Classification and Management of Rare Ecosystems in British Columbia

Donald S. McLennan
Oikos Ecological Services Ltd.
3855 Second Avenue, Box 985, Smithers, BC, V0J 2N0, Canada
Donald@oikos.ca

Irene E. Ronalds
Oikos Ecological Services Ltd.
3855 Second Avenue, Box 985, Smithers, BC, V0J 2N0, Canada

ABSTRACT

This paper reports on the progress in developing a field reference for the identification, description, and assessment of rare ecosystems in British Columbia for the Conservation Data Centre (CDC). To this end, a review of plant community classification concepts is provided. Concepts discussed include (1) the relationship between the plant community and the plant association, (2) vegetation classification concepts used in the biogeoclimatic ecological classification system, (3) clarification of classification concepts and the B.C. CDC's Red- and Blue-listed plant communities, and (4) plant community rarity—the nature of the threat. Management implications and recommendations are outlined as a starting point for further discussion.

Key words: biodiversity, biogeoclimatic ecological classification, protected areas, rare ecosystems.

The objective of integrating conservation of biodiversity as a component of land use strategies has become a common priority in many jurisdictions in North America and around the world. The British Columbia Conservation Data Centre (CDC) was initiated by the British Columbia Ministry of Environment, Lands and Parks in 1991 to collect and standardize information on the status and occurrence of provincially rare vascular plants, vertebrates, and plant communities (Harcombe et al. 1994). Plant communities, as represented by their plant associations, are ranked according to both their global and provincial status using internationally consistent criteria developed by the Science Division of the Nature Conservancy (U.S.). The provincial status is based primarily on the number and areal extent of known occurrences of an element, informed by other factors including abundance, range, protection, trends, and threats (Table 1).

Based on the CDC status ranking, the CDC has identified a preliminary list of 241 rare plant associations for Red- or Blue-listing, according to the criteria outlined in Table 2. Without rare ecosystem inventory and mapping over the whole province, the criteria for Red- and Blue-listing are difficult to apply to rare plant communities at this time. Instead, the CDC uses a "ranking by inspection" system, which is based on available occurrence information, and on the expert opinion of local ecologists, regional ecologists from the Ministry of Forests and the Ministry of Environment, Lands and Parks, as well as experienced naturalists (B.C. Conservation Data Centre 1992).

Information reported in this paper is based on 2 projects carried out by our company for the CDC. These reports identify and map rare ecosystems (Oikos Ecological Services 1998), and summarize floristic and environmental ecosystem characteristics for ecosystems presently included in Red and Blue Lists (Oikos Ecological Services 1999*a*). This paper summarizes many of our findings from completing these projects, outlines difficulties with rare ecosystem classification and management, and provides our perspective on future directions of the rare ecosystem program.

ISSUES WITH CLASSIFICATION OF RARE PLANT ASSOCIATIONS

Plant Communities, Plant Associations, and Forest Ecosystems

While it is accepted that plant species are distributed individually as populations along environmental gradients, the ecophysiological adaptations of certain groups of plants seem similar, so that their distributions along environmental gradients often coincide. Groups of plants that tend to occur together under similar environmental conditions are called *plant communities*. The distinctiveness of plant communities in nature is often a function of the rate of change of environmental gradients. Where environmental gradients change rapidly, such as at the boundary between a floodplain and a rock cliff, or at the margin of a lake, changes in the plant community are rapid and distinct. Often, however, the

Table 1 Conservation Data Centre ranks and definitions for element rarity.

1. Critically imperilled	extremely rare (≤5 extant occurrences or very few remaining individuals) or some factor(s) make it especially vulnerable to extirpation or extinction.
2. Imperilled	rare (typically 6–20 occurrences or few remaining individuals) or some factor(s) make it vulnerable to extirpation or extinction.
3. Rare or uncommon	typically 21–100 occurrences; may be susceptible to large-scale disturbances, such as loss of extensive peripheral populations.
4. Frequent to common	>100 occurrences; apparently secure but may have a restricted distribution or future threats may be perceived.
5. Common to very common	demonstrably secure and essentially ineradicable under present conditions.

environmental gradient is more gradual, such as on long slopes in mountainous terrain. In these cases, identifying where one plant community changes to another is much more difficult.

