Reflections on the life, work, and times of Vladimir Joseph Krajina

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A distinguished teacher, botanist, ecologist, and conservationist, Professor Vladimir Joseph Krajina has made major contributions to basic ecology and to the understanding of Canada's natural environment. He has fostered an enviable rigor in the conduct of ecological studies. Combining a unique blend of European and North American ecological approaches to the study of ecosystems, his original synthesis using a biogeoclimatic classification of the ecosystems of British Columbia is now followed both in the classroom and in natural resource management. As a teacher, he has left a strong legacy to ecology through his many students. His achievements in conservation, through the establishment of 117 ecological reserves in British Columbia, devoted solely to ecological research by law, are legendary.

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Éducateur, botaniste, écologiste distingué et partisan de la conservation, le professeur Vladimir Joseph Krajina a joué un rôle majeur en écologie fondamentale et dans la compréhension des milieux naturels canadiens. Il a appliqué une rigeur remarquable dans la conduite des études écologiques. Il a su réunir de façon unique les concepts écologiques européens et nord-américains dans une synthèse originale basée sur la classification biogéoclimatique des écosystèmes de la Colombie-Britannique; cette théorie est maintenant suivie dans les classes d'enseignement aussi bien qu'aux fins de l'aménagement des ressources naturelles. Comme enseignant, il laisse un fort héritage à l'écologie via ses nombreux étudiants. Ses réalisations en conservation, concrétisées par l'établissement en Colombie-Britannique de 117 réserves écologiques totalement dédiées par la loi à la recherche en écologie, constituent une légende.

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The life and times of Vladimir Joseph Krajina coincide with phenomenal advances in the conceptual and empirical development of ecology, and he has been a distinguished contributor to both. In ecology, community structure and organization, the functional processes of energy and material transfers, ecosystem production, and evolutionary development are rigorously pursued, and this mass of descriptive material has provided a forum for much elegant theory. Such data, concepts, and theories form the very core of decision making in current environmental problems at local, regional, continental, and global levels.

Krajina's caliber as a scientist is matched by few. As a botanist, he handles taxa from lichens and mosses to gymnosperms and angiosperms, from temperate to tropical regions, with authority and ease. As an ecologist, Krajina has always emphasized that ecological phenomena can (must) be understood by thoroughly examining the fundamental causal processes that underlie ecosystem structure and function.

The cause-and-effect approaches in ecology have been, over time, both praised and criticized. At the IX International Botanical Congress in Montréal, Krajina was criticized for following traditional cause-and-effect philosophy (see Hustich 1960). It was during this period, the early 1960s, that the International Biological Programme (IBP) came into being. Perhaps the planners of IBP concentrated their efforts more on quantifying the magnitudes and rates of ecosystem processes and less on delving into the very elusive question "why." However, in the mid-1960s things turned around. Why? became fashionable again. One of the fathers of systems ecology defined that subdiscipline as "an interlocking complex of processes characterized by many cause–effect pathways" (Watt 1966).

Many excellent reviews on the history of ecology and its thematic development are available (Becking 1957; Whittaker 1962; McIntosh 1967, 1985; Burgess 1981). It is not my intention here to provide a summary of the vast amount of work done by Krajina. Rather, my comments are intended to cast his body of research in the light of other ecological studies and to present briefly some major topics of ecology in relation to his contributions. These include community organization, community analysis and synthesis, and ecosystem conservation.

Krajina, the early years

His interest in botany, in particular, plant taxonomy, began when he entered high school in 1917. He joined Charles University in Prague in 1923 and came under the tutelage of Professor Karel Domin. His doctoral thesis in 1927 was on the taxonomy of *Festuca* species, mainly from the Tatra Mountains. His taxonomic interests continued throughout his life. He studied diverse taxa: *Spergularia* (Krajina 1924), *Cerastium* and *Pinguicula* (Krajina 1926*a*, 1926*b*), *Festuca*, *Gunnera*, and *Pipturus* (Krajina 1929, 1930*a*, 1930*b*, 1930*c*, 1930*d*), five new taxa of *Cheirodendron* (Krajina 1931), *Festuca*, *Brachythecium*, *Ranunculus*, *Pinguicula*, and *Pulsatilla* (Krajina 1933*a*, 1933*b*, 1933*c*, 1933*d*, 1933*e*), *Crupina*, *Silene*, and *Danthonia* (Krajina 1934), *Cynoglossum* (Krajina 1935), *Fraxinus*, *Litchi*, *Nephelium*, and *Onosma* (Krajina 1936*a*, 1936*b*, 1936*c*), *Gagea* (Krajina 1938*a*), one new species of *Cibotium* and seven new species of *Elaphoglossum* from Polynesia (Krajina 1938*b*, 1938*c*), *Coronopus* (Krajina 1939), and *Cibotium* (Krajina 1942). His taxonomic interests continued in British Columbia. These include new species of *Dicranella* (Krajina 1950), new species of *Pellia* (Krajina and Brayshaw 1951), nomenclature of Douglas-fir (Krajina 1956), Sarraceniaceae, a new family to British Columbia (Krajina 1968), and *Mecodium wrightii* (Cordes and Krajina 1968).

His field studies in the 1920s increasingly drew him toward ecology. Shortly after receiving his doctorate, he started work on ecological studies of the Tatra Mountains for his Docent degree. He completed these studies after he returned from a sabbatical in the Hawaiian Islands during 1929–1930.

Krajina, the teacher

His teaching career began as an assistant to Karel Domin. When he was given a faculty position after receiving his doctorate, he taught courses in both plant taxonomy and ecology. Although many students were under his tutelage in Czecho-

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TABLE 1. Students completing graduate degrees under the direction of Professor Vladimir J. Krajina at the University of British Columbia*

