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The struggle with biodiversity conservation

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ABSTRACT

Biodiversity conservation in the area of environment^ management has become the new buzzword of this decade. Widely used but little understood, it continues to cause confusion and misgivings. It is expected that new legislation and policies will soon be in place requiring biodiversity conservation to be addressed in Environmental Impact Assessments and land use development projects. This paper describes a first attempt to develop an objective method to qualify and quantify biodiversity for the Line Creek coal properties and leases in the Elk Valley of B.C. Corresponding baseline data are provided through Line Creek's comprehensive biophysical inventories, complemented through additional fieldwork in 1994. The overall objective was to facilitate comparison of ecological entities in terms of biodiversity. Based on a vegetation map of 1 : 20 000, the Map Units identified as "macro-habitats" were rated via a Biodiversity Index developed for this purpose. Key elements of the biodiversity index are flora and fauna as living ecosystem components. To do justice to specific habitat requirements of live organisms, six component indices were assessed. The sum of the component indices provides the overall value of the Biodiversity Index with the assumption that attached values are additive. The numerical rating of component indices with an overall numerical value of the Biodiversity Index permits a relatively objective comparison habitat types. This method is far from being perfect. The most serious drawback is the lack of information and unbalanced information in particular with respect to invertebrates and lower plant species. The objective of this presentation is to stimulate a discussion on a topic which cannot any longer be ignored.

1 BIODIVERSITY

1.1 <u>Biodiversity conservation</u>

The global focus on biodiversity conservation (s.Rio Conference) has to be seen against the background of global warming, massive environment pollution, excessive resource extraction and generally poor land use practices. As a result, animal and plant species are disappearing at an alarming rate to be lost forever. The long-term effects of it all are still widely unknown.

Canada is no exception. The massive conversion of prairie lands into ecologically sterile farmsteads, Ontario's lakes contaminated by chemical rains and B.C'.s massive destruction of coastal rainforests are examples of dramatic man-induced adverse impacts on biodiversity.

Recognizing the urgent need for biodiversity conservation many countries of the world have signed agreements and conventions to slow down the process of environmental degradation and species disappearance. Following this trend, the Province of B.C. has taken first steps towards better land use planning and resource extraction as demonstrated by the new Forest Practices Code, the Core Process and the strong commitment by the Government to sustainable resource management. With mounting public pressure and greater environmental awareness, the new approach to land and resource use in B.C. is expected to shift from the traditional species specific- to a more holistic approach; biodiversity conservation undoubtedly will become the guiding principle for land and resource use management in the future.

