VEGETATION AND ECOLOGY OF RITHET'S BOG, ROYAL OAK, BRITISH COLUMBIA

by

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ABSTRACT

Nine communities within two plant associations were defined in studies of Rithet's bog, Victoria, B. C. Combinations of nine Differential Species Groups characterize the communities. Environmental studies indicate that vegetational distribution has been greatly influenced by drainage and adjacent cultivation. Increased areation and nutrient levels, aided by fertilization resulted in decomposition of Sphagnum peat layers in most communities. The edaphic changes have induced succession, the possible trends of which are given. A map and a diagramatic key to the communities are presented. Methods of vegetational analysis are criticized in an Appendix.

Acknowledgments

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I am grateful for the cooperation of Mr. Freeman King and Mr. Arthur Locke whose direct experience with Rithet's bog provided invaluable information on the recent history.

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Introduction

Few lowland Sphagnum bogs remain on the southern end of Vancouver Island. Like most of these, Rithet's bog, on the northern outskirts of the city of Victoria, has been greatly influenced by adjacent forest clearing and crop cultivation during the past 75 years. A few floristically characteristic communities remain. In view of the fact that this unique vegetation-environmental complex may soon be replaced by a civic park and a golf course resulting from urban development extending north-ward from the city, this study was undertaken to obtain information which would be soon be impossible to obtain.

Bog studies in this region have been few. Those of Rigg (1917, 1919, 1922) describe in detail numerous bogs withiu the Puget Sound area. Rigg describes in detail the bog forest at Lost Lake located a few miles to the South-east of Rithet's bog. Unfortunately species lists are incomplete and no indication of relative species abundance is given. However, these studies do, mention the major details of floristic structure and as such, are useful. A comprehensive inventory of species in Rithet's bog by King (1960) is a useful guide to the flora. This, however, gives little insight into species distribution. At the time of this study, it may be somewhat inaccurate due to floristic change.

Pollen analyses (Nesbitt and Thompson 1966) (Zirul 1967) have given estimates of floristic structure for species whose pollen grains have been preserved in peat deposits within the study area. These studies only give an estimate for the past and are inaccurate for reference to this study since pollen may travel from committies located outside of the study area.

Wade (1965) conducted a detailed study of the vegetation of Sphagnum Bogs in the Tofino area on the West Coast of Vancouver Island. Since environments will be considerably different in this region, caution is necessary when relating Rithet's bog to this study.

The objectives of this study were:

1) to extract "Differential Species" (Ellenberg, 1956), which, either separately or in combination with other groups, are characteristic of each community type;
2) to describe the communities in terms of the Differential Species;
3) to correlate certain environmental features with the presence of Differential Species;
4) to suggest which ecological and historical factors most strongly influence community distribution; and
5) to propose successional relationships between communities.

Certain difficulties arose with the methods of vegetation analysis. In Appendix III I have included a critique of these methods along with proposals for improvement.

Description of the Study Area

Rithet's bog is located at Royal Oak on the Saanich Peninsula of Vancouver Island (Figure 1). Krajina (1965) includes this area in the Garry Oak - Douglas Fir Drier Subzone of the Coastal Douglas Fir Biogeoclimatic Region of British Columbia.[1] The climate is generally moderate, lying within the rainshadow of the Olympic and Vancouver Island Ranges. Precipitation seldom exceeds forty inches per year most of which falls predominantly during the winter months.

Like nearby Swan, Lost and Beaver Lakes, Rithet's bog lies in an eroded hollow bordered by glacial drift. The entire area is part of a glacially subdued lowland which has since uplifted. Characterized by monadnocks, this area is transitional between the Upland and Lowland regions of Vancouver Island (Clapp 1913).

Rithet's bog has naturally poor drainage. That which does occur flows through Colquitz Creek to Portage Inlet descending approximately fifty feet. Drainage ditches (Figure 4) established during the 1930's and in 1956 appear to have had little effect in reducing crop land inundation.

The central portion of the lowland is about four feet higher than the surrounding agricultural land. The former remains relatively dry while the latter region is inundated during the winter months.

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1 According to the more widely known classification of Rowe (1959) the area belongs to the Madrona - Oak Transitions Section of the Coast Forest Region.

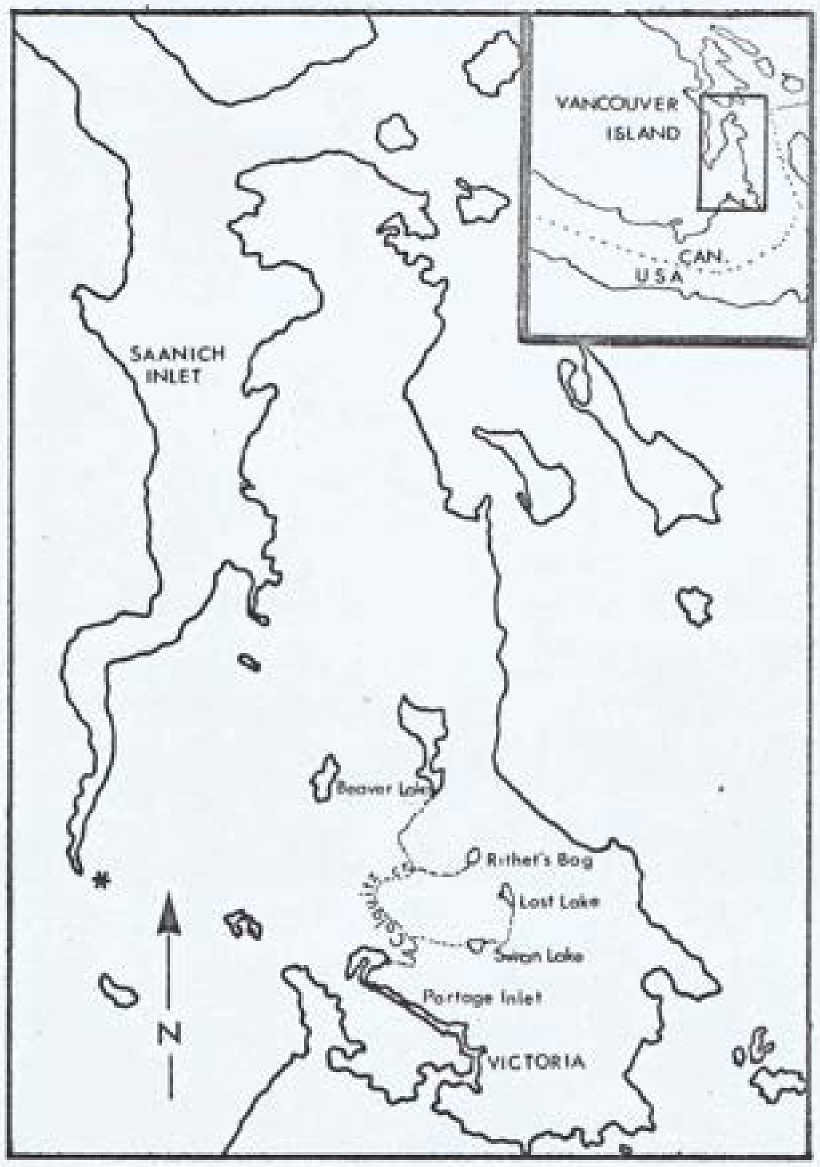

Figure 1.:

Location of Rithet's Bog on the Saanich Peninsula, Vancouver Island, British Columbia.

The vegetation of the surrounding area resembles that of the forest associations of the East Coast of Vancouver Island (Krajina, 1959). Within this dry forest region, Douglas Fir is the climatic climax tree species. The presence of peat bog vegetation in such a climatically dry area is probably due to local topographic features characterized by accumulation and stagnation of water over long periods. The vegetation is therefore an expression of local edaphic features rather than of the regional climate and soils.

The land surrounding Rithet's bog was cleared during the 1880s[1] and has since been used for crop production and the grazing of Short-horned cattle, Clydesdale horses and Oxford sheep. According to Locke, flooding in the agricultural land has been increasing in recent years (Figures 2 and 3). Periodically he has been forced to release from crop production those regions closest to the bog forest. Evidence for this is the presence of old fencing in thick bush adjacent to the bog forest and recent abandonment of agricultural land on the east side of the bog forest.

Extensive lowland drainage, slope logging and grazing, and cultivation and fertilization in Rithet's Lowland has influenced the area considerably yet has not completely destroyed the natural bog communities. Therefore, the region provides a suitable area in which to study both the natural vegetation and man's influence upon it.

