Invited presentation for the
Centennial of the University of British Columbia 2015
History of 100 years of the Department of Botany, 2016

The Legacy of **Vladimir J. Krajina** and Contributions to UBC Botany

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For what is the present after all but a growth out of the past?
— *Walt Whitman,* Passage to India *1869*

One of the lasting and most hopeful legacies of the 20th century has been the establishment of many educational institutions of higher learning, slowly and in small numbers in the technology-advanced world in the first half of the century, vigorously so in the second half in both advanced and advancing countries of the world. In 1915, one of these welcome developments was the founding of our *alma mater*, the University of British Columbia (UBC). From its Department of Botany, we both graduated, only a few years apart. We also take much pride in this (2015) the centennial year of our primary professional society—ESA, the Ecological Society of America (Egerton 2015).

Centennials of collective human enterprises such as academic disciplinary departments are historic, for they impact generations through educating and preparing students for careers in teaching, research and public service. During their development, these academic units have shared the paths of natural ecosystem development and become increasingly complex and diverse with the passage of time. Like natural ecosystems, they are initiated on "bare areas" or "gaps", are inhabited first by a few pioneers, then by new impact-producing individuals capable of gathering mass, increasing niche differentiation, and partitioning resources.

On its way to maturity, the Department of Botany has passed through these ecological developmental changes in its 100-year history. In late 1960s, the first author had the privilege of being a student there under the mentorship of Professor Vladimir Joseph Krajina (VJK) and, in early 1970s, the second author under plant systematist, Professor Katherine I. Beamish, and as a field assistant to VJK for two summers.

Here, on the occasion of UBC Centennial, we pay a respectful tribute to VJK. It is in two parts: the first, covering his life, work, and times, contains material from the 1985 symposium on Community Organization and Ecosystem Conservation commemorating his 80th birthday (Wali 1988). That paper provides insights into VJK's contributions and legacy, his early scientific career in Europe and how it blossomed in later years in North America, his teaching career and the tutelage of an impressive number of students, and the establishment of Ecological Reserves.

The second part of the tribute, which follows below, provides a brief narrative of VJK's arrival at UBC and his stature in European ecology, and concentrates on two aspects: the biogeoclimatic classification of the entire province of British Columbia, and the establishment of Ecological Reserves there. On both aspects, work continued after VJK's retirement and death. The classification of vegetation has recently been found indispensable in environmental management by the Ecological Society of America in developing the U.S. National Vegetation Classification (elaborated below); the establishment of ecological reserves is still without an encore from any country.

Plant Ecology emerges at UBC

The precepts and principles of the science of ecology today owe their development in very large measure to the contributions made in the last century. These studies will continue to be fundamental to both theoretical developments and practical applications. Few would have imagined in 1900 that a hundred years later it would be said that "Ecology is the most comprehensive and diverse of the sciences. Its scope is enormous, and it may be the most important science for managing the earth as an abode for humanity and for what is left of our natural environment" (Egerton 2001).

Here, we show how by an accident of history, plant ecology took hold at UBC. Hence, we review the contributions of VJK (UBC Botany-Ecology-Forestry Professor), in their ecological-conceptual framework, and for their significance to applied ecology. He enriched immensely the science of ecology, the Department of Botany, and the Province of British Columbia. As a researcher and teacher, he left a lasting legacy through his studies and by his mentorship of many students, and in bringing to reality the unique establishment of ecological reserves with legal standing in British Columbia.

VJK has been called a Second World War hero. This dimension of his life has appropriately received much attention, so we refer interested readers to some available works,[3] including VJK's memoirs.[4] As the proverbial dust from the horrors of that war in which many millions had lost their lives was settling, many more millions were unsettled and searching for refuge and a new home. Among the latter group was this formidable central European botanist and ecologist who arrived in British Columbia in 1949. He was well known in Europe but mostly unknown in North America. Not in possession of enough academic documents—not even the 2-part, 407-page reprint from the well-known journal *Botanisches Centralblatt* (Krajina 1933)—that would testify to his academic credentials, he began his career at UBC as a Lecturer.[4] From there, he rose with few handicaps to full professorship. Thus it was by a twist of fate that VJK arrived in British Columbia and proceeded to lay a strong foundation of plant ecology at UBC.

He was an extremely knowledgeable and talented botanist and, in his caliber and rigor, matched by few. He handled with authority and remarkable ease taxa from lichens and mosses to gymnosperms and angiosperms, from temperate to tropical regions. In the *terra nova* of British Columbia, he would explore the new ecosystems, discover and record, analyze and synthesize new plant communities for the next 40+ years. With firm footing in science, he confidently, and with conviction and courage, used this knowledge to suggest ecosystem management policies to decision-makers. His life and times coincided with major advances in the conceptual and empirical development of ecology, and he with his intellect, knowledge and hard work became a distinguished contributor to both.

When he began his career, the importance of ecology as a discipline of science had not been fully realized as it is now. Ecologists began with studies of community structure, organization and community classification. Later, these were combined with functional processes of energy and material transfers, ecosystem production, and evolutionary development, amassing descriptive material that has provided a forum for much elegant theory. It is now increasingly recognized that such data, concepts, and theories form the very core of decision- making in current environmental problems at local, regional, continental, and global levels. VJK always emphasized that ecological phenomena can and must be understood by thoroughly examining the fundamental processes underlying ecosystem structure and function.

As noted earlier, his contributions and stature among ecologists were provided earlier as part of his 80th birthday celebration (Wali 1988; http://www.nrcresearchpress.com/doi/pdf/10.1139/b88-356). Here we concentrate on two aspects: the biogeoclimatic classification of the entire province of British Columbia, and the establishment of Ecological Reserves there. On the first, classification of vegetation communities, VJK championed its need as well as utility at the 1959 Symposium on *Forest Types and Forest Ecosystems* as part of the IX International Botanical Congress in Montreal (Krajina 1960*a*,*b*). We have also added some narrative on his legacy as teacher and updated the list of his graduate Students at UBC.

Now more than 50 years later, the Ecological Society of America in concert with several national and international agencies states that "classifications provide a systematic way of describing and assessing ecological diversity. . . . They address the need for subnational, national and international classification standards for ecosystems, while allowing for classification at a scale fine enough to be used to understand, manage, and protect natural resources on a local or site-by-site basis. The standards can be applied to define ecosystems anywhere in the world; but the emphasis of the classifications are for types that occur in North, Central and South America" (see http://explorer.natureserve.org/classeco.htm#usvegclassification accessed 28 August 2015). [5]
We provide further elaboration of recent classification at the end of next section.

On the second−the ecological reserves, given widespread concern for world environment generally and in North America particularly, the needs for both the maintenance of biological diversity and conservation have been voiced relentlessly over the past many decades. Thus, VJK's success in the establishment of ecological reserves in British Columbia is still unmatched from any country in the world.

Krajina's Biogeoclimatic Classification, a synthetic approach

With over 40 years of untiring work, VJK synthesized attributes of the climate, vegetation, and soils 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 are explained in Mueller-Dombois and Ellenberg (1974), Beil et al. (1976), Grandtner and Vancamps (1982), Kojima (1981), Kimmins (1987, 1988), and Pojar et al. (1987). Phillips (1964) adopted VJK's approach, for teaching biology at the high school and beginning college levels.

VJK's biogeoclimatic classification combines analytic and synthetic attributes in a rigorous way and blends four 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, 1951, 1964; Braun-Blanquet and Jenny1926), the Russian traditions of biogeocoenoses (Sukachev 1945; Sukachev and Dylis 1964) and of environmental grids (Pogrebnyak 1930, 1955; Vorobyov 1953), and the European micropedological approach (Kubiena 1953, 1958). The synthesis is vintage Krajina!

Krajina's classification, noted Beil et al. (1976), organizes ecosystems (i) according to their similarities in occupation of vegetation-inferred climatic space (biogeoclimatic units), and (ii) according to their similarities in vegetation and site properties (biogeocoenoses, *sensu* Sukachev 1945). Analysis begins with the smallest abstract units and considers, in order of importance, species composition (with tree, shrub, herb and bryophyte-lichen strata receiving thorough attention), species organization and community structure, habitat factors ranging from topographic features to the availability of individual nutrients, and influences of microclimate. As these small biogeocoenotic units are grouped hierarchically, consideration of vegetation development or successional trends and climax become increasingly important. 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."