1.2 The Concept

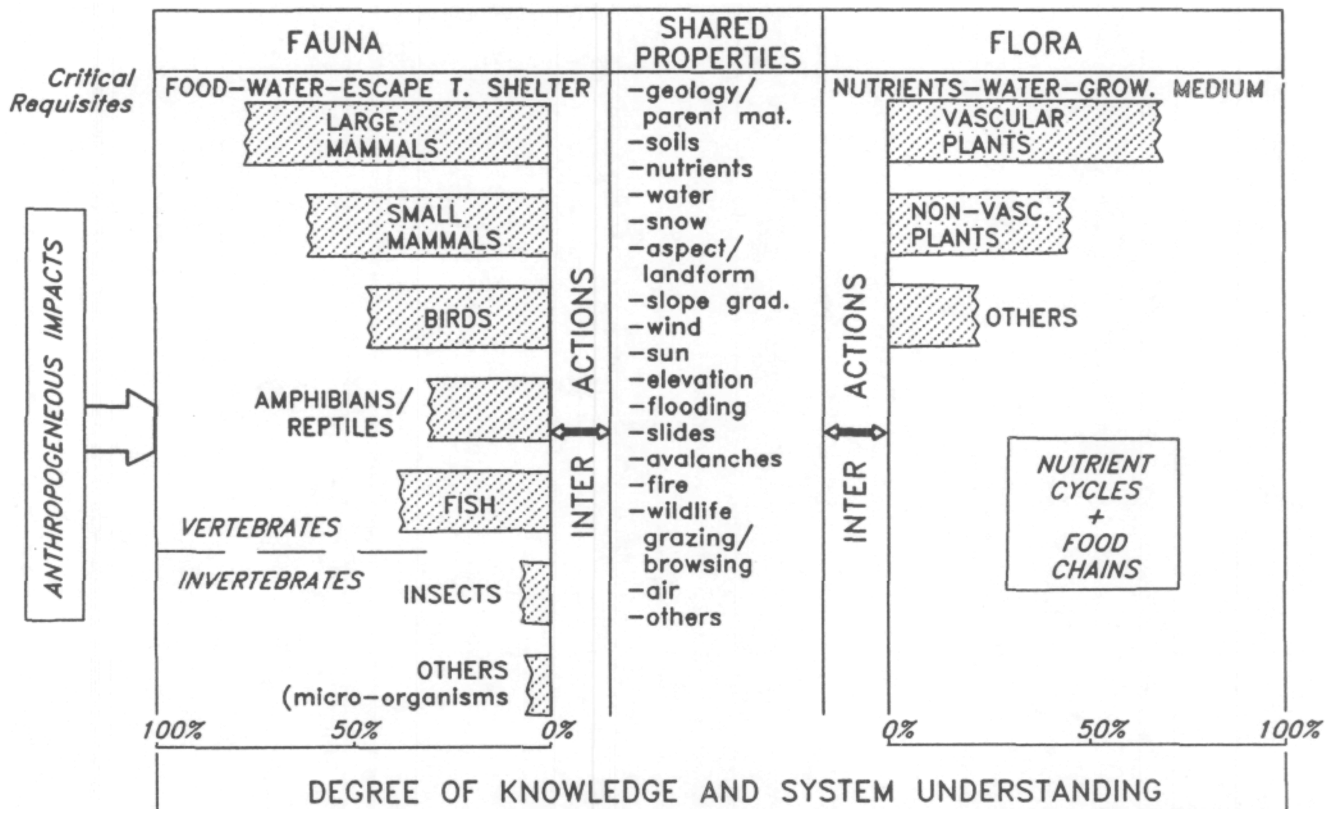
"Biological Diversity" is the variety and variability among organisms and the ecological complexes in which they occur. Biological diversity encompasses all species of plants, animals, and microorganisms and the ecosystems and ecological processes of which they are parts. It is an umbrella term for the degree of nature's variety, including both the number and frequency of ecosystems, species, or genes in a given assemblage. It is usually considered at three different levels: genetic diversity, species diversity, and ecosystem diversity. Genetic diversity is the sum total of genetic information, contained in the genes of individual plants, animals, and microorganisms that inhabit the earth. Ecosystem diversity relates to the variety of habitats, biotic communities, and ecological processes in the biosphere, as well as the tremendous diversity within ecosystems in terms of habitat differences and the variety of ecological processes. Ecosystems cycle nutrients (from production to consumption to decomposition), water, oxygen, methane, and carbon dioxide (thereby affecting the climate), and other chemicals such as sulfur, nitrogen, and carbon. Ecosystems are made up of communities of plants, animals, microorganisms and the non-living elements of their environment (soil, water, minerals etc.) Ecosystem diversity describes the number of species and their relative abundance within a community. Low diversity means there are few species or unequal abundance; high diversity that there are many species or balanced abundance. Estimates of species numbers inhabiting this planet vary wildly; estimates range between five and 80 million, of which only around one and a half million have actually been identified as shown in Table 1.2 -a

Table 1.2 -a Numbers of described species of living organisms

GROUP	COMMON NAME	TOTAL
Virus	Viruses	1,000
Monera	Bacteria and Blue-green algae	4,760
Fungi	Fungi	46,983
Algae	Algae	26,900
Plantae	Lower Plants	28,428
	Higher Plants	220,000
Protozoa	Protozoa	30,800
Invertebrata	Lower Invertebrates	106,300
	Insects	751,000
	Other Arthropodes	123,161
	Other Invertebrates	9,300
Chordata	Lower Vertebrates	1,273
	Fish	19,056
	Amphibians and Reptiles	10,484
	Birds	9,040
	Mammals	4,000
Total		1,392,485

As little as is known about species numbers, much less is known about the intricate inter-dependencies between species and their environment, as may be learned from Figure 1.2 -a. The simplified diagram shows the discrepancy in knowledge (and "ecosystem understanding") between vertebrates vs. invertebrates, and higher plants vs. lower plant species. This is of great concern with respect to biodiversity conservation, especially since invertebrates contribute about 90 % of the total estimated biological diversity. The diagram clearly illustrates how complex and difficult it is to assess any man-caused environmental impacts on a specific component of an ecosystem, let alone the ecosystem itself. And this is what we all will be faced with in the future: the assessment and evaluation of man-caused impacts on ecosystem biodiversity.

