Extension Note

October 1996

Management Concepts for Landscape Ecology PART 1 OF 7[1]

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Biodiversity
Management Concepts in Landscape Ecology

"Understanding the principles of landscape ecology can improve a manager's ability to exercise professional judgement …[and] enhance the exchange of information …"

Introduction

The new Forest Practices Code challenges managers of provincial forests to ensure that biological diversity is maintained. The *Biodiversity Guidebook* (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1995) recommends a process to manage for biodiversity within targeted social and economic constraints and provides guidelines for specific stand and landscape attributes. However, it is primarily a "how-to" book for applied landscape ecology, and as such does not dwell on the fundamental scientific concepts of spatial patterns and structures and the functioning of the landscape as an ecosystem (Bell 1994).

This extension note is the first in a series that will heighten awareness of landscape ecology concepts. The series is designed to provide the necessary background information to explain an ecologically based approach to management, and thus help managers to use the *Biodiversity Guidebook*. Understanding the principles of landscape ecology can improve a manager's ability to exercise professional judgement during landscape-level planning and can also enhance the exchange of information between planning team members, stakeholders, and the public.

The biological concepts documented as individual notes in the series include:

- Natural disturbance ecology
- Spatial patterns
- Connectivity
- Riparian areas and wetlands
- Interior habitats and edge effects
- Seral stages across landscapes

Each extension note will summarize the topic's main points and its relationship to the Forest Practices Code and the *Biodiversity Guidebook*, and discuss associated management approaches. The series is based on Voller and Harrison's *The Ecological Principles of Forest Management* (in prep.). This work provides concepts, definitions, and principles which aid in understanding biodiversity management.[2]

Framed within the context of landscape-level planning, this first note lays the groundwork by introducing some important management concepts that will run throughout the entire series. This provides an overview of the hierarchy of spatial planning scales and the role of the historical range of variability in

1 January 2000. Policy direction for biodiversity is now represented by the Landscape Unit Planning Guide. This Extension Note should be regarded as technical background only.

2 The original chapters are a good reference for those wanting a more "in-depth" understanding.

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determining landscape design objectives.

Landscape-level Planning

Forest practitioners responsible for integrating biodiversity concerns into forest management regimes will find several key management concepts and approaches useful for landscape planning. The planning approach outlined below is presented strictly for discussion purposes; many other approaches may be more appropriate for your planning activities (see references).

A multi-disciplinary team approach to planning

Because forested landscapes encompass multiple resources and values, a multi-disciplinary team should be assembled for landscape planning. Include the following participants: specialists in geographic information systems (GIS) analysis, inventory, planning, operations management, protection, range, recreation, road and harvest engineering, silviculture, small business, and wildlife ecology. The expertise of regional or branch specialists may also be useful. Of this diverse group, probably only a few will focus on the day-to-day activities of analyzing and designing the landscape.

Analysis and design phases

The process for developing a landscape-level plan would usually involve two phases: the analysis phase (when landscape conditions and management objectives are considered) and the design phase (when options are considered and specific actions described). The following steps have been used in landscape-level planning in some jurisdictions.

Landscape analysis phase

1. Description: Identify and gather information about the landscape unit's landforms, soils, topography, ecosystems, flora, and fauna. Outline potential management constraints or opportunities.
2. Analysis: Review both the landscape unit and higher-level management objectives. Identify the local issues (e.g., hydrological values, connectivity) pertinent to this landscape. Determine landscape attributes required to maintain the identified values.

Landscape design phase

3. Design: Examine landscape options and select the landscape patterns that maintain or create the attributes identified in the analysis phase. Implement the chosen design.
4. Monitor: Schedule periodic surveys to determine the effectiveness of the designed landscape patterns and undertake appropriate adjustments.

Use multiple spatial and temporal scales to accomplish the steps in the analysis and design phases (these will be examined in more detail in the next section). The result of these four steps can be a relatively detailed and integrated picture of the landscape—what it was (historically), what it is (currently), and what we want it to be (the desired future condition). By planning at larger spatial scales and with longer time frames (as recommended by the *Biodiversity Guidebook's* "coarse filter" approach),[3] managers can actually achieve greater flexibility because they are not required to manage for each ecological value on every hectare at all times.

3 See Figure 2 in the *Biodiversity Guidebook* (1995, page 6). This conceptual diagram explains the relationships between the Biodiversity, Riparian Management Area, and Managing Identified Wildlife guidebooks as broad-based, coarse filter practices that protect most species and fine-filter practices that protect single species.

Spatial Scales and Time Frames in Landscape Description and Analysis

Spatial scales

Ecological systems are embedded, one within the other, like the layers of an onion. For example, a pileated woodpecker makes a nest in a dead Douglas-fir tree; that tree forms part of a predominantly old-growth western hemlock stand; the stand constitutes one unit in a coastal watershed; the watershed forms one component of a regional ecosystem, in this case, the Coastal Western Hemlock biogeoclimatic zone. While this spatial hierarchy continues to continental and global scales, our forest management efforts usually work within the context of regions, watersheds, and stands.