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1 Mr. Arthur Locke provided most of this information on the recent history of the Rithet's estate. He has farmed the Lowland since World War I.

Figure 2 Rithet's lowland during late summer 1966. Water table depth exceeds 1 m. in open field. The dark band of lowland trees is mainly in Pinus contorta - Gaultheria shallon Association. The light coloured brush land is part of the Spiraea douglassii Association.

Figure 3 Rithet's lowland during December 1966. Inundation lasts from November until March.

Methods

The methods employed assume that vegetation to a large extent expresses the integrated influence of the total environment. Vegetational analysis therefore precedes environmental studies after which correlations between the two are sought.

Further details of methodology are given in Appendix III. The bog was reconnoitered, vegetation observed, and eight to ten plots established subjectively in homogeneous stands of each apparently different community type. The plot size for each community type was determined by species-area curves. (See Appendix III).

Following a modified method of Ellenberg (1956), the vegetation was analysed and synthesized in order to extract any Differential Species, plants which by their presence or absence differentiate one or more community types from other community types. Although synthesis emphasized mainly species presence and absence, cover estimates for each species have been given. These follow a scale similar to that of Braun-Blanquet (1932):

5 = Species covering 3/4 to 4/4 of the plot surface area
4 = " " 1/2 to 3/4 "
3 = " " 1/4 to 1/2 "
2 = " " 1/20 to 1/4 "
1 = " " 1/100 to 1/20 "
+ = Species cover is small yet numerous individuals exist
R = Species cover is small with few individuals

In addition to height and cover of vegetation strata, habitat records for each plot included: quadrat size, location, slope, exposure, and the date of analysis.

Water table levels in seven selected plots were measured periodically from late September to late December. One-half x 36 inch pipe was inserted into the soil and free water levels were recorded as deviations from ground surface level.

Soil measurements included: thickness of upper soil horizons, and for each horizon, measurements of pH, available nitrate, phosphate, and potassium, using the La Motte Soil Testing Kit[1].

Soil samples were taken from random points in each plot and the data statistically examined by Analyses of Variance followed by New Multiple Range Tests (Li, 1965). Means were compared between some Differential Species Groups only, and not between community types. Therefore, some means incorporate measurements common to two or more groups.

Increment cores were taken at 50 metee intervals on a transect through the bog forest, in order to determine if any correlation existed between age distribution and vegetation distribution. Cores were taken 4-1/2 feet above ground level on the northwest side of lodgepole pine

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1 The La Motte method is primarily designed for agricultural soils and gives results in pounds per acre. Rithet's soils are almost entirely organic, a feature not common to agricultural soils.

trees, Pinus contorta.

The communities could not be mapped by transects as planned because the lowland was inundated from December to April (Figure 3). An outline map was constructed from aerial photographs. The community boundaries illustrated were not checked by ground surveys.

Results

Where possible, results have been presented in tables or diagrams. Environment-vegetation correlations do not imply cause and effect. They only serve as a basis for generating hypothesis on the cause of vegetation distribution.

Community Types

The synthesis table (Table 1) shows the community types as characterized by different combinations of Differential Species Groups (hereafter referred to as DSG). The map (Figure 4) shows the distribution of the major community types.

Five floristically weakly defined DSGs complement four well-defined Groups, and permit delineation of two major community types. Each has been progressively divided into a tentative total of nine sub-communities. Since the integrity of DSGs A, B, E and H is almost certain, I have emphasized them in defining the major community types. The remaining DSGs are tentative. Some of these weaker Groups are

TABLE I

Vegetation Synthesis Table

Differential Species Groups are shown to the left, lettered from A to i. Upper case letters indicate major Groups and lower case, minor Groups.

Representative plots for each community type are blocked out as shown.

See "Methods" for explanation of vegetation rating scale.

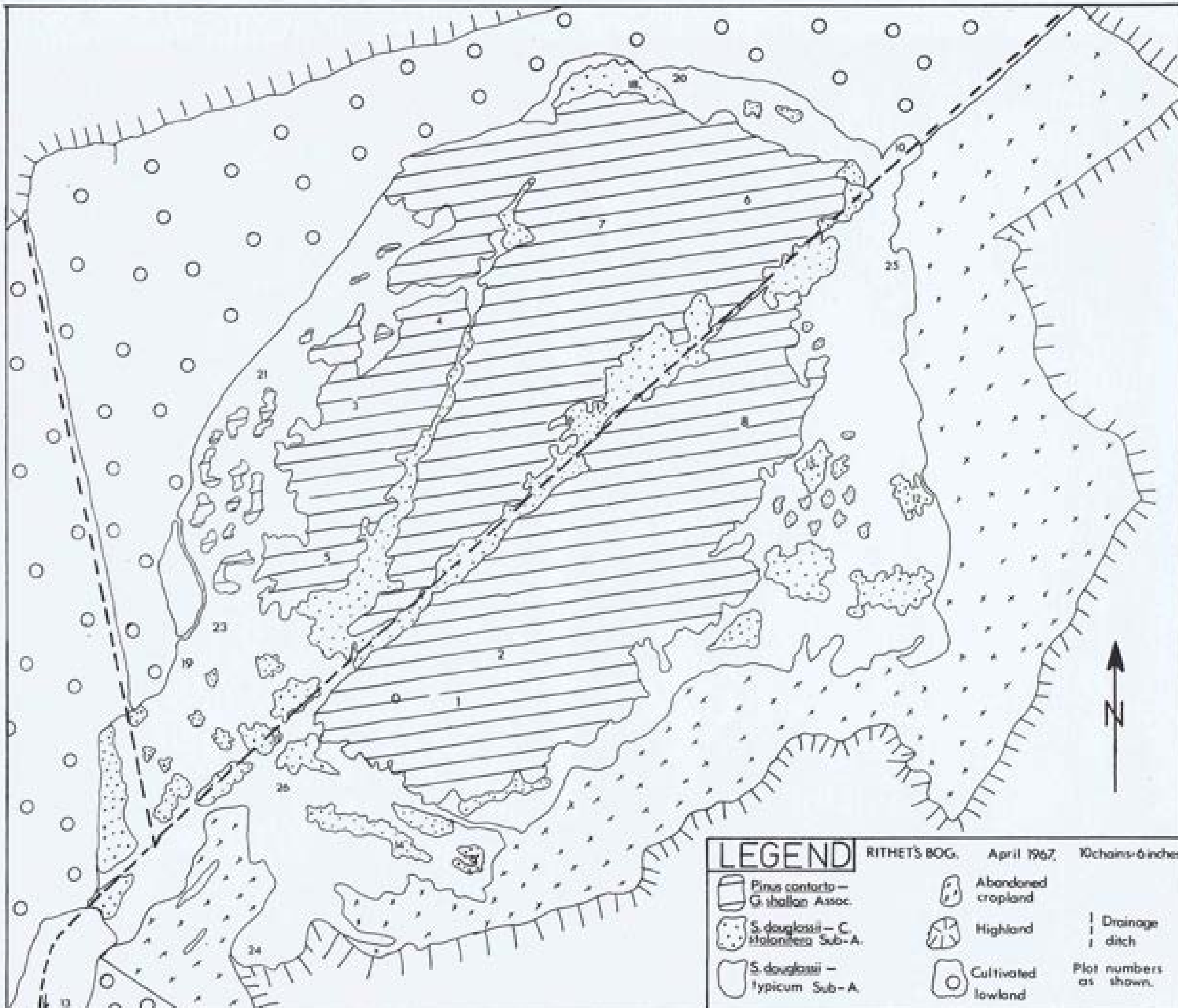
Within each Differential Species Group, species are listed in decreasing order of Presence.

Pertinent plot data is given at the top of the table.