Figure 1.2 -a   Ecosystem Diversity



1.3 The Approach

Traditionally, emphasis in Environmental Impact Assessments (EPA) in British Columbia has been placed on vascular plants, mammals and fish. Birds are usually included, but other fauna is largely ignored; some information -mostly anecdotal- may exist on rare and endangered species. Non-vascular and lower plants, and invertebrates and microorganisms which play a key role in ecological processes, are rarely considered.

Vegetation figures mostly as "forest", because of its potential commercial timber values, and as "wildlife" habitat, providing food and shelter to the critters to be covered by an EPA. Of greatest concern in Eras are ungulates and other large mammals, of less concern furbearers and birds. This reflects the public interests in wildlife. The ecological significance of plant associations in relation to all fauna (i.e. synecology) is usually not addressed.

Times have changed. Much thought has been given lately to the assessment and rating of the biological diversity in our environment. The need for a more amplified approach to ecosystem classification has been recognized. Scientists around the world are currently battling with the problem to develop some objective method to quantify and qualify ecosystem diversity ; the overwhelming complexity of ecosystems, however, makes the task close to impossible. At present, there is no single one method for an objective ecosystem assessment anywhere in the world, and there never may be; data gaps are enormous. On the other hand, there is no time to wait for the results of gap analysis studies; we have to work with what we got, and apply academic judgment wherever necessary. Ideally, a biodiversity index should be developed to provide a numerical rating for any identified ecological entity or habitat unit This would facilitate an objective comparison of different habitat types, thereby allowing the ranking of ecological units for priority protection. Furthermore, a biodiversity index rating would provide a better perspective on the rank order position of a given ecological entity with a clear indication of its relative importance in terms of biodiversity. Such biodiversity index could be used for environmental impact assessments, meaningful habitat enhancement procedures, and as a guideline for sustainable biodiversity management.

1.4 The Biodiversity Index

The following chapters describe an attempt to develop a biodiversity index for the Line Creek Resources Ltd.'s coal properties in the Elk Valley of B.C. Baseline data are provided through the biophysical inventories and comprehensive wildlife research implemented for the Elk Valley study area between 1980 and 1985 (TAESCO, 1985). The biophysical inventories included flora and fauna, surficial materials and soils, geology, fluvial processes and aquatic resources. Since fauna research focused on large mammals, furbearers, birds and fish, very little information is available on amphibians and reptiles, less on invertebrates, non-vascular plants and microorganisms. Lacking data were substituted through professional judgment as based on ecological site description and deduction.

Key elements of the Biodiversity Index are fauna and flora as the living components of an ecosystem. Critical requisites for flora are nutrients, water and the growing medium; for fauna: food, water, escape terrain and climatic shelter. Abundance and availability of high quality requisites within a habitat type are basic needs for healthy animal and plant populations. In addition, there are important habitat requirements which vary between species; cavity nesting birds for example need "snags"; ungulates mineral licks; raptors perch-trees; bears denning areas. Many important requisites are known, many others unknown. Both flora and fauna share many ecosystem components, vital to species survival, as reflected through food chains and nutrient cycles.

Due to insufficient baseline data, a Biodiversity Index may always be biased; there never will be sufficient and, more important, balanced information for an objective ecosystem assessment covering all ecosystem components. We rightfully may ask then, why bother? Although such index may not fulfill all our ambitious expectations, at least it permits a relatively objective comparison of eco-types, hence providing a better perspective on relative ecological values.