Whereas the plant community refers to real assemblages of plants in nature, the *plant association* is a classification concept that groups similar plant communities, often for environmental description and ecosystem-based land management. In the Braun-Blanquet approach, which is the basis of the plant community classification in the biogeoclimatic ecosystem classification (BEC), plant communities are sampled using réléve analysis, and the floristic data are analyzed so that similar plant communities are grouped together, following the rules of vegetation classification (see Mueller-Dombois and Ellenberg [1974] or Shimwell [1971]). Using this approach plant communities are considered part of the same plant association if they meet certain criteria for frequency of occurrence and percent cover of indicator species. The CDC has recently updated its terminology so that rare plant associations, rather than rare plant communities, are the elements of conservation (B.C. Conservation Data Centre 1999).

Ecosystems can be defined as the system that includes the total assemblage of living organisms, together with their nonliving environment, over some particular area (Kimmins 1992). The nonliving component of the ecosystem includes factors such as climate, physiography, and soil, and are together considered as *site* component of the ecosystem. The plant community is the plant component and, with animals, makes up the biotic component of the ecosystem. Thus *plant community* and *ecosystem* should not be considered synonyms.

Table 2. B.C. Conservation Data Centre criteria for Red- and Blue-listed plant communities.

Status	Significance	CDC rank
Red-listed	endangered or threatened	plant communities with ranks of 1, 2, 1–2, 1–3
Blue-listed	vulnerable and at risk	plant communities with ranks of 2–3, 3, or 3–4

The size of an ecosystem is not included in the definition, and is determined by scale of interest. In the BEC system local forest ecosystems are defined as areas of the landscape uniform in soil polypedon, vegetation composition, and vegetation structure (Pojar et al. 1987). These are also the criteria used when selecting the location for a plot to conduct releve sampling of a plant community. Rare plant associations are thus used as labels for defining and identifying rare ecosystems that include identified rare plant communities. The rare ecosystems that support listed rare plant communities should be the focus of conservation to ensure the coarse filter approach to conservation of biodiversity.

Applications of the Plant Association Concept in Biogeoclimatic Ecosystem Classification

The concept of the plant association is central to the classification of ecosystems in BEC at the chronological (successional), regional (subzone), and local (site association) levels of the system (Pojar et al. 1987). Within BEC, changes in plant communities and their plant associations across the landscape are used as bio-indicators to interpret important ecological gradients, and for determining the location of important ecological boundaries. For example, plant communities change over time on the same site as vegetation succession proceeds following stand replacing disturbance. Forest stands develop in a continuous and relatively predictable manner that has been classified into a number of *structural stages* (Initial, Herb, Shrub-Herb, Pole Sapling, Young Forest, Mature Forest, and Old Forest, following RIC [1998]). Plant communities, and the plant associations that circumscribe them, also change along disturbance chronosequences, and floristically unique plant associations along this time gradient are referred to as *seral associations*. A structural stage may have many seral associations within, especially in the Initial, Herb, and Shrub-Herb stages, or the same seral association may include more than one structural stage. This latter situation occurs primarily in midsuccessional forest structural stages, such as the Pole Sapling and Young Forest stages, where subcanopy plant species diversity is often low.

Another important application of the plant association concept in BEC is used to identify biologically important climatic and edatopic boundaries. The distribution of distinct plant associations that occur in Mature Forest and Old Forest structural stages on zonal sites marks the geographic extent of regional climates, or *biogeoclimatic subzones*. Within subzones, the distribution of plant associations that occur on Mature Forest and Old Forest structural stages on nonzonal sites marks the geographic extent of many different *site series*. Thus, a site series is a group of sites that are climatically uniform, and that have the same ecological potential, as indicated by the plant association that characterizes it in Mature Forest and Old Forest structural stages. The same plant association may occur on azonal sites in more than 1 subzone; this group of sites is referred to as a *site association*. Site associations and site series may occur on a range of *site types* where compensating factors result in ecological equivalence, as expressed by the Mature Forest and Old Forest plant associations that characterize the site association. Thus any 1 rare plant community may occur on a wide range of rare ecosystems, and is defined by the rare plant association listed by the CDC.