With his wide-ranging and in-depth knowledge of climate-habitat-plant relationships, VJK questioned why a species that he expected at a site was not there and, equally, why a species occurred that he did not expect to be there. Such interrogation of the site was traditionally practiced by the classical grandmasters of ecology; Becking (1963) narrates a similar story about the German ecologist, Reinhold Tűxen.

VJK metaphorically sat very comfortably on a chair with four sturdy legs, one each from the systems of Braun-Blanquet, Clements, Sukachev and Jenny, and his own solid seat and chair-back. As an illustration of his reach in ecology, here is the opening paragraph of one of his papers: "Ecology of forest trees in British Columbia should encompass all climatic, orographic (physiographic), edaphic and biotic conditions under which these trees grow. The limiting conditions for their growth can be found experimentally. However, such experiments could be very costly, time consuming and frequently incomplete, . . . [and] could not include all factors. Synecological studies, carried out directly in the natural environment, offer a much more satisfactory and complete method for the assessment of ecological functions of plants ... for which the taxon at a specific level is adapted ..." (Krajina 1969, p.1). Comprehensive!

He was, thus, confident in creating a classification of the terrestrial ecosystems of British Columbia. In fact, both for conceptual and practical knowledge, he declared at the IX International Botanical Congress that "there can be no science without classification" (Krajina 1960*a*). VJK started classifying as soon as he arrived in the Province in 1949 and began studying its ecology and plant life. Along with his many graduate students (Table 2 below) over the ensuing nearly 30 years, he developed a biogeoclimatic framework for classification and mapping of forested and non-forested ecosystems of British Columbia, adapting European traditions of geobotany, phytosociology, autecology, and soil science.

Overall , the elegance of Krajina's method lies in its ecological detail—of plant abundance and distribution, of the influence of climatic variables, and of soil, making it very 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), Mueller-Dombois (1988), Meidinger et al. (2005), and Haeussler (2011). Schofield (1988) found Krajina's work and field observations indispensable in explaining phytogeographical aspects of the bryoflora.

His integrated system was taken up by the British Columbia Forest Service in the 1970s and, in expanded and somewhat modified form, underlies much of present-day forest land management in B.C. The classification was extended and amplified after 1975 by the Ecology Program of the B.C. Forest Service. There it continued to receive a strong earth sciences emphasis; thus it is not merely a classification of vegetation but rather of entire ecosystems. Adoption of VJK's work by the Forest Service initially was championed by two of his former students, Karel Klinka and Richard M. Annas. By the early 1980s, additional ecologists and soil scientists were engaged in what came to be known as Biogeoclimatic Ecosystem Classification (BEC) in all six forest regions (Pojar et al. 1987; Meidinger and Pojar 1991; MacKinnon et al. 1992; Klinka et al. 1996; Meidinger et al. 2005).

The BEC plot database currently exceeds 40,000 ecological plots (relevés). Forest ecosystems of virtually the entire province have now been classified. MacKenzie and Moran (2004) produced a provincial wetland classification. BEC continues to be revised and updated as new data are collected. Some of the lightly sampled gaps gradually being filled include non-forested ecosystems (e.g., grasslands, alplands), remote forested areas with little forest harvesting (e.g., northwestern part of the province), and young seral ecosystems (see BECWeb: https://www.for.gov.bc.ca/hre/**becweb/**).

Principles and philosophy of BEC

Ecosystem and biogeocoenose — *Ecosystem* is the term used for the sum total of vegetation, animals, and physical environment in whatever size segment of the world is chosen for study (Fosberg 1967). Ecosystems are interacting complexes of living organisms (plants, fungi, bacteria, animals) and the physical environment (soil, air, water, bedrock) immediately affecting them. Tansley's (1935) broad concept of ecosystem is not easily integrated into a formal classification. For practical purposes, Krajina (1960*b*) proposed that Sukachev's *biogeocoenose* be adopted because he thought it best represented a basic ecosystem. A biogeocoenose is a special case of the ecosystem, but we use the two terms interchangeably here.

Myriad organisms including fungi, bacteria, insects and other invertebrates, birds, and mammals are as much a part of a forest ecosystem as are trees, shrubs, herbs, and mosses. For simplicity, however, the BEC system deals primarily with two components of the ecosystem: vegetation and soil. BEC follows the state factor model of ecosystem function (Major 1951; Amundsen and Jenny 1997): vegetation and soils are products of climate, organisms (including humans), topography, parent material, and time. Vegetation and soil, considered simultaneously, integrate all ecosystem components and reflect ecosystem functioning.

Climate — Climate is the most important determinant of the nature of terrestrial ecosystems. In the BEC system, climate refers to the *regional climate* (Major 1951, 1963) that influences ecosystems over an extended period of time. Because climatic data are inadequate or lacking in many areas and climatic analysis alone will not produce a practical ecosystem classification, BEC classifies climate indirectly, using the concept of zonal (or climatic climax) ecosystems.

Zonal (climatic climax) ecosystem — The *zonal ecosystem* is that which best reflects the mesoclimate or regional climate of an area. The integrated influence of climate on the vegetation, soil, and other ecosystem components is most strongly expressed in those ecosystems least influenced by local relief or by physical and chemical properties of soil parent materials. In British Columbia, zonal ecosystems typically occur on moderate midslopes with moderately deep, medium-textured, freely drained soils. Because zonal ecosystems reflect the regional climate that dominates their development, they are used to characterize and delineate biogeoclimatic units, which represent broad geographical areas of similar climate.

Succession and climax — The process of change called *ecological succession* is the progressive development of ecosystems through time. The BEC system follows the so-called traditional concept (Drury and Nisbet 1973; Perry 1994; Kimmins 1997) of succession. Successional sequences are called *seres*. In theory, succession ends in a mature, climax ecosystem.

The term *climax* in ecology and as we interpret it, refers to a condition of dynamic equilibrium, not a static endpoint. "Climax" is useful shorthand for the "shifting mosaic-steady state" of Bormann and Likens (1979). Certainly in BC, especially in humid regions, many old forests dominated by gap dynamics existed until recently in a shifting mosaic-steady state, with little evidence of change at the landscape scale for hundreds and even thousands of years (Mathewes 1989; Lertzman et al. 1996; Gavin et al. 1997).

Many forest ecosystems in BC have escaped large-scale catastrophic destruction by fire, wind, and other agents (Parminter 1998). Many other areas of BC are dominated by ecosystems that have not attained climax and probably never will. In such areas, the classification was developed primarily with maturing seral stands (usually 70 years and older).

Ecological equivalence — Similar vegetation can occur over a range of sites because of compensating environmental effects. Moreover, several different plant communities can occur on the same site, depending on disturbance, chance, and time. To address the issues of environmental compensation and temporal variations in vegetation, ecosystems can be ordered according to the principle of biological (Cajander 1926) or ecological (Bakuzis 1969) equivalence. This principle, the basis of site classification in the BEC system, holds that sites with the same or equivalent physical properties have the same vegetation potential.

Classification System

Levels of integration — BEC in its current form is a hierarchical classification scheme with three levels of integration: regional, local, and chronological. BEC also combines four classifications: climatic (or zonal), vegetation, site, and seral. At the regional level, vegetation/soil relationships are used to infer regional climates; the resultant climatic or zonal classification defines biogeoclimatic units. At the local level, ecosystems are classified into vegetation and site units, based on vegetation and soils. At the chronological level, ecosystems are organized along chrono-sequences, according to site history and successional status.

Vegetation classification — Vegetation units are determined as per Braun-Blanquet by aggregating plot data and analyzing the floristic similarity of the resultant units in a series of vegetation tables. The outcome of tabular analysis is a hierarchy in which the plant class is the most generalized unit. Classes are divided into plant orders, orders into plant alliances, alliances into plant associations, and associations into plant subassociations. The *plant association* is the basic unit of the vegetation classification.

Vegetation units are differentiated by *diagnostic combinations of species* (see Pojar et al. 1987 and Meidinger et al. 2005 for details). The vegetation classification is key to developing both the zonal (climatic) and the site classification. Plant associations and subassociations help define biogeoclimatic subzones and variants (Climatic classification), and site associations (Site classification).

Zonal (climatic) classification — The biogeoclimatic classification provides the "regional" level of ecological integration. Biogeoclimatic units result from zonal (climatic) classification and represent groups of ecosystems under the influence of the same regional climate. The *biogeoclimatic subzone*, characterized by a distinct climax (or late seral) plant association on zonal sites, is the basic unit of the zonal hierarchy. Subzones are grouped into zones, regions, and formations, and divided into variants or phases.

