot b_1 + T \cdot t_1) + \frac{(B \cdot b_2 + T \cdot t_2)}{10}$$

in which (as an example the values of sample plot 20 are given in brackets):-

B = branchiness value according to the scale mentioned above (V = 5)

b_1 = cover of fruticose lichens on twigs (40%)

b_2 = " " foliose " " " (60%)

t_1 = cover of fruticose lichens on trunks (5%)

t_2 = " " foliose " " " (10%)

T = class of stem number per acre. This was obtained by counting the number of stems per acre in the sample plot and then dividing the number of stems less than 6 in. DBH by two. (The possibilities of young trees to bear lichen loads are smaller than those of older trees.) This number was put in the following scale:

1	less than 201 stems
2	201 - 250 "
3	251 - 300 "
4	301 - 350 "
5	more than 350 "

(sample plot 20: $208 + \frac{240}{2} = 324$, class 4)

This fairly complicated method gave results that are highly parallel to the general impression on the abundance of lichens in the plots as indicated in the writer's field notes. However, it is not claimed that this method is completely satisfactory.

The range indices obtained may be understood in the following way:

0 - 50	very poor (vp)
51 - 100	poor (p)
101 - 150	fair (f)
151 - 200	good (g)
201 - 250	very good (vg)
251 - 1000	excellent (ex)

In the table presented (Appendix III) all the fruticose and foliose lichens in the plots were recorded. The percentage scale used was tr. or + both (less than 5 per cent), 5, 10, 15, 20, etc.

In most cases an analysis of ground vegetation was made in the same stand in which arboreal lichens were sampled. The plot size was 100 sq. m. in these cases.

Field work was conducted during June, July and August in 1961. The more accurately studied districts are the Hemp Creek area, the Murtle Lake area, and top of Battle Mountain. Two to three weeks were spent in each of these areas. Short visits were made to Clearwater and Azure Lakes, to Stevens Lakes, and to Blue River and Fish Lake Hill.

III. ZONATION AND TENTATIVE CLASSIFICATION OF VEGETATION IN WELLS GRAY PARK

In small-scaled maps most of the park is included in subalpine forest. However, as also stated by other authors, there are several distinct zones present. The following zones presented by Krajina (1959) may be distinguished:

(1) Interior Douglas-fir Zone

This zone or vegetation very closely related to it is found on the dry slopes of the Clearwater Canyon (on the Wells Gray Park road, at least). Whether it extends to the park proper is not known to the author. In any event, even the slopes of the Hemp Creek valley near the Ranger Station have several thermophilous plants typical of more arid districts and Hartman (1957) considered that the ridges in this area were partly covered by Douglas-fir forests before the 1926 burn, which devastated all of the climax vegetation. According to Edwards and Ritcey (1959) this zone would be found up to an altitude of about 2000 ft. in the area.

(2) Interior Western Hemlock Zone

This zone, frequently called the Interior Wet Belt, ranges from about 2000 ft. up to about 4000 ft. Thus most of the valley forests, as those found in the Hemp Creek - Murtle River area and around Clearwater, Azure and Murtle Lakes and in the adjacent Blue River district, belong to this zone. Much of it has burned over, usually bearing stands rich in aspen or lodgepole pine. Climax stands dominated by western hemlock on drier sites and by red cedar on moister sites are also present.

(3) Subalpine Engelmann Spruce - Subalpine Fir Zone

This zone is present from about 4000 ft. up to about 6000 ft. (on Battle Mtn.), but the upper levels (above 5300 - 5500 ft.) are thinly stocked island-like stands, alternating with more or less wide subalpine meadows. This meadow zone and adjacent belt down to the upper limit of *Rhododendron albiflorum* thickets is here called the *upper subalpine zone*. It was studied on Battle Mtn. and (outside the park) on Fish Lake Hill. The *lower subalpine zone* was seen in the Stevens Lakes area and on the west slope of Battle Mtn. In the Murtle Lake district at the level of the lake there are forests dominated by Engelmann spruce and subalpine fir, but they clearly belong to the Western Hemlock Zone according to the characteristics of minor vegetation, though affinities to subalpine forests do occur in them.