The Biodiversity Index is composed of "component- indices". Component-index values are calculated as described in the following chapter. Each component-index receives its own numerical rating which may be adjusted by a correction factor.

i) Component Index "Flora" (Fi)

The assessment of flora is based on the 1:20 000 vegetation map and supporting research conducted for the 12 500 has Elk Valley study area (TAESCO, 1985). The study area was grouped into vegetated and non-vegetated landscape features; the two groups are subdivided into broad Landscape Types, which are stratified into "Map Units" (Fig. 1.4 -a). The Landscape Type categories correspond to landscape position and elevational zones with exception of the "disturbed" type which occurs across all landscape positions and elevations. The Map Unit categories represent current vegetation cover based on dominant overstory tree species, physiognomy, landscape position, terrain and disturbance history. For the 14 vegetated Map Units (acronym for Macro-Habitats) 25 key plant communities (acronym for Micro-Habitats)were identified and assessed. Each community type is described by stratum, species composition, cover class and site characteristics (i.e. elevation, slope, aspect, moisture regime, cobbles and stones).

Figure 1.4 -a Vegetation Landscape types and Map Units

Landscape Type	Map Unit
Riverbottom	Riparian Meadow (RM) Engelmann Spruce Riverbottom (ES) Alluvial Complex (A)
Upland Forests	Engelmann Spruce-Subalpine Fir (ESSF) Engelmann Spruce-Lodgepole Pine (ESPI) Lodgepole Pine (PI) Douglas Fir (DF)
Ridgetop-Meadow	Alpine Tundra (AT) Subalpine Meadow (SM) Alpine Larch (LI)
Disturbed	Logged (L) Slide Area (SA) Burned (B) Tallus (T) Disturbed (D)
Aquatic	Ponds (P) Streams (S) Rivers (R)

The Micro-Habitats form the basis for the development of the flora index. The flora index is the sum of four sub-indices: treelayer (a), shrublayer (b), herblayer (c), epiphytelayer (d):

Formula 1 $$Fi = a + b + c + d$$

The assumption is made that ratings are additive; in other words, the higher the rating for the sub- and component indices, the higher the rank order position of the corresponding Micro-Habitat No sub-index was calculated for lower plant species because of lack of information.

Qualifying diversity parameters for the treelayer include (a) **age class composition,** (b) **canopy closure,** (c) **stand density, (d) species diversity, (e) conservation status of species, and** (f) **relative importance to fauna.** Age classes are grouped into *mature, immature,md juvenile;* each age class is divided into categories *dominant, sub-dominant, few,* which are further divided into sub-categories *even distribution, cluster and scattered.* Each diversity parameter is rated as *high, moderate* and *low.* The sub-index for the treelayer is the sum of the numerical ratings assessed for the qualifying parameters (s.formula 2).

Formula 2 $$A=a+b+c+d+e+f$$

Qualifying diversity parameters used for the shrub-and herblayer sub-indices are: **species diversity, cover** (i.e. indicator of spatial distribution), **average height** (i.e. "volume"), **relative importance to animals, and conservation status of species.**

The sub-indices for the shrub- (b), herb- (c) and epiphytelayers (d) are the sums of the numerical ratings calculated for the qualifying parameters. The value ratings affiliated with the **"qualifiers"** are set arbitrarily for all component indices.

ii) Component Index "Vertebrates" (Iv)

This index is based on the assessment of Macro-Habitats in due consideration of corresponding Micro-Habitats as related to animal species diversity and abundance. The vertebrate component index (Iv) equals the sum of the sub-indices for (a) **large mammals, (b) small mammals, (c) birds, (d) amphibians, (e) reptiles, and (f) fish:**

Formula 3 $$.Iv = a + b + c + d + e + f$$

"Qualifiers" for fauna habitat are range type and the relative importance to an animal group (i.e. distribution and availability of habitat), habitat stability, species diversity / habitat type and the conservation status of the animal species found in the habitat type.