BEC groups subzones with affinities in climatic characteristics and zonal ecosystems into zones. A *biogeoclimatic zone* is a large geographic area with a broadly homogeneous macroclimate. A zone has characteristic webs of energy flow and nutrient cycling and typical patterns of vegetation and soil. BEC characterizes zones with a distinct zonal plant order. Zones also have characteristic, prevailing soil-forming processes, and one or more typical, major, climax species of tree, shrub, herb, and/or moss. BEC currently recognizes 16 biogeoclimatic zones in British Columbia (Fig. 1).

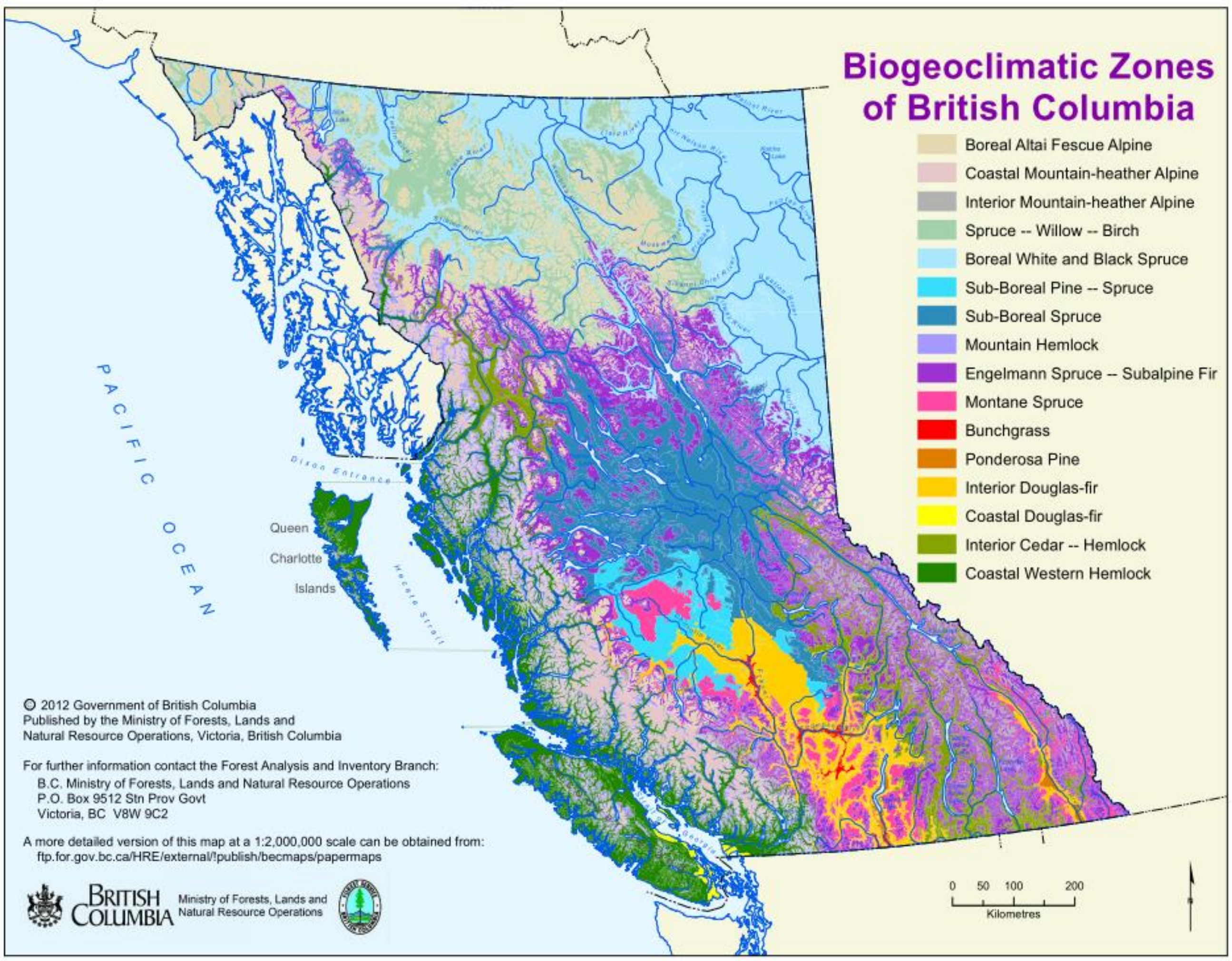

Figure 1. Biogeoclimatic zones of British Columbia. Based upon additional work by B.C. provincial government scientists, this map has five additional biogeoclimatic zones and some

name changes to V. J. Krajina's original vegetation map of 1973. (Courtesy B.C. Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC, Canada.)

Site classification — Site units provide the "local" level of ecological integration. Site units represent groups of sites or ecosystems that, regardless of current vegetation, have the same (or equivalent) environmental properties and potential vegetation.

The potential vegetation of a group of sites provides the initial delimitation of site associations, the basic unit of site classification. A *site association* consists of all ecosystems capable of producing vegetation belonging to the same plant association (or subassociation, in some cases) at the climax or mature stage of succession. Thus, a site association is a group of related ecosystems physically and biologically similar enough that they have, or would have, similar mature vegetation. The site association is equivalent to the habitat type of Daubenmire (1968) and western US Forest Service ecologists (e.g., Cooper et al. 1991) and conceptually similar to the forest type of several European classifications (see Jahn 1982).

A site association can contain ecosystems from several different climates and so be variable in actual site conditions. Partitioning the association into site series according to subzones and variants produces site units that are climatically, and therefore usually edaphically, more uniform, and more predictable in their response to management. *Site series*, then, are subdivisions of site associations and include all sites, within a biogeoclimatic subzone or variant, capable of producing the same mature or climax vegetation (plant association). Site series are described and interpreted in Regional Field Guides (e.g., Lloyd et al. 1990; Green and Klinka 1994; Steen and Coupé 1997; Banner et al. 2014—all accessible via BECWeb: https://www.for.gov.bc.ca/hre/**becweb**/).

Seral (successional) classification — Seral (often termed successional) classification in BEC incorporates structural stage development into the site and vegetation classifications. Seral units provide the "chronological" level of ecological integration.

Applications

The very broad vision and scope of British Columbia`s BEC program springs not only from VJK`s inspirational legacy and vigorous disciples, it is also a response to the province's very diverse landscapes, strong regional climatic gradients, and complex local site variations. Over the past nearly 40 years BEC has provided an ecological framework for forest management in BC. Indeed the province became regarded as a leader in ecologically based management in North America. "When forestry and land management practices in the province faced significant challenges or conflicts because of changes in public expectations or new international conventions and standards, the BEC system has repeatedly provided a rational scientific framework for tackling the problem" (Haeussler 2011; see Table 1). Unfortunately since about 2000, government and industry recidivism in B.C. has eroded many of the resource management advances of the preceding 25 years (Parfitt 2010; Auditor General 2012, 2013; Cooperman 2012; Bunnell 2013).

From the beginning, BEC has provided a tool for determining suitable tree species for regenerating logged-over areas. Subsequently BEC has become institutionalized in many aspects of the management of forests and other resources in British Columbia.

The broad biogeoclimatic (zonal) units have been used for such applications as:

- Forest planning; land management and protected areas planning
- Seed zones
- Forest pest (insects and diseases) risk

- Natural disturbance types
- Wildlife habitat management

The more detailed site units are suitable for site-specific management interpretations. Some common interpretations for each site series include:

- Most suitable tree species for regeneration
- Guidelines for site preparation and stand-tending
- Stocking, stock type, and 'free-to-grow' standards for tree species
- Vegetation competition after harvesting
- Wildlife interpretations
- Tree and forest productivity (site index by tree species; stand growth and yield)

In recent decades, BEC was incorporated into the Forest Practices Code in such guidebooks as Establishment to Free Growing, Landscape Unit Planning, Silviculture and Stand Management Prescriptions, Biodiversity Guidelines, and Identified Wildlife Strategy.

BEC is also used in range management, environmental assessment and monitoring, and conservation of at-risk ecosystems. The system has many other applications, including the provincial Protected Areas Strategy and (more recently) development of climate change scenarios and strategies (Table 1).

