Ecological Principles for
Sustainable Forestry on BC's Coast

A CUT ABOVE

by Ronnie Drever MRM

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THE DAVID SUZUKI FOUNDATION • VANCOUVER

CANADIAN CATALOGUING IN PUBLICATION DATA
Drever, Ronnie, 1968–
A cut above

Includes bibliographical references.
ISBN 1-55054-689-9

1. Sustainable forestry—British Columbia—Pacific Coast.
2. Forest ecology—British Columbia—Pacific Coast.
I. David Suzuki Foundation. II. Title
SD146.B7D73 2000 333.75'09711'1 C00-911159-X

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Cover photograph by Ian McAllister.
Photographs on pages 18 and 32 by Ian McAllister.
Photograph on page 46 by Bill Beese.
Photograph on page 1 by Nicholas Scapillati.

Design and production by Alaris Design, Victoria.
Printed in Canada by Western Printers and Lithographers.

Cover printed on Genesis 80 lb cover snow, 100 % recycled, post-consumer waste.
Inside pages printed on 50 lb Eureka 100, 100 % recycled, post-consumer waste.
All inks vegetable based.

Advisory team

An Advisory Team provided a peer-review capacity for this document; their comments were incorporated at two stages. First, the members of the Advisory Team reviewed an outline of the document and provided comments on its format, scope and content. Second, the members reviewed and provided input into a completed first draft. Comments incorporated into the manuscript were not limited to the field of expertise of individual members.

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Executive summary

The following nine guiding principles of ecologically sustainable forest management are meant to guide human behaviour in the forests of the central and north coast of British Columbia. They are based on the understanding that protecting biodiversity and ecosystem integrity is fundamental to the long-term health and productivity of British Columbia's coastal temperate rainforests and its coastal communities. The health of these forests is key for sustaining forest-dependent species, from arboreal lichens to salmon. The David Suzuki Foundation believes that planning and carrying out forest practices in accordance with these principles will help ensure the ecological sustainability of British Columbia's coastal temperate rainforests and the survival of all species that depend on them.

1. Make ecological sustainability the fundamental objective of forest management. Ecological sustainability is fundamental to economic and social sustainability. Managing forests for ecological sustainability ensures the maintenance of the values that forests provide in the long term (e.g., timber, biodiversity, water quality, spirituality).

2. Use a hierarchy of scales when planning forest practices. A hierarchical approach to planning forest practices requires integrating management objectives and plans across a range of spatial and temporal scales. This ladder-like approach for planning forest practices allows us to use our knowledge of forest function and structure at the scale we best understand it and to set scale-specific management objectives.

3. Establish a rate-of-cut that does not compromise the long-term ecological integrity of landscapes and watersheds. The rate-of-cut has consequences for almost all other decisions regarding forest practices, from appropriate harvesting methods to the number of roads required. Therefore, it is important that the rate-of-cut be low enough to encourage ecologically sound decision-making. This requires that the rate-of-cut be an output of forest planning, rather than an input or constraint on planning.

4. Engage local communities and incorporate local knowledge in establishing decision-making processes and in planning forest management. The communities nearest the forests are the most affected by forest practices. Meaningful involvement of local communities and their knowledge, in particular that of First Nations, in establishing decision-making processes and planning for the management of nearby forests increases the likelihood of ecologically sustainable decisions. Forest-dependent communities have a greater immediate incentive to consider the long-term consequences of forest management and a greater stake in sustainable forest practices. First Nations people have an especially important role in this regard. The cultures and traditional knowledge of First Nations have evolved for thousands of years in conjunction with the ecosystems upon which they rely. The substantial knowledge and spiritual wisdom of long-resident peoples are a critical requirement for the sustainability of ecosystems.

5. Conserve all native species and their habitats within the range of natural variability. Conserving biodiversity in managed forests requires maintaining viable populations of all native species. Current scientific evidence strongly suggests combining a coarse-filter and fine-filter approach to achieve this goal. The coarse-filter, or ecosystem-level, approach requires that forest practices resemble natural disturbances and maintain forest structure, function and composition within the range of variability that occurs naturally, at multiple scales of time and space. The fine-filter, or species-level, approach requires tailored conservation efforts directed at individual species. Priority for these efforts should fall to rare, threatened, endangered and keystone species.

6. Protect hydroriparian areas and functions. Streams and other water bodies, together with their associated riparian areas, are essential for the health and function of forests. Hydroriparian areas link land and water and are among the most biologically productive and diverse sites in the forest. The functions they provide (e.g., shading and fertilization of streams, inputs of coarse and fine woody debris, bank stability) are critical for overall forest functioning and biodiversity. Logging and road-building can seriously affect these areas and reduce their ability to provide these functions.

7. Focus silvicultural systems primarily on what is retained rather than on what is removed. This means retaining attributes of unmanaged forests in managed forests at many spatial and temporal scales. For example, landscape-level attributes such as forest connectivity and diversity of forest ages and types are critical to maintaining biodiversity and ecosystem integrity. At the stand level, attributes such as snags and large living trees are important for retaining habitat and ecological functions in harvested areas. Ecologically sustainable forest practices focus on what is best left behind to ensure that forests remain biologically diverse and productive.

8. Incorporate ecological restoration of degraded landscapes, stands and sites into forest management. In many places, inappropriate forest practices have resulted in forests that no longer function as intact ecosystems. Restoring the ecological functions of degraded landscapes, stands and sites is a key element of sustainability. It is important that restoration be integrated into the culture and decision-making processes of forest management so that the productivity and diversity of forests are maintained in the long term.

9. Acknowledge uncertainty and monitor the ecological consequences of forest practices. Current science is unable to answer many questions about the ecological impact of our forest practices. Given this uncertainty, scientists recommend following the "precautionary principle," which states that when an activity threatens the environment, precautionary measures should be taken even if some causal relationships are not fully established scientifically. Uncertainty also requires adopting an adaptive management framework that allows rigorous learning by doing.

Acknowledgements

This report is the result of collaboration. The input of the Advisory Team was particularly important. Their participation considerably improved the accuracy and depth of this report and was instrumental in creating a report that, in my opinion, reflects a balanced and rigorous perspective of what is necessary for ecologically sustainable management of British Columbia's coastal forests. My sincere thanks goes to them for taking time from their busy schedules and for their insightful comments. The responsibility of any remaining errors or omissions is mine alone.

My fellow staff members at the David Suzuki Foundation were key to the completion of this report – I am especially thankful to Candace Batycki, Cheri Burda, Sarah Frazer, Elizabeth Godley, Jim Fulton, Jean Kavanagh, Siân Messinger, Ann Rowan and Kim Wright. I also thank Meredith Brown, Brigitte Dorner, Joseph Fall and Carmen Wong for, as always, being an excellent sounding board. The map of ecological sub-units is the result of Jim Pojar's input and Marcel Pepin's GIS expertise. Bill Beese provided photos of Weyerhaeuser's Variable Retention treatments on Haida Gwaii. Thanks to Arifin Graham, Dave Butcher and Andrew Kielbowicz for the design and layout of this report.

Table of contents

Introduction

The fate of the coastal temperate rainforests of the central and north coast of British Columbia (B.C.) is in dispute. First Nations of the region, environmental organizations, forest companies and labour unions, as well as the federal, provincial and municipal governments, are involved in a confusing array of land-use planning processes, treaty negotiations and shifting tenure agreements. The integration and resolution of these various processes and agreements will undoubtedly have important consequences for people and the environment – the cultural and biological diversity – of this relatively pristine region.

In March, 2000, the David Suzuki Foundation (DSF) organized a millennium conference called *Turning Point*. Chiefs, councillors and elders from First Nation communities and Tribal Councils of B.C.'s central and north coast, including Haida Gwaii (Queen Charlotte Islands), gathered to discuss current land- and resource-management issues and the sustainability of First Nation coastal communities. The purpose of the conference was:

> *"to determine if the central and north coast First Nations can establish a framework to deal with land- and resource-management issues and community viability and sustainability based upon shared principles and common ground and, if so, to initially draft a Declaration for consideration by these coastal First Nations"* (Gordon and others, 2000).

At the close of the conference, the DSF committed to produce a set of science-based principles to guide forest managers towards ecological sustainability in First Nation traditional territories on B.C.'s central and north coast. These principles may also guide a wider audience – essentially anyone interested in the management and ecological sustainability of coastal temperate rainforests.

Report objectives

The objectives of this report are to:

i. outline guiding principles for ecologically sustainable forest practices on B.C.'s central and north coast;
ii. offer examples of best practices in similar ecosystems;
iii. provide an overview of current practices and regulations in B.C.; and
iv. identify knowledge gaps and areas of uncertainty.

The underlying goal of these principles is to guide human behaviour with respect to forest planning and practices. In other words, these principles are designed to address the management of people, rather than forests, towards ecological sustainability (e.g., Burda and others, 1997; M'Gonigle, 1998). Forests are complex self-organizing systems that have the capacity to sustain themselves.

Terminology

Ecological sustainability

In this report, **ecological sustainability** is defined as the maintenance of biological diversity and ecosystem integrity at multiple scales of time and space (Scientific Panel, 1995). **Biological diversity** (or biodiversity) is the variety of plants, animals and other living organisms in all their forms and levels of organization, from genes to species to ecosystems, and the evolutionary processes (e.g., natural selection and mutation) and functional processes (e.g., predation, competition and nutrient cycling) that link them (Scientific Panel, 1995; MacKinnon, 1998; Purvis and Hector, 2000). **Ecosystem integrity** refers to the soundness of the evolutionary and functional processes and organisms comprising an ecosystem. Ecosystem

Table of Acronyms

AAC	Allowable Annual Cut
BEO	Biodiversity Emphasis Options
CAD	Conservation Area Design
CORE	Commission of Resources and the Environment
DSF	David Suzuki Foundation
EMP	Effectiveness Monitoring Program
FDP	Forest Development Plans
FPC	Forest Practices Code
FRBC	Forest Renewal British Columbia
LRMP	Land and Resource Management Planning
LTHL	Long Term Harvesting Level
LU	Landscape Unit
LWD	Large Woody Debris
MAI	Mean Annual Increment
MELP	Ministry of Environment, Lands, and Parks
NFMA	National Forest Management Act
RMA	Riparian Management Area
RMZ	Riparian Management Zone
RRZ	Riparian Reserve Zone
SFF	Silva Forest Foundation
SP	Silvicultural Prescription
TEK	Traditional Ecological Knowledge
TERP	Terrestrial Ecosystem Restoration Program
TFL	Tree Farm Licence
TML	Timber Management Landbase
TSA	Timber Supply Area
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
WHA	Wildlife Habitat Area
WRP	Watershed Restoration Program

integrity is maintained when an ecosystem is both resistant, i.e., has the capacity to absorb small disturbances and prevent them from amplifying into large disturbances, and resilient, i.e., has the capacity to return to a given level of productivity and species composition following a disturbance (Pimm, 1984; Perry, 1994; Scientific Panel, 1995; Folke and others, 1996).

Biological diversity and ecosystem integrity are "bridging concepts" (Ehrenfeld, 1992; Scientific Panel, 1995). These concepts are not strictly scientific; rather, they are concepts that *bridge* or *connect* social values and perceptions about the desired state of an ecosystem with scientific concepts about the state or properties of an ecosystem. For example, it is possible to measure the frequency and extent of landslides in a watershed before and after logging (and ideally in another similar control watershed where no logging occurs) and make scientific inferences about how logging alters the natural landslide regime of a watershed within the time scale of the observations. However, whether the ecosystem integrity of the logged watershed remains intact, i.e., whether the processes that provide slope stability remain sound, is open for interpretation and depends on where an individual makes the distinction between sound and unsound. Such openness is acceptable, since the science of forest management is ultimately a human endeavour that requires recognizing human objectives for the ecosystem being managed, even when attempts are made to ground forest practices in rigorous scientific principles (Scientific Panel, 1995).

Ecological sustainability is the fundamental dimension of the broader concept of sustainable forest management (Dale and others, 1999). However, in addition to ecology, sustainable forest management incorporates cultural, socio-economic and political dimensions (e.g., the sustainable use of energy resources during the harvesting and processing of wood, and the allocation of tenure and harvesting rights). The interaction of these dimensions shapes human behaviour in the forest and determines the consequences of this behaviour for ecological sustainability and the fulfillment of human needs in the long term. Because of the time and resources required to address the full diversity and breadth of issues that play a role in sustainable forest management, this report focuses only on the ecological dimension. The DSF firmly believes that ecological sustainability is the fundamental prerequisite for sustaining the cultural, social and economic values that forests can provide in perpetuity.

This report makes the implicit assumption that ecologically sustainable forest management must maintain the current structure and functions of the forests on B.C.'s coast. From the perspective of human use, this may not be a logical necessity, since many of the world's most productive ecosystems are highly modified by humans. However, in the context of coastal temperate rainforests, it remains doubtful whether forestry, as presently practiced, can sustain the current timber productivity of these forests, particularly in the long term and over multiple rotations.

Guiding Principles

The principles outlined in this report represent fundamental rules to follow when planning and implementing ecologically sustainable forest practices. No single principle can ensure ecological sustainability on its own. Rather, the principles are meant to be applied together; only their application in concert will help ensure the long-term maintenance of biodiversity and ecosystem integrity in managed forests.

These principles are strongly shaped by the recommendations of the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound (Scientific Panel, 1995). The Scientific Panel was formed in 1994 by the Government of B.C. on the request of the Commission on Resources and the Environment. The mandate of the Scientific Panel was to develop recommendations for sustaining the stability of local communities and the productivity and natural diversity of Clayoquot Sound, which lies on the west coast of Vancouver Island. Nineteen members sat on the Panel, 15 scientists from various fields (e.g., forest ecology, hydrology and wildlife biology) and four Nuu-Chah-Nulth elders. The Panel achieved full consensus on more than 100 recommendations regarding silvicultural systems, harvesting systems, transportation systems, scenic and tourism resources, planning for sustainable ecosystem management and monitoring. In July 1995, the B.C. government accepted the recommendations of the Panel with the promise to implement them fully.

In addition to the Scientific Panel recommendations, these principles are based on the sciences of landscape ecology, conservation biology and forest ecology, among others. Like the Scientific Panel recommendations, the principles invoke the *precautionary principle*. This principle states:

> "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof."
> (Ashford and others, 1998)

Following the precautionary principle means acknowledging the significant uncertainties present in managing natural systems and being cautious about forest practices when negative long-term consequences or irreversible changes to the forest ecosystem may result from forest practices (e.g., loss of site productivity due to logging in shallow soils or destruction of fish habitat from logging riparian areas) (Costanza and Cornwell, 1992; Scientific Panel, 1995).