The Elk Valley Biophysical Inventories provide good quality baseline data for sub-indices large mammals, small mammals, birds and fish. Little is known about reptiles and amphibians in the study area.

iii) Component Index "Invertebrates" (Ii)

This group covers invertebrates and microorganisms. Although invertebrates constitute by far the highest number of species in any habitat type in comparison to other fauna groups, the lack of knowledge about this group leaves any value estimate to professional judgment. Invertebrates and microorganisms may well be the most important fauna in terms of biodiversity. Life history and habitat requirements are unknown for most invertebrates and microorganisms in the study area. Some invertebrate families are better known than others (i.e. butterflies, beetles, spiders). The serious information gaps undoubtedly result in biased results. Habitat rating for the li is based on the assumption that diverse habitats with a high flora index have a high species diversity of invertebrates and microorganism (i.e. Map Units Talus slope vs. Subalpine Meadows; or Alluvial Complex vs. Lodgepole Pine). In the overall, the invertebrate index is only one of six sub-indices. The method of rating follows the same principles as described for the vertebrate sub-index.

iv) Component Index "Requisites" (Ir)

Critical and important **habitat requisites** for vertebrates and invertebrates require special attention. Recognized significance of ecotones and edge and known requisites such as snags, mineral licks, water, litter, escape terrain, climatic shelter and many others are therefore assessed according to their relative abundance and availability for each habitat type. Some requisites may be part of some other sub-index; their importance, however, justifies a separate evaluation, hence increasing the overall value of the habitat type.

The abundance and availability of standard requisites are grouped into broad value categories (i.e. high, medium, low). Each requisite is given a rating according to its known importance to fauna. Snags, mineral licks and ecotones receive the highest ratings as being critical to many species. The assumption is made that the importance of habitat requisites is additive; the higher the rating,, the higher the overall habitat quality, and the higher the Biodiversity Index.

v) Component Index "Site" (Is)

The site index rates the productivity of a habitat. Qualifiers are soil, water, nutrients and drainage. Although habitat productivity is indirectly included in the flora sub-index, its own status underlines the importance of site quality for flora and fauna.

vi) Component Index "Aspect, Slope and Elevation" (lase)

The three habitat parameters are directly linked to sub-indices "plant cover" and "site". Although indirectly covered by the two sub-indices, their critical importance to some groups of fauna justify their separate assessment.

1.5 Rating the Biodiversity Index

The Biodiversity Index (BI) is the sum of the six component indices for flora *(If),* vertebrates (Iv), invertebrates (li), requisites (Ir), site (Is) and aspect/slope/elevation (lase):

Formula 4 BI = If + Iv + Ii + Ir + Is + lase

The biodiversity rating reflects the rank order position of a Map Unit in terms of biodiversity value: the higher the rating, the higher the value. To reduce unreasonably large value figures, the calculated BI value is divided by 100.

Table 1.5 -a shows the Biodiversity Index assessment for the Map Units of the Line Creek study area.

Table 1.5 -a Rating of Biodiversity Index for Macro-habitats

Map Unit	Development Stage	Number of Associations	If	Iv	Ii	Ir	Is	lase	BI
			Value Ratings						
LANDSCAPE TYPE: RIVERBOTTOM									
RM	Climax	one to six	45	119	54	29	19	0	2.7
ES	Climax	one to six	36	140	73	12	15	0	2.8
A	Climax	one to five	58	169	185	69	18	0	5
LANDSCAPE TYPE: UPLAND FORESTS									
ESSF	Climax	one to five	70	165	152	69	15	6	4.8
ESPI	Climax	one to five	63	143	140	58	28	6	4.4
PI	Climax	one to four	34	104	91	13	15	6	2.6
DF	Climax	two	48	79	92	10	2	0	2.3
LANDSCAPE TYPE: RIDGETOP MEADOW									
AT	Climax	one to six	47	124	232	3	5	0	4.1
SM	Seral-Climax	two to twelve	38	170	188	9	25	24	4.5
LI	Climax	one	27	30	65	6	2	0	1.3
LANDSCAPE TYPE DISTURBED									
L	Early - midseral	one to three	67	167	148	58	28	6	4.7
B	Early - midseral	one to three	42	152	187	69	28	6	4.8
T	Climax	one	19	21	45	6	2	0	0.9
SA	Early - midseral	one to three	48	121	150	23	15	10	3.7