Year	Student	Title of thesis
		Doctor of Philosophy
1953	A. F. Szczawinski	Corticolous and lignicolous plant communities in the forest associations of the Douglas-fir forest on Vancouver Island
1955	T. C. Brayshaw	An ecological classification of the ponderosa pine stands in the southwestern interior of British Columbia
1957	Robert G. McMinn	Water relations in the Douglas-fir region on Vancouver Island
1959	Dieter Mueller-Dombois	The Douglas-fir forest associations on Vancouver Island in their initial stages of secondary succession
1960	W. F. Murison	Macronutrient deficiency and its effect on coniferous growth
1962	Slavoj Eis	Statistical analysis of tree growth and some environmental factors of plant communities in a selected area of the Coastal Western Hemlock zone
1963	R. B. Smith	Edaphic aspects of an ecological classification of the Interior Western Hemlock dry subzone forests of British Columbia
1964	M. A. M. Bell	Phytocoenoses in the dry subzone of the Interior Western Hemlock zone in British Columbia
	Alexander Jablanczy	Influence of slash burning on the establishment and initial growth of seedlings of Douglas-fir, western hemlock, and western red cedar
	Laszlo Orlóci	Vegetational and environmental variations in the ecosystems of the Coastal Western Hemlock zone
	Everett B. Peterson	Plant associations in the Subalpine Mountain Hemlock zone in southern British Columbia
1966	Robert C. Brooke	Vegetation – environment relationships of Subalpine Mountain Hemlock zone ecosystems
1968	John D. Lambert	The ecology and successional trends of tundra plant communities in the low arctic subalpine zone of the Richardson and British mountains of the Canadian western arctic
1969	Charles E. Beil	The plant associations of the Cariboo Aspen – Lodgepole Pine – Douglas-fir Parkland zone
	Mohan K. Wali	Vegetation – environment relationships of Subboreal Spruce zone ecosystems in British Columbia
1970	Bruce E. C. Fraser	Vegetation development on recent alpine glacier forelands in Garibaldi Park, British Columbia
1971	Karen Eady	Ecology of the alpine and timberline vegetation of Big White Mountain, British Columbia
	Satoru Kojima	Phytogeocoenoses of the Coastal Western Hemlock zone in Strathcona Provincial Park, British Columbia
1972	Paul E. Barrett	Phytogeocoenoses of a coastal lowland ecosystem, Devon Island, N.W.T.
	L. D. Cordes	An ecological study of the Sitka spruce forest on the west coast of Vancouver Island
	Richard D. Revel	Phytogeocoenoses of the Subboreal Spruce biogeoclimatic zone in north central British Columbia
1974	Isabel L. Bayly	The ecology of genus *Typha* in wetland communities of the eastern Ontario – western Quebec region of Canada
1976	Karel Klinka	Ecosystem units, their classification, interpretation and mapping in the University of British Columbia research forest
1977	Richard M. Annas	Boreal ecosystems of the Fort Nelson area of northeastern British Columbia
		Master of Science
1955	J. W. C. Arlidge	A preliminary classification and evaluation of Engelmann spruce – alpine fir forest at Bolean Lake, British Columbia
	R. T. Ogilvie	Soil texture of *Pinus ponderosa* plant communities in British Columbia
1958	Richard Garm	Some aspects of the nitrogen cycle in soil of the Douglas-fir forest
1961	J. G. N. Davidson	A nutritional study of grand fir and amabilis fir in the greenhouse
	G. I. Lesko	Ecological study of soils in the Coastal Western Hemlock zone
	Laszlo Orlóci	Forest types of the Coastal Western Hemlock zone
1963	A. C. Archer	Some synecological problems in the alpine zone of Garibaldi Park
1965	R. T. Kuramoto	Plant associations and succession in the vegetation of the sand dunes of Long Beach, Vancouver Island
	L. K. Wade	Vegetation and history of the *Sphagnum* bogs of the Tofino area

*Professor Krajina also guided graduate student research at Charles University in Prague (1928–1948), and intermittently at the University of Hawaii throughout his career.

slovakia in his early career, and later in Hawaii, his major contributions in this area come from British Columbia.

Here, 33 students completed work for their graduate degrees (Table 1). The range of projects covered not only the entire province of British Columbia but other areas in Canada as well. These included many fundamental studies other than those relating to the biogeoclimatic zonal approach. He was a demanding teacher, inculcating a meticulous approach to ecology. In the classroom he was equally at ease describing ecological attributes of the vegetation of Europe, North America, and the tropical zones. His skills in the field were matched by few.

Krajina visited his students in the field, discussed methodology, noted their field data collection techniques, provided much useful advice, and imbued a sense of great enthusiasm for the fieldwork. To cite an example, Krajina's first visit to the Canadian Arctic in 1964 came late in his academic career, where two of his students, Lambert and Barrett (see 1968 and 1972 in Table 1), carried out comprehensive plant ecological studies in the Richardson Mountains in western Northwest Territories and Cape Sparbo, Devon Island. Both studies were completed just before the much accelerated oil and gas exploration in the early 1970s. They were important sources of ecological information on plants and soils in the Arctic Land Use Research Program established by the Canada Department of Indian and Northern Affairs. It has been Krajina's constant conviction that comprehensive data gathering is essential both for ecology as well as for resource development.

Krajina, the ecologist

Community organization

Although Krajina completed a prodigious number of projects on ecology and systematics in his early career in Prague, what may be regarded as the most comprehensive work of that period in his two-part treatise on the plant ecology of the High Tatra Mountains (Krajina 1933*f*). (It is unfortunate that the third part of this study, dealing with soils and microclimate, was destroyed during the war.) Although this work was strongly grounded in the tradition of the European community classification system (specifically the Braun-Blanquet system), it combined, in a most elegant manner, both physiognomic and floristic detail, thorough observations on the autecological characteristics of species, and edaphic differentiation in community organization. This was a system that provided much useful data for deciphering the adaptive strategies of plants. Dahl (1956) used Krajina's study as the basis for his ecological studies in southern Norway.

Two fundamental questions, relevant even today in plant ecological studies, were summarized best by Dahl (1956): (*i*) Why classify? and (*ii*) Is it possible to classify the unclassifiable? In answer to the two questions, Dahl suggested that entities are and should be classifiable "largely independent of the observer" and that ecological problems are much better comprehended in the perspective of a classification. Krajina carried this European bias into his studies in North America with admirable results.

Krajina has been regarded as a champion of the classification school in ecology, and for good reason. He declared, "Without classification there is no science of ecosystems, and no ecology. And, indeed, no science" (Krajina 1960*b*, p. 110; see also, Krajina 1960*a*). Few areas of ecology were so emotionally charged as the classification and continuum concepts during the 1950s and 1960s. The polarization of views was clear even to the most uninitiated. Although the adherents of classification followed different leads, the Braun-Blanquet system was especially singled out for criticism, perhaps because it was the most organized and also because it had an immense following throughout the world.

I cite several studies to cast the trends in their appropriate temporal context. The landmark text *Pflanzensoziologie* of Braun-Blanquet, was published in 1928. Krajina modified his cover–abundance scale ("Artmächtigkeit"), known in ecological literature as the Domin–Krajina scale (see Krajina 1933*f*), for its use in ordinating communities (see Bannister 1966). As the homogeneous nature of vegetation and subjective methods to study it were being debated, and the definition of plant association was being formalized by some ecologists in Europe, others were becoming concerned with the lack of objectivity in methodology. Thus, Jaccard (1908), Kulczyński (1928), Paczoski (1930), and Nordhagen (1943) were proposing mathematical formulations of similarity in vegetation stands. Sørensen (1948, p. 33) summed up their work and comments on the different trends thus: "During its victorious northward advance the Zurich School, too, has become a victim to the same mingling of floristic and ecological points of view that was always the Achilles' heel of the Uppsala School. This tendency will, if carried to the extreme, cause the objective unambiguousness of the floristic method to fall to the ground." The first diagrams depicting a continuum of vegetation came from Paczoski (Maycock 1967).