Best practices

The sections on *best practices* provide examples that serve as models for how best to comply with the principle in question. Where possible, these examples of regulatory frameworks or on-the-ground practices were drawn from ecosystems similar to those of B.C.'s north coast. It is worth noting that best practices are site-specific and that the best practices outlined here comply with the principles *in general*. For example, best practices regarding the adequate protection of riparian areas and functions depend strongly on the watershed context of a planned harvesting practice (e.g., clearing of riparian vegetation). Regulated minimum widths for a streamside no-harvest zone may not always result in adequate protection of riparian functions, as some stream reaches may require wider margins than the prescribed minimum (e.g., sites with high windthrow hazard).

Current practices

For each principle, this section provides a brief overview of the relevant regulatory frameworks or on-the-ground practices in coastal British Columbia. These provide only a general picture; exemptions and variations are expected.

Areas of uncertainty

Areas of uncertainty are framed as questions that illustrate important gaps in ecological knowledge relevant to the principle under discussion. It is possible to answer these questions while managing the forest through **adaptive management** and applied research. Adaptive management is the systematic application of cumulated experience to improve management policies and practices (Holling, 1978; Walters, 1986; Walters and Holling, 1990). Based on the understanding that uncertainty is an inherent component of managing complex and dynamic natural systems, adaptive management allows for rigorous learning-by-doing by framing management as an experiment (Halbert, 1993; Ludwig and others, 1993). This innovative combination of management, research and monitoring allows the collection of credible information and the time- and cost-effective modification of management policies and practices (Walters and Holling, 1990; Ludwig and others, 1993; Scientific Panel, 1995).

Study Area

This report covers the area from sea level to alpine, north of Cape Caution to the Alaska Panhandle (Figure 1). Its eastern limits are the height of land of the Coast Mountains and its southern limits the watershed boundaries of Rivers Inlet and Oweekeno Lake. It includes Haida Gwaii. It is important to note that southeast Alaska and adjacent inland B.C. are ecologically very similar to the study area, making the principles developed here applicable there.

The human landscape

FIRST NATIONS

B.C.'s central and north coast is home to many First Nations. First Nations peoples have occupied the area for thousands of years and this region had, at the time of European contact, one of the highest densities of settlements found anywhere in North America (Sturtevant, 1978; Kellogg, 1995). Today, six coastal First Nations reside in the region: Haida, Tsimshian, Haisla, Heiltsuk, Nux̱alk and Oweekeno. Seven distinct languages are spoken: Haida, Tsimshian, Haisla, Heiltsuk, Nux̱alk, Sm'algynax and Oowekayla. First Nations peoples live primarily in small communities distributed throughout the study area – for example, Old Massett, Skidegate, Lax Kw'alaams, Metlakatla, Kitkatla, Kitamaat Village, Hartley Bay, Klemtu, Waglisla (Bella Bella), Bella Coola and Oweekeno. Their history, culture, spirituality and future well-being are inextricably intertwined with the waters, fish and forests of the coast. This interdependency makes ecologically sustainable forest management important not only for conserving biodiversity but also for the conservation of cultural diversity and integrity.

NON-INDIGENOUS PEOPLES

In addition to First Nations people, B.C.'s central and north coast is inhabited by non-indigenous peoples who live primarily in Prince Rupert, Queen Charlotte City, Sandspit, Shearwater, Hagensborg, Terrace and Kitimat. These communities are largely dependent on natural resources for employment and income. Their principal industries are commercial fisheries and industrial forestry, with an emerging tourism industry based on recreation and sport fishing. As with First Nations, but not necessarily in the same way, these communities depend on functional ecosystems for social and economic well-being in perpetuity.

The ecological landscape

Coastal temperate rainforests occupy less than one per cent of the Earth's surface. These are rich and diverse ecosystems, among the most biologically productive environments on the planet at temperate latitudes (Waring and Franklin, 1979; Cannings and Cannings, 1996). In North America, these forests previously ranged from central California to southern Alaska (Alaback, 1995; Kellogg, 1995). Nearly half of their range has been affected by forestry, farming or urbanization. What remains undeveloped is almost all within the study area and southeast Alaska (Kellogg, 1995). Unlogged landscapes in the study area are dominated by mature and old-growth forests that are diverse in structure, composition and ecosystem function (Broadhead and others, 1984; Lertzman and others, 1997; Pojar and others, 1999). From a global and regional perspective, this area offers unparalleled opportunities for the study and conservation of biodiversity (Kellogg, 1995; Salim and Ullsten, 1999; World Resources Institute, 2000).

ECOLOGICAL SUB-UNITS

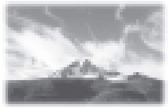
The study area can be divided into four distinct ecological sub-units: the Hecate Lowland, the Outer Coast Mountains, the Inner Coast Mountains and Haida Gwaii (Pojar and others, 1999; Pojar, J., personal communication; Figure 1). These ecological sub-units differ in climate and physical geography and are also differentiated by biogeoclimatic subzone within the Coastal Western Hemlock biogeoclimatic zone (Green and Klinka, 1994; Pojar and others, 1999). The other biogeoclimactic zones in the study area (e.g., Alpine Tundra and Mountain Hemlock) are not included in this classification of ecological sub-units as they are largely outside the productive forest land base and harvesting is usually not an issue in the forests of these zones (Pojar and others, 1999).

Generally, a west-to-east transition in climate exists, with the westernmost portion of the study area having a hypermaritime climate, shifting to maritime and submaritime as one travels east. Two mountain ranges have orographic influences on the patterns of precipitation: the Queen Charlotte Mountains and the Coast Mountains. These ranges typically create a wetter band to the west of their summits and a rainshadow effect to the east.

The environmental differences among these ecological sub-units are important to recognize when planning and implementing forest practices (Pojar and others, 1999). For example, the Outer Coast Mountains receive higher rainfall and have steeper topography than the Hecate Lowland, making landslides an important contributor to the natural disturbance regime of the Outer Coast Mountains. This means a higher standard of care is necessary in the Outer Coast Mountains during the planning and building of logging roads to minimize the potential for landslides.

HECATE LOWLAND

This hypermaritime landscape, stretching from Johnstone Strait to north of Prince Rupert (Pojar and others, 1999), is primarily low-elevation terrain



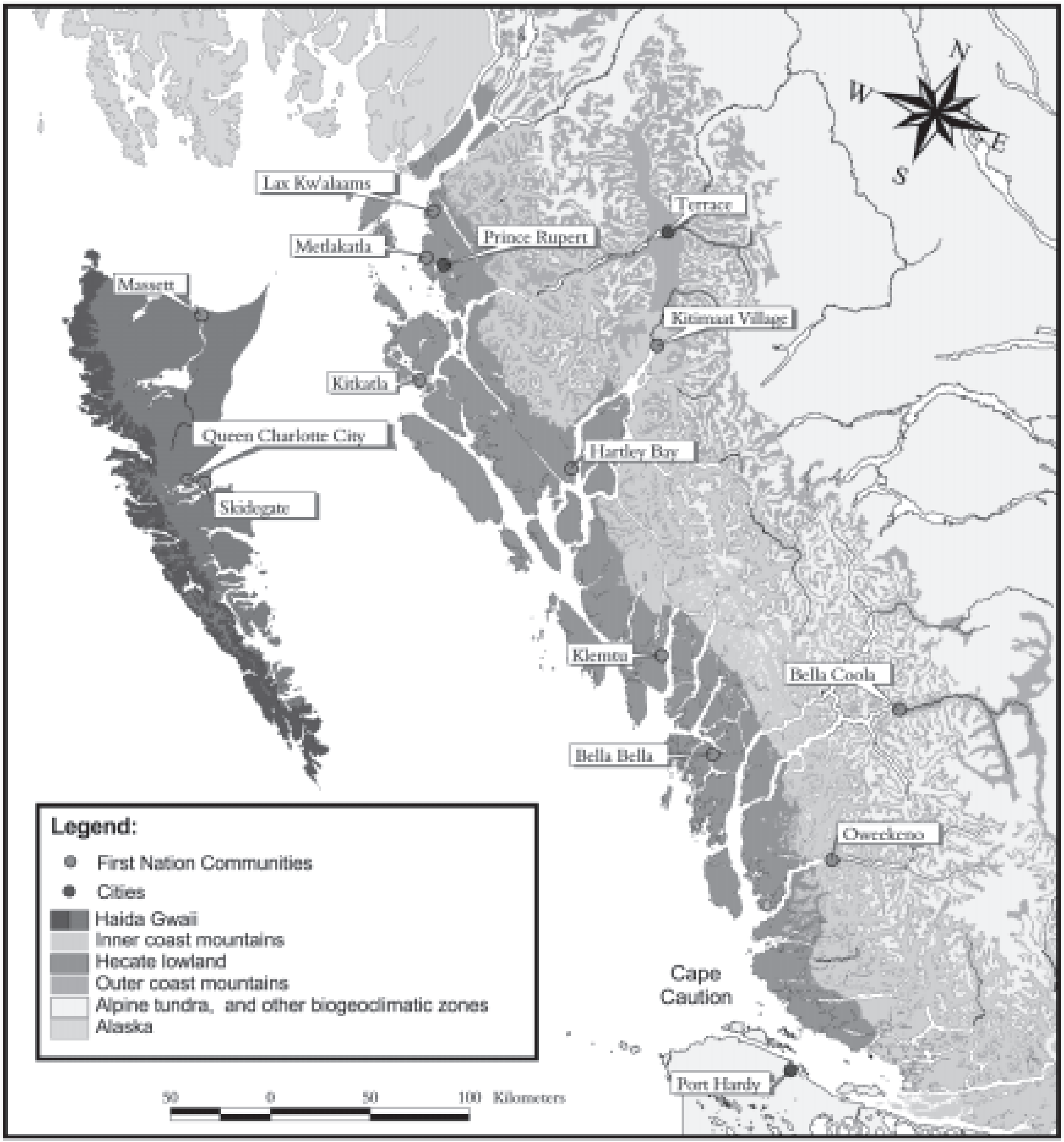


FIGURE 1.

Ecological sub-units of the central and north coast of B.C. Adapted from Pojar and others 1999. This figure roughly shows the distribution of the ecological sub-units. It is provided primarily to illustrate how physiography and climate interact to create distinguishable sub-units useful for regional-level planning. Care is necessary in using this map for any planning purposes. For example, the area designated as the Hecate Lowland likely extends too far inland – the eastern half of the area shown as Hecate Lowland contains much rolling and mountainous terrain with an ample supply of timber.

of undulating but rough topography. The climate is very mild, wet and cool, with abundant cloud cover, fog and drizzle and little persistent snowfall.

Large areas of lower-productivity forests are common, composed predominantly of Yellow Cedar (*Chamaecyparis nootkatensis*), Western Redcedar (*Thuja plicata*), Western Hemlock (*Tsuga heterophylla*) and Mountain Hemlock (*Tsuga mertensiana*) (Pojar and others, 1999). Productive forests of Western Hemlock, Sitka Spruce (*Picea sitchensis*), Amabilis Fir (*Abies amabilis*), Western Redcedar and Yellow Cedar occur on steep and well-drained slopes, on floodplains and on sites with soils of rich parent materials. Bogs and boggy forests of gnarled Shore Pine (*Pinus contorta*), Western Redcedar, Yellow Cedar and Western Hemlock are extensive on subdued terrain of poor drainage. Bogs and boggy forests form a landscape matrix dotted with small to medium patches of more productive forests.

Natural disturbances include windthrow, landslides, avalanches and floods (Pojar and others, 1999). They are typically small in scale and sometimes intense. Windthrow is occasionally extensive. Although industrial logging has historically been limited in this ecological sub-unit, considerable logging is taking place at present and more is planned.

OUTER COAST MOUNTAINS

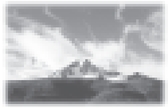
This sub-unit is wet and mountainous, with deep fjords covered in thick forests (Pojar and others, 1999). Terrain is rugged and many valleys have steep walls and abundant slide tracks from avalanches and debris slides. Valley bottoms are often broad with large riparian areas. The maritime climate is mild, very wet and cool. Winter storms from November to March can bring as much as five metres of rainfall each year (Green and Klinka, 1994). This precipitation accumulates as thick, often persistent, snowpacks at higher elevations.

The forest cover is predominantly Western Hemlock and Amabilis Fir (Pojar and others, 1999). Western Redcedar is also an important but variable component in the species mix of these forests. Many hemlock and fir trees in older stands are quite decayed, prompting the industrial nomenclature “decadent hembal” (i.e., hemlock-balsam or hembal). Sitka Spruce is abundant on valley bottoms and Yellow Cedar is common at higher elevations.

Natural disturbances are frequent, low-intensity and small-scale (Pojar and others, 1999). Typically, the death of single or small groups of trees by lightning, disease or windthrow creates gaps in the forest canopy. The creation and eventual closure of canopy gaps results in a shifting mosaic of forest openings across the landscape (Lertzman and others,1996). This sub-unit has been moderately logged in an uneven fashion, with certain watersheds heavily logged by progressive clearcutting (e.g., Clyak River in Moses Inlet and Farquar Creek on King Island).

INNER COAST MOUNTAINS

The Inner Coast Mountains are a rugged and variable landscape (Pojar and others, 1999). Much of the terrain is steep and extreme, although some of the larger valleys have extensive intermediate slopes and operable land. The climate is transitional between coastal and interior, ranging from relatively dry in the inland valleys to moist in the inner fjordland at lower elevations and wet at middle and upper elevations. Warm, dry spells occur during summer, accompanied by moisture



stress and wildfire in some areas. Snowpacks are moderate to heavy, often persisting well into spring.

Western Hemlock and Western Redcedar dominate the forests of the Inner Coast Mountains (Pojar and others, 1999). From Kemano south, Douglas-fir (*Pseudotsuga menziesii*) becomes part of the species mix at low elevations and on warm aspects, especially further inland. Amabilis Fir is common at middle to high elevations.

These transitional forests have a broad mix of natural disturbances (Pojar and others, 1999). The type and scale depend on elevation, terrain and distance from the ocean. Generally, small-scale, low-intensity, gap-forming disturbances are common in the wet upper elevations, while large-scale, intense wildfires burn in the drier lower elevations. The Inner Coast Mountains have been relatively heavily logged, with most valleys having been logged at least once.