Each spatial level has its own particular set of attributes: the wildlife tree can be described by its size, species, and state of decay; the surrounding stand by the proportion and distribution of trees of various species, size, and age; the watershed by its topography, soils, hydrologic regime, and the proportions and arrangement of different types of stands; and the regional ecosystem by its characteristic combination of biogeoclimatic units.

In addition, the attributes of each level provide ecological context for the next lower level of scale. For example, the wildlife tree in the middle of an old-growth forest would have a different habitat value for a pileated woodpecker than the same tree would have in the middle of an extensively burned area.

Biodiversity management must identify and subsequently maintain the important attributes at each spatial scale and recognize the linkages between management at the various levels. An important management unit at the landscape level is the landscape unit, which in British Columbia is one or more complete watersheds with a total area of approximately 5000–100 000 hectares. It is delineated on the basis of physiographic or ecological boundaries.

Working with spatial scales

Gather information When describing the landscape unit, consider the context in which it is located by using maps and interpretations associated with the ecoregion and biogeoclimatic classification systems, as well as satellite and air photo images, tabular data, and field visits. It will also be important to identify the direction provided by the Forest Practices Code and higher-level plans and associated landscape issues of concern at this stage.

List the requirements or guidelines that must be considered from the code guidebooks, higher-level plans, and memorandums of understanding. Also identify various ecological, social, and economic issues that may constrain (or provide opportunities for) landscape management. For example, consider fire and insect protection requirements, hydrological concerns, connectivity for biodiversity and recreation, and maintenance of endangered animal and plant species.

Some of this information may be available in the office; other information may be gathered from the research literature, inferred from other similar landscapes, or collected during field inventories.

Stratify and map Because landscape units can be very large, it may help to divide, or stratify, the landscape unit into various map layers using broad groupings of similar characteristics. These strata may require different sets of prescriptions in order to meet management objectives.

Map layers that may help you stratify include groupings of similar

- ecological processes (e.g., natural disturbance regimes such as fire potential, flooding, insects/disease, and mass wasting);
- physical characteristics (e.g.,

- geology, landforms, topography including aspect, and soils); and
- potential vegetation.

You may end up with 5–15 strata repeated throughout the landscape unit. Relatively simple strata that emphasize the dominant landscape components and processes and that explain variability in stand composition and structure will be most easily understood.

Time frames

To ensure that stated ecological objectives are met, planners will need to project the efforts of recommended management regimes over long time frames. For example, at the stand level, wildlife tree patches maintained in clearcuts may not initially attract the species of interest, but as the surrounding forest develops they become more attractive for wildlife and provide important habitat for them in the longer term. At the landscape level, a particular management regime may maintain adequate caribou migration corridors during the first 20 years of a plan, but fail to sustain habitat linkages, or connectivity, during years 21–50.

Historical range of variability An idea that recurs in current forest management literature is that of historical range of variability (hrv). This concept is used to characterize the fluctuations or variations in ecosystem conditions or processes over a period of time. For instance, Kimmins (1995) interprets a forest ecosystem to be healthy when stand-level attributes, such as structure, condition, and species composition, are all within the historical range shown by the forest's seral stage, or the stage that is being managed for. At the landscape level, the forest is healthy if the pattern of forest ages, conditions, and seral stages is within the typical range for that landscape. Kimmins considers "the historic reference period to be that period during which the regional climate has not changed enough to cause a significant directional change in ecosystem potential or processes of change."

Similarly, Swanson et al. (1994) contend that managing an ecosystem within its range of variability is appropriate to maintain diverse, resilient, productive, and healthy ecosystems for viable populations of native species. Using the historical range of variability, they believe, is the most scientifically defensible way to meet society's objective of sustaining habitat.

One of the fundamental assumptions of the management approach described in the *Biodiversity Guidebook* is that if managed forests can resemble those that were established from natural disturbances, then it is highly probable that all native species and ecological processes can be maintained.

At the landscape level, the concept of historical range of variability is meant to aid our understanding of underlying variation in ecosystem processes and the patterns, connectivity, seral stages, and cover types produced by them. This concept can be applied at multiple scales to define the outer bounds of ecosystem behaviour that will remain relatively stable over time. Figure 1 displays one way that fluctuations in ecosystem conditions and processes can vary.

Working with time frames

Understanding the historical range of variability provides a reference point to assess the present condition of the landscape and its attributes, and the range of desired future conditions.