Table 1.5 -a indicates that the Alluvial Complex may be the most important Map Unit in terms of biodiversity. It is followed by Map Unit Engelmann Spruce- Subalpine Fir (ESSF) which is

a highly diversified and common Map Unit in the study area. It is interesting to note that Map Units "Logged" (L) and "Burned" (B) have equally high value ratings. Both Map Units are associated with early successions at lower elevations displaying a high species diversity in the shrub-/herblayers with a correspondingly high species diversity in the invertebrate group. Furthermore, both Map Units can be of great importance to ungulates. The rating of the Subalpine Meadow type (SM) is comparatively high due to its importance as sheep winter range and because of the presence of rare plant and animal species. There could be great variations within the value rating for this Map Unit, depending on aspect, slope steepness and general site conditions. In the absence of rare species, the value rating is expected to decrease dramatically. The Lowest Biodiversity Index values are given for Map Units Tallus (T), Pine forests (PI), Larch (LI) and Riparian Meadows (RM). Riparian Meadows in the study area occur mostly as bog communities with a very low species diversity. The BI for this Map Unit could change with increasing knowledge about amphibians and invertebrates.

1.6 Shortcomings

The numerical assessment of the Biodiversity Index by macro-habitat using the proposed method reveals many shortfalls.

- There is a wide range in value ratings for the component indices within the same Map Unit depending on the numbers and quality of plant communities involved. Some community types are more common than others and may occur in many different Map Units.

- The component index "Flora" (If) is consistently lower than indices for vertebrates and invertebrates. The reason is that no correction factor (C) was used for If, but for both Iv and Ii. Insufficient baseline data did not allow the use of a correction factor.

- The Biodiversity Index does not provide sufficient information on system components; the Alpine Tundra Map Unit (AT) for example lacks tree- and shrublayers; the expected result would be a very low rating for component index "Requisites" (Ir); but Ir turns out to be very high; this is explained through the high rating of rare plant species identified for the herblayer and the high rating this Map Unit receives because it is "unique", offsetting the low values caused by the lack of the tree- and shrublayers.

- The Biodiversity Index by Map Unit represents a statistical mean value of the variations within plant communities for a specific Map Unit. Ideally, the Biodiversity Index should be assessed for each plant community separately.

- Map Unit ESSF has a comparatively high value for mid-slope communities compared to upper slope communities as a result of better site conditions and larger species/habitat use diversity.

- Map Unit ESPI shows very high values for early serai stages on mid-slopes but quite low values for maturing, tree-dominated communities. Climax communities of PI typically lack well developed shrub-/herblayers but have a distinct epiphytelayer, resulting in a low rating. In contrast, the same Map Unit in early serai stages displays pronounced shrub-/herblayers of great importance to invertebrates, thus enhancing the value rating.

- The Component Index "Site" (Is) would be expected to be low for Map Unit Alpine Tundra (AT). However, the rating is relatively high due to the importance of AT as critical ungulate winter range offsetting the generally low values for other site parameters.

- The rating for Map Unit Larch (LI) is very low, although this Map Unit is classified as "rare" in its conservation status. The actual value rating should therefore be somewhat higher.

2 CONCLUSIONS

The proposed method to assess and rate ecosystems through a Biodiversity Index may become a useful tool in principle; the method , however, needs refinement. The method was tested in an exceptionally well researched area for which good quality data were available; still, the bias may be unacceptably high for some Map Units. This is due to data gaps -in particular with respect to invertebrates/microorganisms and lower plants-, and due to the high input of "professional judgment". The numerical rating of a Biodiversity Index may be quite useful for a general comparison of macro-habitats. Intimate knowledge of the systems to be assessed and high quality baseline data are critical to reduce the inherent bias caused through subjective judgment.

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REFERENCES

Schuerholz, G. 1982. An ecological survey of the Ewin Sheep Population based on a one year field program. Unpubl.final report to CNRL, Calgary.

Schuerholz, G. 1984. MtMichael Avalanche Slope Biodiversity Assessment. Unpubl. report Line Creek Resources Ltd.

Schuerholz, G. 1984. Horseshoe Ridge Mine Extension. Impact Assessment on Biodiversity. Unpubl. document Line Creek Resources Ltd.

TAESCO, 1984. Environmental Sensitivity Assessment of the Line Creek Study Area. Unpubl. materials CNRL.

TAESCO, 1985. Line Creek Biophysical Inventories Vol. I, Terrain Analysis; Vol. II, Vegetation; Vol. HI, Wildlife; Addendum I, Radiotelemetry; Addendum D, Ungulate Carrying Capacity; Addendum III, Furbearers; Addendum IV, Birds. Unpubl. reports CNRL.