HAIDA GWAII

Haida Gwaii is an archipelago of more than 150 islands (B.C. Ministry of Forests, 2000). Its hypermaritime climate is cool and wet, with little snowfall at low elevations and frequent fog, clouds and drizzle (Green and Klinka, 1994). The Queen Charlotte Mountains create a rainshadow that divides this sub-unit into a very wet western half and a wet eastern half (Pojar, J., personal communication).

The eastern half coincides roughly with the Queen Charlotte Lowland and the Skidegate Plateau. The Queen Charlotte Lowland is quite similar to the Hecate Lowland, with extensive low-elevation, poorly drained terrain covered with bogs and unproductive forests. The Skidegate Plateau, however, has greater relief and much more productive forest land. Occasional dry summertime periods occur (Green and Klinka, 1994).

The western half of this sub-unit consists of the windward side of the Queen Charlotte Mountains, except on South Moresby Island, where it covers most of the area. Precipitation is heavy but highly variable, reflecting the variation in elevation and its effects on the way air masses rise over the mountains.

Haida Gwaii has unique forest vegetation, reflecting its distinct evolutionary history and the legacies of glacial refugia, as well as widespread overbrowsing by introduced deer (Broadhead and others, 1984; Byun and others, 1997). Forests are dominated by Western Hemlock, Western Redcedar, Sitka Spruce and Yellow Cedar, in decreasing order of abundance. Neither true firs (*Abies* spp.) nor Black Cottonwood (*Populus balsamifera* ssp. *trichocarpa*) occur naturally on the islands.

Natural disturbances on Haida Gwaii are typically small-scale and gap-forming (B.C. Ministry of Forests, 2000), although windthrow and landslides are sometimes extensive in more exposed or unstable areas, especially on the west side. Logging has been intense and extensive on Haida Gwaii, especially on the northeast side of Moresby Island and south of Masset Inlet on Graham Island.

BIOTA

A comprehensive description of the rich and varied biota of the central and north coast is outside the scope of this report. However, it is possible to generalize the following:

- the vast majority of the biota of this region is in some way associated with forests (Bunnell and Chan-McCloud, 1997);

- the diversity of life depends on maintaining forests of different ages and types;
- different organisms vary in their capacity to adapt to the impacts of conventional industrial forestry (Bunnell, 1995; Pojar and others, 1999). Canopy insects and lichens, for example, are more sensitive to conventional forestry than are deer and other ungulates; and,
- both on Haida Gwaii and the coastal mainland, the biotic inventory is far from complete.

Deciduous trees

In addition to the coniferous tree species listed above, B.C.'s central and north coast is home to various deciduous tree species (Pojar and others, 1999). Red Alder (*Alnus rubra*) is widespread and abundant, especially in disturbed sites and riparian areas in the western portion of the region. Black Cottonwood is the dominant species in alluvial forests along the large rivers in the eastern portion of the region. Paper Birch (*Betula papyrifera*) occurs in mixed stands in dry rocky or moist well-drained areas, increasing in abundance in the inland valleys. Trembling Aspen (*Populus tremuloides*) is found only occasionally on drier sites near the eastern portion of the region.

Non-vascular flora, lichens, fungi and microbes

The importance of these organisms for the ecological functions and biodiversity of B.C.'s coastal forests should not be understated (Scientific Panel, 1995). For example, mosses contribute strongly to the water-retaining capacity of the forest floor and are an important component of soil organic matter. Underground fungal networks, along with soil microfauna, algae and bacteria, are integral to tree growth, decomposition, nitrogen fixation and nutrient cycling (Pojar and others, 1999).

Fauna

As with the biota in general, the majority of animals in this region are in some way associated with forests. Invertebrates make up most of the terrestrial animal biomass of these forests and contribute significantly to soil processes and a variety of ecosystem functions (Pojar and others, 1999). The vertebrate fauna is rich and diverse. Many large mammals are sparsely distributed and have large home ranges – for example, Grizzly Bears (*Ursus arctos*), Black Bears (*Ursus americanus*), Kermode Bears (*Ursus americanus kermodei*) and Mountain Goats (*Oreamnos americanus*). Certain species are dependant upon and sensitive to the maintenance of forested conditions and intact riparian areas and estuaries – for instance, salmon, bears, and many bird species (Bunnell, 1995; Bunnell and others, 1997; Pojar and others, 1999).

Haida Gwaii has a distinct fauna (and flora) from the coastal mainland. The presence of ice-free refugia during the most recent glaciation and thousands of years of isolation from the mainland have resulted in the divergent evolution of a unique, impoverished relative to the mainland, set of animals and plants (Broadhead and others, 1984; Scudder and Gessler, 1989; Byun and others, 1997; Byun and others, 1999). Many species common on the mainland are not found here, or have evolved as unique subspecies (Scudder and Gessler, 1989; Byun and others, 1997).

GUIDING PRINCIPLES

P R I N C I P L E 1

Make ecological sustainability the fundamental objective of forest management

Rationale

Ecological sustainability is fundamental to social and economic sustainability for present and future generations (Dale and others, 1999; Christensen and others, 1996; Pearse, 1998). In the long term, human life simply cannot continue without sustaining ecosystems (Grumbine, 1994; 1997). Healthy forests provide products and services[1] that help maintain healthy and stable human communities (Scientific Panel, 1995; Pearse, 1998). Perhaps equally important to maintaining social and economic benefits in perpetuity, managing forests for ecological sustainability also allows the well-being of other forest-dependent species – species with intrinsic value, regardless of human needs or wants.

Uncertainty is an important impetus for striving to achieve ecological sustainability in managed forests. There is much scientific ignorance about many of the ecological processes and patterns of coastal temperate rainforests and much uncertainty about the ecological impacts of the current rate and scale of forestry operations (Pojar and others, 1999; Scientific Panel, 1995). This uncertainty makes it difficult to rigorously decide which ecosystem elements to favour in our management efforts, thereby making it prudent to give ecosystem integrity precedence over any other management objective (Grumbine, 1994; 1997).

It is important that governments and other regulatory agencies acknowledge ecological sustainability as a fundamental objective of forest management (Grumbine, 1994; 1997; Burda and others, 1997; Dobell, 1998; M'Gonigle, 1998; Dale and others, 1999). Other management objectives must be subordinate to maintaining the integrity of forest ecosystems. To this end, regulatory agencies must implement policies that create incentives for users of the forest to act in ecologically sustainable ways and disincentives for ecologically unsustainable behaviour (Folke and others, 1996; Gibson and others, 1998; Scarfe, 1998). In short, regulatory agencies must manage forests as ecosystems, rather than as commodities (Scientific Panel, 1995; Costanza and others, 2000). This requires planning and implementing forest practices that maintain the ecosystem components and processes that allow the land, water and air to sustain life, productivity and the capacity to adapt to change (Scientific Panel, 1995).

Best practices

Proposed Planning Rule for the National Forest System

The Forest Service of the United States Department of Agriculture is responsible for the management of the National Forest System[2]. The National Forest System's protocols for planning forest and range management are outlined in the *National Forest Management Act (NFMA)*. Until recently, this act, along with the *Multiple-Use Sustained-Yield Act*, mandated management of the National Forests for a variety of uses on a sustained-yield basis to ensure a continued supply of products and services in perpetuity.

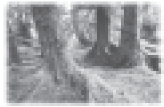
As a response to the continuing conflict amongst users of National Forests, in October 1999, the Forest Service proposed amending the *NFMA* by incorporating a new Planning Rule (Mann and Plumber, 1999; Paul, 2000). This Planning Rule makes ecological sustainability the foundation for the planning and management of the National Forest System (USDA Forest Service, 1999). In addition, this rule focuses planning efforts on what is left behind by forest management activities, rather than on what is taken. As a consequence of this, the primary goal of the draft Strategic Plan for the year 2000 and onward is to promote "ecosystem health and conservation using a collaborative approach to sustain the nation's forests, rangelands and watersheds" (USDA Forest Service, 2000)[3].

Pennsylvania Bureau of Forestry's Mission Statement

In addition to the commitment to ecological sustainability shown at the national level in the United States, commitment to ecological sustainability also exists at the state level. In Pennsylvania, for example, a conservation ethic is written into Article 1, Section 27 of the Pennsylvania Constitution:

> *"Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."*

The Bureau of Forestry, Department of Conservation and Natural Resources, is responsible for managing the state forest system[4]. Its mission is to ensure the long-term health, viability and productivity of the Commonwealth's forests and to conserve native wild plants (Pennsylvania Bureau of Forestry, 2000). The Bureau of Forestry endeavours to meet this goal by managing forests under sound ecosystem-based management to retain their wild character and maintain biological diversity. Other management goals include: providing pure water, opportunities for low-density recreation, habitats for forest plants and animals, sustained yields of quality timber and



environmentally sound utilization of mineral resources. The practices within and products of the Pennsylvania State Forests are certified by the Forest Stewardship Council[5] (Forest Stewardship Council-United States, 2000).

Current practices

Under the Canadian Constitution, forest management in British Columbia is the responsibility of the provincial government. Roughly 95 per cent of the approximately 46 million hectares of productive forest land in British Columbia is managed by the B.C. Ministry of Forests[6] (Jones, 1990; Marchak and others, 1999). The overarching management objectives and policy direction for the B.C. Ministry of Forests are set out in the *Ministry of Forests Act*. Section 4 states:

> *"The purposes and functions of the ministry are, under the direction of the minister, to do the following:*
>
> (a) *encourage maximum productivity of the forest and range resources in British Columbia;*
>
> (b) *manage, protect and conserve the forest and range resources of the government, having regard to the immediate and long-term economic and social benefits they may confer on British Columbia;*
>
> (c) *plan the use of the forest and range resources of the government, so that the production of timber and forage, the harvesting of timber, the grazing of livestock and the realization of fisheries, wildlife, water, outdoor recreation and other natural resource values are coordinated and integrated, in consultation and cooperation with other ministries and agencies of the government and with the private sector;*
>
> (d) *encourage a vigorous, efficient and world competitive timber-processing industry in British Columbia;*
>
> (e) *assert the financial interest of the government in its forest and range resources in a systematic and equitable manner."*

These purposes and functions translate into a mandate of managing for many uses, including timber, recreation, forage and wilderness and, in cooperation with other agencies, for water, fish, wildlife, tourism, heritage, energy and minerals (B.C. Ministry of Forests, 2000). In practice, the primary focus of this multiple-use mandate has been the production of timber to provide social and economic benefits for the people and forest industries of British Columbia (Forest Resources Commission, 1991; Marchak and others, 1999).

Although ecological sustainability is an important management consideration, it is not the fundamental objective of the B.C. Ministry of Forests. This is illustrated by the arbitrary constraints imposed for biodiversity regulations on the provincial timber supply. The management of biodiversity and ecosystem integrity is partly the responsibility of the Forest Practices Code, a system of laws, regulations, standards and guide books established in 1995 to regulate forest practices. The recently released Landscape Unit Planning Guide is the key component of the Forest Practices Code with regard to biodiversity management.

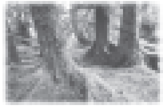
The impact of these biodiversity objectives on provincial timber supply is not permitted to exceed 4.1 per cent of the allowable annual cut in the short term and 4.3 per cent in the long term (Pedersen and others, 1999). A similar cap exists (1 per cent) for the impacts on timber supply resulting from the regulations of the Identified Wildlife Management Strategy. These arbitrary caps pose a serious obstacle to striking a balance among the varied mandates of the ministry, and for achieving ecological sustainability.

Areas of uncertainty

Where are the limits of ecological sustainability? How do we know if they have been exceeded? Ecologists propose that ecological limits are exceeded when either habitats or ecological processes are degraded (Perry, 1994). Habitat degradation occurs when an area no longer has the elements of forest structure that a given species depends on for survival. For example, logging forests on short rotations eliminates and prevents the formation of the deep mossy mats on large old trees that Marbled Murrelets (*Brachyramphus marmoratus*) use as nesting sites (Rodway and others, 1992i 1993; Manley, 1999). An example of a degraded ecological process is the loss of productive capacity in a forest, i.e., when a forest does not return to the same level of biomass and leaf area that was present before harvest, or does so unusually slowly (Perry, 1994). Other examples of degraded processes include the reduced ability of forests to retain limiting nutrients, to store and cycle water or to resist pathogens or insect outbreaks (Perry, 1994).

Is it therefore possible to define the limits of ecological sustainability by tracking changes in habitat or ecological processes? It is indeed possible for forest managers to measure and monitor the effects of forest practices on a set of credible criteria regarding various aspects of forest habitat and ecological processes (e.g., quantity of available habitat for old-growth dependent species, frequency and extent of landslides, internodal growth of trees) (Grumbine, 1997; Pojar and others, 1999). The uncertainty lies in what set of criteria best measures ecological sustainability and where the thresholds of sustainability occur.

Forest managers can establish the ecological limits of forested landscapes by setting thresholds of physical and hydrological processes. Exceeding these thresholds would have undesirable ecological consequences. It is possible to map areas that, by various criteria, are too sensitive to human disturbances to warrant any timber management (Hammond and others, 1996). Sensitive areas can be classified and mapped based on a combination of physical factors such as slope gradient, soil depth and moisture and complexity of terrain. Setting the thresholds of how these physical factors combine to create areas too sensitive for disturbance is an exercise not based exclusively on objective determinations of ecological impacts, but rather on a philosophy of ecosystem conservation (Hammond and others, 1996; Costanza and others, 2000).



NOTES TO PRINCIPLE 1

1 Ecosystem products include timber, medicinal plants, food, tourism and recreation. Ecosystem services include maintaining hydrological cycles, regulating climate, storing and cycling nutrients, generating and maintaining soils, absorbing pollutants and providing beauty, inspiration and spiritual values (Christensen and others, 1996).

2 The National Forest System comprises 155 national forests, 20 national grasslands and various other lands (USDA Forest Service, 1999). These lands encompass over 192 million acres (76.8 million hectares) in 42 states, the Virgin Islands and Puerto Rico.

3 More information about the Planning Rule is available at: http://www.fs.fed.us/forum/nepa/rule

4 The Pennsylvania state forest system encompasses 2.2 million acres (0.9 million hectares) of cherry, oak and maple forests.

5 The Forest Stewardship Council (FSC) is a non-profit, non-governmental organization established to support environmentally sound, socially-beneficial and economically viable forest management, as well as the labelling and marketing of forest products from such forests.