ASSOCIATION	PINUS CONTORTA GAULTHERIA SHALLON								SPIRAEA DOUGLASII																		
SUB ASSOCIATION	TYPICUM	HYLOCOMIUM SPLENDENS							TYPICUM										CORNUS STOLONIFERA								
VARIANT		SPHAGNUM CAPILLACEUM		TYPICUM					TYPICUM			GALIUM TRIFLORUM							GALIUM TRIFLORUM						POPULUS TREMULOIDES		
SUB VARIANT												TYPICUM				POTENTILLA ANSERINA			TRANSITION	BETULA PAPYRIFERA			LEDUM GROENLANDICUM				
Plot Number	3	2	1	6	8	7	4	5	19	26	20	21	23	22	24	15	10	25	9	18	14	12	11	15	17	16	Median Cover
Plot Size m²	256	256	256	256	256	256	256	256	8	8	8	8	8	8	8	16	16	8	16	16	16	16	16	16	16	16	
Date (1966)	19/9	17/9	17/9	17/9	1/10	23/9	19/9	19/9	8/10	1/10	9/10	8/10	8/10	8/10	8/10	2/10	1/10	1/10	7/10	8/10	5/10	1/10	1/10	27/9	8/10	8/10	
Tree Cover %	60	40	30	60	40	50	40	70	0	0	0	0	0	0	0	80	85	0	40	50	90	80	80	60	70	60	
Shrub Cover %	90	85	85	80	70	70	90	95	95	99	85	75	90	80	80	10	10	90	70	85	10	10	10	80	60	80	
Herb Cover %	5	4	5	2	2	2	5	3	5	0	2	5	10	5	5	50	20	3	2	2	5	10	20	25	50	50	
Moss Cover %	40	60	50	50	70	60	60	50	0	0	0	10	0	0	0	1	0	2	1	1	1	1	1	1	2	1	
Group A																											
Ledum groenlandicum	5	5	5	5	5	5	5	5	·	·	·	·	1	·	·	·	·	·	·	R	·	·	R	2	·	1	5
Betula glandulosa	·	+	+	+	1	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	1	·	R	R	·	·	+
Eurynchium oreganum	·	·	2	R	+	·	R	·	·	·	·	2	·	·	·	·	·	·	·	·	·	·	·	R	1	·	+
Group B																											
Pinus contorta	4	3	5	4	2	3	3	4	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	3
Gaultheria shallon	4	1	2	4	1	4	4	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	3
Kalmia polifolia	+	1	1	R	R	R	R	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Vaccinium oxycoccus	R	R	R	R	R	R	R	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R
Dicranum scoparium	R	R	R	R	·	+	R	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R
Sphagnum recurvum	·	2	2	1	·	3	R	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2
Group C																											
Hylocomium splendens	·	·	R	2	2	+	3	3	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2
Rhytidiadelphus triquetrus	·	·	+	2	3	2	2	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2
Rhamnus purshiana	+	·	·	+	R	R	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R
Pteridium aquilinum	·	+	1	R	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	+
Betula papyrifera	·	·	·	+	R	R	·	R	·	·	·	·	·	·	·	·	·	·	·	5	1	5	·	·	·	·	+
Alnus rubra	R	1	·	·	·	·	R	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R
Group d																											
Eriophorum chamissonis	·	R	R	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R
Camptothecium megaptilum	·	3	R	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Sphagnum capillaceum	·	+	+	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Drosera rotundifolia	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Sorbus aucuparia (sitchensis)	R	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Thuja plicata	R	·	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Group E																											
Spiraea douglasii	+	R	·	R	·	·	·	·	5	5	5	5	5	5	5	2	1	5	3	3	2	2	1	2	2	3	·
Group f																											
Galium triflorum	·	·	·	·	·	·	·	·	R	·	+	R	R	R	+	R	R	R	R	R	R	R	+	R	·	·	R
Carex flava	·	·	·	·	R	·	·	·	·	·	R	R	R	·	R	R	·	R	·	R	+	·	·	·	·	·	R
Lonicera involucrata	·	·	·	·	·	·	·	·	·	·	·	R	1	R	·	·	·	·	2	+	2	2	·	2	·	·	2
Salix geyeriana	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	5	5	·	2	2	3	2	1	1	·	·	2
Carex sp.	·	·	·	·	·	·	·	·	·	·	·	2	R	+	·	·	R	·	·	·	·	+	·	3	·	·	+
Rosa pisocarpa	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	+	·	+	+	R	·	·	·	+
Calamagrostis sp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	R	R	·	·	·	+
Group g																											
Poa sp.	·	·	·	·	·	·	·	·	·	·	R	·	·	·	1	+	+	+	R	·	·	·	·	·	·	·	+
Viola sp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	R	+	R	·	R	·	·	·	·	·	R
Potentilla anserina	·	·	·	·	·	·	·	·	R	·	·	·	·	·	R	R	+	+	·	·	·	·	·	·	·	·	R
Myosotis laxa	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2	R	·	R	·	·	·	·	·	·	·	R
Equisetum arvensis	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	R	R	·	·	·	·	·	·	·	R
Group H																											
Cornus stolonifera	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	3	2	+	2	3	3	+	3	3
Pyrola asarifolia	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	R	R	+	1	2	R	3	3	+
Salix sitchensis	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2	2	2	1	2	1	2	3	2
Salix scouleriana	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	1	1	1	1	1	·	1	1
Pyrus fusca	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	R	1	·	R	+	R	1	+
Group i																											
Populus tremuloides	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	1	1
Oenanthe sarmentosa	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	2	2
Others																											Presence %
Isothecium stoloniferum	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	1	R	R	·	R	·	·	+	+	35
Trientalis arctica	·	·	·	·	·	·	·	·	·	·	·	R	R	·	·	·	·	·	·	R	·	·	·	1	R	R	23
Crataegus oxyacantha	·	·	·	R	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	R	R	R	R	·	·	23
Cirsium edule	·	·	·	·	·	·	·	·	R	·	·	·	·	·	R	+	·	·	·	·	·	·	R	·	·	·	15
Rubus vitifolius	·	·	·	·	+	·	·	·	·	·	·	·	1	·	·	·	R	·	·	·	·	·	·	·	R	·	15
Rhytidiadelphus loreus	·	·	·	·	R	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	12
Rosa nutkana	·	·	·	·	·	·	·	·	2	·	·	·	·	·	·	R	·	·	·	R	·	·	·	·	·	·	12
Mnium punctatum	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	R	·	·	·	12
Ilex aquifolium	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	8
Lophocolea sp.	·	·	R	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	8
Ranunculus sp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	R	·	·	·	·	·	·	·	·	·	·	8
Lycopus lobiatus	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	R	·	·	·	·	·	·	·	·	8
Stellaria media	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	R	·	·	·	·	·	·	·	·	·	·	8
Sanguisorba sp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	R	·	·	8
Juncus balticus	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	2	·	·	·	·	·	·	·	·	·	8
Drosera rotundifolia	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	4
Epilobium angustifolium	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	4
Eschholtzia californica	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	4
Hedera helix	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	4
Hieracium albiflorum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	4
Lysichiton americanum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	4
Populus trichocarpa	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	4
Porella sp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	4
Pseudotsuga menziesii	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	4
Quercus garryana	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	4
Sisymbrium officinale	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	4
Veronica scutellata	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	4

FIGURE 4

Map of major communities of Rithet's bog, drawn from 1964 aerial photograph of the B. C. Lands Service. Photograph scale was 30 chains per inch.



N
LEGEND
RITHET'S BOG.
April 1967.
10chains=6inches.
Pinus contorta – G. shallon Assoc.
S. douglasii – C. stolonifera Sub-A.
S. douglasii – typicum Sub-A.
Abandoned cropland
Highland
Cultivated lowland
Drainage ditch
Plot numbers as shown.

represented by too few plots, while the component species of others are more diffusely spread than is desirable for a strong Group. Only further sampling and analysis will verify or reject the validity of these minor Groups.

Since DgGs B and E are mutually exclusive for the two major communities, by definition they can be termed "Associations" following the Braun-Blanquet system of classification (1932). I have used this terminology, as well as "sub-Association", "Variant" and "sub-Variant".

It should be emphasized that this classification is valid only for the Rithet's bog area. Subsequent phytosociological studies in the region may require reclassification according to a geographically more consistent scheme.

The communities recognized are:

I. Pinus contorta - Gaultheria shallon Association
   1) P. contorta - G. shallon - typicum Sub-Association
   2) Hylocomium splendens Sub-Association
      a) Sphagnum capillaceum Variant
      b) Hylocomium splendens - typicum Variant

II. Spiraea douglassii Association
   1) S. douglassii - typicum Sub-Association
      a) S. douglassii - typicum Variant

b) Galium triflorum Variant

i. G. triflorum - typicum Sub-Variant

ii. Potentilla anserina Sub-Variant

2) S. douglassii - Cornus stolonifera Sub-Association

a) C. stolonifera - Galium triflorum Variant

i. Betula papyrifera Sub-Variant

ii. Ledum groenlandicum Sub-Variant

b) Populus tremuloides Variant

I. Pinus contorta - Gaultheria shallon Association

The Pinus contorta - Gaultheria shallon Association includes the bog forest proper. A heavy cover of P. contorta, G. shallon, and Ledum groenlandicum predominate (Figure 5)[1]. DSGs A, B, c and d are characteristic, the last two differentiating sub-communities. Group A's range outside of the Association may be inaccurately shown because of sampling errors (see Appendix III).