In the United States, what was later to become known as the "continuum" concept of vegetation received early stimulation from the seminal thoughts of Gleason (1917, 1926). However, few, until the emergence of the Wisconsin School, led by John T. Curtis (see Curtis 1959), and followed closely and independently by Robert H. Whittaker (see Whittaker 1962), were able to generate much useful debate on the continuous or discontinuous nature of vegetation. Although clichés like "The two schools are at war!" were used, a careful study of ecological literature shows that the champions of the two schools, most of their followers, and a few well-read critics of both concepts were indeed remarkable people, who had great appreciation for each other's viewpoints. The following comments are thus most appropriate.

Egler (1954, p. 60): "I would like to say that the Braun-Blanquet system is a noble scientific experiment. It is one of several logical and rational approaches that mankind sooner or later would have to take. [The system] is one of the most significant milestones of vegetation science."

Curtis (1959, p. 52): "It must not be assumed that this blending of one community type into another, or one vegetation type into another (continuum), is always expressed in the field. On the contrary, there are many examples of abrupt shifts from one assemblage into another, sometimes along a line so sharp that it may be crossed at a single step."

Whittaker (1972, p. 41): "Braun-Blanquet's method is a fully fashioned method — a coherent selection of concepts, techniques and objectives that fit together into a highly effective approach to vegetation." Whittaker added that he did not expect quantitative methods to produce a "revolution" but that these would be treated "only as adjunct to classification."

A well-known contemporary plant population ecologist (Harper 1967, p. 268), in what I see as his only commentary on the subject, noted: "The concept of natural selection operating between groups of organisms and adjusting their mutual strategies to permit increasing diversity and more efficient environmental exploitation strengthens the image of community as an integrated whole rather than a Gleason-type assemblage of individuals." Perhaps, this may be an unjustified simplification of Gleason's views, but it illustrates the ambivalence.

Proponents of classification recognized the continuous or gradual nature of communities blending into one another and even provided justification for the Gleason view. Braun-Blanquet (1928): "Du Rietz (1921: 202) suggests that 'a whole group of species for some reason has a really common ability to compete, in other words that the species react together to a change in the ecological factors and not singly.' The facts are otherwise. The ecological factors can often vary within one and the same association, and the individual species react individually to these variations within the association itself. If these were not the case, one association would be immediately and completely replaced by another. Experimental studies of succession in the Swiss National Park and elsewhere show, however, the replacement is gradual" (from Ponyatovskaya 1961, p. 374).

Krajina saw the centrality of these discussions and wrote, "Gleason's individualistic-concept of plant communities can be understood as a view in which the time and influence of secondary and primary succession (mainly by plants established first) are phylogenetically stressed with greater emphasis than in certain other views. This space–time factor in phylogeny of plants plays such a great influence upon the distribution of plant communities that they are geographically more restricted than their potential environments'' (Krajina 1960*b*, pp. 109–110).

Although not antithetical to the followers of the continuum school, adherents of the classification school laid great emphasis on field experience and judgement rather than relying on randomized theoretical constructs (see also Maynard-Smith 1974).

In summary, several points can be made. (*i*) Questions relative to the existence of discrete communities in nature versus continuous variation represent fundamental differences in thinking. They will never be resolved to the point of universal acceptance. (*ii*) Regardless of what school or tenet one follows, there is no substitute for comprehensive, well-planned and well-executed studies. (*iii*) There are areas where vegetation data are easily classifiable, but there are others where discrete community types are not so easily discerned.

At times Krajina may have conveyed the impression that he was universally critical of quantitative methods, particularly those utilized by the followers of the continuum school. Such impressions appear exaggerated to me. A perusal of theses and dissertations submitted under him clearly shows that quantitative methods have been pervasive in nearly all of them; an excellent example is the work of Orlóci (see Orlóci 1978, 1988). Krajina has found no substitute for reading nature other than through thorough field studies. Thus, his criticisms have not been so much of the use of quantitative methods, as of mathematical population–theoretical models, in line with those of Beals (1973) and Slobodkin (1974). The latter cautioned, ''I wish they would stop developing biological nonsense with a mathematical certainty'' (Slobodkin 1974, p. 320).

Community change — succession

Community organization is, of course, intimately related to its dynamic nature and the attendant external factors. The influence of regional climate is one of the mainstays of Krajina's system. The original Clementsian monoclimax as a rigid tenet is now relegated to history, although some would argue that it is still very much alive in schools, nature centers, conservation organizations, and elsewhere. The boundaries of once sharply defined autogenic and allogenic succession have been found to be indeed hazy. As we do for many workers of the past, we may read Clements out of the context of his times. The Clementsian view, as Johnson (1979, p. 240) provocatively notes, may be ''a view of typology vs. populations, neo-Lamarckian vs. Mendelian evolution, organismic vs. systems approaches, Aristotelian vs. hypothetical-deductive methods, in linguistic vs. mathematical descriptions.''

This might well be so, but few ecological schemes proposed in North America and elsewhere have provided the basis for such an impressive array of subsequent ecological hypotheses as did those of Clements. Krajina regarded the succession and climax concepts of Clements (1916, 1928) to be of value in his system, and to both basic and applied ecology. Krajina (1959*a*, 1965) found ecological classification and consideration of successional stages ''indispensable for an ideal interpretation of ecosystems.'' In addition to the important habitat factors, Krajina (1965, p. 2) noted that ''a tree species growing as a climatic climax on mesic habitats ... is shade-tolerant. The same tree species becomes shade-requiring in drier climates ... and shade-intolerant in more humid climates.''

Thus, Krajina's views show a remarkable convergence (on the usefulness of successional and climax concepts) with those of Whittaker (1974, pp. 152–154), who wrote, ''The climax concept has these continued values: 1) It expresses a real and important (though relative) difference in stability between successional and self-maintaining communities. 2) It offers by this means a basis for reducing research variables. Effects of climate, topography, and parent material, etc. on community composition and function may be compared on the basis of climaxes, without complication of the comparison by different successional stages. 3) It provides a standard of comparison for the study of characteristics, function and practical management of successional communities. 4) It provides a means of ordering and understanding in relation to one another, the diverse stable and unstable communities of an area. 5) It thus makes possible comprehension of the vegetation of a landscape through a climax pattern (or mosaic) and the successional communities related to parts of this. 6) It provides a standard of comparison by which may be measured the increasingly widespread effects of disturbance and pollution by man that cause communities to retrogress. 7) It contributes through concepts of regional climaxes to understanding of the broad patterns of climatic adaptation of the vegetation of the world.'' Whittaker further noted that the climax concept, more appropriately, his climax mosaic concept, ''remains an essential means to the interpretation of the complexity of vegetation in space and the flux of vegetation in time, in the world around us.''

Plant adaptation, edaphic factors, and biogeochemistry

Krajina stressed individual population fluxes in relation to root competition for water and nutrients, and in their adaptations to light conditions and air temperature. Those who have been on field trips with Krajina will remember well his comments on competition between plants as a very important factor in phytosociological and ecological studies. Plant ecologists have long been aware of self-thinning, now codified and given scientific elegance by Yoda et al. (1963), Harper (1977), Iverson and Wali (1982), Westoby (1984), and others. And now that the consideration of carrying capacity of the world has found a legitimate place in the discussion of economics of virtually all societies, can competition be ignored?