6 Also known as the B.C. Forest Service, the branch of the B.C. Ministry of Forests charged with forest management.

PRINCIPLE 2

Use a **hierarchy of scales** when planning forest practices

Rationale

Planning forest practices in a hierarchy of scales across space and time allows various ecological processes and features to be addressed at the appropriate scale (Scientific Panel, 1995). Different ecological processes and features occur and are best understood at different scales of space and time (Levin, 1992). For example, the foraging behaviour of the Mountain Beaver (*Aplodontia rufa*) is best understood by following these animals in a small area outside their burrow, as Mountain Beavers rarely travel more than 25 metres in search of fern fronds and other delicacies (Smurthwaite, 1992; Cannings and Cannings, 1996). In contrast, to understand the foraging behaviour of Grizzly Bears requires tracking these animals over hundreds of hectares, from the alpine to valley bottoms, in their search for salmon, ground squirrels and berries (Hewitt and Robbins, 1996; Mowat and Strobeck, 2000).

The same reasoning applies to temporal scales. For example, understanding how a burned area is colonized by seed rain from adjacent trees can involve a temporal scale of only a few years, whereas understanding the successional pathway[1] needed to establish an old-growth forest involves a temporal scale of several hundred to a thousand years. Using multiple scales in forest planning allows incorporation of ecosystem processes and features at the scale these processes and features are best understood (Levin, 1992).

Using a hierarchy of scales requires a top-down approach (Scientific Panel, 1995; Eng, 1998). Planning starts at the scale of an ecologically defined region (e.g., Haida Gwaii), progresses downward to a sub-regional level (e.g., Banks Island), to a watershed level, and then finally to a site or stand level. In theory, planning can continue at the scale of a single tree (e.g., to manage for wildlife trees) (Eng, 1998; Perera and Euler, 2000). Each scale defines the scale beneath it. For example, site-level planning can only determine what silvicultural system is appropriate after watershed-level planning determines the sites where harvesting can occur (Scientific Panel, 1995; Eng, 1998; Perera and Euler, 2000). A multiple-scale approach to planning allows specific management objectives to be set at the scale at which they are most appropriate (Scientific Panel, 1995). This planning process is iterative, allowing information from lower levels to inform higher levels (e.g., protection of cultural values at the watershed level by identifying and protecting individual sites or features).

Best practices

Clayoquot Sound Scientific Panel Planning Framework

The Scientific Panel recognized four levels of planning: regional, sub-regional, watershed and site (Scientific Panel, 1995). It is critical that each level be addressed in the planning of forest practices. The **regional level** delineates areas that are physiographically, ecologically and operationally similar (e.g., Figure 1) and addresses regional land-use allocation and objectives (Scientific Panel, 1995). This is also the scale at which to set broad sustainability objectives and identify large areas for conservation. Regional planning involves areas of between 100,000 to millions of hectares and temporal scales in the hundreds to thousands of years.

Physiographic provinces define the **sub-regional level** of planning. This level considers issues and resources that span extensive areas and sets the context for watershed-level plans. More specific sub-regional planning objectives include:

1. To identify watershed-level planning units.
2. To integrate reserves established during watershed-level planning with known land-use zones (e.g., protected areas) in order to establish an adequate network of reserves. This network should retain a mosaic of forest patches at different seral[2] stages and make gradual transitions among them (Harrison and Voller, 1998).
3. To assess and plan for resources such as scenery, recreation and other values that cannot be addressed adequately at only the watershed level. This is the scale to plan for the habitat of animals with large home-ranges, such as Grizzly Bears, and for planning landscape connectivity[3] and dealing with the issue of fragmentation and its consequences for habitat and species loss (Franklin, 1993). This is also the relevant scale for identifying and planning the appropriate level of protection of culturally important areas for First Nations.
4. To plan linkages among watershed-level planning units (e.g., corridors for biological diversity) and for road and water transportation.
5. To estimate the anticipated harvest level from area-based, watershed-level plans. This allows estimating timber volume over time.
6. To coordinate monitoring for sub-regional, watershed and site-levels.

Sub-regional planning involves planning units that are between 10,000 hectares and many hundreds of thousands of hectares. It uses time scales of hundreds of years. This is the relevant temporal scale for setting rotation periods that will allow processes that require hundreds to thousands of years to recover (e.g., the establishment of canopy soil layers that enhance the diversity of arthropod species in the tree tops; Winchester, 1999). The Panel recommended major revisions of sub-regional plans every 10 years.

The **watershed level** is key for successful long-term planning of ecologically sustainable forest management. It is within individual watershed planning units that the cumulative effects of land use degrade and create stress on forest ecosystems, as a result of changes in the flow and quality of water and changes in the access to water for various organisms (Scientific Panel, 1995). Stress also occurs through changes in extent, structure and fragmentation of habitat (Harrison and Voller, 1998). Therefore, to ensure the protection of ecosystem integrity and biodiversity, adequate reserves must be identified at the watershed level.

The objectives of watershed-level planning are:

1. To identify and describe the environmental resources, from timber to habitat, along with cultural, scenic and recreational values in the planning unit.
2. To map "reserve" areas within the watershed that:
   - maintain both watershed integrity and the habitats of aquatic and terrestrial organisms (e.g., hydroriparian ecosystems, unstable terrain, habitat of rare, threatened or endangered species, and rare communities and ecosystems),
   - are of special significance to First Nations, and
   - have high recreational or scenic value.
3. To map "harvestable" areas where forest harvesting does not compromise the above.
4. To develop management plans for harvestable areas that respect the sensitivities of resources. This includes determining an appropriate watershed-specific rate-of-cut within the harvestable areas, identifying post-harvest management and restoration activities and projecting an appropriate pattern of forest roads. Road density is a critical variable in the planning of forest practices compatible with the conservation of biodiversity[4]. For example, many mammals are strongly affected by high road densities (e.g., Grizzly Bears, Black Bears and Wolverines) (Groom and others, 1999; Trombulak and Frissell, 2000). These management plans should incorporate a long-term perspective that considers the utilization and conservation of resources in an integrated fashion (e.g., distribution of seral stages over time and space and the effects on habitat, hydrological integrity and other values).
5. To identify species especially sensitive to human disturbance, map their habitat and avoid these during forest development.
6. To design and implement a monitoring program to determine whether practices meet management objectives.

Watershed-level planning applies to a single watershed or a group of watersheds. Typically, it will include one or more primary watersheds[5]. Units of watershed-level planning are between 5,000 and 35,000 hectares and use a time scale of

100 years, showing projected activities in 10-year increments. Revisions should take place every five years.

Site-level planning includes a variety of sites and management practices (Scientific Panel, 1995). Sites may be areas allocated for logging, recreation or wildlife management. Therefore, the area defined as a unit for site-level planning will vary with the type of use being planned. Units established for logging or stand-tending activities (e.g., fertilization or thinning) must be within the boundaries of harvestable areas determined at the watershed level. The objectives of site-level planning include:

1. To identify smaller features not identified at the watershed level that require protection (e.g., ephemeral streams, wildlife trees, and culturally important features such as Culturally Modified Trees).
2. To ensure that planned activities at individual sites are well integrated with other existing and potential sites.

In sites proposed for logging, further objectives are:

3. To identify the precise location of roads and cut-block boundaries.
4. To determine the silvicultural prescription, including the level(s) of retention of forest structure and habitat.
5. To specify the harvesting method(s) and any seasonal constraints on harvesting.
6. To identify any other specific constraints on road-building and logging.

Site-level planning units range in size from one hectare to tens of hectares. They may be larger if required to meet ecosystem-based management objectives. The time scale of site-level planning is 10 years, with planning typically starting five or more years ahead of the work and with yearly revisions during active operations.

Current practices

Currently, planning of forest practices in British Columbia occurs at a variety of scales. In general, the boundaries of planning units at different scales are a political and ecological mix. The degree of integration among planning scales varies depending on the scales in question. The broadest scale is set by the provincial *Ministry of Forests Act* and the *Forest Act*. The *Ministry of Forests Act* outlines the mandate of the Ministry of Forests to manage the provincial forest on behalf of the public, and the *Forest Act* clarifies the position of the government and licensees, detailing the rights and responsibilities of each party.

At the regional level, the Government of British Columbia created the Commission on Resources and the Environment (CORE) in 1992 to provide the government with advice on land-use and resource and environmental issues through community participation and consensus-based decision-making. As a result, the CORE process developed regional-level plans and maps, a process that had a 12 per cent area-based cap on the designation of protected areas. The maps used data of landscape attributes (e.g., ungulate winter range, topography and timber volume) and were instrumental in influencing the decisions made at CORE tables (B.C. Ministry of Forests, 2000).

The CORE process was a difficult one; only three regions completed discussions, none of them in the study area.

The Land and Resource Management Planning (LRMP) tables have a narrower context and more direct bureaucratic control than the CORE process. LRMP tables use a consensus-based multi-stakeholder process[6] that divides public land into zones and determines the best use within each zone, ranging from commercial harvest to park creation. The LRMP process focuses on sub-regions of the province and expresses the goals of local communities and the province in general (B.C. Ministry of Forests, 2000). Although some areas have completed the LRMP processes, many more are not yet finished (e.g., the Mid-Coast LRMP). This creates a problem, largely on paper, when licencees operate without the benefit of higher level plans, a requirement of the Forest Practices Code.

Five-year Forest Development Plans (FDP) must be devised for all area- or volume-based tenures. These tenures range from very small woodlots to very large Tree Farm Licenses. FDPs include information regarding wildlife habitat and soil stability, as well as maps of landscape elements within an FDP area. FDPs are submitted to and reviewed by the manager in each Forest District. Five-year FDPs usually encompass the entire tenure area and must include LRMP information. Cutting permits follow the approval of these plans and transfer the rights to timber from the provincial Crown to the licensee. This five-year scale is the primary planning horizon for licencees, as no other detailed plans are required that have longer time horizons.

Silvicultural Prescriptions (SPs) detail the actions to be taken in the stand. These actions include building secondary roads, harvesting trees, preparing the site for regeneration, replanting new crop species and applying herbicides, pesticides or fertilizers, along with plans for thinning, pruning or spacing and road deactivation. SPs also include information on wildlife trees, retained forest patches and riparian reserves.

Areas of uncertainty

How are disparate management objectives efficiently integrated into planning across and within different scales? Forest managers must often balance multiple management objectives that sometimes conflict among different scales. For example, managers must meet previously determined targets for the allowable annual cut while simultaneously retaining large old trees in cutblocks and riparian areas and maintaining connectivity of forested landscapes. Moreover, the multiple management agencies often have artificial jurisdictional boundaries and conflicting objectives. For example, wildlife management is primarily the responsibility of the B.C. Ministry of Environment, Lands and Parks, while the management of the habitat of these species falls to the Ministry of Forests – a distinction that makes little ecological sense given the interconnections between habitat availability and population dynamics. It is therefore essential to identify regulatory conflicts and find ways to coherently integrate the objectives of multiple agencies into planning forest practices. Failing to integrate planning across scales can have unintended consequences (e.g., if watershed-level planning is inadequate, stand-level planning will likely have unintended watershed-level consequences).

NOTES TO PRINCIPLE 2

1 The term *successional pathway*, or *succession*, refers to a roughly predictable pattern of forest development that begins with a disturbance such as a wildfire and culminates when a stand reaches old-growth stage. Ecologists typically recognize the following successional stages: stand initiation, stem exclusion, understory re-initiation and old-growth (Oliver, 1981; Oliver and Larson, 1992).

2 Seral stage: any stage in the sucession of a forest ecosystem from a disturbed state to a climax plant community.

3 Connectivity is "an ecological term that describes the spatial and functional connections among habitats, species, communities and ecological processes" (Harrison and Voller, 1998). It enables the flow of energy, nutrients, water, natural disturbances, organisms and genes at many scales of time and space.

4 Roads affect terrestrial and aquatic ecosystems by increasing mortality of organisms from road construction and roadkill, modifying animal behaviour, altering the physical and chemical environment, spreading exotic species and increasing habitat and use alterations by humans. For an excellent recent review of the ecological impacts of roads, see Trombulak and Frissell, 2000.

5 Primary watersheds drain directly into the ocean. In secondary watersheds, the main stream drains into the main channel of a primary watershed. A tertiary watershed drains into the main channel of a secondary watershed and so on.

6 The LRMP tables deal with First Nations as stakeholders – a condition which they generally oppose as the lands in question are under treaty negotiations.

PRINCIPLE 3

Establish a rate-of-cut that **does not compromise the long-term ecological integrity** of landscapes and watersheds

Rationale

Rate-of-cut is the rate at which a forest is harvested over a predetermined area (Scientific Panel, 1995). The rate-of-cut is a critical variable for ecological sustainability. The assumptions and process used in its determination are therefore very important. It is a key variable in planning forest practices as it affects almost all forest-practice planning decisions on B.C.'s coast (e.g., appropriate silvicultural systems, the length and number of roads and the size and number of biological reserves) (Pojar and others, 1999). Establishing a rate-of-cut that does not compromise the ecological integrity of a forested landscape allows for the provision of ecological services (e.g., timber, water quality, hydrological integrity and salmon habitat), theoretically, in perpetuity. An ecologically sustainable rate-of-cut maintains the stability and productivity of soils, maintains water quality and the integrity of streams and other waterways, and conserves biodiversity in managed landscapes and ecosystems (Scientific Panel, 1995). A sustainable rate-of-cut allows the regeneration of forest structure and functions in a manner that balances losses due to harvesting.

Best practices

Scientific Panel for Sustainable Forest Practices in Clayoquot Sound

The Scientific Panel recommended an area-based rate-of-cut of a maximum of one per cent of a watershed per year, based primarily on hydrological considerations (Scientific Panel, 1995). In other words, the Panel recommended determining the rate-of-cut as a percentage of the total area in a given watershed to be logged in a year, rather than as a volume of timber to be extracted from a given area per year. The Panel recognized that watersheds, or groups of small watersheds, are ecologically and hydrologically discrete units that provide a useful scale for planning forest practices, particularly for setting a harvest rate.

Moreover, the Scientific Panel recommended that the setting of the rate-of-cut be an *output* of planning, rather than an *input*. In other words, establishing an ecologically sustainable rate-of-cut requires first identifying harvestable areas and no-harvest areas within watersheds. The amount of area to be harvested per year should be determined *after* this planning occurs. Anticipated annual volumes of timber can then be calculated from these area-based plans, thereby allowing the planning of a sustainable flow of forest products.