Soils in the P. contorta - G. shallon Association have a very thick litter layer (Aoo)[2] extending to a depth of 8-10 cm. The partially decomposed A1 horizon extends to a depth of 20-25 cm. beneath which is

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1 Because of film spoilage, it was necessary to use some photos from similar gegetation types in Turner Bog, Goldstream.

2 Definitions used in this paper: Aoo horizon - litter;
Ao horizon - partially decomposed litter;
A1 horizon - decomposed litter and peat;
Ap horizon - undecomposed peat.

Figure 5 Pinus contorta - Gaultheria shallon Association in background with abundant Betula glandulosa and Ledum groenlandicum in center. Note hydrarch succession of aquatics in foreground. Photo taken at Turner Bog, Goldstream.

almost pure Sphagnum peat. Tree and shrub roots predominate in the A_1 horizon indicating that nutrient availability is sufficient for vascular plant growth.

Within the Pinus contorta - Gaultheria shallon Association two sub-Associations may exist. These are the P. contorta - G. shallon typicum and the Hylocomium splendens sub-Associations. The former is characterized by DSGs A and B and is represented by one plot only, leaving its existence open to considerable doubt.

Hylocomium splendens Sub-Association

This is characterized by Group c in addition to Groups A and B. Further study may show that in fact DSG c should be included in Group B. The general features of this community are essentially those of the Association. DSG d characterizes the Sphagnum capillaceum Variant of this sub-Association. S. capillaceum and Eriophorum chamissonis grow together in small pockets within the sample plots. Because of their fragmentary nature, they could not be sampled adequately and the Variant's importance has therefore probably been underestimated. Comparing Rithet's bog with other local bogs, it appears that this Variant actually represents remnants of an Association which was formerly more extensive (Figure 5).

The pockets of S. capillaceum Variant lack large shrubs and trees. Vaccinium oxycoccus and Kalmia polifolia tend to be more abundant. The pockets are particularly wet with unmodified Sphagnum peat layers extending to the surface.

II. Spiraea douglassii Association

DSG E, composed solely of Spiraea douglassii differentiates the Spiraea douglassii Association from the P. contorta - G. shallon Association. S. douglassii is dominant in the majority of stands. DSGâ f, g, H and i may also be considered characteristic of this Association, even though they differentiate some of its sub-communities (Figure 6).

Although the number of soil horizons present is generally constant, their development varies within the Association. The Aoo horizon varies from almost nil to an extraordinarily thick depth of 40 cm. The Ao horizon is almost entirely absent. The Ai horizon reaches an average depth of 35 cm., below which undecomposed peat extends to an unknown depth. This rich black Ai soil is characteristic for this Association.

S. douglassii - typicum Sub-Association

This sub-Association is characterized by the presence of DSG E and the absence of Group H. A dense cover of S. douglassii is typical, particularly in the S. douglassii - typicum Variant where trees and mosses are absent and where litter reaches a depth of 40 cm. (Figure 7).

The Galium triflorum Variant is differentiated by DSGs E and f and is characterized by Group g. The litter layer is usually very thin

Figure 6 Spiraea douglassii Association in Rithet's bog. The dark green foliage is part of the P. contorta - G. shallon The tall brushland is in the Cornus stolonifera sub-Association.

S. douglassii in foreground falls in the Potentilla anserina sub-Variant.

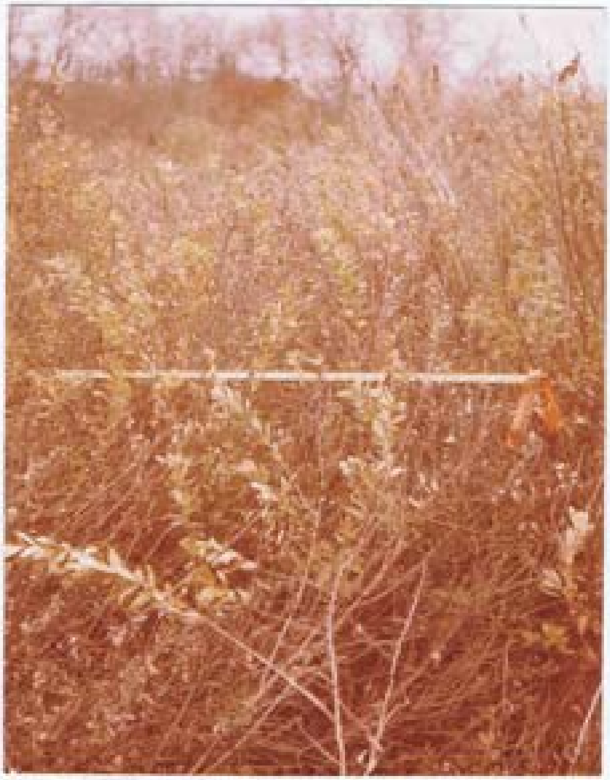

Figure 7 Spiraea douglassii typicum Variant. Note heavy cover and thick layer of fallen S. douglassii.

and sparse. This Variant contains the Galium triflorum - typicum and the Potentilla anserina sub-Variants, the former being characterized by the presence of DSGs E and f only, and the latter also by Group g. The P. anserina Variant is found near the cropland and abandoned cropland, possibly because of abundant side-light availability from adjacent open areas (Figure 8).

The Galium triflorum - typicum sub-variant lies closer to the P. contorta - G. shallon Association where light access is restricted by dense forest.

S. douglassii - Cornus stolonifera Sub-Association

This community is characterized by DSG H. Group E is always present and DSGs A, c, f and i typify certain variants (Figure 9). There is little doubt about the integrity of this sub-Association since Group H contains five abundant, faithful species. Three of these species (Cornus stolonifera, Salix sitchensis and S. scouleriana) are deciduous trees so that the sub-Association differs strikingly from all communities except the Potentilla anserina Variant. Within this Association, the litter layer and the Ao horizon are negligible, indicating that decomposition is rapid because of substantial microbial activity.

The C. stolonifera - Galium triflorum Variant usually occupies that portion of the sub-Association lying between the cropland and the bog forest and may be further tentatively divided into the Betula papyrifera and Ledum groenlandicum sub-Variants. The former lies closer

Figure 8 Dense stand of Salix geyeriana in the Potentilla anserina sub-Variant.

Figure 9 Dense stand the Cornus stolonifera sub-Association. Note Spiraea douglassii typicum sub-Association in background.

to the cropland while the latter is more closely associated with P. contorta - G. shallon Association.

The Populus tremuloides Variant borders the drainage ditches (Figure 4) which transect the P. contorta - G. shallon Association, and is characterized by DSG i.

The DSGs characteristic for each of the last communities may be readily seen in Table 6. Their validity is doubtful because each occurs in only a few plots.

The communities described above are surrounded by cropland in varying degrees of use. The cropland obviously support different communities, some of which undoubtedly are related to the fringe communities bordering the study area.

Ecological Factors

Environmental differences reported here are significant in the statistical sense only. Wherher these differences materially influence vegetation distribution must be determined by autecological experimentation. Time and sampling limitations allowed comparisons to be made only between some DSGs. More complete analyses are necessary.

Soil pH

In most cases significant differences existed between pH of horizons of preserved peat and decomposed peat (Table 2). The preserved

DSG / horizon	H A_1	H A_0	H A_{00}	g A_1	g A_0	g A_{00}	f A_{f_1}	f A_1	f A_0	f A_{00}	d A_{f_3}	d A_{f_2}	d A_{f_1}	B A_{f_1}	B A_0	B A_{00}	A A_{f_1}	A A_0	A A_{00}
A A_{00}											#								
A A_0											#								
A A_{f_1}											#								
B A_{00}											#								
B A_0																			
B A_{f_1}		#			#	#			#	#									
d A_{f_1}					#	#			#										
d A_{f_2}		#	#		#	#			#	#									
d A_{f_3}	#	#	#	#	#	#	#	#	#	#									
f A_{00}																			
f A_0																			
f A_1																			
f A_{f_1}																			
g A_{00}																			
g A_0																			
g A_1																			
H A_{00}																			
H A_0																			
H A_1																			

Table 2. pH — Significance between soil horizons of various Differential Species Groups. (#) indicates significant differences. See text.