Krajina's work on habitat factors has been much more comprehensive than just considering the thin mantle of soil that supports the root zone. It is truly biogeochemical. He has stressed the importance of the dominant landforms, nature and placement of parent materials, their relative degrees of weathering, and the resulting soil physical and chemical factors, at times overwhelmingly.

Krajina's work on nitrogen nutrition of northwestern coniferous trees (Krajina 1958, 1959*b*; see also Krajina et al. 1973) was the earliest to clearly demonstrate interspecific differences in adaptations for the uptake and utilization of nitrate and ammonium, and is often quoted as demonstrating the use of ammonium by calcifuge species (see Hewitt 1966; Haynes and Goh 1978; Ruess et al. 1983; Runge 1983). Because different physical–chemical–biological conditions may favor the accumulation of ammonium or nitrate in the soil mineral nitrogen pool, Krajina's work was fundamental to the studies that followed and led to hypotheses examining the temporal and spatial occurrence of these two nitrogen forms and their concomitant utilization. Since nitrogen commonly limits the primary and secondary production of terrestrial ecosystems

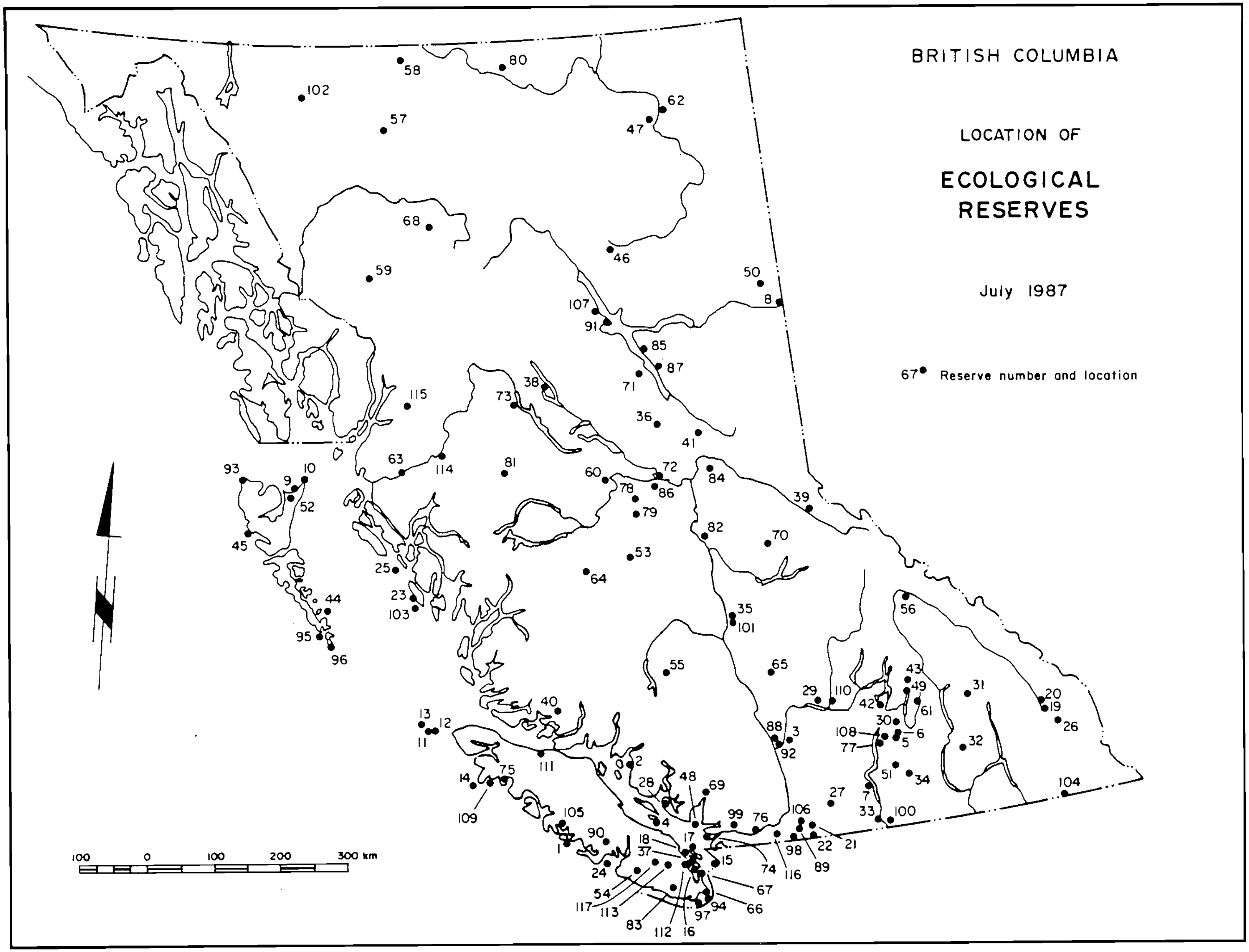

FIG. 1. Map of British Columbia showing the location of ecological reserves (compiled by British Columbia Ministry of Environment and Parks).