Using watershed-level planning, i.e., one or more watersheds ranging from 5,000 to 35,000 hectares, the Panel recommended the following:

1. Limit the area harvested in any watershed larger than 500 hectares to a maximum of five per cent within a five-year period.
2. In primary watersheds of between 200 hectares and 500 hectares, limit the area harvested to a maximum of 10 per cent of the watershed area within a 10-year period.
3. In watersheds larger than 500 hectares and primary watersheds of between 200 and 500 hectares in which harvesting has exceeded 20 per cent of the area in the past 10 years, no further cutting should occur until the watershed conforms with the specified rate-of-cut.
4. In any watershed as specified above in which recent harvesting is greater than five per cent in the past five years but less than 20 per cent in the past 10 years, no further cutting should be allowed until a sensitivity analysis of the watershed[1] and an audit of the stream channel[2] have been completed. If these assessments show no significant changes in the hydrology of the watershed, in the sediment yield of the stream, or deterioration of fish habitat, harvesting may continue at a rate that brings the watershed within the recommended limits of the rate-of-cut.
5. Review these recommendations periodically and reformulate them as the results of monitoring accumulate.

These recommendations, while not unequivocally based on empirical data, appear appropriate for meeting the goal of ecological sustainability (Scientific Panel, 1995). A rate-of-cut of one per cent per year of the watershed will likely maintain the hydrological integrity of harvested watersheds. The recommendations also provide for a long-term sustainable timber supply (Scientific Panel, 1995). Note that this recommended rate-of-cut is only a rule-of-thumb; it may be reduced after a watershed analysis is conducted.

A rate-of-cut of one per cent of the watershed per year will not necessarily result in all the watershed being cut after 100 years or in a watershed where all trees are less than 100 years old. The recommended rate-of-cut *must* be part of a hierarchical planning framework that retains trees and patches of trees by removing them from the operable land base. This requires outlining “no harvest” areas within a watershed as well as employing silvicultural systems that retain a diversity of forest structure within cutting units and of seral stages across the watershed (Scientific Panel, 1995).

Silva Forest Foundation Ecologically Sustainable Allowable Annual Cut

The Silva Forest Foundation (SFF) is a non-profit organization based in Slocan Park, British Columbia[3]. The SFF advocates ecosystem-based planning and ecologically responsible forest use.

The organization has designed and implemented several ecosystem-based plans for forest management in British Columbia (e.g., Cortes Island, Harrop-Procter Community Forest and Slocan Valley) (Silva Forest Foundation, 2000). An important output of these plans is a long-term Ecologically Sustainable Allowable Annual Cut that maintains fully functioning forests, as determined by the SFF.

The SFF determines an Ecologically Sustainable Allowable Annual Cut in a way similar to that recommended by the Scientific Panel (Silva Forest Foundation, 2000). The SFF first delineates what areas of the total land base are not available for timber management. This is done by using a rating scale to assess the *Ecosystem Sensitivity to Disturbance* of different areas of a landscape. This rating scale is based on physical factors such as slope gradient, soil depth and site moisture. Areas rated as having high or extreme sensitivity to disturbance include non-forested areas, sub-alpine forests, environmentally sensitive areas (e.g., areas difficult to regenerate and unstable terrain), inoperable areas, riparian ecosystems, protected landscape networks, headwaters protection zones, and other "netdowns." These areas are excluded from the total land base and the remainder is deemed the Timber Management Landbase (TML). The Ecologically Sustainable Allowable Annual Cut is then set as equal to Mean Annual Increment (MAI)[4] of the forests in the TML – a process analogous to planning to spend only the interest on banked savings.

Current practices

Harvest levels are determined by the Chief Forester[5] of B.C., who sets the Allowable Annual Cut (AAC[6]). Setting the AAC is required by Section 8 of the *Forest Act* for each of the province's 37 Timber Supply Areas (TSAs) and 34 Tree Farm Licences (TFLs). This *Act* requires that the AAC be determined at least once every five years for each TSA and TFL. Forest companies and other tenure holders are required by law to log the volume of timber set by AAC determination for each TFL or TSA[7]. Once the AAC is set, it becomes an input into planning forest practices, thereby greatly influencing what silvicultural options are economically feasible and ecologically appropriate (Pojar and others, 1999; Scientific Panel, 1995).

The Chief Forester considers a variety of both technical and non-technical criteria when determining the AAC. The technical criteria include objective assessments of forecasted timber supply, species composition of forests, expected rates of timber growth and yield, planned silvicultural treatments and other silvicultural considerations such as timber utilization, timber waste and decay and outbreaks of insects and disease (Pedersen, 2000). Technical criteria also include constraints imposed on timber extraction by use of the area in question for non-timber resources (e.g., community watersheds, wildlife corridors and visual quality objectives).

The non-technical criteria, as outlined in Section 8 of the *Forest Act*, are:

- *The short- and long-term implications to British Columbia of alternative rates of timber harvesting from an area;*
- *the nature, production capabilities and timber requirements of established and proposed timber processing facilities; and*
- *the economic and social objectives of the government, as expressed by the minister*

for the area, for the general region and for British Columbia.

Fundamentally, AAC determination is a policy choice based on social, political, biological and economic criteria about how much timber production a given tenure area may sustain. The Chief Forester is not required to set an ecologically sustainable rate-of-cut. Rather, he sets a rate-of-cut that maintains the social and economic objectives of the B.C. government, in particular maintaining fibre flow to mills to allow the "continued availability of good forest jobs" and "the long-term stability of communities that rely on forests[8]" (Pedersen, 2000). Ecological criteria, such as stand and landscape-level biodiversity, are viewed as constraints when determining the AAC, rather than as fundamental requirements for forest health.

Many have argued the current process of AAC determination demonstrates little regulatory commitment to ecological sustainability (e.g., Forest Resources Commission, 1991; Dellert, 1999; Marchak and others, 1999; Utzig and Macdonald, 2000). For example, the B.C. Ministry of Forests recently set the AAC for the Mid-Coast TSA at 998,000 cubic metres per year (Pedersen, 2000). This target is 37 per cent higher (or 268,000 cubic metres per year) than the Long-Term Harvesting Level (LTHL)[9] determined for the Mid-Coast TSA[10]. This disparity between the short-term harvest level and the LTHL is a legacy of the explicit policy of converting all old-growth forests in B.C. into second-growth stands – a policy initiated by the Sloan Royal Commissions of 1943-45 and 1956 that still resonates in current AAC determinations (Marchak and others, 1999).

Areas of uncertainty

What is an ecologically sustainable rate-of-cut? This rate is unknown, and largely watershed-specific. It also depends on what ecosystem attributes managers wish to maintain and on ecosystem resilience. Although the Clayoquot Sound Scientific Panel proposed that harvesting one per cent of the area of a watershed per year likely protects the ecosystem and hydrological integrity of coastal watersheds, this estimate is a still-untested approximation of what level of cut is ecologically sustainable for coastal watersheds. It is imperative that forest managers address this question explicitly by monitoring indicators of ecological sustainability in harvested watersheds (e.g., the rate of loss of vulnerable species and the rate of soil loss from slopes by mass wasting).

What are the ecological consequences of shortening natural succession in forests managed for industrial timber production, especially at the landscape scale? Most industrial forest management in coastal British Columbia typically sets rotation periods for forest crops that are shorter than the period between natural disturbances in unmanaged forests (Gavin and others, 1996; Pojar and others, 1999). Moreover, a large-scale conversion of old-growth forests into second-growth plantations leads to a simplification of forest structure at many scales. Uncertainty exists regarding how long a forest landscape managed under shortened rotations can sustain populations of organisms that require large, contiguous areas of forest or organisms associated with shrub-herb early successional forests or with late-successional forests (e.g., Grizzly Bears and epiphytic lichens).

NOTES TO PRINCIPLE 3

1 A watershed sensitivity analysis estimates the total effect of logging on the hydrology, sediment production and streamflow in logged watersheds.

2 A stream channel audit measures specified conditions (e.g., average width of the channel, volume of organic debris, sediment type and volume) using a defined procedure to allow comparisons with previous assessments or with desired channel conditions.

3 For more information on the Silva Forest Foundation, see http://www.silva.org

4 The Mean Annual Increment (MAI) refers to the amount of wood that grows in a forest per hectare per year. This amount varies according to the productivity of a site, the tree species present and the age of the forest. The SFF employs the same software, the Variable Density Yield Prediction program, that the B.C. Ministry of Forests uses to determine the MAI. Ecologically Sustainable AACs are typically between 70 per cent and 90 per cent lower than the AACs set by the Ministry of Forests for the same areas (Hammond and others, 1996; Marchak and others, 1999).

5 The Chief Forester, presently Larry Pedersen, is also the assistant deputy minister of the Forestry Division of the Ministry of Forests.

6 The AAC differs from the rate-of-cut. The AAC is expressed as a volume of timber and should be an output of forest-practices planning, rather than an input (as currently practiced). The recommended rate-of-cut is area-based and determined as an output of planning, following the consideration of fisheries, biodiversity, etc. (Scientific Panel, 1995).

7 Sections 64, 65 and 66 of the *Forest Act* (known as "the log-it-or-lose-it" clause) state that tenure holders may harvest above or below the AAC in any one year by 50 per cent, but must log within 10 per cent of the volume specified by the Chief Forester over a five-year average.

8 These quotes are from a July 28, 1994 letter written by the Minister of Forests to the Chief Forester outlining the future direction of forest policy and detailing the social and economic objectives of the B.C. Government for the forest sector.

9 The LTHL, a key input into AAC determination, is an estimate of how much the second-growth stands in the timber harvesting landbase will grow each year, after all the old-growth forests are harvested and converted into managed second-growth stands. It is based on certain assumptions regarding the regime of forest management (defined by the timber harvesting land base and objectives and guidelines for non-timber values) and modeled predictions of future timber growth and yield (B.C. Ministry of Forests, 1997; Utzig and Macdonald, 2000). The LTHL is not an ecologically sustainable measure; rather, it is a prediction of the harvest level that is biologically and economically sustainable as managed second-growth stands reach financial or technical maturity. The LTHL makes no provision for certain types of reserves, nor for maintaining all age classes and seral stages within the harvesting landbase.

10 The disparity between the AAC and the LTHL, known as "falldown", is replicated for the north coast and Queen Charlotte Islands TSAs and for the province as a whole (Marchak and others, 1999).

PRINCIPLE 4

Engage local communities and incorporate local knowledge in establishing decision-making processes and in planning forest management

Rationale

Forest management directly affects the water quality, employment, fisheries, viewscapes and land-use of local communities. Many authors argue that if nearby communities are engaged in decision-making and have control of forest management, the probability of locally appropriate and ecologically sustainable decisions being made will increase (e.g., Ostrom, 1990: 1999; Travers, 2000). Communities have much greater incentives to consider the long-term negative consequences of unsustainable forest practices than do centralized management agencies (Ostrom, 1990; 1999).

First Nations people have a distinct and especially important role in planning forest management. Integral to their cultures is respect and honour for the land and the sea. Their *traditional ecological knowledge* (TEK) evolved during thousands of years of interactions with the forest and marine ecosystems upon which they rely for survival and well-being (Scientific Panel, 1995b; Lertzman, 1999). Meaningful and respectful incorporation of TEK and First Nations' perspectives and practices into planning forest management can increase the understanding of humanity's place in ecosystems and guide management towards ecological sustainability (Lertzman, 1996). Moreover, TEK can enrich the knowledge base of forest management with observations of natural systems that extend into the past well beyond those recorded by science. Inclusion of local wisdom, especially TEK, offers a strong signal that forest managers recognize the importance of the traditional use of forests for the cultural and spiritual well-being of First Nations and society at large.

Best practices

Scientific Panel for Sustainable Forest Practices in Clayoquot Sound

The Scientific Panel offers an example of the successful integration of TEK and science. An important element of this success was the recognition by the Panel that Nuu-Chah-Nulth concepts and philosophies were integral to its work and to the development of highest standards for sustainable forest management (Lertzman, 1999; Scientific Panel, 1995b). More specifically, the Panel recognized:

- and adopted an internal working protocol based on the inclusive approach of the Nuu-Chah-Nulth to discussion and sharing to reach agreement. The protocol embodies a demonstrable respect for all life, for other people and their values, as well as for data founded in science and traditional knowledge.
- the need to incorporate Nuu-Chah-Nulth values into its recommendations, foremost among these being the sacredness of and respect for all life.
- the need to respect Nuu-Chah-Nulth social structures and incorporate them into the Panel's recommendations. In particular, the Panel recognized *ha huulhi* – the hereditary chief's system of ownership and control – as a traditional form of ecosystem-based management. This system recognized that ownership and responsibility to care for the lands and waters within clearly defined and widely known territorial boundaries, in addition to the well-being of tribal members, fell to the hereditary chiefs.

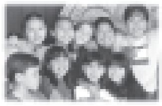
The Cortes Initiative

The proposed Cortes Initiative is a multi-party solution to land-use problems on Cortes Island, B.C. It is the result of collaboration among the Klahoose First Nation, the Cortes Ecoforestry Society[1] and Weyerhaeuser Company. This initiative consists of two integrally related parts. The first is the conversion of 1,800 hectares owned by Weyerhaeuser on Cortes Island, B.C., to Crown land. In return, Weyerhaeuser would be provided lands of equivalent value from a yet-undetermined location in a straight land exchange. The second part of the Initiative involves a unique partnership between the Klahoose First Nation and the Cortes Ecoforestry Society to manage the new Crown lands on Cortes, along with the existing 5,700 hectares of Crown land on the island. This partnership proposes an ecosystem-based forestry model that would be the largest tenure held under such management in B.C.

Iisaak Forest Resources Limited

Iisaak Forest Resources is an innovative forest company based in Ucluelet, B.C. (Iisaak 2000). The Central Region Nuu-chah-nulth First Nations own 51 per cent through Ma-Mook Natural Resources Limited and Weyerhaeuser owns the remaining 49 per cent. The company was created through the commitments made by the Nuu-chah-nulth Central Region First Nations and MacMillan Bloedel Ltd. in a 1996 Interim Measures Extension Agreement. Its tenure area is principally in Clayoquot Sound.