Challenges

The notion of climax ecosystems in equilibrium with climate and local environmental conditions does not conform to current mainstream thinking in ecology (Haeussler 2011). It is also at odds with the realities of rapid environmental change (climate change, land uses, landscape industrialization, habitat fragmentation, invasive species).[6]

Most BEC-knowledgeable professionals in government, academia, and the private sector have now retired and/or their positions have disappeared through organizational restructuring. The replacement generation of ecologists and pedologists is small, with limited opportunities to be mentored and to acquire the field experience needed to understand, apply and train others in the use of BEC, and to continue to refine and adapt the system.

Few contemporary North American ecologists are aware of BEC and its conceptual precursors, much less their intellectual richness and contemporary significance; few comprehend the significance of the dying of the field ecology light (but see Noss 1996; Middendorf and Pohlad 2014; Tewksbury et al. 2014); few understand how these structured knowledge systems can enhance science and applied ecology (Haeussler 2011).

Table 1. Application of biogeoclimatic ecosystem classification (BEC) to environmental and resource management issues in British Columbia (modified from Haeussler 2011).

Issue	**Example References**
BC contribution to International Biological Programme (IBP) survey of conservation sites (1964 – 1974)	Krajina 1974
Ecological reserves selection and establishment	Krajina 1973; Krajina et al. 1978
Tree species selection and stocking standards for reforestation	Klinka et al. 1984; Silviculture Interpretations Working Group 1993
Tree seed zones and transfer guidelines	O'Neil et al. 2008; BC Ministry of Forests, Lands and Natural Resource Operations 2012
Slashburning guidelines	Klinka et al. 1984
Silvicultural techniques for backlog reforestation	Coates et al. 1987
Wildlife habitat mapping	Banner et al. 1985
Old-growth forest management	BC Ministry of Forests 1992; LePage and Banner 2014
Protected areas strategy	Province of British Columbia 1993
Biodiversity management guidelines	Parminter 1995
Biodiversity monitoring (ecological communities at risk)	Conservation Data Centre 2015
Forest productivity and site index assessment	Mah and Nigh 2003
Sustainable forest management: planning criteria and indicators	FSC Canada 2005
Forest and rangeland monitoring (Forest and Range Practices Act)	BC Ministry of Forests and Range 2008
Terrestrial ecosystem mapping	Banner et al. 1996
Environmental assessment process for major project development	Hilton et al. 2013
First Nations land claims; reconciling traditional ecological knowledge and use with "western" science and management	Daly 2005
Inventory and monitoring of non-timber forest resources	Keefer et al. 2008; Kranabetter et al. 2009
Climate change: assessment and monitoring of impacts	Hamann and Wang 2006; Eddington et al. 2009; Wang et al. 2012
Climate change: adaptation strategy	Holt et al. 2012; Haeussler & Hamilton 2012

Ecological Society of America's U.S. National Vegetation Classification System

In 1994, ESA constituted a "Panel on Vegetation Classification to . . . support and facilitate the creation of standardized, scientifically credible North American vegetation classification", granting it a Standing Committee status in 2009. In April 1999, the Panel formalized a Memorandum of Understanding with The Nature Conservancy/NatureServe and the U.S. Geological Survey, on behalf of the National Biological Information Infrastructure and the U.S. Federal Geographic Data Committee, for the purpose of forming a partnership to develop, implement, and maintain the National Vegetation Classification (NVC)" (see http://esa.org/vegweb2/ accessed 28 August 2015). To provide a common methodology for NVC, Peet et al. (1998) proposed "A flexible, multipurpose method for recording vegetation composition and structure".

Jennings et al. (2009) in their opening paragraph clearly articulate the pressing need for and application of the U.S. National Vegetation Classification:

"Vegetation documentation and classification are central to biological conservation from planning and inventory to direct resource management. They are also important to basic scientific research as a tool for organizing and interpreting ecological information and placing ecological research in an appropriate biophysical context. All of these activities require that plant assemblages be defined within a consistent typological framework and that their distribution on the landscape be known and understood. Vegetation documentation and classification contribute considerably to the basic understanding of ecological patterns and to the analysis of problems that vary in scale from the persistence of tiny populations of rare species to global projections of human impacts on the biosphere."

The above, together with other recent and enthusiastic writings of ecologists and environmental scientists (see for some examples, Faber-Langendoen et al. 2009, 2014, Franklin et al. 2012, 2015.)—the developments of the U.S. National Vegetation Classification and the contributions to it by other national and international agencies would have delighted VJK. A member of the Ecological Society of America for 43 years (Wali 1994), he, like us, would have rejoiced at the Society's centennial.

Krajina's legacy as teacher

The larger portion of VJK's teaching career spanning over 21 years was at UBC. He had started teaching plant taxonomy and ecology at Charles University in Prague shortly after receiving his doctorate there. At UBC, he taught a senior undergraduate course, *Forest Ecology*. As the reputation of his prowess as a first-rate ecologist gained ground on campus, this course was sought after by forestry majors; this despite his European views of forest management — especially clearcutting versus selective harvesting or partial cutting — the latter was much opposed by Canadian and U.S. forest industry.

At the graduate level, he taught two 2-semester long courses, in alternating years, titled *Plant Autecology*, and *Plant Synecology*. He was a vintage old-world style teacher who spoke without notes, cited a vast array of examples drawn from many places in the world, nearly all from first-hand experience, and accompanied by color slides on most of them. Given the Vancouver weather especially in the winter semester, the 3-hour lecture once a week from 7-10 a.m., would test any graduate student's allegiance and commitment to ecology!

As mentor guiding graduate student research, he was matchless. This is borne out by his legacy of students who completed their Ph.D. (25) and M.S. (9) work successfully (Table 2). All one had to do was to have the privilege of going on a field trip with him and be spellbound. No matter what the taxa, lichens, mosses, ferns or trees, he knew them all and could tell authoritatively, why each was growing in a particular place. His unique gift of knowledge was equally well known to his faculty colleagues as it was to students.

Table 2. Students who completed graduate degrees under the direction of Professor Vladimir 1. Krajina at the University of British Columbia[1]

Year	Student	Title of dissertation/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
	Frank F. Tusco[2]	A study of variability in certain Douglas-Fir populations in 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 Or1oci	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 low land 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[3]	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	I. 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	1. 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 Orloci	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 Totino area

[1]This list is only from Professor Krajina's tenure at UBC; he also guided graduate student research at Charles University in Prague (1928-1948), and intermittently at the University of Hawaii.
[2]Mentored jointly with Professor G. E. Rouse, and [3]Professor P. J. Haddock.

Krajina, the champion of biological diversity and conservation

Throughout history, but more so in this century, humans have significantly altered earth's ecosystems, earning them the title of mighty geological agent. The drastic disturbances have not been limited to land and inland water systems alone. The conservation imperative has been emphasized as never before in the latter half of the 20th century. But even in 1930s and 1940s, Arthur Tansley worked hard and wrote "largely" (Anker 2001) the 1943 Draft Report and 1944 Report on Nature Conservation and Nature Reserves for the Committee of the British Ecological Society (see *Journal of Ecology* 1948).

Likewise, Julian Huxley not only helped in the British efforts for conservation and nature reserves but had also begun to work on similar programs in East Africa, which he then continued as the first Director General of UNESCO. He provided an enviably-stated blueprint for management and conservation when he wrote of natural African habitats: "The ethic of conservation has two fundamental commandments -- Thou shalt maintain energy flow; and Thou shalt not sacrifice the eternal or the continuing to the temporary or the expedient" (Huxley 1961). These commandments are true principles of applied ecology for all regions of the world.

The reasons for conservation evolved dramatically and vigorously in the last century based on new knowledge gained from diverse ecosystems worldwide. "Ecosystems worldwide are rapidly losing taxonomic, phylogenetic, genetic, and functional diversity as a result of human appropriation of natural resources, modification of habitats and climate, and the spread of pathogenic, exotic and domestic plants and animals" (Naeem et al. 2012). Despite their yeoman efforts, Tansley and Huxley did not succeed as well as VJK did. With equal capability and fierce dedication like the former, changed times and a different setting assured the success of the latter.[7]

Notable organizations with a global reach include the United Nations Educational Scientific and Cultural Organization (UNESCO), World Conservation Strategy of the International Union of the Conservation and Natural Systems (IUCN), the World Wildlife Fund (WWF), and the United Nations Environment Programme (UNEP). Both in the United States and Canada, numerous organizations are doing excellent work on conservation; the designated governmental portfolios, of course, have the regulatory authority.