Past The *Biodiversity Guidebook* uses the concept of historical range of variability, tempered by socioeconomic considerations, when recommending management guidelines for landscape attributes such as seral stage representation and patch size

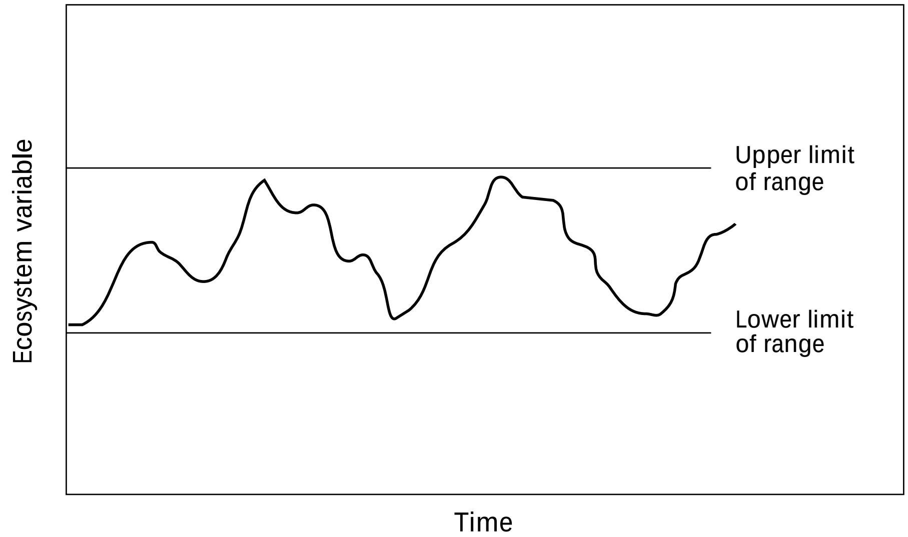

figure 1 *Historical range of variability in ecosystem processes or structure over time (from Morgan et al.* 1994).

distribution.[4] Therefore, during biodiversity planning and management efforts, consider how the landscape appeared before extensive management (e.g., fire suppression, domestic grazing, and timber harvesting activities) took place. Use a combination of available literature, databases, and specialists to gain an understanding of the historical range of variability.

As part of your analysis, ask the following questions about each strata and the landscape unit:

- What did the pre-industrial forests look like (e.g., consider seral stage distribution; patch size, shape, composition, and arrangement; and connectivity)?
- What were the directions, location, pathways, and cycles of living and non-living flow phenomena within the landscape unit, including those that would flow into and out of the unit (e.g., consider movement of fauna, fire and other disturbances, flora, genes, humans, propagules, water, and wind)? Which are most important to the function of this landscape?
- What ecosystem processes would have played a role in shaping the landscape unit (e.g., consider prevalent natural disturbances, hydrology, succession, and insect/pathogen regimes). How would these have affected patch size, arrangement, shape, composition, and connectivity?
- How did the landscape function (e.g., consider the flows of species, materials, and energy through the landscape over time)?

Present After gaining an understanding of the historical range of variability, use those same elements and processes to characterize the current condition of the landscape.[5] Assess current departures from the historical range of variability and estimate whether present trends are within or outside the HRV. For

4 However, the guidebook uses a fixed value (rather than a range) when recommending seral stage proportions within a biodiversity emphasis option.

5 Note that for some resources, it may be easier to consider existing conditions first, then work backwards to the HRV, and then forward to the desired future condition.

instance, how do historic disturbance regimes compare with disturbance regimes under managed conditions?

Determining where current conditions or trends depart from the historical range can inform the landscape design phase by identifying those landscapes or strata that will require active management to restore seriously degraded ecosystems. At the stand level, for example, tree spacing may restore more natural levels of productivity and insect resistance in stands where wildfire has been excluded. At the landscape level, deactivating logging roads may be needed to restore watersheds where high road densities have caused hydrological problems affecting important fish-bearing streams or community watersheds.

Future By using the concept of historical range of variability, we can develop a reasonable understanding of the patterns and processes at work. From this analysis, it should be possible to determine what future conditions would be desirable to sustain genetic, species, and functional diversity in the landscape unit. Objectives can then be developed that describe the desired future state of each strata and the landscape as a whole and that incorporate adaptive management[6] to resolve major uncertainties over time.

Tie these desired future condition statements to the objectives identified in higher-level plans. These objectives will then guide the design phase of landscape planning.

Conclusion

To effectively manage ecosystems for biodiversity, we need to expand our vision to larger spatial and temporal scales. This larger vision is required to accommodate the needs of organisms (e.g., grizzly bears and caribou) and ecological processes (e.g., wildfire, succession, water regimes, genetic evolution) that operate over large spatial and temporal scales. By understanding the underlying ecological processes that drive the ecosystems within which we are planning, we will be better able to analyse and design landscapes to meet the objectives that we have set.

6 Adaptive management is a disciplined approach to "learning by doing." Our current understanding becomes "working hypotheses" that we must continually test and revise to provide management alternatives that meet our objectives (refer to Taylor [1996]). A future extension note is planned on this topic.

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