Using the Plant Association Concept for Rare Plant Associations

The CDC lists rare plant associations in British Columbia to identify ecosystems considered to be at risk. Many of the listed plant associations are the plant associations of forest ecosystems in the Mature Forest and Old Forest structural stages that are used in BEC to identify and define site associations. These older structural stages are rare or threatened across the landscape, and are generally the object of conservation. Younger structural stages that have developed following forest harvesting or other disturbance within these site associations are represented by different plant associations (seral associations) and, generally, are not considered rare or endangered.

We have stated that the plant association is used to classify plant communities by sampling plant communities across the landscape in a standardized manner, and then using the methods of phytosociological analysis to group similar plant communities into plant associations. The rare plant association acts as a label to describe all rare plant communities (and rare ecosystems) that have a similar floristic composition. The floristic composition of the rare plant association is then used as a criterion to identify rare plant communities in the field. Potential rare plant communities are sampled using the releve sampling procedure and membership in the rare plant association is determined by their floristic similarity.

At present, no criteria have been established for determining how similar the sampled plant community must be to the target rare plant association to consider it as an example of that rare plant association. A potential situation for the Submontane Very Wet Maritime CWH Variant (CWHvm1) is illustrated in Figure. 1. The *Thuja plicata/Tsuga heterophylla - Polystichum munitum* and *Abies amabilis/Thuja plicata - Rubus spectabilis* - very wet maritime rare plant associations are separated by an unlisted plant association, BaCw - Foamflower. The bell curves are intended to show the central concept (or average condition) of each of the 3 plant associations, and how the floristic composition of 30 plant communities varies along the underlying moisture gradient. The critical question is, "At what point along this moisture and similarity gradient do we assign membership to the 2 rare plant associations?" The gradient need not be soil moisture or soil nutrients. It may be a gradient of increasing herbivory in a grassland ecosystem, or increasing invasion of nonnative plant species near developed areas that is causing the floristic variation from the central concept of the rare plant association. To successfully apply the plant association concept to the conservation of rare ecosystems similarity criteria must be developed to determine if sampled plant communities belong to the listed plant association. These criteria could be derived by multivariate methods such as discriminant analysis and built into existing vegetation tabulation software such as VENUS (B.C. Ministry of Environment, Lands and Parks and B.C. Ministry of Forests 1997) or VTAB (Kayahara 1992).

An additional problem with identifying rare plant community membership is the lack of data for many of the listed associations. Use of similarity indices will require solid databases to define the average floristic composition of rare plant associations for comparison with candidate plant communities sampled in the field. At least 5 sample plots are required for reliable vegetation classification and as many as 10 are desirable. At this time, many of the rare plant associations listed by the CDC are defined by fewer than 5 plots, and sometimes by only 1 or 2. A low number of sample plots will make the application of multivariate methods for deciding membership in a rare plant association unreliable. More field sampling is required for rare plant associations that are defined by less than 5 plots.

CONSERVATION OF RARE ECOSYSTEMS

Relationship to the Biogeoclimatic Ecosystem Classification

Rare plant associations and the ecosystems that they define are largely based on information collected for developing the BEC. This integration with BEC facilitates efforts to conserve rare ecosystems, because BEC provides an ecological framework for identifying, mapping, modelling and managing rare ecosystems. For example, terrestrial ecosystem mapping (TEM) uses BEC, and has recently been carried out in many tree farm licences (TFLs) and other forest licence areas in British Columbia; TEM provides an immediate inventory of rare ecosystems in the areas mapped (Fig. 2). The identification and mapping of rare