TABLE 2. Location and description of British Columbia ecological reserves

Reserve no.	Reserve name	Location	Main feature(s)	Area (ha)
1	Cleland Island	Clayoquot Sound	Seabird colony	7.7
2	East Redonda Island	North end of Georgia Strait	Three biogeoclimatic zones with many habitats	6 212.0
3	Soap Lake	South of Spences Bridge	Alkaline lake with Douglas-fir forest	883.8
4	Lasqueti Island	Georgia Strait	Shoreline forest with Rocky Mountain juniper	200.8
5	Lily Pad Lake	South of Lumby	Undisturbed highland lake	101.2
6	Buck Hills road	South of Lumby	Western larch stand	16.2
7	Trout Creek	South-southwest of Summerland	Ponderosa pine parkland	74.9
8	Clayhurst	South of Clayhurst	Peace River parklands	315.8
9	Tow Hill	Graham Island, Queen Charlotte Islands	Forested sand dunes, swamp, and peat bogs	514.2
10	Rose Spit	Graham Island, Queen Charlotte Islands	Sand dunes and shoreline meadows	170.4
11	Sartine Island	Part of Scott Islands	Seabird colony	13.0
12	Beresford Island	Part of Scott Islands	Seabird colony	7.7
13	Anne Vallee (Triangle Island)	Part of Scott Islands	Largest seabird and sea-lion colonies in province	85.4
14	Solander Island	Off Cape Cook, Vancouver Island	Seabird colony	7.7
15	Saturna Island	Strait of Georgia	Coastal Douglas-fir forest	131.2
16	Mount Tuam	Saltspring Island	Arbutus – Douglas-fir forest	253.8
17	Canoe Islets	Near Valdes Island	Seabird colony	0.6
18	Rose Islets	Trincomali Channel, north of Reid Island	Double-crested cormorant colony	0.8
19	Mount Sabine	North of Canal Flats	Sedge meadow	7.9
20	Columbia Lake	East side of lake	Calcareous vegetation along stream and on a meadow	32.4
21	Skagit River forest	South of Hope	Douglas-fir forest	72.8
22	Ross Lake	South of Hope	Ponderosa pine in coastal Douglas-fir forest	60.7
23	Moore–McKenney–Whitmore Islands	Hecate Strait	Seabird colony	72.9
24	Baerla Rocks	Barkley Sound	Seabird colony and subtidal marine life	52.6
25	Dewdney and Glide islands	Hecate Strait	Variety of maritime bog, pond, and scrub-forest communities	3 844.7
26	Ram Creek	East Kootenays	Hot springs and burnt forest	121.4
27	Whipsaw Creek	Southwest of Princeton	Ponderosa pine stands	32.4
28	Ambrose Lake	Sechelt Peninsula	Coastal bog lake	228.3
29	Tranquille	West of Kamloops	Ponderosa pine and sagebrush plant communities	234.7
30	Vance Creek	North of Lumby	Transitional forest between the Interior Douglas-fir and Interior Western Hemlock zones	48.5
31	Lew Creek	East of Upper Arrow Lake	Three biogeoclimatic zones in one drainage basin	815.0
32	Evans Lake	Valhalla Park, east of New Denver	Subalpine forests including stand of rare yellow cedar	185.4
33	Field's Lease	West of Osoyoos Lake	Semiarid plant communities	4.2
34	Big White Mountain	Big White Mountain	Subalpine and alpine plant communities	951.0
35	Westwick Lake	South of Williams Lake	Shoreline and area surrounding an Interior saline lake	30.0
36	Mackinnon Esker	Northwest of Prince George	Long compound esker, well-developed lichen communities	583.0
37	Mount Maxwell	Saltspring Island	Gary oak stand	65.0
38	Takla Lake	East of Hazelton	Most northerly known occurrence of Douglas-fir	263.0
39	Sunbeam Creek	North of McBride	Engelmann Spruce – Subalpine Fir zone	511.0
40A	Kingcome River	Head of Kingcome Inlet	Rich alluvial swamps and bogs	157.8
40B	Atlatzi River	Head of Kingcome Inlet	Alluvial swamps, bogs, and steep rocky slope	255.8
41	Tacheeda Lakes	North of Prince George	Subboreal Spruce zone in the McGregor Plateau	526.0
42	Mara Meadows	East of Salmon Arm	Unique calcareous fen; rare orchids	189.0
43	Mount Griffin	North of Mabel Lake	Secondary and climax Interior Western Hemlock forests	1 376.0
44	East Copper – Jeffrey – Rankine islands	East coast of Moresby Island	Seabird colony	121.4
45	Vladimir J. Krajina (Port Chanal)	West coast of Graham Island	Virgin littoral environment, lowland Sitka spruce forest, alpine communities, rare mosses, seabird colony	9 834.0

TABLE 2 (*continued*)

Reserve no.	Reserve name	Location	Main feature(s)	Area (ha)
46	Sikanni Chief	Headwaters of Sikanni Chief River	Englemann spruce at northern extremity of range. Subalpine lichens	2 401.0
47	Parker Lake	West of Fort Nelson	Natural bog habitat. Preservation of *Sarracenia purpurea* (pitcher plant)	259.0
48	Bowen Island	West of Apodaca Provincial Park	Forest of Douglas-fir and red cedar. Dry subzone of Western Hemlock zone	397.0
49	Kingfisher Creek	Hunters Range, east-southeast of Sicamous	Representative flora of northern Monashee Mountains	1 441.0
50	Cecil Lake	Northeast of Fort St. John	Sphagnum bog community with black spruce	128.5
51	Browne Lake	North of McCulloch	Marsh and forest, rich in wild flowers	124.0
52	Drizzle Lake	Southeast of Masset	Lake and surroundings; unique species of stickleback	837.0
53	Narcosli Lake	Between Coglistiko and Baezaeko rivers	Protection of waterfowl breeding grounds. Well-developed aquatic communities	1 098.0
54	Nitinat Lake	Vancouver Island, southeast of Bamfield	Steep west coast forest; maritime population of Douglas-fir	79.2
55	Cardiff Mountain	East of Chilko River	Example of lava plateau, basalt columns and crater lake	65.0
56	Goosegrass Creek	West of McNaughton Lake	A cross section of three biogeoclimatic zones, which includes a stand of mountain hemlock	2 185.4
57	Chickens Neck Mountain	North of Dease Lake	Climax stand of white spruce and subalpine fir	608.5
58	Blue–Dease rivers	West of Lower Post	Terrestrial and aquatic communities associated with the Boreal Black and White Spruce zone	777.3
59	Ningunsaw River	Southeast of Bob Quinn Lake	Coastal Western Hemlock zone near its northern limit and associated Engelmann Spruce – Subalpine Fir and Alpine Tundra zones	2 046.1
60	Drywilliam Lake	South of Fraser Lake	To preserve an excellent old-growth stand of Douglas-fir	95.2
61	Upper Shuswap River	East of Mable Lake	Western red cedar in Interior Western Hemlock zone	69.6
62	Fort Nelson River	North of Fort Nelson and Muskwa Rivers	White spruce developing within alluvial stands of black cottonwood	120.6
63	Skeena River	Near confluence of Exchamsiks River	To preserve mature cottonwood on alluvial floodplain	91.1
64	Ilgachuz Range	In vicinity of Far Mountain	Subalpine vegetation of Interior Plateau and Coast Mountains	2 913.8
65	Chasm	North of Clinton	Ponderosa pine near its northern limits	197.3
66	Ten Mile Point	Victoria	Inter- and sub-tidal marine life	11.0
67	Satellite Channel	Between Saltspring Island and Saanich Peninsula	Subtidal marine life	343.3
68	Gladys Lake	Spatsizi Plateau	Stone sheep, mountain goats, and their environment	48 560.0
69	Baynes Island	Squamish River	Alluvial black cottonwood forest on undisturbed island	70.8
70	Mount Tinsdale	East-southeast of Barkerville	Representative communities of Alpine and Subalpine zones	418.6
71	Blackwater Creek	Northwest of Mackenzie	Boreal forest and portion of extensive low moor area	234.0
72	Nechako River	West of Prince George	Good stand of tamarack	132.8
73	Torkelsen Lake	West of Babine Lake	Low moor wetlands with cloudberry	182.2
74	University of British Columbia Endowment Lands	Vancouver	Second-growth forest of Puget Sound Lowlands	89.5
75	Clanninick Creek	Near Kuyquot	Alluvial Sitka spruce	36.8
76	Fraser River	Northwest of Chilliwack	Alluvial forest of cottonwood and willows	75.7

TABLE 2 (*continued*)