Ap horizon of the Hylocomium splendens typicum variant and the three levles of peat (Ap_1, Ap_2 and Ap_3) of the Sphagnum capillaceum Variant were more acidic than decomposed peat layers both within the Variants and within other communities. Significant differences occurred between these acid layers and those of the Potentilla anserina sub-Variant.

Available Nitrate Nitrogen

Available nitrate nitrogen was significantly higher in DSG g than it was in DSGs B and H (Table 3). Within DSG g, the Ao horizon contained significantly more nitrate than did the A1 horizon. Since DSG g differentiates the Potentilla anserina sub-Variant, it can be concluded that this community contains more nitrate than the Cornus stolonifera sub-Association and the P. contorta - G. shallon Association. Tests should be made on the remaining DSGs in order to determine if nitrate levels differ significantly between other communities.

Available Phosphate

No significant differences were revealed in available phosphate comparisons between DSGs B, g and H (Table 4).

Available Potassium

Potassium may be less abundant in DSG B and thus in the P. Contorta - G. shallon Association (Table 5). Statistical significance, however, is lacking.

Table 3- Available Nitrate Nitogen estimates.

Significance from New Multiple Range Test. Those means connected by a given letter are not significant.

Standard error of mean= 2.33
Estimates given in pounds per acre.

Species Block	Soil Horizon	Ranked NO_3 Means	Significance @95%
g	A_1	46.9	a
g	A_0	34.9	b
H	A_0	22.8	c
H	A_1	18.7	c
B	A_1	15.0	c
B	A_0	13.1	c

Species Block	Soil Horizon	Ranked PO_4 Means	Signicance @95%
B	A_1	162.5	a
H	A_0	143.8	a
g	A_0	125	a
B	A_0	125	a
g	A_1	119	a
H	A_1	119	a

Table 4- Available Phosphate.

Those means connected by the letter "a" are not significant.

Standard error of mean= 83.7

Estimates given in pounds per acre.

Water Table

Figure 10 illustrates the distinct difference in water table depths and fluctuations between DSGs B, d, g and H. Water table fluctuation is greatest in the S. douglassii Association and least in the P. contorta - G. shallon Association. In the former the water table rose more than a metre during the three-month period, and in the latter only about 15 cm. In the Sphagnum capillaceum Variant the water table remained nearly constant. After January 1st the water level beneath the pines changed little, while it rapidly inundated the S. douglassii Association by more than a metre. Increasing amplitude of water level fluctuations appears to be correlated with increasing amounts of decomposed peat.

Other Observations

The center of the bog forest is about one metre higher than the surrounding communities, a feature typical of so-called "high moor" bogs.

No particular pattern of age or productivity is evident from tree growth ring analysis. The oldest individuals approach 65 years, while a few younger ones occur. Many 50 to 60 year old pines are small and stunted. Large pine windfalls scattered through the forest indicate that 60 years is about the maximum age an average tree may attain before

Table 5- Available Potassium.

Those Means connected by the letter "a" are not significant.

Standard error of mean: 26.3

Estimates given in pounds per acre

Species Block	Horizon	Ranked K Means	Significance @95%
H	A_0	250	a
g	A_0	235	a
H	A_1	230	a
g	A_1	225	a
B	A_1	206	a
B	A_0	181	a

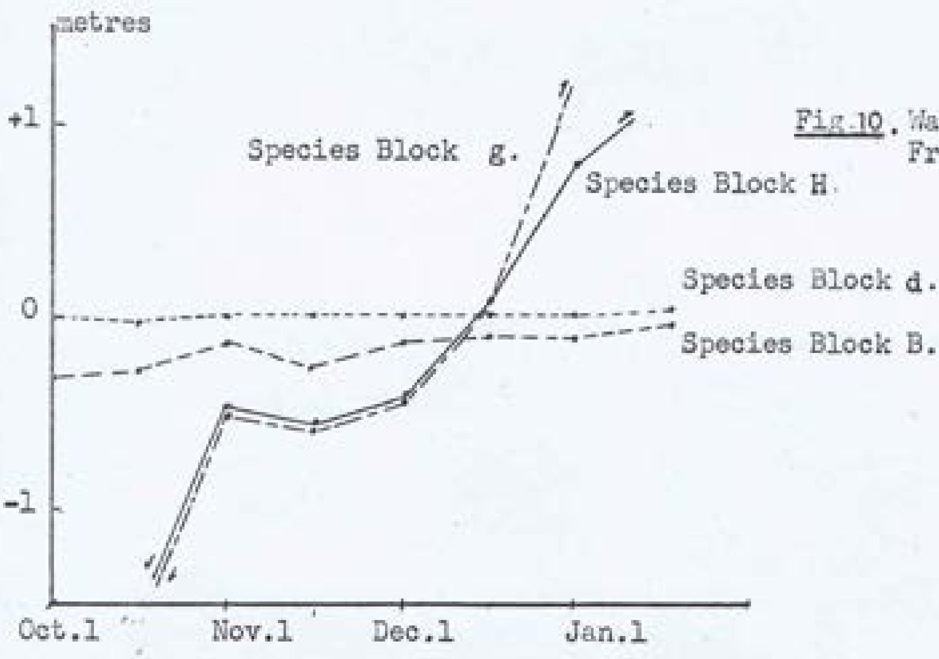

Fig.10. Water Table Deviation From Surface Level.

falling over, probably because of insufficient support provided by the combination of a soft substrate and a shallow root system.

Rare individuals of *Picea sitchensis*, *Pseudotsuga menziesii* and *Thuja plicata* were found in the *Pinus contorta* - *G. shallon* Association. These species, now 10 metres high, were recorded as seedlings by Rigg (1922). Certain species previously recorded in the bog forest were not seen including *Sphagnum palustre*, found in more hydric communities in nearby bogs (Figure 11). This indicates that the hydric *Sphagnum* communities have been replaced by the *P. contorta* - *G. shallon* Association.

Cattle, squirrels, owls and pheasant frequented the lowland during the study period.

Discussion

The data collected combined with some knowledge of the bog's history facilitate discussion on possible causes of present vegetation distribution and of successional trends. Nevertheless, while environmental differences may correlate with community variation the reasons for vegetation change may be for quite different: e.g. competition which restricts certain Differential Species to a range of environments which might be wider if competition was not present; or vegetation may induce environmental changes which may or may not be self-limiting. Further

NATURAL HYDRARCH SUCCESSION

SUBSEQUENT TRENDS RESULTING FROM CULTIVATION AND DRAINAGE.