Although VJK worked mostly outside of the North American academic establishment, he anticipated modern trends in forest management and conservation biology, and used his considerable political skills and large personality to influence the government of British Columbia. He taught undergraduate forestry students about the importance of understanding whole ecosystems/biogeocoenoses, sharply criticized industrial forest practices, and urged the Province to base forest management on ecological principles and ecologically defined management units (Haeussler 2011). He also lobbied the provincial government to establish a representative system of legally protected ecological reserves.

Canadians in general, and British Columbians in particular, can take a great deal of pride in having the world's most comprehensive ecological reserves program. The British Columbia Ecological Reserves program began as a one-man crusade by VJK in the 1950s amid accelerated logging operations in his home province. During the debates on the reserve concept, he 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. "I suspect that this may be the grandest development of its kind on this continent," noted F. E. Egler (personal communication- MKW). The legal aspects of the ecological reserve program are discussed in Franson (1975). Today, British Columbia has 148 of them! (Fig. 2; for details see http://ecoreserves.bc.ca/). The total area (including marine) of these ecological reserves now stands at 160,456 ha. The largest of these, the Gladys Lake Ecological Reserve in Spatsizi Plateau, covers 44,098 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 9,834 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's sheep and mountain goat, wolves, and black and grizzly bears. The total area of protected lands (Federal and Provincial) in British Columbia is currently about 13,600,000 ha or roughly 14% of the province.

What makes ecological reserves 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." Ecological reserves are legally protected areas of Crown (public) land where human interference with natural processes is supposed to be kept to a minimum. The major purposes of ecoreserves are:

- scientific research and educational use
- establishment of representative "benchmark" areas against which to measure the effects of change in natural and managed ecosystems
- protection and maintenance of genetic resources and biological diversity
- protection of rare and endangered organisms in their natural habitat
- preservation of unique, rare, or outstanding natural phenomena.

The B. C. government 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 humans, they can teach us how to soften the impacts on the environment."

Legacy of Krajina and the Outlook ahead

"Ecology would be easy," noted a recent editorial in *Nature* (2014) "were it not for all the ecosystems – vastly complex and variable as they are. . . . History, chance, climate, geology, and – increasingly – human fiddling mean that no two ecosystems work in the same way." Many ecosystems have been destroyed completely, others have fragmented, and all receive inputs from many industrial activities. "Two insidious changes, one visible and the other invisible have taken place over the last many decades at an unprecedented pace and are likely to continue in the foreseeable future. The visible change of land use is the number one environmental problem of the world. The second is invisible, the cumulative changes in the chemistry and temperature of the atmosphere. Much is now known from path-breaking and vigorous studies in many fields about the causes and consequences of all of these environmental changes but the human response is woefully small given the extent and magnitude of the problems. To connect all proverbial dots among environmental insults substantively, the economic-scientific-social sectors need both the open minds and the will of decision makers to bring about policy changes" (Wali 2014).

In leaving his 'footprints on the sands of time', Professor Krajina left behind a rich body of work, a group of well-trained students, a comprehensive scientific-ecological methodology, and Ecological Reserves ─ permanent areas for research with firm provincial governmental mandate and regulation. The Friends of Ecological Reserves make a most appreciative contribution in presenting a comprehensive web site showing VJK's landmark efforts.[9]

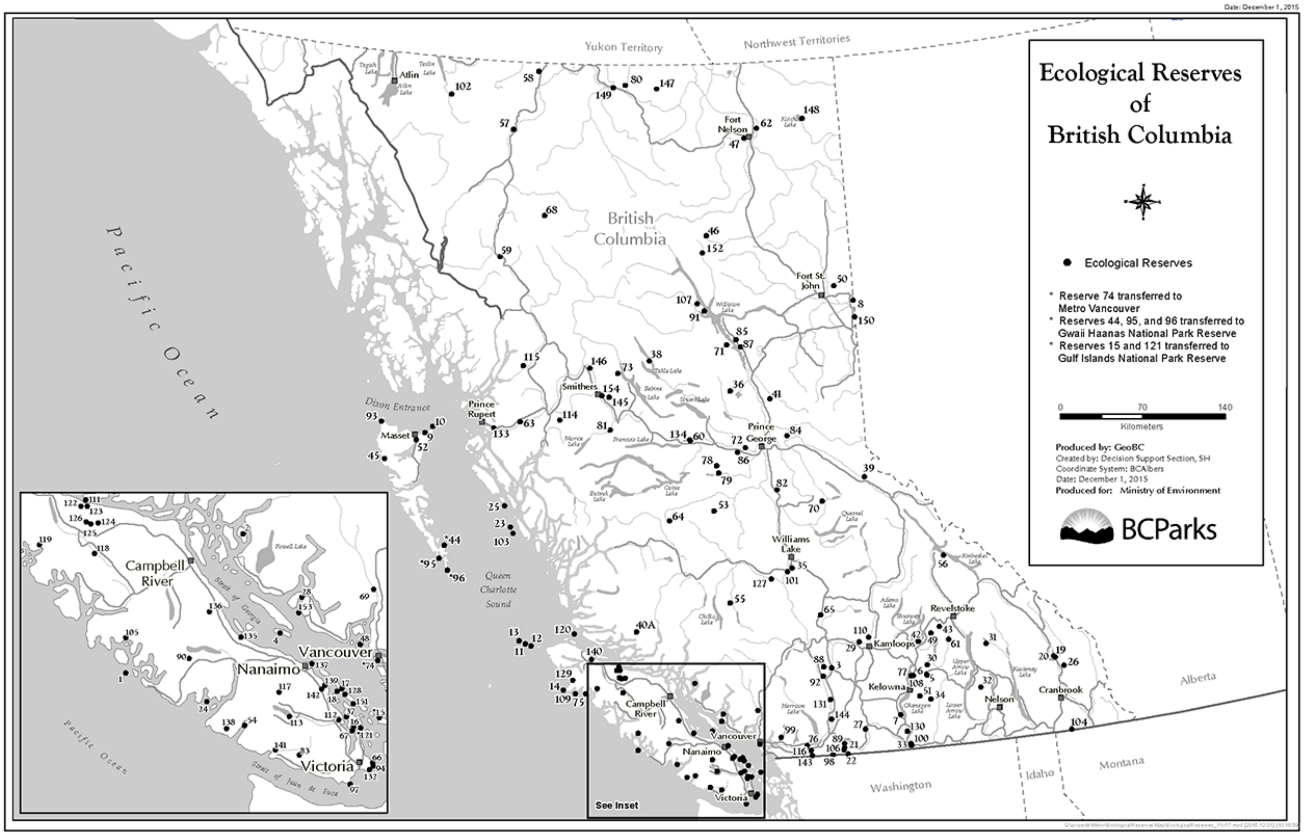

Figure 2. Ecological Reserves in British Columbia, December 2015 (courtesy of K. Morrison, BC Parks Victoria, BC, Canada).

Our personal gratitude

Unrelenting as a scientist and scholar, VJK was a kind, polite, courtly and urbane gentleman, very gracious but with a steely core. He had a delightful sense of humor and liked to tease his students occasionally, when he detected weaknesses in their performance. Equally, he did not conceal his outrage at the environmental insults that were being inflicted on nature. He was a proud man; always welcoming, never forbidding. VJK was an old-fashioned scholar, fond of Greek and Latin and Latinate constructions. He mistrusted the use of random sampling in terrestrial plant ecology: "Ecologists should be able to see and read the plant life." See what, where and how and, then, ask why? He was an excellent mentor who inspired fierce loyalty among his graduate students.

We congratulate our *alma mater* UBC and our home Department of Botany on the centennial. We wish both another 100 years of honor and prestige!

Figure 3. Vladimir J. Krajina Ecological Reserve, seaward over Port Chanal, Haida Gwaii (Queen Charlotte Islands). Photo by W. MacKenzie (reproduced with permission).

Figure 4. Vladimir J. Krajina Ecological Reserve, looking southwest. Photo by W. MacKenzie (reproduced with permission).

Figure 5. Nechako River Ecological Reserve. VJK in 1972, explaining the difference between *Betula pumila* and *B. glandulosa*. Photo by Jim Pojar.