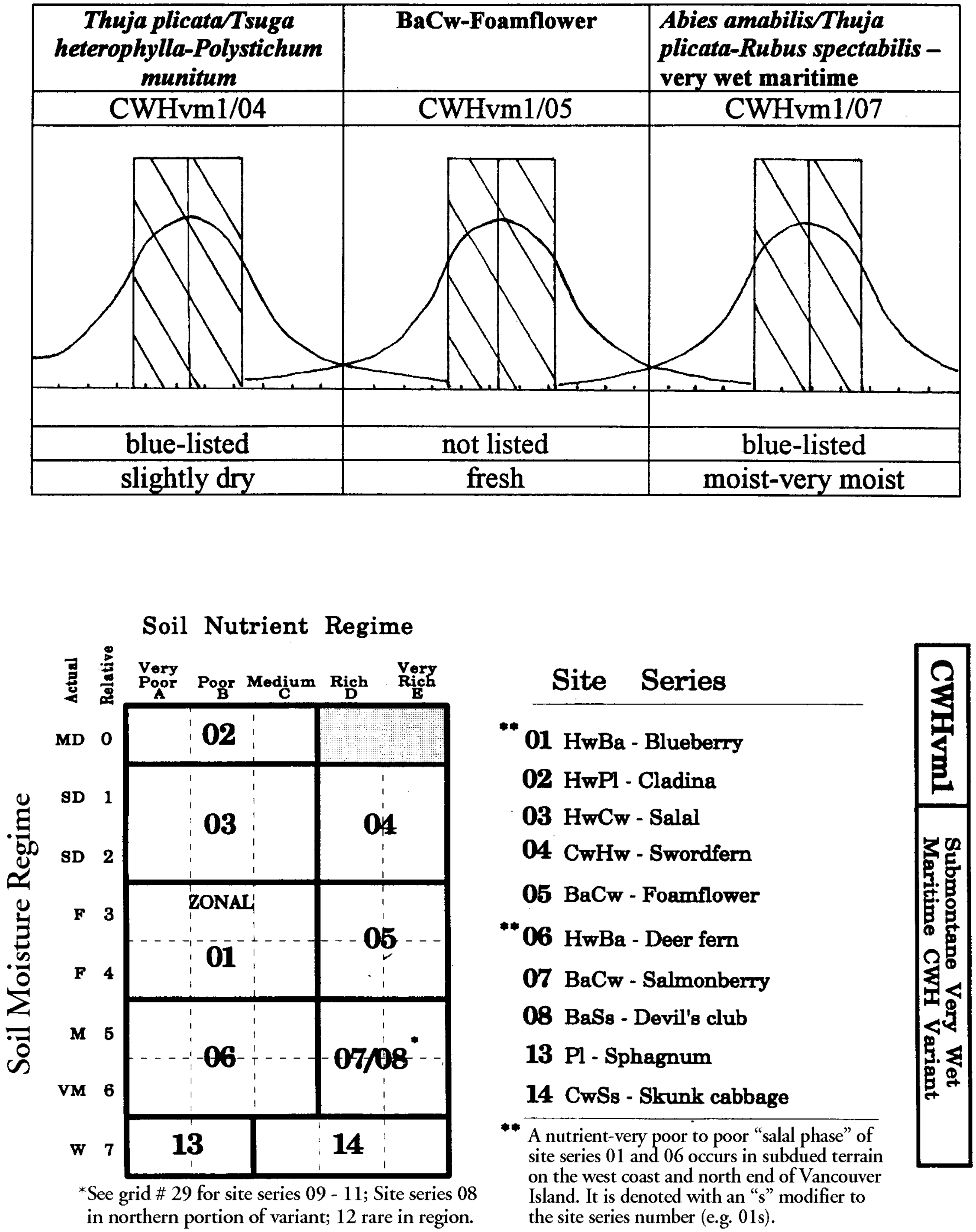

Figure 1. Changes in floristic similarity of 30 plant communities across 3 site series along a moisture gradient in the CWHvm1 variant. Site series in the upper diagram can be located on the edatopic grid in the lower diagram (grid from Green and Klinka 1994).