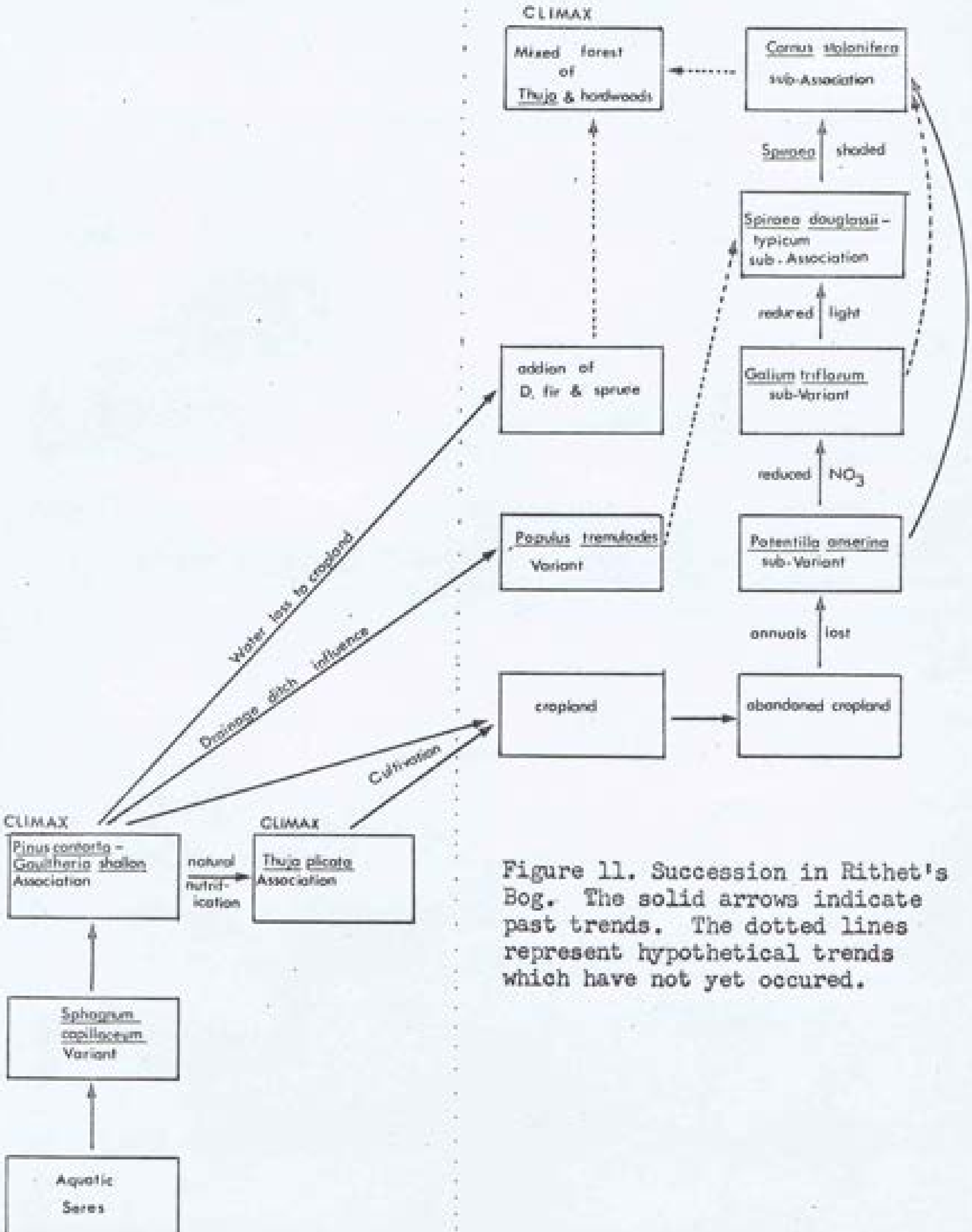

Figure 11. Succession in Rithet's Bog. The solid arrows indicate past trends. The dotted lines represent hypothetical trends which have not yet occured.

observation and experiment should clarify these points. The following comments may facilitate subsequent investigations.

The bog forest is the last region of relatively undisturbed vegetation in the lowland. Apparently it has changed relatively little in the past fifty years. The wet Sphegnum capillareum Variant differs from the typical Hylocomium splendens Variant in having more undecomposed peat and a stable water table at surface level, and probably represents the community closest, in the successional sense, to what must have been an open water conditinn in the lowland. Continuous surface soil saturation and hence low aeration probably prevents establishment of many species found in the successionally adjacmnt Hylocomium splendens Variant. Within the Association, high acidity of the peat induced by Sphagnum respiration and water stagnation probably prevents all organic matter decomposition in the subsurface horizons.

Had man not drained and cultivated the area, succession from the originally more widespread Sphagnum capillaceum community to the Pinus contorta - Gaultheria shallon Association would not have been so rapid. Without disturbance, this Association would probably be self-perpetuating since poor drainage would maintain the acid Sphagnum peat soil indefinitely in the center of the lowland. Nutrient rich seepage and runoff from the adjacent slopes might maintain a slightly higher pH and base content thus encouraging peat decomposition and thereby support a fringe of communities dominated by nitrophilous wetland species such as Thuja plicata. The comments of Locke and the palynological of Zirul (1967) tend to support this view.

During the 1880's all but the central portion of the lowland was cleared. Improved soil aeration, through tilling and drainage, probably stimulated microbial action in the upper layers of peat so that decomposition took place rapidly. There are now approximately 30 cm. of humus overlying the peat in the *Spiraea douglassii* Association. This decomposition probably resulted in: 1) a reduction in the physical volume of the substrate; and 2) a concurrent loss of the characteristically high water holding capacity of undecomposed *Sphagnum sp.* Consequently the cleared region gradually became lower with respect to the water table. Assuming that the same quantities of water still drain from the watershed and reach the lowland as before cultivation, this would contribute to progressive annual increases in flooding. Silting in of drainage ditches may also be a contributing factor allowing higher water levels to accumulate in the lowland. Relatively more water would accumulate in the cultivated areas and less in the bog forest. Although a bog forest may fluctuate with the water table level (Buell, 1941), reduced amounts of water reaching the *Pinus contorta* - *Gaultheria shallon* Association may be contributing to drying of the soil in this Association thereby accelerating the disappearance of *Sphagnum* communities and the establishment of more mesic species such as *Pseudotsuga menziesii* and *Picea sitchensis*.

Whatever its cause, increased flooding has forced periodic release of the cleared agricultural land. I suggest that each region vacated may be represented by a different community. If the cultivated portions have been fertilized every year, the high nitrate content of the *Potentilla anserina* sub-Variant is explainable. Since the sub-Variant lies adjacent to recently used cropland where *Potentilla anserina* occurs extensively, the species of this community in DSG g may also have demanding light requirements and thus be restricted by excess shade in the other communities. Light need may also play a major role in delineating the *Spiraea douglassii* (DSG E) boundary with the *Pinus contorta* - *Gaultheria shallon* Association, probably in combination with reduced nutrient availability and lower pH of the latter. Reduced *S. douglassii* cover in the *Cornus stolonifera* sub-Association supports this hypothesis.

Having been modified from undecomposed peat to muck soil, the lowland will subsequently support different vegetation types. This change in the vegetation is either artificially induced or secondary succession. Assuming that the lowland was at or nearing the edaphic climax condition, then any discrepancy from the climax communities can be attributed to man's influence.

Based on the foregoing data and discussion, both naturally and artifically induced successional trends are suggested in Figure 11.

Summary and Conclusion

During the fall and winter of 1966, the bog forest and adjacent vegetation and the environments of Rithet's lowland were studied.

Vegetation analysis based on the methods of Ellenberg (1956) revealed nine Differnetial Species Groups of Varying integrity. The Vegetation Synthesis Table (Table 1) gives the detailed species composition of these Groups which in various combinations delineate nine communities comprising two Associations. Four important communities are:

1) Pinus contorta - Gaultheria shallon Association.
   This is differentiated by DSG B and includes DSGs A, c and d. P. contorta, G. shallon and Ledum groenlandicum are dominant. Soils are acidic with little decomposition. Water table fluctuations are moderate.

2) Sphagnum capillaceum Variant. This is represented by small fragments of a previously more extensive community within the pine forest. The Variant is characterized by Group c. Sphagnum capillaceum, Eriophorum chamissonis, Vaccinium oxcycoccus and Kalmia polifolia are dominant. Undecomposed Sphagnum peat prevails in all soil horizons. The water table level does not fluctuate.

3) Spiraea douglassii typicum sub-Association. This part of the S. douglassii Association and includes Groups f and g. S.

douglassii is dominant. Water table fluctuations are large. The soil nutrient level is high.

4) Cornus stolonifera sub-Association. This is part of the S. douglassii Association and is differentiated by DSG H. It includes Groups A and part of E, f and i. Soil nutrient levels are high. Water table fluctuations are large.

Figure 12 briefly summarizes distribution of the DSGs within the communities. This diagram may also serve as a practical key for field identification of communities in Rithet's bog.

The major environmental features influencing vegetation distribution appear to be pH, soil nitrate content, water table fluctuation and the history of disturbance.

a) Low pH in undisturbed areas maintains a high undecomposed peat content and leads to support typical high moor vegetation.

b) Cultivation and drainage probably encourages increase in nitrate nitrogen content and permits development of the Potentilla anserina sub-Variant in abondoned croplands.

c) Peat decomposition has not only increased soil richness, but has probably caused increased flooding and water table fluctation, particularly in areas where substantial flooding occurs.