Notes

1. Professor Emeritus and former Director, School of Environment and Natural Resources, The Ohio State University, Columbus, OH 43210-1085, USA
2. Semi-retired, Smithers, British Columbia, Canada; formerly Assistant Coordinator, British Columbia Ecological Reserves Programme (1975-1978); Forest Ecologist, British Columbia Forest Service (1978-2003); Executive Director, Yukon Chapter of Canadian Parks & Wilderness Society (2004-2007)
3. VJK was a major figure in the Allied effort during the Second World War; these aspects of his political life have been much heralded appropriately. We shall not dwell on them and refer the reader to the numerous newspaper articles (especially in the *Vancouver Sun*), and to books notably by Korbel (1959), Krajina (1994), and Drabek (2012).
4. On VJK's memoirs (Krajina 1994): here is what his daughter, Milena Janda, had to say: "The name [title of the memoirs] was not father's choice, but Professor Dolezal's who took father's 4600-page memoir and made it into the 238-page book. Father's memoirs were more in the nature of a scientific thesis. Mother and I cut it down to 720 pages, but it still needed editing." (Personal communication - MKW)
5. http://explorer.natureserve.org/classeco.htm#usvegclassification "Developed by NatureServe and its natural heritage member programs in collaboration with federal, international, academic and state partners, these classifications provide a systematic way of describing and assessing ecological diversity. They address the need for subnational, national and international classification standards for ecosystems, while allowing for classification at a scale fine enough to be used to understand, manage, and protect natural resources on a local or site-by-site basis. The standards can be applied to define ecosystems anywhere in the world; but the emphasis of the classifications are (*sic*) for types that occur in North, Central and South America.".
6. We note, however, that the concept of dynamic equilibrium was until very recently applicable to large areas of B.C., especially in wetter regional climates—unlike most of North America east of the Rockies.

Climatic climax (we dare utter the phrase) forests and other ecosystems most definitely occurred, and there **are** still big chunks of intact wildlands in the province.

7. The thinking of Arthur G. Tansley, H. G. Wells and Julian S. Huxley and others on ecological conservation in Peder Anker (2001) Chapter 6 Planning a New Human Ecology is recommended reading
8. Three ecological reserves were transferred to Gwaii Haanas National Park, two to Gulf Islands National Park, one to Pacific Spirit Regional Park (Metro Vancouver).
9. The formation of a non-profit organization, Friends of Ecological Reserves (http://ecoreserves.bc.ca/), is a most welcome organization. The following preamble is from its homepage:
   "The Friends of Ecological Reserves (FER) is a volunteer based, not-for-profit charitable organization. We promote the interests of the ecological reserves program in British Columbia, Canada, by raising public awareness of the ecological reserve program and by raising funds that are used to: Support researchers in and around ecological reserves. Support wardens and the warden function within ecological reserves. Prepare and circulate a regular newsletter. Educate the public regarding the important features of ecological reserves, including plant and animal conservation, within BC. "

On page 1 above, the photograph of Professor Krajina in a light-hearted mood was taken on the occasion of his 80th birthday celebration and symposium held in his honor at the University of Western Ontario in London on 27 June 1985. The symposium, "Community Organization and Ecosystem Conservation: A Contemporary Synthesis" was held as part of the joint first meeting of Canadian Congress of Biology and the Annual Meeting of Canadian Botanical Association. Papers from the symposium are in the *Canadian Journal of Botany*, Volume 66, Number 12, pages 2603-2692. Photo by M. K. Wali.

Literature Cited

Amundsen, R. and H. Jenny. 1997. On a state factor model of ecosystems. *BioScience* 47: 536-543.

Anker, P. 2001. *Imperial Ecology: Environmental Order in the British Empire 1895-1945*. Harvard University Press, Cambridge, MA, USA.

Auditor General. 2012. *An Audit of the Ministry of Forests, Lands and Natural Resource Operations' Management of Timber.* Report 11, British Columbia Office of the Auditor General, Victoria, BC. http://www.bcauditor.com

Auditor General. 2013. *An Audit of Biodiversity in B.C.: Assessing the Effectiveness of Key Tools.* Report 10, British Columbia Office of the Auditor General, Victoria, BC. http://www.bcauditor.com

Bakuzis, E. V.1969. Forestry viewed in an ecosystem perspective. Pages 189-258 in *The Ecosystem Concept in Natural Resource Management* edited by G. M. Van Dyne. Academic Press, New York, NY.

Banner, A., J. Pojar, R. Trowbridge, and A. Hamilton. 1985. Grizzly bear habitat in the Kimsquit River valley, coastal British Columbia: classification, description and mapping. Pages 36-49 in *Proceedings, Grizzly Bear Habitat Symposium,* Missoula, MO, 30 April–2 May 1985. Compiled by G.P. Contreras and K.E. Evans. USDA Forest Service General Technical Report INT-207.

Banner, A., D. V. Meidinger, E. C. Lea, R. E. Maxwell, and B. C. von Sacken. 1996. Ecosystem mapping methods for British Columbia. *Environmental Monitoring and Assessment* 39: 97-117.

Banner, A., W.H. MacKenzie, J. Pojar, A. MacKinnon, S.C. Saunders, and H. Klassen. 2014. *A field guide to ecosystem classification and identification for Haida Gwaii.* Land Management Handbook Number 68. BC Ministry of Forests Lands & Natural Resource Operations, Victoria, BC. 258 p.

B.C. Ministry of Forests. 1992. Old growth strategy for British Columbia. Victoria, BC. 74 p.

B.C. Ministry of Forests and Range. 2008. Tree species composition and diversity in British Columbia. Forest Practices Branch, Forest and Range Evaluation Program, Victoria, BC, FREP Report 14. 65 p.

B.C. Ministry of Forests, Lands and Natural Resource Operations. 2012. *Climate change adaptation: Transitioning to a climate-based (forest tree) genetic resource conservation and management system in British Columbia.* Victoria, BC. 16 p.

Becking, R. W. 1969. A tribute to Reinhold Tüxen. *Vegetatio* 18: 1-3.

Beil, C.E., R.L. Taylor, and G.A. Guppy. 1976. The biogeoclimatic zones of British Columbia. *Davidsonia* 7: 45-55.

Bormann, F.H. and G. E. Likens. 1979. Catastrophic disturbance and the steady state in northern hardwood forests. *American Scientist* 67: 660-669.

Braun-Blanquet, J. 1932. *Plant Sociology*. McGraw-Hill Book Co., New York. (English translation of *Pflanzensoziologie: Grundzüge der Vegetationskunde* by G. D. Fuller and H. S. Conard.).

Braun-Blanquet, J. 1951. *Pflanzensoziologie: Grundzüge der Vegetationskunde*. Second edition. Springer-Verlag, Vienna, Austria.

Braun-Blanquet, J. 1964. *Pflanzensoziologie: Grundzüge der Vegetationskunde*. Third edition. Springer-Verlag, Vienna, Austria.

Braun-Blanquet, J., and H. Jenny. 1926. Vegetations-Entwicklung und Bodenbildung in der Alpinen Stufe der Zentralalpen (Klimax- gebiet der Caricion curvu lae). Mit besonderer Beriicksichtigung der Verhiiltnisse im Schweizerischen Nationalparkgebiet. Natur- forsch. *Ges. Denkschr.* 63: 181-349.

Bunnell, F. 2013. Social license in British Columbia: Some implications for energy development. *BC Journal of Ecosystems and Management* 14: 1–16. http://jem.forrex.org/index.php/jem/article/viewFile/550/492

Cajander, A.K. 1926. The theory of forest types. *Acta Forestalia Fennica* 2(3):11-108.

Clements, F. E. 1916. *Plant Succession: An Analysis of the Development of Vegetation*. Carnegie Institution of Washington Publication 242, Washington, DC.

Coates, D., S. Haeussler, A. MacKinnon, L.Bedford, and J. Maxwell. 1987. *A guide to the use of mechanical site preparation equipment in north central British Columbia.* Second edition. BC Ministry of Forests and Forestry Canada, FRDA Handbook 002. 64 p.

Conservation Data Centre. 2015. Website of the British Columbia Conservation Data Centre, Victoria, BC. http://www.env.gov.bc.ca/cdc/ecology/index.html

Cooper, S.V., Neiman, K.E., Steele, R., and Roberts, D.W. 1991 Forest habitat types of northern Idaho: A second approximation. Revised ed. USDA Forest Service, Intermountain Forest and Range Experiment, Station, General Technical Report, INT-236, Ogden, Utah. 143 p.

Cooperman, J. 2012. BC Forest Mismanagement. *Watershed Sentinel* 22.

Daly, R. 2005. *Our box was full: An ethnography for the Delgamuukw Plaintiffs.* UBC Press, Vancouver, BC. 352 p.

Daubenmire, R. 1968. *Plant communities.* Harper and Row, New York, NY.

Drabek, J. 2012. *Vladimir Krajina—World War II Hero and Ecology Pioneer*. Ronsdale Press, Vancouver, BC, Canada.