(4) Alpine Zone

The Alpine Zone of Battle Mtn. was visited. There the ground is rich in stones and bare rocks with discontinuous vascular plant vegetation. A considerable number of species confined to this zone were found. The highest point (7635 ft.) is without any higher plants. Small snow-beds were present (at the end of July) near the patrolman's cabin and particularly on the eastern slopes. The Alpine Zone is represented by much larger areas on some other mountains in the park.

For long-range silvicultural calculations the productivity of a site as to the growth of tree stand is an essential thing, while in wildlife management studies on the existing undergrowth is often of greater importance. Also, secondary stages of plant communities are frequently more favourable to game than the respective climax phases. However, as has been stated by many authors, caribou usually prefer climax to subclimax stands.

In any event, it is useful for ecological studies, in forested zones at least, to recognize the potential value of those site types where the studies are carried out. In North Europe the forest site types based on Cajander's theories have a universal use in national economy. Many different schools and many poor applications of some useful theories have confused the classification of sites to such a degree that one cannot readily accept any single method.

In B.C. much information on forest site types has not been published. It is, indeed, a very difficult country because of its highly varying climatic and edaphic conditions, which means that the existing types must be comparatively numerous and variable.

Some data concerning the site types in the Wells Gray Park area are found in Kujala's (1945) and Hartman's (1957) accounts. The zonal division and species lists by Krajina (1959) also contribute to the knowledge of the major types present. Other papers have not been consulted in this tentative report.

It is obvious here, as in any district, that mere forest types, i.e. cover-types distinguished according to the dominant tree species alone, do not often agree with the essential undergrowth types, which are generally more sensitive to environmental conditions than the trees with their usually broad ecological amplitude. In fact, all the components of a unified vegetation - site system or ecosystem type (see Rowe, 1960, and the other instructive papers in the same symposium) have to be taken into account in classification of sites.

Of course, the recognition of cover-types alone frequently gives an adequate picture on the range conditions for wildlife, but it may be claimed that the dynamic understanding of the cover-types is necessary for a proper range management. So, for example, it is useful to know, what will happen to secondary willow stands in different sites during the next 50 years or which species will dominate after cutting-over in a virgin hemlock stand in each region. The same site-types in the same climatic region behave in the same way as to broad features. Hartman (1957), although he distinguished cover-types based on dominant trees in Wells Gray Park, was actually well aware that his types (Coniferous Type, Regeneration Type, Alder Type, etc.) are extremely heterogeneous.

The present author and particularly his wife made descriptions of the forest types and subalpine meadow types in the park, but a thorough treatment of these analyses and of the pertaining literature was not possible before the completion of this report. Only a preliminary classification is given in this connection. Division of other vegetation types is also outlined. It is to be noted that many kinds of habitat pockets having small areas (riverside forests, shoreline vegetation, etc.) are poorly represented or entirely omitted the list given below.

1. ALPINE ZONE

   1. Snow fields
   2. Boulder beds
   3. Stony grass-lichen heaths
   4. Peat flats
   5. Herb stands on brooksides

II. UPPER SUBALPINE ZONE

1. Forests (meadow-forests)

   a. *Arnica* - *Mitella* type
   b. *Luetkea* type
   c. *Lupinus* - *Valeriana* type

2. Upland meadows

   a. *Antennaria* - Lichen type
   b. *Anemone occidentalis* type
   c. Mesic *Antennaria* type
   d. *Caltha* - *Trollius* type
   e. *Phyllodoce* - *Luetkea* type
   f. *Valeriana* type

3. Peatlands

   a. *Carex nigricans* meadow
   b. *Calamagrostis* flood meadows
   c. Periodically wet sedge swales
   d. Sedge pools
   e. Sedge bogs
   f. Spring-fed brooksides

III. LOWER SUBALPINE ZONE

1. Forests

   a. Dry sites
   b. *Rhododendron* type
   c. Other fresh sites
   d. Bog forests

2. Open peatlands

IV. HEMLOCK ZONE

1. Forests

   a. Dry sites
   b. Fresh sites
   c. Moist sites
   d. Brookside sites flooded in spring
   e. Bog forests

2. Rock lands

   a. Lichenous rock outcrops
   b. Mossy rock outcrops

3. Open peatlands

   a. Eutrophic fens
   b. Mesotrophic bogs

IV. GENERAL NOTES ON THE ECOLOGICAL REQUIREMENTS OF LICHENS

The life-form group of fungi called lichens is by no means uniform in ecological sense. Even the large lichens, the macrolichens, including the fruticose and foliose species, are distributed in very different climates.