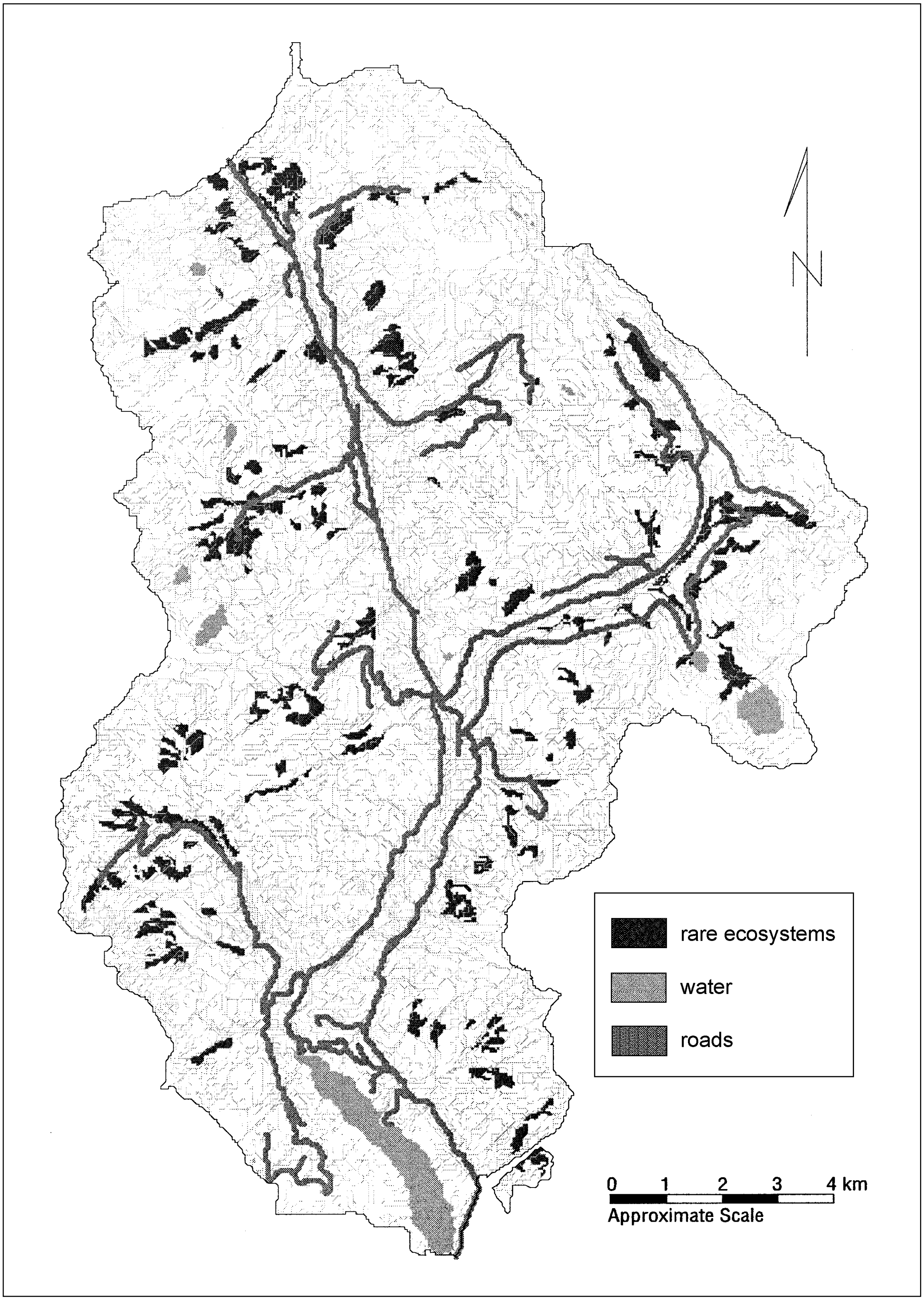

Figure 2. Distribution of rare ecosystems in the Capilano watershed (Oikos Ecological Services 1999*b*).

ecosystems in operational areas makes it possible to account for them in landscape unit planning and harvesting plans. TEM uses a standardized approach to defining stand structural stages so that the long-term recovery of the Mature Forest and Old Forest stages that define many rare plant associations can be predicted (Fig. 3).

Rare Ecosystems in Protected Areas

Rare ecosystems in British Columbia occur on public land in protected areas and in operational forest and mining areas, as well as on private land. Because a rare ecosystem occurs in a protected area does not mean it will be conserved. For example, in BC Parks there is a movement towards allowing natural disturbances such as fire and pest outbreaks to create a natural mosaic of ecosystems. Under this regime rare ecosystems will be disturbed along with those that are not listed, and this may significantly decrease rare ecosystem representation. Conversely, fire suppression may also result in undesirable changes to the plant community, such as forest ingrowth. A significant part of the problem is the lack of inventory on rare ecosystem occurrence and distribution in our protected areas. Without this information it is difficult to decide on the best policies for managing protected areas, and the rare ecosystems they contain.

Rare Ecosystems in Operational Areas

Rare ecosystems are also widespread on public lands where forest harvesting and other kinds of development are planned. At this time only 4 of 241 rare ecosystems are listed in the Identified Wildlife Management Strategy (B.C. Ministry of Environment, Lands and Parks and B.C. Ministry of Forests 1999). The remaining 237 rare ecosystems do not have official protected status and this situation should be rectified as soon as possible. Note that just listing the rare ecosystems provides an important service in identifying them, because land managers are aware of their existence and may consider them in development plans.