Cultivation and drainage during the past eighty years has

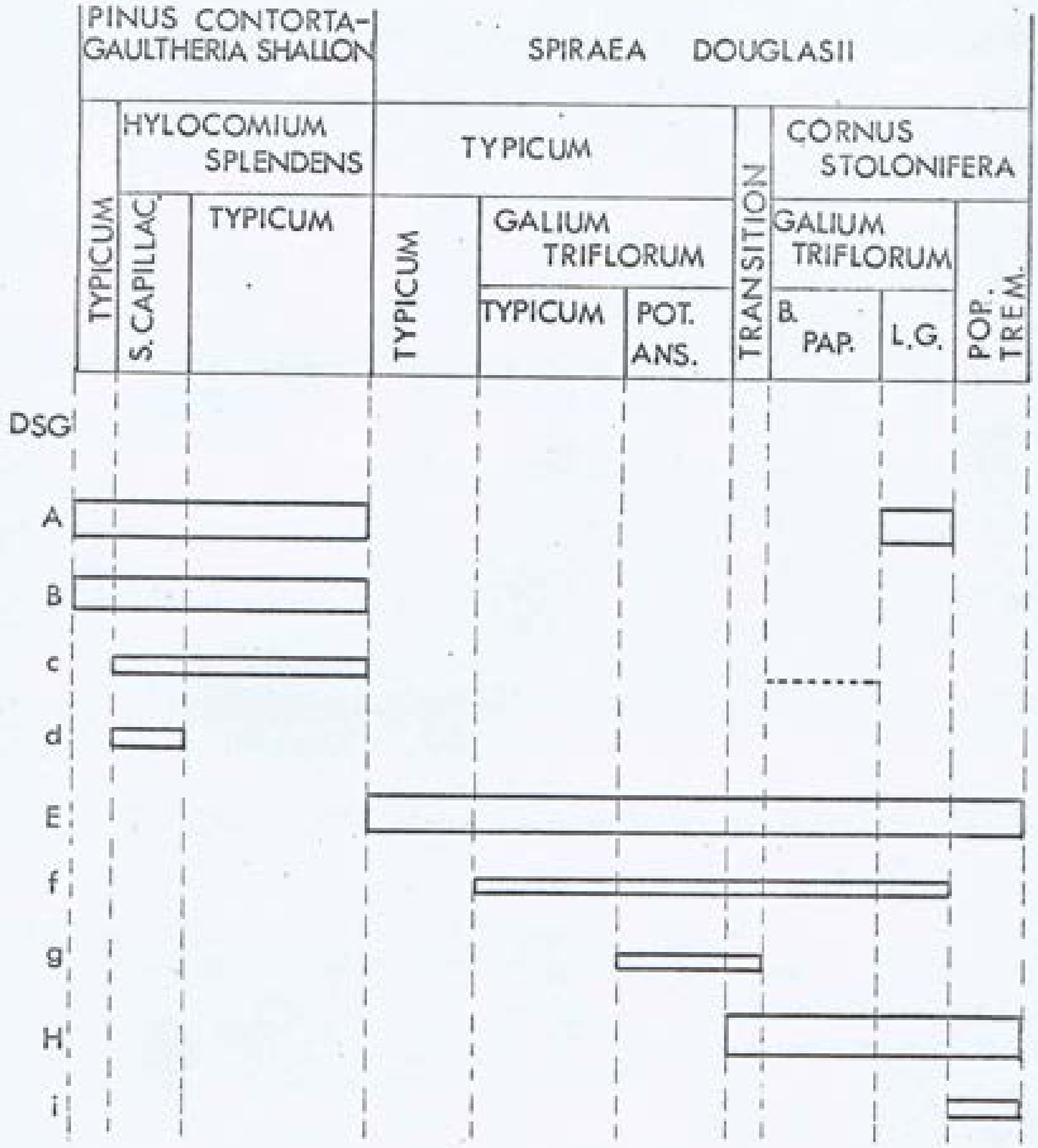

Figure 12. Diagrammatic key for identification of communities in Rithet's Bog using Differential Species Groups. See the Vegetation Synthesis Table (Table 1) for species composition of DSGs. The width of band indicates "strength" of DSG.

Pot. Ans. - Potentilla anserina; L.G. - Ledum groenlandicum; Pop. trem. - Populus tremuloides.

stimulated an irreversible change in the edaphic features of Rithet's bog resulting in considerable vegetation change. Once nutrification had resulted in transformation of undecomposed Sphagnum peat to muck soils, the vegetation composition evolved from acidophilous to neutrophilous species. The new edaphic climax has not yet been reached but will probably lead to a Thuja plicata-hardwood forest.

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Appendix I

Check List of Species

Seed Plants

Alnus rubra Bong
Betula glandulosa Michx.
Betula papyrifera Marsh
Calamagrostis sp.
Carex flava L.
Carex sp.
Cirsium edule Nutt.
Cornus stolonifera Michx.
Crataegus oxyacantha L.
Drosera rotundifolia L.
Epilobium angustifoliam L.
Eriophorum chamissonis Mey.
Escholtzia californica Cham.
Galium triflorum Michx.
Gaultheria shallon Pursh.
Hedera helix L.
Hieracium albiflorum Hook.
Ilex aquifolium
Juncus balticus Willd.
Kalmia polifolia Wang.
Ledum groenlandicum Oeder.
Lonicera involucrata Banks
Lycopus labiatae
Lysichiton americanum Hulten and St. John
Myosotis laxa Lehm.

Oenanthe sarmentosa Presl.

Pinus contorta Dougl.

Poa sp.

Populus tremuloides Michx.

Populus trichocarpa T & G

Potentilla anserina L.

Pseudotsuga menziesii (Mirb.) Franco

Pyrola asarifolia Michx.

Pyrus fusca

Quercus garryana Dougl.

Ranunculus sp.

Rhamnus purshiana D.C.

Rosa nutkana Presl.

Rosa pisocarpa Gray.

Rubus vitifolius Cham. & Sch.

Salix geyeriana Anderss

Salix scouleriana Andress

Salix sitchensis Andress

Sanguisorba sp.

Sisymbrium officinale (L) Scop. Var. leiocarpum D.C.

Sorbus aucuparia Roem.

Spirea menziesii Var douglassii

Stellaria media (L.) Cyrill.

Thuja plicata Donn.

Trientalis arctica Fisch.

Vaccinium oxycoccus var. intermedium Gray.

Veronica scutellata L. (Marsh S.)

Viola sp.

Pteridophytes

Equisetum aruensis L.

Pteridium aquilinum Underw.

Bryophytes

Camptothecium megaptillum L.
Dicranum scoparium L.
Eurynchium oreganum
Hylocomium splendens S. & S.
Isothecium stoloniferum
Lophocolia sp.
Mnium punctatum L.
Porella sp.
Rhytidiadelphus loreus (Hedw.) Warnst.
Rhytidiadelphus triguetrus (Hedw.) Warnst.
Sphagnum capillaceum Weiss.
Sphagnum recurvum tenue Kling.

Appendix II Basic Data

Table 6

pH Estimates

Plot No.	Horizon Aoo	Ao	Ai	Ap
1	4.4	4.0	3.8	-
2	4.8	5.0	3.7	-
2	5.0	4.2	3.9	-
2	5.3	5.1	3.7	-
6	6.4	6.5	5.2	-
7	6.0	5.2	6.1	-
10	-	6.4	6.0	-
10	-	6.2	6.2	-
12	5.9	6.0	6.7	-
13	6.5	5.5	5.6	-
13	6.4	5.9	5.8	-
13	6.1	6.2	6.0	-
14	6.5	5.9	6.0	5.5
15	5.5	5.7	5.4	5.2
16	5.5	6.3	5.8	-
17	-	5.5	6.0	6.0
20	6.9	6.0	6.5	5.5
21	5.6	7.0	4.8	4.9
22	6.5	5.0	6.5	6.8
24	6.0	6.3	5.2	6.4
25	6.2	6.2	5.1	-

- Absent values in Aoo indicate that no litter was present.

Table 8

Nitrate Nitrogen Estimates

Plot No.	Horizon Ao	A1
1	15, 25, 20, 20	15, 10, 10, 10
2	5, 5, 5, 5	5, 20, 20, 20
3	10, 10, 10, 10	20, 10, 20, 10
7	20, 10, 25, 15	20, 15, 10, 15
10	25, 40, 35, 40	35, 40, 30, 50
10	30, 30, 25, 40	50, 50, 40, 60
13	40, 30, 30, 35	50, 50, 50, 60
14	20, 10, 10, 10	15, 20, 15, 20
15	30, 20, 30, 35	25, 20, 20, 25
16	45, 40, 40, 40	25, 20, 30, 25
18	5, 10, 15, 5	20, 10, 5, 5
25	25, 50, 30, 50	45, 50, 50, 40

- 4 replications per treatment
- units in pounds per acre

Table 9

Available Phosphorus and Potassium

Plot No.	Available Phosphorus A1	Available Phosphorus A2	Available Potassium A1	Available Potassium A2
Horizon	A1	A2	A1	A2
1	75	150	250	200
2	150	175	175	150
3	175	150	100	175
7	100	175	200	300
10	200	75	220	280
10	75	75	300	200
13	175	150	220	180
14	150	100	220	200
15	150	125	260	220
16	125	150	300	260
18	150	100	220	220
25	150	175	200	250

Table 10

Water Table Depths (cm.)