Reserve no.	Reserve name	Location	Main feature(s)	Area (ha)
77	Campbell–Brown (Kalamalka Lake)	West side of lake near Rattlesnake Point	Ponderosa pine – bunchgrass site; rattlesnake den	106.8
78	Meridian Road (Vanderhoof)	South of Vanderhoof	Engelmann spruce – subalpine fir – lodgepole pine forest	262.2
79	Chilako River	South of Vanderhoof, north of Batnuni Lake	Tamarack, at its southern limit in British Columbia; swamp, fen, bog ecosystem mosaic	64.4
80	Smith River	Near junction with Liard River	Representative boreal black and white spruce forest	1 326.0
81	Morice River	South of Houston	Burnt subboreal spruce forest	357.5
82	Cinema Bog	North-northeast of Quesnel	Lowland black spruce – sphagnum bog	68.0
83	San Juan Ridge	East of Port Renfrew	Protection of rare white avalanche lily (*Erythronium montanum*)	97.9
84	Aleza Lake	"Big Bend" of Fraser River	Subboreal spruce forest, lakes, and wetland ecosystems	242.4
85	Patsuk Creek	Northeast of Mackenzie	Paper birch and other seral forest	554.0
86	Bednesti Lake	West of Prince George	Kettle Lake wetland succession	139.2
87	Heather Lake	Northwest of Mackenzie	Deciduous forest with aspen	235.0
88	Skwaha Lake	North of Lytton	Subalpine forest and superb flower meadows	850.0
89	Skagit River Cottonwoods	Skagit River Valley	Excellent cottonwood stands reserved for genepool purposes	69.0
90	Sutton Pass	West of Port Alberni	Rare adder's-tongue fern, *Ophioglossum vulgatum*	3.4
91	Raspberry Harbour	Williston Lake, northwest of Finlay Forks	Lodgepole pines with high site indices for use in forest research	143.1
92	Skihist	Northeast of Lytton	Ungrazed ponderosa pine – bunchgrass site	35.9
93	Lepas Bay	Northern Graham Island, Queen Charlotte Islands	Seabird colony on island	3.6
94	Oak Bay Islands	East of Victoria	Spring flowers, a seabird colony, and marine life	170.0
95	Anthony Island	West of Moresby Island, Queen Charlotte Islands	Twenty small islets with nine species of nesting seabirds, and rich marine life	324.0
96	Kerouard Islands	South of Moresby Island, Queen Charlotte Islands	Major sea-lion rookery, seabird colony, and rich marine life	130.0
97	Race Rocks	Metchosin, Vancouver Island	Outstanding marine community including sea-lion haul-out sites	220.0
98	Chilliwack River	United States border, southeast of Chilliwack	Mature alluvial forest with large western red cedars	86.0
99	Pitt Polder	Maple ridge	Two forested hills surrounded by swamp and bog	88.0
100	Hayne's Lease	North end of Osayoos Lake	Representative semiarid land with elements of "pocket desert" vegetation	101.0
101	Doc English Bluff	Southeast of Williams Lake	Limestone cliff with 10 species of rare flowers and ferns, and colony of white-throated swifts	51.8
102	Charlie Cole Creek	South of Teslin; east-southeast of Atlin	Cold-water mineral springs used by ungulates as salt licks	161.9
103	Byers–Conroy–Harvey–Sinnett islands	Hecate Strait	Important seabird and marine mammal breeding areas	12 205.0
104	Gilnockie Creek	East of Kingsgate in East Kootenays	Mature western larch	58.0
105	Megin River	Northeast of Estevan Point, west coast of Vancouver Island	Typical west coast alluvial and upland forests	50.0
106	Skagit River Rhododendrons	Southwest of Hope	Two stands of California rhododendrons, seral forest	70.0
107	Chunamon Creek	Northeast of Germanson Landing, Williston Lake	Two small drainages; Engelmann and white spruce forest	ca. 344.0

TABLE 2 (*concluded*)

Reserve no.	Reserve name	Location	Main feature(s)	Area (ha)
108	Cougar Canyon	South of Vernon on east side of Kalamalka Lake	Mosaic of plant communities including wetlands in an enclosed drainage	ca. 550.0
109	Checleset Bay	Southwest of Kyuquot, Vancouver Island	British Columbia's prime sea-otter population and rare native oyster population	34 650.0
110	McQueen Creek	North of Kamloops	Native grasses and flowers on small hill	35.0
111	Robson Bight	Midway between Port McNeil and Sayward, Vancouver Island	Killer whales and a crucial part of their habitat	1 248.0
112	Mount Tzhuhalem	Duncan, Vancouver Island	Garry oak, spring wild-flower ecosystems	17.5
113	Honeymoon Bay	Cowichan Lake, Vancouver Island	Outstanding population of pink fawn-lily (*Erythronium revolutum*)	7.5
114	Williams Creek	Southeast of Terrace	Representative coastal western hemlock forest and outstanding terraced bogs	700.0
115	Gingietl Creek	30 km upstream of mouth of Nass River	Undisturbed watershed in virgin coastal western hemlock forest	2 873.0
116	Katherine Tye (Vedder Crossing)	5 km southeast of Chilliwack	To conserve the rare phantom orchid, *Euborophyton austinae*	3.08
117	Haley Lake	32 km southwest of Nanaimo	To preserve Vancouver Island marmot	93.0

NOTE: Total area, 154 558 ha.

(and other ecosystems as well), physiological mechanisms for the improvement of nitrogen acquisition and utilization ultimately are important in ecosystem nutrient cycling.

The Pogrebnyak (1930) edaphotopic grid, combining soil moisture and nutrient gradients, provides a valuable tool to illustrate the behavior of both communities and species in their synecological mode (Krajina 1969; see also Giles 1983; Kojima 1984; Kimmins 1987, 1988; Courtin et al. 1988; Kabzems and Klinka 1987*a*, 1987*b*). Triangular grids, based on similar synecological coordinates, have been used effectively by Bakuzis (1959, 1969) in forest management. When backed by physiological studies, such data become indispensable in understanding the ecology of plant species. Krajina's intensive scheme of species autecological characteristics can be useful in the analysis of pattern, neighborhood size, and proximity in the niche concepts proposed by Shugart et al. (1988).

Biogeoclimatic classification, a synthetic approach

On the basis of the ecological philosophy already discussed, Krajina synthesized the attributes of the vegetation of British Columbia into what is generally referred to as the biogeoclimatic (or zonal) classification. Its conceptual framework and its overall place in vegetation schema have been given in Mueller-Dumbois and Ellenberg (1974), Beil et al. (1976), Grandtner and Vaucamps (1982), Kojima (1981), Kimmins (1987, 1988), and Pojar et al. (1987). Phillips (1964) adopted this for teaching biology at the high school and beginning college levels.

Krajina's biogeoclimatic classification combines analytic and synthetic attributes in a rigorous way and combines a number of venerable ecological traditions: the American tradition of community change in a broad phytogeographic sense (Clements 1916), the "state factor" approach (Jenny 1941, 1980; Major 1951), the "southern" European tradition of plant classification (Braun-Blanquet 1932, 1964; Braun-Blanquet and Jenny 1926), the Russian tradition of biogeocoenoses (Sukachev 1945) and of environmental grids (Pogrebnyak 1930, 1955; Vorobyov 1953), and the European micropedological approach (Kubiena 1953, 1958). In my opinion, however, none of these approaches have been used in their nascent form as given by their proponents. The synthesis is vintage Krajina!