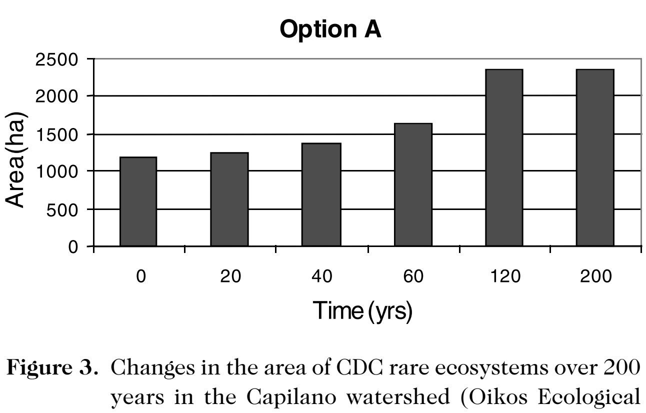

Figure 3. Changes in the area of CDC rare ecosystems over 200 years in the Capilano watershed (Oikos Ecological Services 1999b).

Without a complete ecosystem inventory for all areas presently being developed, rare ecosystems should be identified as part of the development process. Ideally, rare ecosystems should be identified as part of the landscape unit plan so that harvesting plans can optimize rare ecosystem conservation and resource extraction. If not identified at the landscape level before development, rare ecosystems can be identified at the silviculture prescription stage. To accomplish this effectively, materials and training sessions will need to be developed that facilitate the identification of rare ecosystems. Field personnel conducting silviculture prescriptions are already trained in the identification of BEC site series, so they could easily learn to identify the Mature Forest and Old Forest stands within site series where rare ecosystems occur. Once identified, whether at the landscape unit plan stage or at the silviculture prescription stage, the locations of rare ecosystems can be noted on forest cover maps and noted permanently as the maps are updated.

Ecosystem-Level Conservation Strategies for Rare Ecosystems

Once they have been identified and located, rare ecosystems will require a management plan to ensure their continued protection. Conservation of rare ecosystems at the landscape level is an important component of rare ecosystem conservation and approaches are well summarized by Noss (1995). However, our paper deals with the development of a rare ecosystem management approach at the local level, where individual ecosystems have been identified for protection.

A management plan for local rare ecosystems seeks to conserve ecosystem structure, composition, and function. This objective is best met by conserving ecosystem processes that support these ecosystem characteristics. Another aspect of BEC relevant to effective conservation is the analysis of an ecosystem process that is inherent in ecosystem interpretation. Processes important to maintaining ecosystem integrity may occur completely within or outside the ecosystem boundary. Examples of internal processes to be conserved are mineral soil and humus form processes (e.g., mineral weathering, moisture and nutrient uptake, and mineralization of organic matter), and stand structural dynamics (e.g., dead wood cycling, microclimatic effects, reproduction, and plant interactions). External processes include hydrologic effects such as the seasonality and chemical composition of seepage water, water table depths, or the periodicity of flooding that characterizes the ecosystem. Other important processes determined by factors outside the ecosystem are climatic conditions that determine natural fire frequency and periodic windthrow events, and mesoscale factors such as cold air drainage and deep snow accumulation.

Effective rare ecosystem management plans will include recommendations for preserving ecosystem structure, composition and function, and should consider maintenance of internal and external ecosystem processes. Internal ecosystem characteristics and processes can be protected by establishing a rare ecosystem management and/or reserve zone around the ecosystem, and by excluding all extractive and development activities. Recreational use should be restricted or carefully planned to prevent ecosystem degradation. The width and other details of management/reserve zones around rare ecosystems will vary depending on the ecosystem structural attributes that require protection. For example, in forested ecosystems, the management and reserve zones should be designed to protect the structure of the ecosystem by reducing windthrow risk. It may sometimes be desirable to reduce fuel continuity in these reserves to decrease the risk of fire damage. Reserves around protected grassland or shrub-steppe ecosystems should be designed to reduce border effects of grazing, including trampling and soil disturbance that may provide access for nonnative species. Often, fencing will be required to protect grassland and shrub-steppe ecosystems from overgrazing, especially on private land or public range areas.