DSG

Date	B	d	g	H
29/09/66	+ 33	+ 2	> + 100	> + 100
12/10/66	+ 30	+ 4	> + 100	> + 100
30/10/66	+ 20	0	+ 53	+ 48
13/11/66	+ 28	0	+ 60	+ 55
28/11/66	+ 14	0	+ 46	+ 42
18/12/66	+ 11	0	- 8	- 7
6/01/67	+ 12	0	< - 100	- 80

Appendix III

A. <u>Plot Size Determination by Minimal-Area Technique</u>

1) Relatively homogeneous stands were selected in each subjectively chosen community type.

2) In each stand a quadrat was established which appeared to be substantially smaller than that required for full expression of the community type. The number of species in the quadrat was recorded.

3) Quadrat size was repeatedly doubled, each time recording the accumulative total of the number of species found within the plot. This process was continued until the increase in the number of species had decreased markedly.

4) Species-area curves were constructed (Figure 13).

5) The minimal area was chosen as that point on the curve where the increase in the number of species approached zero.

6) The plot size was then taken as twice the minimal-area in order to obtain an adequate sample.

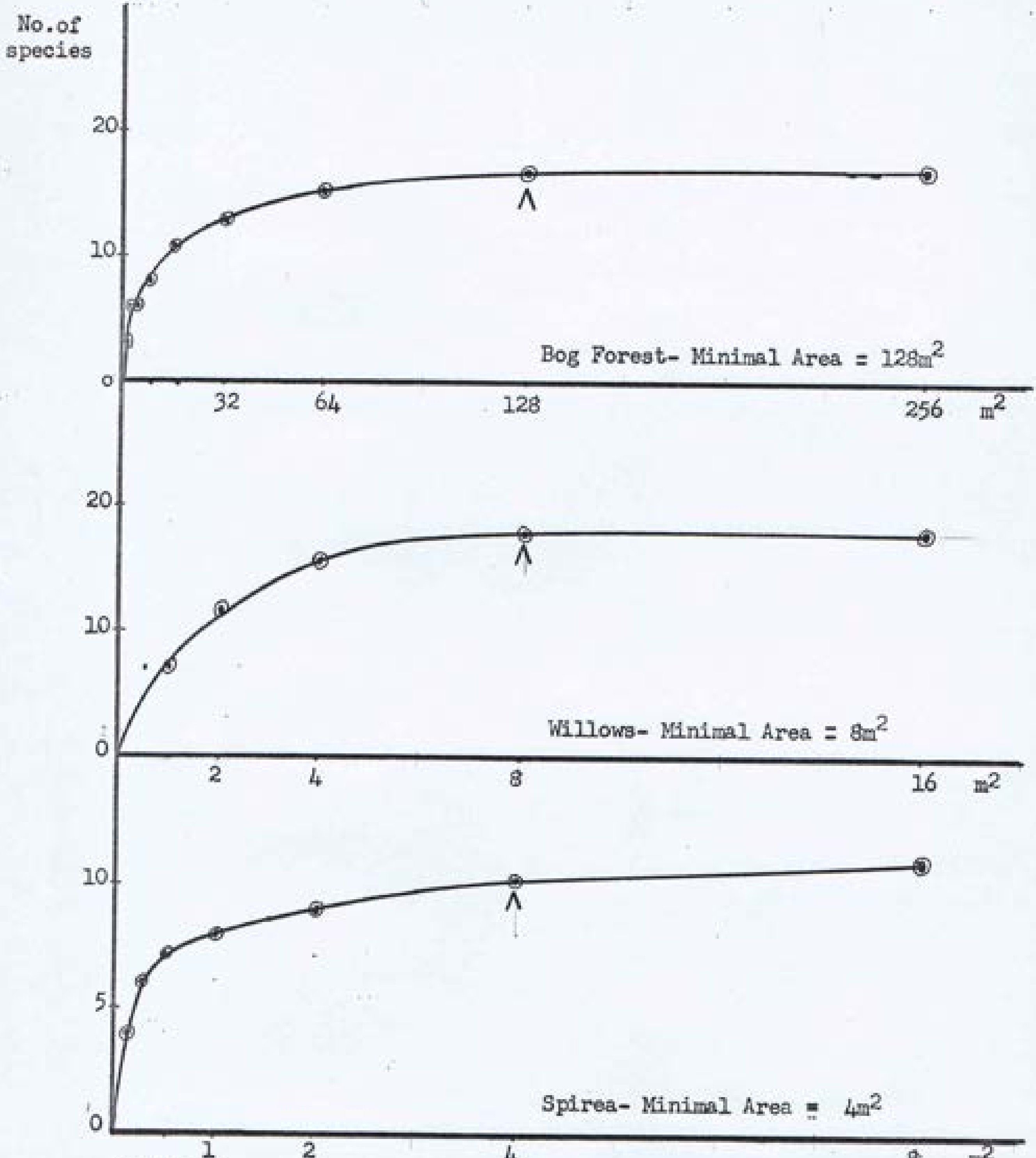

Figure 13.
Minimal Areas For Plot Size Determination.

8. Critique of the Methods of Vegetation Analysis

The purpose of this section is to point out shortcomings of the methods used in this study and to present some ideas which may contribute to improved methodology.

Determining Plot Size by Species-Area Curves

By definition the minimal area is the smallest area in which a community may fully develop and thus in which the community can be adequately sampled. Species-area curves have generally been the means for determination of minimal area (Figure 13), yet, for this purpose they are deficient in two major respects:

1) Choice of the minimal area point on the curve is subjective and will vary from person to person.

2) For the same data and the same person, the minimal area will vary if the ratio of the ordinate to the abscissa are changed.

The "ten percent method" outlined by Rice and Keating (1955) eliminates these failings to some extent, yet the results are still dependent on both the units of area used, and the total number of quadrats included.

Even Kilburn's (1966) method of differentiating the equation which describes the species-area curve is not area independent. This can be illustrated by the following proof.

If one considers the equation, $Y = X^2/2$, as representing a typical species-area curve, then $dY/dx = X$ where Y is the accumulative total of the number of species and where X is the area of the quadrat. If X is the area of the quadrat, then $\sqrt{X}$ is the unit of measurement. For example, where $\sqrt{X}$ = 1 meter, X = 1 meter^2.

Assuming that $\sqrt{X}$ = 1 meter, then $\sqrt{X}$ = 3.281 feet. If $\sqrt{Z}$ = 1 foot, then $\sqrt{X} = 3.281\sqrt{Z}$. Substituting into the species-area equation we get: $Y = (3.281\sqrt{Z})^4/2 = 57.6422\ Z^2$. Differentiating this equation yields $dY/dz = 115.884\ Z$. Since $X = 10.7649\ Z$, $dY/dx \neq dY/dz$. Therefore, Kilburn's method is still dependent on the unit of area used. If a standardized unit of measure was employed, the results would be objective and identical for all workers. Since $dY/dx = dZ/dx \cdot dY/dz$, a correction factor (dZ/dx) could be introduced to convert all data into the standard unit.

Although standardization of the units of measure along with conversion factors permit objective plot size determinations by the minimal area technique, the fundamental question seems to be "can one logically determine minimal area using a method whose results are area dependent in the first place?"

Comparing Vegetation From Plots of Different Sizes

The concept of minimal-area may not be as useful as it is thought to be in plot size determination for community comparisons. Consider this study where DSG. A of the Vegetation Synthesis Table (Table 1) is spread over three sample plot sizes. Plot 4 is 256 m^2 and plot 23 is 8 m^2. In town of probability a species such as Eurynchium oreganum which occurs once in every plot of 256 m^2 should occur only once in 32 plots each being 8 m^2. On this basis one cannot legitimately discard plot 23 from DSG A. Therefore DSGs cannot be analysed objectively if there is variation in the size of their plots. By the same token communities delineated according to DSG distribution would also be open to question.