As Beil et al. (1976) point out, Krajina's ecological classification uses two levels of integration: (*i*) regional, which organizes ecosystems according to their similarities in their distribution in vegetation-inferred climatic space (biogeoclimatic units), and (*ii*) local, which organizes ecosystems according to similarities in vegetation and site properties (biogeocoenoses, *sensu* Sukachev 1945). The latter begins with units at the smallest possible abstraction level and considers rigorously, in order of importance, species composition, species organization and community structure, the habitat relations ranging from topographic features to the availability of individual nutrients, and influences of microclimate. As these small biogeocoenotic units are grouped hierarchically, the consideration of vegetation development or successional trends and climax become increasingly important. Both at lower as well as at the higher levels of integration, tree, shrub, herb and moss–lichen strata receive thorough attention. Major (1971, p. 541) found the work of Krajina and his students in British Columbia to be "thorough, imaginative, and logical. Site data are more complete than is usual."

Although Krajina and most of his students have utilized the Braun-Blanquet (1932, 1951, 1964) system at the association (or community type) level of abstraction, there is no pervasive reason to believe that other vegetation study methods cannot be used just as effectively. Such effective use of different ecological methodologies was demonstrated in a study by Wali and Krajina (1973) in which the Krajina system was used in combination with the ecological groups of Ellenberg (1956) and gradient analysis of Whittaker (1967). Overall, the elegance of Krajina's method lies in its overwhelming ecological detail, of plant abundance and distribution, of the influence of climatic variables, and of soil, making it most useful for basic ecological studies, ecosystem mapping, and guiding resource management (for forest land management, see Krajina, 1977). This view is shared by Mueller-Dombois and Ellenberg (1974), Beil et al. (1976), Kimmins (1987), Pojar et al. (1987), and Mueller-Dombois (1988). Schofield (1988) found Krajina's work and field observations indispensable in explaining phytogeographic aspects of the bryoflora.

Krajina, the conservationist

Throughout history, but more so in this century, man has significantly altered the complexion of earth's ecosystems, earning for him the title of "mighty geological agent." The drastic disturbances have not been limited to land and inland water systems alone.

Historical references for the conservation of ecosystems are many; some of these works are compelling. However, the reasons for conservation have evolved dramatically and vigorously in recent years. New knowledge gained from diverse ecosystems worldwide has borne directly upon the essentiality of conservation. Efforts at conserving ecosystems until the 1950s were local and regional, at best national. In the last three decades, the efforts of nature conservancies, the International Biological Progam, the International Union for the Conservation of Nature and Natural Systems, the World Wildlife Fund, the UNESCO's Man and the Biosphere Program have done much to raise the consciousness of conservation globally.

The conservation imperative has been the subject of numerous studies. Raven and others (see Tangley 1985) stress that if worldwide destruction of ecosystems continues at its present rate, at least 20% of all of today's species could be gone within 20 years; by some estimates, that represents nearly a million species. The United States Congress recently amended its Foreign Assistance Act of 1961 to help developing countries conserve their genetic resources. Under these amendments, collectively known as the International Environmental Protection Act of 1983, United States government agencies have been instructed to develop comprehensive strategies for conserving biological diversity (Tangley 1985).

But Canadians in general, and British Columbians in particular, can take a great deal of pride in already having the world's most comprehensive ecological reserves program. The British Columbia Ecological Reserves program began as a one-man crusade by Krajina in the 1950s amid accelerated logging operations in his own province. During the debates on ecological reserves, Krajina emphasized time and again, "They [the ecological reserves] serve as genetic banks of paramount importance which accomplish a 'nature museum' function. Distinctive, large, heterogeneous, natural gene pools of different organisms and especially indigenous trees are an irreplaceable resource."

Two historic events in the mid-1960s were to prove indispensable to this early idea: the institution of IBP and the preparations that were being made for the celebration of Canada's centennial in 1967. The Canadian Council of Resource Ministers accepted the guiding principle of IBP's Section on Conservation of Terrestrial Biological Communities in 1965 (for IBP CT Section, see Nicholson 1968). The chairman of that council was British Columbia's Minister of Lands, Forests, and Water Resources, Mr. Ray G. Williston. At that time, 33 land areas, with thorough ecological documentation by Krajina, were being proposed as ecological reserves. On 21 February 1969, Williston declared in the Provincial Legislature, "These land areas represent specific examples of biogeoclimatic zones of the Province. Their reservation will ensure that the present and future requirements of ecologists for biological study will be satisfied for all time."

The British Columbia Ecological Reserves Act was passed in 1971 (see Appendix). "I suspect that this may be the grandest development of its kind on this continent," noted F. E. Egler (personal communication). The legal aspects of the ecological reserve program are discussed in Franson (1975). Today, British Columbia has 117 of them! (Fig. 1; Table 2). The total area of these ecological reserves now stands at 154 558 ha. The largest of them, the Gladys Lake Ecological Reserve in Spatsizi Plateau, covers 48 560 ha. By an order-in-council of the British Columbia Legislature, Ecological Reserve No. 45 at Port Chanal, on the west coast of Graham Island, an area of 9834 ha, was named the Vladimir J. Krajina Reserve. These areas now span alpine and subalpine, coastal rainforest communities, bogs and lakes, and the subtidal zones, even the semiarid land with "pocket desert vegetation." They preserve the habitats of rare and endangered plants, of mighty coastal trees and seabird colonies, stone sheep and mountain goat, wolves, and black and grizzly bears.

What makes them unique is the following legislative mandate. "Ecological Reserves should not be confused with parks or other types of recreational areas, historic or archaeological sites and wildlife management areas. They are areas of Crown land set aside for . . .

- scientific research and educational purposes to study nature in an undisturbed environment;
- benchmarks against which to measure the effects of changes created by man or nature;
- banks of genetic materials;
- preserving rare, unique and endangered native plants or animals in their natural surroundings."

The brochure further notes, "Ecological reserves are needed to unravel and help understand some of the basic ecological processes. As genetic pools they serve the function of a nature museum. As man continues to modify the surface of the earth, some plants and animals can become extinct before they are even known to science. Used as benchmark areas against which to measure changes wrought by man, they can teach us how to soften the impact of man on the environment."

These vignettes were presented to show the rigor of the man, a man incomparably warm and generous, the trials, tribulations, and triumphs of his time, and the justly deserved position of his work among the great names of ecology. A brilliant Roman of the first century A.D., now considered the father of modern hydrology, Sextus Julius Frontinus, wrote, "Remembrance will endure if the life shall have merited it." Krajina's life and work certainly merits such recognition and this symposium attempts in a small way to celebrate his accomplishments.