Each lichen species is generally confined to rather limited climatic zones and within them to certain kinds of microenvironments. In fact, lichens are often better indicators of climate than are the vascular plants.

This last statement is especially true with epidendric lichens. Barkman (1958 p. 18) lists the following features that are of special importance to cryptogamic epiphytes in their relation to climate: (1) Their sensitivity to changes in atmospheric humidity and temperature; (2) the intensive contact with the air; and (3) the fact that they are perennial, evergreen, and active both in summer and in winter (snow cover on trees is less effective than on ground). Besides, they may grow very old.

Very roughly we can state that the macrolichens are most abundant in humid districts and, particularly the fruticose species, in cool districts. Thus, for instance, the writer has observed that on an average the coastal provinces of Newfoundland and British Columbia possess forests with heavier loads of epidendric lichens than do the interior areas of northern Ontario and the Great Slave

Lake district. Of course, there are also poor lichen districts in British Columbia and good areas in Ontario, such as on the coasts of Lake Superior, Lake Nipigon, and Hudson's Bay.

Another decisive factor for the epidendric lichens is light. The macrolichens are generally clearly photophilous. Thus in dense forests they are poorly developed at lower levels, but closer to the crowns, where more light is available, they often flourish in considerable amounts. In thin forests lichens may be abundant down to the bases of trees, if the climate is humid enough. This fact is especially apparent in the coast forests of Vancouver Island, as emphasized by Szczawinski (1953), but it is also seen in Wells Gray Park.

Temperature has a great influence upon epiphytes through the rate of evaporation. Subalpine epidendric vegetation would be favoured, then, by low summer temperatures. Also, the snow cover in winter has a considerable thermic effect. Thus there are lichen species that clearly are dependent on the protective, thick snow accumulations, the qali formations (see Pruitt, 1959) on trees. These formations are characteristic of subarctic spruce forests (e.g. in Alaska and Lapland) and are undoubtedly well-developed in the tree-line forests of Wells Gray Park.

Fruticose lichens draw their nutrition almost entirely from the air and from water running down the trunk, while foliose species may also profit by nutrients dissolved from the bark (Barkman, 1958). Thus the chemical properties of the bark particularly affect the growth of foliose lichens. The physical properties are more important for the fruticose species. The characteristics of the tree species of Wells Gray Park are discussed in Part VI in more detail.

Since the photosynthesis of lichens is less intensive than in higher plants, their growth rates are low even in optimal conditions. Adequate measurements on their growth rates are scarce. Frey (1952) is probably the only one who has studied the annual increase of _Alectoria_ species, important in this study. He stated in Switzerland that _Alectoria jubata_ grew 29 cm. in 21 years, which gives a rate of about 1.4 cm. per year. This is probably a maximum value rather than an average. In foliose lichens 0.2 - 0.5 mm. per year are common rates (Barkman, 1958 p. 17). In reindeer lichens 0.5 mm. is a frequent average.

V. THE EPIDENDRIC MACROLICHENS IN THE PARK

1. General

The lichen flora of British Columbia is very poorly known, especially in its interior areas. No modern lichen floras or floristic lists cover this province. However, the papers by Macoun (1902), Fink (1935), and Howard (1950), which are largely out of date, are available, besides scattered records on various species and genera in British Columbia. The paper by Howe (1911) on North American *Alectoria* may be also mentioned here. There are some common 'western' species in the province which are absent elsewhere in Canada, but the majority of the mountain species represent largely circumpolar, boreal elements.

Thus it is understandable that unsolved taxonomic problems are encountered in several western Canadian lichen groups. For this reason and for the short time available for identification some of the present writer's determinations are to be regarded as tentative only. However, a key for identification of most of the macrolichens found on trees in the park is presented. The majority of the species included are not abundant enough to be of any importance to caribou. All the macrolichens found are listed in Appendix I.

2. Keys

The keys include all of the macrolichens that are commonly found on trees in Wells Gray Park plus some rare ones. A few species (e.g. some species of *Cladonia* and *Nephroma*), which were collected on trees, are omitted because of their only occasional arboreal occurrence