Drury, W.H. and I.C.T. Nisbet. 1973. Succession. *J. Arnold Arboretum* 54: 331-368.

Ecological Reserves Program. 1992. *Guide to ecological reserves in British Columbia.* Planning and Conservation Services, BC Parks, Victoria, BC.

Eddington, M.M., Innes, J.L., McHugh, A.E., and Smith, A.C. 2009. Monitoring forest and rangeland species and ecological processes to anticipate and respond to climate change in British Columbia. BC Ministry of Forests and Range, Forest Practices Branch, Forest and Range Evaluation Program, Victoria, BC. FREP Report 20. 41 p.

Egerton, F.N. 2001. A history of the ecological sciences: early Greek origins. *Bulletin of the Ecological Society of America* 82: 93-97.

Egerton, F. N. 2015. *A Centennial History of the Ecological Society of America*. CRC Press – Taylor &Francis, Boca Raton, FL, USA: 222-244.

Faber-Langendoen, D., R. H. Crawford, and D. Tart. 2009. Contours of the revised U.S. National Vegetation Classification standard. *Bulletin of the Ecological Society of America* 90: 87-93.

Faber-Langendoen, D., T. Keeler-Wolf, D. Meidinger, D. Tart, B. Hoagland, C. Josse, G. Navarro, S. Ponomarenko, J-P. Saucier, A. Weakley, and P. Comer. 2014. EcoVeg: a new approach to vegetation description and classification. *Ecological Monographs* 84: 533–561.

Fosberg, F.R. 1967. A classification of vegetation for general purposes. Pages 73-133 *in* G.F. Peterken, editor, *Guide to the Check Sheet for IBP Areas.* IBP Handbook No. 4. Blackwell Scientific Publications, Oxford and Edinburgh.

Franklin S., D. Faber-Langendoen, M. Jennings, T. Keeler-Wolf, O. Loucks, R. Peet, S. D. Robert, W. Mckerro. 2012. Building the United States National vegetation Classification system. *Annalidi Botanica* 2: 1–9.

Franklin, S. and ESA Vegetation Classification Panel. 2015. How a national vegetation classification can help ecological research and management. *Frontiers in Ecology and the Environment* 13: 185-186.

Franson, R. T. 1975. *The legal aspects of ecological reserve creation and management in Canada.* International Union for Conservation of Nature and Natural Resources. Environmental Policy Law Paper 9: 1-108.

FSC Canada. 2005. Forest Stewardship Council regional certification standards for British Columbia, Main Standards. Forest Stewardship Council Canada, Toronto, Ont. http://www.fsccanada.org/docs/48B4F585905BF469.pdf

Gavin, D.G., K.P. Lertzman, L.B. Brubaker, and E. Nelson. 1997. Holocene fire size and frequency in a coastal temperate rainforest. *Bulletin Ecol Society of America* 78: 93.

Grandtner, M. M., and F. Vancamps. 1982. Vegetation science and forestry in Canada. Pages 15-45 in *Application of vegetation science to forestry,* edited by G. Jahn. Dr. W. Junk Publishers, The Hague.

Green, R.N. and K. Klinka. 1994. *A field guide to site identification and interpretation for the Vancouver Forest Region.* BC Ministry of Forests, Land Management Handb. No. 28. Victoria, BC.

Haeussler, S. 2011. Rethinking biogeoclimatic ecosystem classification for a changing world. *Environmental Review*19: 254–277.

Haeussler, S. and E. H. Hamilton. 2012. *Informing Adaptation of British Columbia's Forest and Range Management Framework to Anticipated Effects of Climate Change: A Synthesis of Research and Policy Recommendations.* Report for BC Future Forest Ecosystem Scientific Council (FFESC). Victoria, BC. 44 p.

Hamann, A. and T. Wang. 2006. Potential effects of climate change on ecosystem and tree species distribution in British Columbia. *Ecology* 87: 2773–2786.

Hilton, S., L. Andrusiak, R. Krichbaum, L. Simpson, and C. Björk. 2013. Part 1. *Vegetation and Ecological Communities. Terrestrial Vegetation and Wildlife Report.* Site C Project. Report to BC Hydro, Vancouver, BC. http://www.ceaa-acee.gc.ca/050/documents_staticpost/63919/85328/Vol2_Appendix_R-1-Vegetation.pdf

Holt, R.F., G. Utzig, H. Pinnell and C. Pearce. 2012. *Vulnerability, Resilience and Climate Change: Adaptation Potential for Ecosystems and Their Management in the West Kootenay.* Final Report for FFESC Project B8, West Kootenay Resilience, Nelson BC. http://www.for.gov.bc.ca/HFP/future_forests/council/

Huxley, J. 1961. *The Conservation of Wildlife and Natural Habitats in Central and East Africa.* United Nations Educational, Scientific and Cultural Organization, Paris, France.

Jahn, G. , editor. 1982. *Application of vegetation science to forestry.* The Hague.

Jennings, M. D., D. Faber-Langendoen, O. L. Loucks, R. K. Peet, and D. Roberts. 2009. Standards for associations and alliances of the U.S. National Vegetation Classification. *Ecological Monographs* 79: 173-199.

Jenny, H. 1941. *Factors of Soil Formation.* McGraw-Hill Book Co., New York.

Jenny, H. 1980. *The Soil Resource - Origin and Behavior*. Springer-Verlag, New York.

Keefer, M.E., T. Ehlers, and N. Macpherson. 2008. *A regional profile of commercial harvesting of non-timber forest products in the Cascade Forest District, British Columbia.* Contract report prepared for Centre for Non-Timber Forest Resources, Royal Roads University, Victoria, B.C. 36 p.

Kimmins, J. P. 1987. *Forest ecology.* Macmillan Publishing Co., New York.

Kimmins, J. P. 1988. Community organization: methods of study and prediction of the productivity and the yield of forest ecosystems. *Canadian Journal of Botany* 66: 2654-2672.

Kimmins, J.P. 1997. *Forest Ecology: A Foundation for Sustainable Management.* 2nd edition. Prentice Hall, New Jersey, NJ.

Klinka, K., R.N. Green, P.J. Courtin, and F.C. Nuszdorfer. 1984. *Site diagnosis, tree species selection, and slashburning guidelines for the Vancouver Forest Region.* BC Ministry of Forests, Land Management Report No. 25. Victoria, BC.

Klinka, K., H. Qian, J. Pojar, and D.V. Meidinger. 1996. Classification of natural forest communities of coastal British Columbia, Canada. *Vegetatio* 125: 149-168.

Kojima, S. 1981. Biogeoclimatic ecosystem classification and its practical use in forestry. Journal College of Liberal Arts, Toyama University14: 41-75.

Korbel, J. 1959. *The Communist Subversion of Czechoslovakia 1938-1948.* Princeton University Press, Princeton, NJ.

Krajina, V.J. 1933. Die Pflanzengesellschaften des Mlynica-tales in den Vysoke Tatry (Hohe Tatra). Mit besonderer Beriicksichtigung der őkologischen Verhiiltnisse. Beihefte zum Botanischen Zentralblatt, Abt. 2, 50: 774 -957; 51: 1 -224.

Krajina, V. J. 1960*a*. Can we find a common platform for the different schools of forest type classification? *Silva Fennica* 105: 50 -55.

Krajina, V. J. l960*b*. Ecosystem classification of forests (Summary of contributions to the Forest Ecosystem Symposium). *Silva Fennica* 105: 107 -110.

Krajina, V. J. 1969. Ecology of forest trees in British Columbia. *Ecology of Western North America* 2(1): 1-147.

Krajina, V.J. 1973. The conservation of natural ecosystems in British Columbia. *Syesis* 6: 17–31.

Krajina, V.J. 1974. *Ecological reserves in British Columbia.* Canadian Committee for the International Biological Programme, Region 1, British Columbia. 185 p.

Krajina, V. J. 1977. On the need of an ecosystem approach to forest land management. Pages i-ii In *Ecological classification of forest land in Canada and Northwestern U.S.A.*, edited by G.A. Drew and J.P. Kimmins. Centre for Continuing Education, University of British Columbia, Vancouver, B.C.

Krajina, V.J., J.B. Foster, J. Pojar, and T. Carson. 1978. *Ecological reserves in British Columbia.* Ecological Reserves Unit, BC Ministry of Environment, Victoria, BC. 269 p.