"Iisaak" means respect in Nuu-chah-nulth. The primary mandate of this company is to provide a new model of forest management in Clayoquot Sound by operating within the spirit and intent of the recommendations of the Clayoquot Sound Scientific Panel. Iisaak uses an ecosystem-based management approach to planning and operations that protects cultural, social and ecological values (e.g., biodiversity, all timber and non-timber resources, water-related resources, eco-tourism and recreational opportunities, spiritual and sacred values, and traditional cultural uses). Key objectives for Iisaak in planning forest practices include: retaining a continuous reserve network that maintains the integrity of the hydroriparian



ecosystems, implementing Variable-Retention harvesting systems to maintain structurally complex managed stands, implementing adaptive management and monitoring programs, and emphasizing product value through value-added manufacturing.

Current practices

Public input into forest practices occurs at a variety of planning stages and processes. An in-depth description of all of these is outside the scope of this report. Generally, how the public is engaged in decision-making varies considerably in the following aspects: who initiates and controls the process (e.g., Ministry of Forests, Ministry of Environment, Lands, and Parks, forest companies), who participates (e.g., members of the general public, interest groups, First Nations), how the public input is handled (e.g., degree of inclusion into plans, advertisement in local newspapers), and how disputes are settled (e.g., consensus decision-making, arbitration). Opportunities for public input include the Timber Supply Review, Land Resource Management Plans, Forest Development Plans and Silvicultural Prescriptions. The Forest Practices Board also provides a venue for public concerns about forest practices by investigating alleged infractions of the Forest Practices Code. A number of excellent references exist for understanding how the public is engaged in forest planning in B.C. (e.g., Haddock, 1999; Integrated Resource Planning Committee, 1993).

Areas of uncertainty

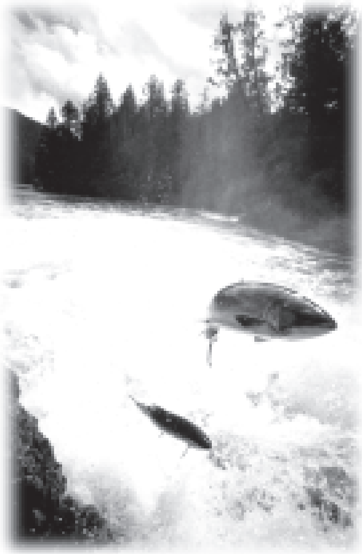
Is there common ground among the disparate and hotly contested worldviews of different users of the forest? Is that ground ecologically sustainable? There is much variation in the range of values and uses that people seek from forests, as well as in what people consider are sustainable ways to manage forests. It is uncertain whether the compromises necessary to include the entire range of these values and opinions in forest management will foster ecological sustainability. Moreover, uncertainty exists about what process will best strike a balance among the needs of First Nations and local, regional and provincial stakeholders.

How do we develop the appropriate protocols to bridge traditional ecological knowledge and science for ecologically sustainable forest planning and management? Scientists and forest managers are becoming increasingly aware of the importance of TEK for ecosystem-based forest management. Unfortunately, many of those interested in using TEK may be ignorant of the cultural protocols or guidelines necessary to communicate TEK and of the philosophies upon which TEK rests (Lertzman, 1999). This has resulted in a lack of trust and misunderstanding between those who hold traditional knowledge and those who wish to learn and use it. Bi-cultural protocols will be necessary for the respectful and effective linking of traditional knowledge and science in ecologically sustainable forest management (e.g., Clayoquot Sound Scientific Panel; Lertzman, 1999). Bi-cultural protocols guide the bringing together of the holders of traditional knowledge and science so that they can work together in a respectful and effective manner. This enables the proper documentation and use of both scientific and traditional knowledge.

NOTES TO PRINCIPLE 4

1 The Cortes Ecoforestry Society (CES) is a non-governmental organization that advocates ecosystem-based forestry. CES's membership is comprised of 60 per cent of the adult population of Cortes Island.

P R I N C I P L E 5



Conserve all native species and their habitats within the range of natural variability

Rationale

Maintaining biodiversity in managed forests requires the conservation of all native species within their natural range of variability[1] (Perry, 1994). This requires combining a coarse-filter and a fine-filter approach in developing conservation strategies and silvicultural systems that retain habitat at multiple scales (Noss, 1991; B.C. Ministry of Forests and Ministry of Environment, Lands and Parks, 1995). The coarse-filter, or ecosystem-level, approach uses habitat diversity as a surrogate to maintain biodiversity. This approach rests fundamentally on the assumption that managed forests will likely maintain all native species (even the ones that science has yet to identify and describe) if managed forests resemble the unmanaged forests established by natural disturbances (e.g., windthrow, fire, insects outbreaks, disease and landslides). These disturbances interact with natural successional pathways to determine the species composition, size, age, stand structure and distribution of different forest types across the landscape. Therefore, clues to maintaining most native species by creating managed landscapes that resemble unmanaged landscapes come from studies of how natural disturbances and ecosystem conditions vary across different scales of time and space (Franklin and Forman,1987; Swanson and others, 1994; Lertzman and Fall, 1998; Lertzman and others, 1998).

To ensure the habitat needs of most forest-dependent species, the coarse-filter approach requires developing forest practices after analyses of at least three scales (Noss, 1991; Scientific Panel, 1995; B.C. Ministry of Forests and Ministry of Environment, Lands and Parks, 1995; Parminter, 1998). First, it is instructive to analyze the structural heterogeneity (e.g., large old trees, snags and downed wood) *within* a stand (e.g., 0.01 to one hectare) and examine how this structure changes over time as a result of natural disturbances and succession. This scale of analysis allows understanding of the distribution, type and amount of forest structure to retain during harvesting. Second, the scale of the natural disturbance patch (e.g., between one and 100 hectares) should be analyzed, focusing principally on the size, shape, intensity and severity of disturbances and how these change over time. The patch scale provides insights into size, pattern, and frequency of logging-created openings that are ecologically appropriate. The third important scale is the forest landscape (e.g., greater than 10,000 hectares). Analyses at the landscape scale should focus on the composition and distribution of patch sizes and seral stages and the connectivity between them in forested landscapes across time and space (Parminter, 1998). The landscape scale is critical for creating landscape patterns that integrate the various land uses (e.g., protected areas and urban developments) while preventing the negative ecological impacts of isolating remnant forest patches (e.g., loss of interior-forest habitat, edge effects and creation of barriers to gene flow and dispersal) (Saunders and others, 1991; Franklin, 1993; Turner and others, 1994; B.C. Ministry of Forests and Ministry of Environment, Lands and Parks, 1995; Parminter, 1998). These characterizations of the natural variability of the structure and composition of forests at multiple scales are critical for developing forest practices that are within the limits of acceptable ecological change (Morgan and others, 1994). Special emphasis on attributes such as stand structure, amount of old-growth forest, old-growth forest connectivity and interior-forest habitat is justified since those are properties especially affected by logging and of direct consequence for biodiversity (Eng 1998).

The coarse-filter approach will not adequately address the conservation needs of all species (Noss, 1991; Perry, 1994). In some cases, a fine-filter, or species-level, approach is necessary to target the conservation of individual species. Since developing conservation strategies for all individual species is unfeasible and ineffective (Franklin, 1993), it is necessary to priorize species for the fine-filter approach. Priorities for conservation using the fine-filter approach include keystone species and species considered endangered, threatened or rare (Terborgh, 1974; Terborgh and others, 1999).

Keystone species, or simply keystones[2], are species that have unique functional roles critical for the integrity of the entire ecological community, relative to their biomass or numerical abundance (Paine, 1969; Miller and others, 1999). Loss of keystones can cause a cascade of effects through an ecosystem, resulting in the loss or degradation of ecosystem functions (e.g., pollination, nutrient cycling, energy inputs and maintaining balances in predator-prey relationships) (Perry, 1994; Dobson and others, 1999). Their loss may also result in population explosions or collapses of other species interconnected with the dynamics of keystone species (Dobson and others, 1999).

In the central and north coast, a keystone interaction has been identified among bears, salmon and trees in riparian forests (Willson and others, 1998; Reimchen, 2000). A number of animals, principally bears but also Bald Eagles (*Haliaeetus leucophalus*), River Otters (*Lutra canadensis*) and Common Ravens (*Corvus corax*) drag spawned-out salmon onto streambanks and into riparian forests (Ben-David and others, 1998; Reimchen, 2000). The carcasses fertilize the forest soils up to 100 metres away from the streambank, providing up to 75 per cent of the nitrogen in riparian trees (Reimchen, 1994). Salmon-derived nitrogen is absorbed by trees and shrubs which in turn contribute to the maintenance of healthy salmon populations by providing instream woody habitat and nutrient inputs (Reimchen, 2000). The abundance of salmon returning to their natal rivers directly defines the abundance and diversity of species in riparian areas (Reimchen, 1994; Willson and others, 1998).

Fine-filter approaches must also target endangered, threatened or rare species. Extinction or extirpation of such species represents a direct reduction in biodiversity (Terborgh, 1974). In many cases, the loss and endangerment of these species is linked to habitat loss and fragmentation (Harris, 1984; Wilcox and Murphy, 1985; Noss, 1991), especially when the habitat lost or fragmented is that in which they evolved and depend upon for survival (Mooney, 1981; Wilson, 1992).

Best practices

Central Coast Conservation Area Design

A Conservation Area Design (CAD) has been conducted for the central coast (Jeo and others, 1999). It used three taxa as focal species[3]: Grizzly Bears, salmon stocks and selected tree species. As mentioned previously, these taxa play a keystone role in coastal forests. The CAD is based on the assumption that the conservation of habitat for these taxa will "help conserve biodiversity at natural levels of abundance and distribution," as well as allow "preservation of ecotypes and ecosystem functions" on the Mid-Coast (Jeo and others, 1999). Their conservation, in theory, also provides for the conservation of threatened, endangered and rare species. The primary product of the CAD is a set of maps created to assist in planning and implementing a regional conservation strategy.

The maps identify a large network of interconnected conservation areas to meet four primary goals:

1. Maintain and/or restore viable populations of large carnivores.
2. Maintain and/or restore viable populations of all salmon stocks.
3. Maintain and/or restore representation of all native ecosystem types and successional stages across their natural range of variation.
4. Maintain and/or restore natural landscape connectivity.

Using a variety of data sources, the CAD combined a coarse-filter ecosystem approach with a fine-filter species-based approach. The data used included biogeoclimatic zones, watershed boundaries, old-growth forest areas, salmon escapement, logging, roads and other forest development, as well as special ecosystem elements such as estuaries and riparian areas. The coarse-filter approach, using watersheds as the minimum unit of conservation, identified watersheds with less than 10 per cent logging that contained old-growth structural features (e.g., large areas of woody debris and large old trees). These watersheds were deemed Core Intact Areas. The fine-filter approach, based on the ecological needs of Grizzly Bears and salmon, identified relatively intact watersheds (less than 15 per cent logged) with productive low-elevation old-growth forests that are potentially suitable habitat for Grizzly Bears and salmon. These watersheds were deemed Core Grizzly Bear/Salmon

Habitat Areas. Watersheds having less than 15 per cent logging and high potential for being suitable habitat for Grizzly Bears and salmon were deemed Core Restoration Areas. These three types of areas make up the Core Conservation Areas. The CAD authors recommend that industrial logging, road-building, commercial and residential development, mining and trophy hunting be limited or prohibited in these areas, as they are incongruent with the continued conservation of the focal species.

The Conservation Area Design also identifies Linkage Areas. These include riparian areas and alpine and sub-alpine watersheds that connect the Core Conservation Areas to keep them contiguous. Some forest development is acceptable in the Linkage Areas, i.e., Variable-Retention forestry, hunting and recreation.

Current practices

The conservation of biodiversity and rare, endangered, and threatened species and ecological communities falls to the *Forest Practices Code Act of British Columbia* (B.C. Ministry of Forests 2000). The primary regulatory bodies are the B.C. Ministry of Forests and the B.C. Ministry of Environment, Lands, and Parks. In general, biodiversity as well as rare, threatened and endangered species and ecological communities are thought to be conserved through the retention of old growth forests and wildlife trees, appropriate seral stage distribution, landscape connectivity, maintenance of stand structure and tree species composition present before harvest, as well as through the management of the temporal and spatial distribution of harvested areas.

Conserving biodiversity and rare, endangered, and threatened species and ecological communities combines a coarse- and a fine-filter approach. The coarse-filter approach is ostensibly filled by the Forest Practices Code (FPC), through the implementation of the Biodiversity Guidebook and the establishment of Landscape Units (LU). The fine-filter approach is filled by the Identified Wildlife Management Strategy[4] , a process designed to protect those species-at-risk and ecological communities inadequately provided for in the FPC[5] . Identified Wildlife is defined in the FPC as "species or plant communities requiring special forest practices to be applied where forest activities are planned." The BC government expects the Identified Wildlife Management Strategy to impact the provincial timber supply by less than one percent and the implementation of LUs by less than 4.5 per cent.

LANDSCAPE UNITS

Landscape Units are specific areas of land and water delineated to assist in the long-term planning of resource management with an initial priority for biodiversity conservation. How these areas are mapped and incorporated into forest management is outlined in the recently released Landscape Unit Planning Guide. Working in complement with the Identified Wildlife Management Strategy, the Landscape Unit Planning Guide provides direction and advice for forest managers on the amount and location of old-growth forest to retain through the establishment of Old-Growth Management Areas and on the number of wildlife trees to retain within LUs.

The LU designation process is currently stalled in each of the four forest districts under examination in this paper: Mid Coast, North Coast, Queen Charlotte Islands, and Kalum Forest

Districts. In some regions, LU boundaries have not been defined and licensees are operating without the benefit of this long-term planning tool. Where the LU boundaries are defined, they have not been made into law. In some cases, this is due to the length of time required by the LRMP process.

KEYSTONE SPECIES

Two keystones in the study area are under active management: Grizzly Bears and salmon. The Identified Wildlife Management Strategy under the FPC protects Grizzly Bears through two categories of Wildlife Habitat Areas (WHA): security areas and foraging areas. These two types of WHAs are intended to maintain the ecological integrity of critical habitat patches and compensate for habitat alienation. The Identified Wildlife Management Strategy allows establishment of WHAs, given approval of District Manager and Forest Ecosystem Specialist. Neither of these WHAs have yet been established. Other important conservation and policy strategies include the provincial Grizzly Bear Conservation Strategy[6] and Grizzly Bear Harvest Management Policy[7] (B.C. Ministry of Environment, Lands, and Parks 2000).