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Appendix

ECOLOGICAL RESERVE ACT[1]

CHAPTER 101

[*Act administered by the Ministry of Lands, Parks and Housing*]

Interpretation

1. In this act

''disposition'' means and includes every act of the Crown where Crown land, mines, minerals, coal, petroleum, natural gas, timber and water, or any right, title, interest or estate in them is granted, disposed of or affected, or by which the Crown divests itself of or creates a right, title, interest or estate in, or permits the use of land, mines, minerals, coal, petroleum, natural gas, timber and water;
''ecology'' means the study of the interrelations between man, other animals, or plants and their environment;
''ecosystem'' means a complete system composed of man, other animals and plants in a defined area, and with the soil and climate comprising their habitat in that area;
''environment'' means all the external conditions or influences under which man, animals and plants live or are developed;
''habitat'' means that kind of place or situation in which a man, animal or a plant lives;
''minister'' means the Minister of Lands, Parks and Housing.

1971-16-1; 1977-75-3; 1979-20-14.

Purpose

2. The purpose of this Act is to reserve Crown land for ecological purposes, including areas
(a) suitable for scientific research and educational purposes associated with studies in productivity and other aspects of the natural environment;
(b) that are representative examples of natural ecosystems within the Province;
(c) that serve as examples of ecosystems that have been modified by man and offer an opportunity to study the recovery of the natural ecosystem from modification;
(d) where rare or endangered native plants and animals in their natural habitat may be preserved; and
(e) that contain unique and rare examples of botanical, zoological or geological phenomena.

1971-16-2.

Lieutenant Governor to establish reserves

3. The Lieutenant Governor in Council may, by notice signed by the minister and published in the Gazette, establish ecological reserves of Crown land.

1971-16-3.

Lieutenant Governor may cancel or amend reserves

4. The Lieutenant Governor in Council may, by notice signed by the minister and published in the Gazette, add to, cancel in its entirety or delete any portion of an ecological reserve established under section 3.

1971-16-4.

Ecological reserves not available for disposition

5. After April 2, 1971, any area established as an ecological reserve under this Act shall be immediately withdrawn and reserved from any further disposition that might otherwise be granted under any Act or law in force in the Province including, without limiting the generality of the foregoing, dispositions under the *Land Act*, *Forest Act*, *Range Act*, *Water Act*, *Mineral Act*, *Mining* (*Placer*) *Act*, *Coal Act*, *Petroleum and Natural Gas Act*, *Mining Right of Way Act*.

1971-16-5; 1977-75-13; 1978-23-66; 1978-34-52; 1978-36-51.

Nature conservancy as ecological reserve

6. A nature conservancy or any portion of it, now or hereafter designated as such under the *Park Act* may, notwithstanding that Act, be established as an ecological reserve under this Act.

1971-16-6.

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Regulations

7. The Lieutenant Governor in Council may make regulations and orders and, without limiting the generality of the foregoing, may make regulations

(a) for the control, restriction or prohibition of any use, development or occupation of the land or any of the natural resources in an ecological reserve;

(b) for the control, restriction or prohibition of exercise of powers granted by any other Act or regulation by a minister, ministry of the government, or agent of the Crown specified in the regulations;

(c) for the control, restriction or prohibition of the dumping, deposit or emission within an ecological reserve of any substance; and

(d) generally for any other matter or thing necessary or incidental to the protection of an ecological reserve.

1971-16-7; 1977-75-1.

Administration

8. Land established as an ecological reserve under this Act, subject to the regulations and orders made under this Act, shall be under the jurisdiction of and administered by the minister.

1971-16-8.

Advisers

9. The minister may appoint a person or persons to advise him on any matter relating to the establishment and administration of ecological reserves, and a person appointed under this section shall have the duties specified by the minister and shall be subject to the regulations made under this Act.

1971-16-9; 1983-10-21, effective October 26, 1983 (B.C. Reg. 393/83).

Other Acts

10. This Act, and any regulation or order made under this Act, applies to every ecological reserve, notwithstanding any other Act or regulation.

1971-16-10.

ECOLOGICAL RESERVE REGULATIONS

1. No person shall enter upon an ecological reserve for a purpose inconsistent with the *Ecological Reserve Act*, and without limiting the generality of the foregoing, no person shall prospect for minerals, cut timber, allow domesticated animals to graze, camp, light fires, trap or molest animals, build roads or trails, use motorized vehicles within an ecological reserve, or remove plants, animals or material from an ecological reserve.

2. Research or educational use of an ecological reserve may be undertaken only when authorized by permit issued pursuant to these regulations.

3. The administrator of ecological reserves may, by permit, authorize the use of an ecological reserve for research or educational purposes. The administrator shall include in each permit issued under this section conditions that, in his opinion, are adequate to protect the reserve and any ongoing research from disruption; provided however that minimally disruptive procedures, such as collection of some plant and animal specimens, soil samples, and the like, may be specifically permitted.

4. The administrator may not issue a permit authorizing research or educational use of a reserve that is likely to cause any significant disruption within the reserve without first consulting the advisory committee. After he has consulted with the advisory committee, the administrator may issue a permet authorizing such research and containing such conditions as he deems advisable for the protection of the reserve and any ongoing research.

5. An application for a permit under sections 2 and 3 shall contain the following information:

(a) a description of the proposed use;

(b) a description of the areas of land to be affected, with an accompanying map;

(c) a description of the means of access to be used;

(d) the duration of the proposed use;

(e) the ecological impact of any activities that will be undertaken within the reserve under the permit;

(f) the number of individuals that will be entering the reserve under the permit and, where possible, their names;

(g) the name of the individual who will direct the proposed research or educational programme.

6. Permits issued under sections 3 and 4 may be limited to one entry or may cover a specified period of time.

7. The minister may, by order, close any reserve or portion thereof to any or all uses or entry for a specified period of time, and the minister may, by order, permit limited camping, hunting, fishing and use of motorized vehicles in any reserve or portion thereof, providing no significant disruption results to the reserve or to any research which may be in progress.

8. No person shall introduce into an ecological reserve any plant or animal species without the written permission of the administrator.

9. Subject to the terms of a permit, no person shall deposit, discharge or emit sewage, waste materials, contaminants or any other substance within the boundaries of an ecological reserve.

10. Upon completion of any research project authorized under section 3 or 4, the permittee shall, within 6 months, file a report with the administrator including, if applicable:

(a) a statement of the methodology used in the research;
(b) an inventory of any plants or animals identified during the research;
(c) a description of land forms and soil conditions in the research area; and
(d) a statement of the results obtained and any conclusions or recommendations reached as a result of the research.

11. (1) The administrator may, by order, cancel or modify any permit where he considers such action advisable because

(a) a conflict has arisen between users;
(b) the activities authorized by the permit may cause, or have caused, unauthorized or unanticipated damage to the reserve;
(c) a beneficial use is not being, or has not been, made of the permit;
(d) the terms or conditions of the permit have been broken, or these regulations have been violated by the permittee or his agents.

(2) The administrator is not required to conduct a hearing before issuing an order under subsection (1).

(3) The permittee may appeal any order issued by the administrator under subsection (1) to the minister by notifying the minister and the administrator of his intention to appeal within 30 days of having received the administrator's order.

[Provisions of the *Ecological Reserve Act* relevant to the enactment of this regulation: section 7]

B.C. Reg. 335/75
O.C. 1456/75 Filed April 28, 1975