Krajina, V. J. 1994. *Vyoská hra Vzpomínky*. [“A Risky Game – Remembrances”.] Nakladatelstvi Eva, Prague, Czech Republic.

Kranabetter, J.M., Williams, H., and Morin, J. 2009. Ecological descriptions of Pacific golden chanterelle (*Cantharellus formosus*) habitat and estimates of its extent in Haida Gwaii. *BC Journal of Ecosystems and Management* 10: 59 – 67.

Kubiena, W. L. 1953. *The Soils of Europe.* Thomas Murby and Co., London.

Kubiena, W. L. 1958. Classification of soils. *Journal of Soil Science* 9: 9-19.

LePage, P., and A. Banner. 2014. Long-term recovery of forest structure and composition after harvesting in the coastal temperate rainforests of northern British Columbia *Forest Ecology and Management* 318: 250–260.

Lertzman, K.P., G.D. Sutherland, A. Inselberg, and S.C. Saunders. 1996. Canopy gaps and the landscape mosaic in a coastal temperate rain forest. *Ecology* 77: 1254-1270.

Lloyd, D., K. Angove, G. Hope, and C. Thompson. 1990. *A guide for site identification and interpretation of the Kamloops Forest Region.* Volume 2. BC Ministry of Forests, Land Management Handbook No. 23. Victoria, BC.

MacKenzie, W.H. and J.R. Moran. 2004. *Wetlands of British Columbia: a guide to identification.* Land Management Handbook No. 52. Research Branch, B.C. Ministry of Forests, Victoria, B.C.

MacKinnon, A., D. Meidinger and K. Klinka. 1992. Use of the biogeoclimatic ecosystem classification system in British Columbia. *Forestry Chronicle* 68: 100-120.

Mah, S. and G. Nigh. 2003. *SIBEC site index estimates in support of forest management in British Columbia.* BC Ministry of Forests, Forest Science Program Technical Report 004, Victoria, BC. http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/research/sibec

Major, J. 1951. A functional, factorial approach to plant ecology. *Ecology* 32: 392-412.

Major, J. 1963. A climatic index to vascular plant activity. *Ecology* 44: 485-498.

Major, J. 1971. Vegetation of British Columbia [a review]. *Ecology* 52: 540-541.

Mathewes, R. 1989. Paleobotany of the Queen Charlotte Islands. Pages 75–90 *in* G. G. E. Scudder and N. Gessler, editors, *The Outer Shores.* Queen Charlotte Islands Museum Press, Skidegate, B.C.

Meidinger, D. and J. Pojar, editors. 1991. *Ecosystems of British Columbia*. B.C. Ministry of Forests Special Report Series 6, Victoria, B.C., Canada. (See especially Chapter 2. Concepts by J. Pojar, D. Meidinger and K. Klinka, pp. 10-37).

Meidinger, D., J. Pojar, and S. Mah. 2005. Biogeoclimatic ecosystem classification. Pages 47-119 in *Forestry Handbook for British Columbia.* S.B. Watts and L. Tolland, editors. Faculty of Forestry, University of British Columbia, Vancouver, BC, Canada.

Middendorf, G. and B. R. Pohlad. 2014. Ecoliteracy for ecology and ecologists: eroded underpinnings. *Frontiers in Ecology and Environment* 12: 194-195.

Mueller-Dombois, D. 1988. Community organization and ecosystem theory. *Canadian Journal of Botany* 66: 2620-2625.

Mueller-Dombois, D. and H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. John Wiley and Sons, New York.

Naeem, S., J.E. Duffy, and E. Zavaleta. 2012. The functions of biological diversity in an age of extinction. *Science* 336: 1401-1406.

Nature. 2014. Editorial—An elegant chaos. *Nature* 507: 139-140.

Nicholson, E. M. 1968. *Handbook to the Conservation Section of the International Biological Programme.* International Biological Programme Handbook No. 5. Blackwell Scientific Publications, Oxford.

Noss, R.F. 1996. The naturalists are dying off. *Conservation Biology* 10: 1-3.

O'Neill, G.A., N.K. Ukrainetz, M.R. Carlson, C.V. Cartwright, B.C. Jaquish, J.N. King, J. Krakowski, J.H. Russell, M.U. Stoehr, C. Xie, and A.D. Yanchuk. 2008. *Assisted migration to address climate change in British Columbia: recommendations for interim seed transfer standards.* B.C. Min. For. Range, Res. Br., Victoria, B.C. Tech. Rep. 048. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr048.htm

Parfitt, B. 2010. *Axed: A decade of cuts to BC's Forest Service.* Sierra Club of Canada and Canadian Centre for Policy Alternatives. Victoria, BC. 15 p.

Parminter, J. 1998. Natural disturbance ecology. Pages 1-41 *in* Voller, J. and S. Harrison (eds.). *Conservation Biology Principles for Forested Landscapes.* University of British Columbia Press, Vancouver, BC.

Parminter, J. (co-author & co-editor). 1995. *Biodiversity guidebook – Forest Practices Code of British Columbia.* BC Ministry of Forests and BC Environment, Victoria, BC. 99 p.

Peet, R.K., T.R. Wentworth and P.S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. *Castanea* 63: 262-274.

Perry, D.A. 1994. *Forest Ecosystems.* The Johns Hopkins University Press, Baltimore, MD.

Phillips, E. A. 1964. *Field Biology: A Laboratory Block.* D. C. Heath and Co., Boston, MA.

Pogrebnyak, P. S. 1930. Uber die Methodik der Standortsuntersuchungen in Verbindung mit den Waldtypen. Pages 455-471 *in* Proceedings of the International Union of Forestry, Experimental Station, Stockholm, 1929.

Pogrebnyak, P. S. 1955. *Foundations of forest typology.* Acad. Sci. Ukr. SSR, Kiew (In Russian).

Pojar, J., K. Klinka, and D. V. Meidinger. 1987. Biogeoclimatic ecosystem classification in British Columbia. *Forest Ecology and Management* 22: 119-154.

Province of British Columbia. 1993. *A protected areas strategy for British Columbia*. BC Land Use Coordination Office, Victoria, BC. 38 p.

Schofield, W. B. 1988. Bryogeography and the bryophytic characterization of biogeoclimatic zones of British Columbia, Canada. *Canadian Journal of Botany* 66: 2673-2686.

Silviculture Interpretations Working Group. 1993. *Correlated guidelines for tree species selection (1st approximation) and stocking standards (2nd approximation) for the ecosystems of British Columbia.* BC Ministry of Forests and Forestry Canada, Victoria, B.C. 328 p.

Steen, O. and R. Coupé. 1997. *A field guide to forest site identification and interpretation for the Cariboo Forest Region.* 2 parts. BC Ministry of Forests Land Management Handbook No. 39. Victoria, BC.

Sukachev, V. N. 1945. Biogeocoenology and phytocoenology. *C.R. Acad. Sci. URSS* 47: 429-431 (In Russian).

Sukachev, V. N., and N. Dylis. 1964. *Fundamentals of Forest Biogeocoenology.* Translated from the Russian *Osnovi lesnoi biogeotsenologii* by J. M. MacLennan. Oliver & Boyd, London, UK.

Tansley, A. G. 1935. The use and abuse of vegetational terms and concepts. *Ecology* 16: 284–307.

Tewksbury, J.J., J.G.T. Anderson, J.D. Bakker, T.J. Billo, P.W. Dunwiddie, M.J. Groom, S.E. Hampton, S.G. Herman, D.J. Levey, N.J. Machnicki, C.Martínez Del Rio, M.E. Power, K.Rowell, A.K. Salomon, L. Stacey, .S.C. Trombulak, and T.A. Wheeler. 2014. Natural history's place in science and society. *BioScience* 64: 300-310.

Vorobyov, D. V. 1953. Forest types of the European part of the USSR. *Acad. Sci. Ukr. SSR, Kiew* (In Russian).

Wali, M. K. 1988. Reflections on the life, work, and times of Vladimir Joseph Krajina. *Canadian Journal of Botany* 66: 2605-2619.

Wali, M. K. 1994. Resolution of Respect – Vladimir Joseph Krajina (1905-1993): A tribute. *Bulletin of the Ecological Society of America* 75(4): 194-195.

Wali, M. K. 2014. Climate: the prime invisible driver of global change. *Landscape Ecology* 29: 359-360.

Wang, T., E.M. Campbell, G.A. O'Neill, S.N. Aitken. 2012. Projecting future distributions of ecosystem climate niches: Uncertainties and management applications. *Forest Ecology and Management* 279: 128–140.