Protecting ecosystem processes that are external to the boundary of the rare ecosystem will be much more difficult than the protection of internal processes, and will sometimes be impossible. Many rare ecosystems depend on hydrologic effects that are determined by factors outside the ecosystem. For example, wetlands occur as complex ecosystem mosaics where each wetland ecosystem is controlled by often slight differences in hydrologic regime. The negative impact of road building on wetland hydrologic regime, and consequently on wetland ecosystem structure, composition, and function, is easy to observe along all of our highways and logging roads. Many rare forested ecosystems are located on floodplains and alluvial fans, where above- and below-ground flooding are important determinants of ecosystem function. These hydrologic factors should be considered in management plans designed to protect the rare ecosystems that rely on them. Recommendations for upslope road building and drainage, area-based cutting restrictions, and hydroelectric development should accompany rare ecosystem management plans to ensure maintenance of these ecosystem processes.

In some rare ecosystems, periodic fire is essential for maintenance of ecosystem structure and composition; however, fire control has permitted the establishment of shrubs and poorly growing trees that would not occur under a natural fire regime (Haeussler and Heatherington 2000). Many grassland and shrub-steppe ecosystems throughout the province will require prescribed burning for their maintenance, and optimal fire periodicity and intensity for these ecosystems should be determined. Other external factors such as maintenance of cold air drainage, snow accumulation areas in alpine ecosystems, or significant slope effects in semiarid climates are beyond the scope of management, but in general should be little affected by development.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

The rare ecosystem list produced by the CDC represents an important starting point for protection of biodiversity in British Columbia. The list should be seen as the beginning of a process—much has yet to be done. At present 186 of the 241 plant associations listed are Mature Forest and Old Forest stages of overharvested site series. The remainder include shrub-grasslands and grasslands in dry subzones, deciduous stands on floodplains, forested and nonforested wetlands, alpine ecosystems, and marine foreshore ecosystems. Wetlands and alpine ecosystems are clearly underrepresented, and the recent wetland classification being completed for British Columbia will help fill in this important area (see MacKenzie and Shaw 2000). Alpine ecosystems require more work but the priority is relatively less given reduced pressure on alpine ecosystems.

To continue protecting rare ecosystems in British Columbia, several areas have a high priority for action.

1. Rare ecosystem protection needs to be integrated into the operational processes of forest harvesting, mining, and other land development as soon as possible by providing training and distributing field materials so that technical field staff and government and industry planners can account for rare ecosystems in their operational activities. Rare ecosystems in all completed TEM areas should be identified as a theme and included in development plans. Inclusion of all listed rare ecosystems in a revised Identified Wildlife Management Strategy should be a priority, and the full implementation of the Forest Practices Code *Biodiversity Guidebook* (B.C. Ministry of Environment, Lands and Parks and B.C. Ministry of Forests 1996) at the site level should be reinstated.
2. Floristic similarity criteria need to be developed for determining plant community membership in rare plant associations. To reliably apply these criteria, vegetation databases for the present list of rare ecosystems should be upgraded so that each rare plant association is defined by a minimum of 5 plots, and ideally 10 plots.
3. The present list of rare ecosystems should be upgraded and studied in each forest region to confirm the present designations, to exclude those rare ecosystems not truly requiring protection, and to add new ecosystems as required.
4. Management approaches for protecting rare ecosystems at the landscape and local ecosystem levels should be developed and published so that they can be included as operational activities. Landscape-level protection should follow an approach similar to that proposed by Noss (1995). At

the local level, where relatively isolated rare ecosystems are excluded from harvesting or other development, research should be conducted to determine the size and nature of management and reserve zones for different types of rare ecosystems. Details of prescribed fire for rare ecosystems requiring periodic fire for their maintenance should also be researched.

5. To ensure a comprehensive approach to conservation of rare ecosystems, surveys of rare ecosystems in protected areas should be surveyed to provide critical information on rare ecosystems that are presently protected from development. Based on these inventories management plans should be developed for rare ecosystems within protected areas.

British Columbia is fortunate enough to have landscapes and ecosystems that are important both regionally and globally; we should consider it our public responsibility to preserve the integrity of all components of our natural biodiversity mosaic. The CDC listing of rare ecosystems is an important contribution to this objective, but identification and protection of these important ecosystems are incomplete. Completing the identification and classification, and implementing effective rare ecosystem policies should be a high priority for all land managers in British Columbia.

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