The management and protection of salmon in B.C. is very complex. It involves a multitude of management agencies, laws, regulations, and jurisdictions. These include the Department of Fisheries and Oceans, that has the responsibility to enforce the federal *Fisheries Act*; the B.C. Ministry of Environment, Lands, and Parks and the B.C. Ministry of Fisheries, that have jurisdiction over instream flows and habitat protection through the provincial *Water Act* and *Fish Protection Act*; and the B.C. Ministry of Forests that has the responsibility of riparian management through the FPC.

Areas of Uncertainty

Which organisms have keystone roles? Ecologists classify species as keystones when they understand the unique interconnecting role these species (or habitats) play in forest ecosystems. Given the gaping lack of basic taxonomic and autoecological knowledge for many groups (e.g., fungi and canopy insects) in the study area, it is likely that many other species play unique roles yet unknown to science. Other possible keystones include soil fauna and flora, including mycorrhizal fungi and nitrogen-fixing and cellulose-converting bacteria (Perry, 1994).

Does the present rate of species loss or endangerment indicate that the ecosystem is clearly out of balance? Is the natural rate of species loss or endangerment accelerating as a result of the loss of keystone species, habitats or ecosystem functions? Forests are dynamic systems, characterized by constant change in species composition, habitat structure and ecological function. Understanding how forest management affects biodiversity requires determining natural rates of change (i.e., considering how the long-term forces of ecological succession and climate fluctuations interact with the more immediate effects of natural disturbances to affect species abundance and distribution) (Parminter, 1998; Noss, 1990). Characterizing the effects on biodiversity of forest management also requires testing focused hypotheses about how specific management practices affect specific target species or ecosystems, thereby allowing short-term knowledge gains.

NOTES TO PRINCIPLE 5

1 The range of natural variability refers to the spectrum of conditions possible in ecosystem composition, structure and function, when considering both temporal and spatial scales. It is typically assessed as the spectrum of conditions present before the influence of European settlers (Swanson and others, 1994; Eng, 1998).

2 Keystones can also be functional groups of species (e.g., soil bacteria), habitats (e.g., large deadwood) or abiotic factors (e.g., fire) that have a pivotal function in ecosystem processes and upon which a large part of the ecosystem relies (Noss, 1991; Perry, 1994).

3 Focal species are species chosen, usually as a set, to make planning for biodiversity conservation more manageable (Lambeck, 1997; Miller and others, 1999). Since it is extremely difficult, if not impossible, to create conservation plans for all species in a given ecosystem, conservation efforts can focus on focal species to allow for setting and identifying specific and measurable management objectives for appropriate practices and conservation areas. The assumption is that maintaining viable populations of focal species will concurrently protect all or most of the diversity of native species.

4 See http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/other/wild/part1.htm for more information.

5 In the Identified Wildlife Strategy, the provincial government considers the following species-at-risk in the north and mid Coast: Pelagic Cormorant (*pelagicus*), Northern Goshawk (*laingi*), Thick-Billed Murrelet, Marbled Murrelet, Horned Puffin, Swainson's Hawk, Peregrine Falcon (*anatum*), Keen's Long-Eared Myotis, Northern Sea Lion, Sea Otter, Black Right Whale, Northern Sea Lion, Ermine (*haidarum*) and the Giant Black Stickleback.

6 See http://www.elp.gov.bc.ca/wld/grzz/ for more information.

7 See http://www.elp.gov.bc.ca/wld/grzz/gb70404.html for more information.

PRINCIPLE 6

Protect hydroriparian areas and functions

Rationale

Hydroriparian areas are the intimately interconnected aquatic and adjacent terrestrial environments[1] of streams, lakes, wetlands and marine shores. They represent the circulatory system of forested landscapes, connecting entire watersheds through the movement of water and sediments (Scientific Panel, 1995). These areas are often the most productive and biologically diverse of forested watersheds (Burton, 1998).

Generally, hydroriparian areas are the focus of activity for a large number of animal species and typically have a very high diversity of plant species (Naiman and others, 1993). Many terrestrial and aquatic organisms use hydroriparian areas as critical habitat (e.g., American Dippers) or as travel corridors (e.g., salmon) (Scientific Panel, 1995). Hydroriparian areas of the central and north coast are also the site of the keystone interaction among salmon, bears and trees – a mutually reciprocal interaction that maintains the productivity of riparian forests on the coast through a major horizontal transfer of salmon nutrients back into the forest (Willson and others, 1998; Reimchen, 1994 and 2000).

The richness and diversity of hydroriparian areas is a function of the continuum of physical conditions, trophic processes[2] and ecological communities that occurs from the headwaters to the ocean (Vannote and others, 1980; Scientific Panel, 1995). Generally, headwater streams are heavily shaded and have trophic processes that fundamentally depend on the inputs of insects, leaves and twigs from streamside vegetation. Downstream, the channel typically becomes less shaded, with a higher range in water temperatures, more algal production, higher insect diversity and trophic processes primarily driven from within the stream. The entire stream system is connected, with upper reaches influencing lower reaches and estuarine areas (e.g., through the input of organic matter, from leaves to logs) (Vannote and others, 1980).

The vegetation of hydroriparian areas performs many essential ecological functions. Riparian trees, shrubs and herbs protect water quality by holding soil in place, providing shade and regulating stream temperatures, providing inputs of fine and coarse woody debris, stabilizing streambanks and moderating the impacts of rainfall events and peak flows (Bilby, 1981; Murphy and Koski, 1989; Nakamura and Swanson 1993; Scientific Panel, 1995; B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks,1995b). Moreover, riparian vegetation is essential for sustaining natural subsurface flows of water – important for maintaining biodiversity and soil stability (Scientific Panel, 1995; Pojar and others, 1999).

Logging and road-building in riparian areas can strongly affect the character and function of riparian areas (Hartman and Scrivener, 1990; Scientific Panel, 1995; Voller, 1998). These forest practices alter the inputs of water, sediment and organic debris into streams and floodplains. Alterations in the timing and volume of inputs of water, sediment or organic debris can change the morphology of stream channels[3] and can result in channel widening, loss of pool/rifle complexes, reduced low-flow capacity of the stream and other effects (Bren, 1993; Slaney and Martin, 1997). Other important consequences of logging riparian forests include decreased bank stability and altered shading and thermal regimes, especially in smaller headwater streams (Voller, 1998).

Changes in the physical structure and function of hydroriparian areas can have profound biological effects. Generally, physical changes modify the life histories and success of various organisms in the hydroriparian area, shift the zones where maximum biodiversity occurs and change the composition and age structure of different species and ecological communities within the various zones of a stream system (Scientific Panel, 1995; Voller, 1998). Physical changes can also cause the degradation and loss of fish spawning, rearing and over-wintering habitat (e.g., through the siltation of spawning beds) (Scientific Panel, 1995; Hartman and others, 1996; Voller, 1998). Logging and other forest practices in riparian areas have also been associated with decreases in the foraging success, behaviour and survival of aquatic organisms, including fish and riparian-dependent invertebrates, birds, mammals and amphibians (Hicks and others, 1991; Ralph and others, 1994; Scientific Panel, 1995; Slaney and Martin, 1997; Voller, 1998).

The large trees and the more gradually increasing elevation of hydroriparian areas make them attractive places for logging and road-building. However, the central role these areas play in maintaining biodiversity and ecosystem integrity should make them areas of special management concern. This requires keeping vegetation in riparian areas, restricting the rate of forest harvest within watersheds and locating and building roads very carefully, if at all (Scientific Panel, 1995).

Best practices

The Aquatic Conservation Strategy of the Northwest Forest Plan

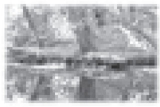
In the federal forest lands of western Washington, western Oregon and northwestern California, the protection of hydroriparian areas is legislated by the Aquatic Conservation Strategy of the Northwest Forest Plan[4]. Under the Aquatic Conservation Strategy, **Riparian Reserves** form the principal component of a strategy that has as its overarching goal "to maintain and restore the productivity and resiliency of riparian and aquatic ecosystems" (USDA and USDI, 1994). The three other components of the Aquatic Conservation Strategy are:

- **Key watersheds**, essentially a system of large refugia in watersheds crucial to at-risk fish species;
- **Watershed analysis**, analyses that contextualize the goal of the Strategy within the geomorphic and ecological realities of specific watersheds; and,
- **Watershed restoration**, a comprehensive long-term program to restore watershed health and habitat of fish and other riparian-dependent species.

The Aquatic Conservation Strategy uses riparian reserves for a number of reasons. These include maintaining and restoring riparian structures and functions of intermittent streams, benefiting riparian-dependent and associated species other than fish, enhancing habitat conservation for species dependent on the transition zone between upslope and riparian areas, improving corridors for travel for many terrestrial animals and plants, and providing landscape connectivity within watersheds (USDA and USDI, 1994). The riparian reserves also serve to link and provide connectivity among old-growth reserves. A limited set of management activities is permitted in riparian reserves (e.g., timber harvest is largely prohibited, road management and construction must not compromise the objectives of the Aquatic Conservation Strategy, and grazing impacts on streambank vegetation must be minimized) (USDA and USDI, 1994). Approximately 2,627,500 acres (1,051,000 hectares) of riparian reserves are interspersed among the forest matrix of the federal forest lands.

Riparian reserves are specified for five categories of waterbodies:

- *Fish-bearing streams*: Riparian reserves comprise the stream and the area on each side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edges of riparian vegetation, or to the distance equal to the height of two site-potential trees, or 300-feet (90 metres) slope distance (600 feet or 150 metres total, including both sides of the stream channel), whichever is greatest.
- *Permanently flowing non-fish-bearing streams:* Riparian reserves comprise the stream and the area on each side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edges of riparian vegetation, or to the distance equal to the height of one site-potential tree, or 150-feet (45 metres) slope distance (300 feet or 90 metres total, including both sides of the stream channel), whichever is greatest.
- *Wetlands greater than one acre[5] (0.4 hectares):*



Riparian reserves comprise the body of water or wetland and the area to the outer edges of the riparian vegetation, or to the extent of seasonally saturated soil, or to the extent of unstable and potentially unstable areas, or to the distance equal to the height of one site-potential tree, or 150-feet (45 metres) slope distance from the edge of the wetland greater than one acre (0.4 hectares) or the maximum pool elevation of constructed ponds and reservoirs, whichever is greatest.

- *Lakes and natural ponds:* Riparian reserves comprise the body of water and the area to the outer edges of the riparian vegetation, or to the extent of seasonally saturated soil, or to the extent of unstable and potentially unstable areas, or to a distance equal to the height of two site-potential trees, or 300-feet (90 metres) slope distance, whichever is greatest.
- *Seasonally flowing or intermittent streams[6], wetlands less than one acre and unstable and potentially unstable areas:* This category applies to waterbodies that are highly variable in size and character. At a minimum, the riparian reserves must include:
  - All unstable and potentially unstable areas (including earthflows).
  - The stream channel extending to the top of the inner gorge.
  - The stream channel or wetland and the area from the edges of the stream channel or wetland to the outer edges of the riparian vegetation.
  - The edges of the stream channel extending to a distance equal to the height of one site-potential tree, or 100 feet (30 metre) slope distance, whichever is greatest.

A transition area is recommended between the riparian reserves and the timber management area to manage windthrow and provide benefits for wildlife (e.g., FEMAT 1993; Scientific Panel, 1995; B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks, 1995b). The width of the transition area varies between 10 and 200 metres beyond the riparian reserve, depending on the waterbody in question. Recommended practices in the transition area include: timber extraction with a high level of retention, between 50 per cent and 70 per cent; reducing windthrow hazard by topping, feathering and removal of windthrow-prone trees; and retaining wind-firm and wildlife trees (FEMAT 1993; Scientific Panel, 1995; B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks, 1995b). This is relevant to many sites in the study area, where heavy winds and rain make windthrow an important management concern for riparian reserves (Dhanwant, K., personal communication).

Clayoquot Sound Scientific Panel Recommendations for Hydroriparian Management

The Scientific Panel recommended an innovative system of hydroriparian classification and management. This system differs from other classification systems (e.g., B.C. Ministry of Forests riparian management) by its lack of reliance on fish presence to distinguish among waterbody types and acceptable management practices, and by its thorough specifications of suitable management activities in floodplains. Using an ecosystem-based approach in developing its classification system, the

Panel recognized that the stream channel (or standing waterbody) and adjacent terrestrial surface are discrete ecosystem units that have an essential connectivity across the entire drainage system. The Panel therefore recommended a protected zone that spans the entire drainage system, forming a skeleton of continuously connected forest that allows movement and dispersal of animals and plants through the landscape, including passage to ridgelines and into neighbouring watersheds.

The Panel organized its recommendations for hydroriparian management according to the type of waterbody and character of the adjacent riparian land. Most basically, the Panel differentiated among streams (lotic), standing fresh water (lentic, e.g., lakes), and marine waters. Streams are further differentiated according to whether the channel is alluvial, i.e., flowing through its own sediments, and according to its gradient, confinement, and channel width. Lentic systems are differentiated by the shore morphology (e.g., rocky or sandy) and wetland type (e.g., bog or swamp). Marine shores are classified by the physical nature of the shore (e.g., with beach or without) and by the degree of shelter from open waters.

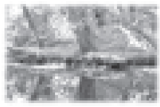
For each waterbody type, the Panel recommended a Riparian Reserve and a Hydroriparian Management Area. The Riparian Reserve ranges from 20 to 50 metres horizontal (map) distance from the streambank and is a "no harvest" zone. Road construction should be avoided in all Reserves. The Hydroriparian Management Area, i.e., the remaining area adjacent to the Riparian Reserve that is still under influence of the waterbody, may be harvested with high-retention logging (i.e., greater than 70 per cent). For more detailed descriptions of acceptable practices and the recommended system of hydroriparian classification, see Appendix II in Scientific Panel, 1995.

Current Practices

Protection for hydroriparian areas and functions is legislated by B.C.'s Forest Practices Code (FPC), in accordance with the Riparian Management Area Guidebook (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks, 1995b). Generally, the FPC offers protection to designated zones adjacent to streams, wetlands and other waterbodies in harvested watersheds. The degree of protection, ranging from mandatory no-harvest zones to purely discretionary measures, depends on the type of waterbody, the presence of fish[7] and whether the harvesting in question is in a community watershed[8]. The designated zone is deemed the Riparian Management Area (RMA). It is composed of the Riparian Reserve Zone (RRZ), a no-harvest zone, and the Riparian Management Zone (RMZ) – where forestry practices are not prescribed by regulation, but rather come under the discretion of forest managers and are subject to approval by the District Manager of the Ministry of Forests.

Streams

Streams are classified into six riparian classes based on channel width, the presence or absence of fish within the stream and whether the stream lies within a community watershed (Table 1). The stream classification determines the width of the RMA that borders the stream and



the management objectives within the RMA. It also determines whether a no-harvest zone (i.e., an RRZ) is required.

In general, the objectives for riparian management include reducing windthrow, maintaining stream bank stability, protecting fish and wildlife habitat and providing a future source of large woody debris (LWD) to the channel. These management objectives determine which constraints will be applied to silvicultural practices. Constraints include increasing the level of timber retention, reducing instream activities, restricting herbicide application and modifying various harvesting and road-building practices.

Wetlands and Lakes

Wetlands are assigned one of five riparian classes based on the size of the wetland, whether it is a simple wetland or wetland complex and the biogeoclimatic unit in which the wetland occurs. Silvicultural prescriptions within a wetland Riparian Management Area also hinge on the abundance of sphagnum mosses and the wetland's size and stream proximity. Lakes are assigned to one of four riparian classes based on lake size and the biogeoclimatic unit in which the lake occurs. In regions where lakes and wetlands are less common, they are afforded greater protection. Lake and wetland classification determines the presence of reserve zones, the width of management zones and the management objectives within the RMA. Objectives of RMAs for lakes and wetlands include maintaining wildlife values, managing windthrow risk and retaining sources of coarse woody debris.

Fish-bearing Streams

Fish presence is confirmed by the occurrence of any life phase of a certain species, including spawning and holding adults of anadromous species; incubating eggs; overwintering and rearing juveniles and adults; and migrating juveniles and adults. If the stream has not been classed using the above criteria, it is considered a fish stream if it has a slope gradient less than 20 per cent (for both coastal and interior streams) and flows directly into a fish stream, the Pacific Ocean or a lake known to support fish.

TABLE 1.

Riparian area management under the Forest Practices Code.

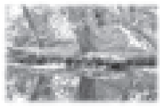
Riparian Class	Average Channel Width (m)	Fish stream or Community Watershed?	Reserve Zone Width (m)	Management Zone Width (m)	Total RMA Zone Width (m)
S1 large rivers	>100	Yes	0	100	100
S1	>20	Yes	50	20	70
S2	>5–20	Yes	30	20	50
S3	1.5–5	Yes	20	20	40
S4	<1.5	Yes	0	30	30
S5	>3	No	0	30	30
S6	<=3	No	0	20	20

Areas of uncertainty

How effective are reserves for conserving the full range of functions and character of hydroriparian areas? Various riparian functions occur at different distances from the stream bank. Leaf litter, for example, typically falls into the stream from trees and other vegetation within 20 metres of the stream bank, whereas inputs of large woody debris are typically from trees within 40 metres of the stream bank (Scientific Panel, 1995). Wildlife use along riparian corridors may extend up to 100 metres away from the stream (e.g., Compton and others, 1988; Reimchen, 1994; 2000). Moreover, much scientific ignorance exists about adequate width of riparian reserves for the protection of many organisms (e.g., amphibians and birds; Voller, 1998). This means that a single prescriptive minimum for riparian buffers may not maintain biodiversity in the long term, suggesting instead that a landscape- or watershed-level approach be taken to protect riparian biodiversity and processes (Scientific Panel, 1995; Burton, 1998).

What are the cumulative impacts of logging the riparian areas and felling and yarding across small headwater streams? The lack of mandated riparian buffers for small streams in the FPC (i.e., S4, S5 and S6) has allowed continued and widespread clearing of streamside vegetation in these stream types (B.C. Ministry of Environment, Lands and Parks, 2000b). This may have important negative consequences not only for these stream types, but also for downstream reaches and other streams and waterbodies in the same stream system[9]. Possible effects include increased water temperatures, changes in loading of leaf litter and other woody debris, and higher sediment loads (Burton, 1998). These cumulative downstream impacts need to be understood for effective design of riparian reserves and management practices.

What criteria, besides the absence or presence of fish, are suitable determinants for riparian classification and management? The presence of fish is a key element in the classification scheme for riparian zones (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks, 1995b). However, fish presence varies greatly seasonally and among different reaches of the same stream, making errors in fish sampling an important consideration. Moreover, fish are only one group among many that depend on functional hydroriparian areas, making fish protection a narrow focus for riparian management. Other criteria need to be developed that more fully characterize the function and integrity of hydroriparian ecosystems.



NOTES TO PRINCIPLE 6

1 The term Riparian refers to the terrestrial component of hydroriparian areas. These areas include some upland sites and periodically flooded ecosystems (Banner and Mackenzie, 1998).

2 Trophic processes refer to the manner by which organisms and communities of organisms obtain energy, e.g., photosynthesis, grazing, predation.

3 The morphology of stream channels refers to the shape of the stream, as quantified by variables such as the width-to-depth ratio, spacing of pools and riffles and the texture and quantity of sediments in the streambed.

4 The Northwest Forest Plan formally adopted as federal policy the findings of the Forest Ecosystem Management Assessment Team (FEMAT). The FEMAT was a multi-disciplinary task force created in 1993 to produce a plan to break the gridlock and strife among regulatory agencies and users of federal lands resulting from conflicting laws, regulations and mandates, particularly within the range of the endangered and old-growth dependent Northern Spotted Owl.

5 This category also includes *Constructed Ponds and Reservoirs.*

6 The term "intermittent streams" (also called ephemeral streams) refers to any non-permanent flowing watercourse that has a definable channel and shows evidence of annual scour or deposition.

7 According to the Forest Practices Code, "fish" are:

- anadromous salmonids;
- game fish such as Rainbow Trout, Cutthroat Trout, Brown Trout, Bull Trout, Dolly Varden Char, Lake Trout, Brook Trout and Kokanee;
- identified threatened or endangered fish; and
- regionally important fish as determined by the District Manager of the Ministry of Forests and the Deputy Minister of the Ministry of Environment Lands and Parks, or a person authorized by the Deputy Minister.

8 The Community Watershed Guidebook is used to determine community watershed status. For more information, contact the local B.C. Environment Regional Water Manager.

9 A May 8, 2000 letter from the Department of Fisheries and Oceans Director General (Pacific Region) to the Deputy Minister of the Ministry of Forests and all District Managers in the Ministry of Environment, Lands and Parks and Ministry of Forests, expressed concern that current logging practices on small fish-bearing streams (S4) and on direct tributaries to fish-bearing streams (S5, S6) threaten the long-term health of salmonid and fresh-water fisheries.

P R I N C I P L E 7

Focus silvicultural systems primarily on what is retained rather than on what is removed

Rationale

Traditional silvicultural systems[1] are primarily timber-oriented, focusing on the removal of valuable timber and the subsequent regeneration and growth of commercially important tree species (Smith, 1986; Franklin and others, 1997). This type of silviculture can result in the loss of the complex forest structure that maintains biodiversity and ecosystem integrity (Keenan and Kimmins, 1993). Maintaining biodiversity and ecosystem integrity in managed forests requires designing and implementing silvicultural systems that retain elements of forest structure present before harvest (e.g., large woody debris, trees of various sizes and species including large canopy dominants, snags of various sizes and stages of decay, and canopy gaps) (Franklin, 1990; 1993; Scientific Panel, 1995; Franklin and others, 1997). This retains the ecological processes and functions associated with forest structure (e.g., soil stability, water storage, nutrient cycling and animal habitat). The retention of structure also preserves genetic information in the forest, provides habitat immediately after harvest for organisms and processes that would otherwise be lost temporarily or permanently[2] (e.g., ectomycorrhizal connections essential for soil fertility), enriches current and future forests by maintaining structural complexity and improves connectivity between cutting units and forested areas (Perry, 1994; Scientific Panel, 1995; Franklin and others, 1997; Harrison and Voller, 1998).

Natural disturbances provide clues for deciding the type, amount and spatial distribution of forest structure to retain during harvesting (Hansen and others, 1991; Bunnell, 1995; Scientific Panel, 1995; DeLong, 1996; Lertzman and Fall, 1998; Lertzman and others, 1997). As mentioned previously, this requires understanding the nature of natural disturbances at many scales of time and space (Lertzman and Fall, 1998). For example, landscape-level characterizations of the effects of wildfire can shed light on how much forest structure can be harvested over time, or how forest openings and age-class distributions shift over time and space across a landscape (White, 1987; Parminter and Daigle, 1997; Lertzman and others, 1998). Understanding individual disturbances illustrates ecologically appropriate amounts and patterns of stand-level retention of forest structure (e.g., the species, size and pattern of retained trees within a harvesting unit).

Best practices

Variable-Retention Silvicultural System

The Clayoquot Sound Scientific Panel recommended adopting a Variable-Retention Silvicultural System to replace conventional silvicultural systems. The primary goal of this system is to maintain ecological integrity, i.e., to retain characteristics of natural forests in managed stands so that ecosystem functions do not depart from the range of natural variability present before harvest (Scientific Panel, 1995). The specific management objectives (and therefore the degree of recommended retention) vary depending on whether the site in question has significant values for resources other than timber (e.g., visual, cultural, or wildlife resources) or is a sensitive area (e.g., dry floodplains outside of riparian reserves and areas with high visual landscape management objectives). In these areas, recommended retention levels are high (greater than 70 per cent). On cutting units without significant values for resources other than timber or without sensitive areas (e.g., with no steep slopes or unstable soils) low levels of retention, i.e., 15 per cent, can be implemented. The Variable-Retention system provides the flexibility to address multiple management objectives (including timber production and site regeneration), maintain ecosystem functions and protect non-timber values (Scientific Panel, 1995).

Prescriptions for Variable Retention focus on what to retain by specifying the type, amount and spatial distribution of forest structure (Scientific Panel, 1995; Franklin and others, 1997). The type of forest structure refers to the kind of material retained (e.g., snags and large live trees). The amount of forest structure refers to the density or cover of retained structure within the harvesting unit. Spatial distribution refers to whether retained structure is aggregated as intact patches of forest or dispersed as individual structures within the unit. A continuum of options for retention exists, from light retention where few or no stems are retained (e.g, similar to seed tree or clearcutting systems) to heavy retention where most trees are retained (e.g., as in single tree selection). The type, amount and spatial distribution of retained structure depends on management objectives and site-specific characteristics.

The Panel noted that watershed context was critical to successful implementation of Variable-Retention silviculture. Watershed-level planning must first identify the areas within a watershed where harvesting can occur. See Principle 2 for details.

Current Practices

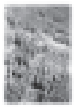
Clearcutting is the dominant silvicultural system in the central and north coast (Pojar and others, 1999). This system removes part or all of a stand, creating open and uniform conditions and generating a largely even-aged cohort of trees. As outlined in the Forest Practices Code, the maximum size[3] for clearcut blocks on B.C.'s coast is 40 hectares, with cutting somewhat restricted in riparian management areas and on unstable terrain. Clearcutting has a number of operational advantages over other systems (e.g., it is more economically efficient, easier logistically, safer for workers, allows complete removal of forest diseases, and provides the open and uniform light conditions that allow efficient growth of trees) (Scientific Panel, 1995; Pojar and others, 1999).

From an ecological perspective, clearcutting provides good habitat for species that require or are strongly associated with open, early successional conditions or edge habitat (e.g., deer and other game species) (Chen and others, 1992; Scientific Panel, 1995; Eng, 1998; Pojar and others, 1999). However, this silvicultural system has a number of ecological consequences that can reduce biodiversity and degrade ecosystem integrity in coastal forests. Clearcutting (Scientific Panel, 1995; Pojar and others, 1999):

- rarely approximates the pattern or process of natural disturbances.
- usually retains few structural legacies of the original forest, such as large old trees and snags.
- results in a simplified stand with little internal heterogeneity of stand structure, reducing biodiversity in both the harvested area[4] and, depending on the existing distribution of seral stages, across the landscape.
- provides poor or unsuitable habitat for species associated or dependent upon old-growth forests.
- can create poor conditions for regeneration in sites with cold air drainage, frequent frosts or strong exposure to direct sunlight.
- can create landscapes dominated by early-seral structural stages, resulting in increased susceptibility to pest outbreaks and pathogens of young or even-aged forests.

In general, as a silvicultural system, clearcutting has timber production as its primary focus and lacks the needed flexibility, imagination and innovation required for the more ecologically enlightened forest management demanded by present markets and the public (Franklin and others, 1997; Pojar and others, 1999).

The use of Variable-Retention systems is increasing. A growing number of licencees[5] and the Ministry of Forests' Small Business Forest Enterprise Program have commited to phase out clearcutting during the next few years (B.C. Ministry of Forests, 2000). The ecological consequences of Variable-Retention silviculture depend on how this system is implemented and the management objectives behind its design. Where it is being implemented, Variable Retention often retains between 15 and 25 per cent of the stand by volume as small patches of trees (Beese, B., personal communication; Pojar and others, 1999). However, without reductions in the Allowable Annual Cut, the widespread implementation of this type of Variable Retention will require more roads and affect a larger landbase than will more traditional management. (Pojar and others, 1999).



Areas of uncertainty

What patterns of openings and retention best approximate the structural ecosystem components that disturbances produce? Although still in its emerging stage, the science of natural disturbance ecology is shedding light on how landscape- and stand-level patterns of retention are created and best approximated by our harvesting practices (Parminter and Daigle, 1997; Lertzman and others, 1997). Perhaps a more pressing question is: What practical pattern of forest openings least disturbs the successional trajectory of the forest and how does forest harvesting interact with other disturbances?

How do the various patterns and levels of retention affect forest organisms and ecosystem processes? This question is a focal point for initiating a cascading set of queries to address the uncertainty about how the types, levels and spatial patterns of retention fare in achieving various management objectives (Franklin and others, 1997; Pojar and others, 1999). For example, what are the tradeoffs between levels of coarse woody debris left on harvested areas and the persistence and movement of small mammal populations? How is the diversity of cavity nesters affected by increasing numbers of retained snags and green trees? These questions are likely best answered by a combination of monitoring the ecological consequences of new silvicultural systems and natural disturbance ecology.

NOTES TO PRINCIPLE 7

1 A silvicultural system is a planned cycle of activities that includes the harvesting, regeneration and tending of a forest stand. This differs from a harvesting system, which refers to the mix of felling, bucking and yarding systems used in a logging a forest stand (Scientific Panel, 1995).

2 A process termed “lifeboating” (Franklin, 1990).

3 In practice, the average size of recent clearcuts in the central and north coast is roughly between 18 and 22 hectares (Pojar and others, 1999).

4 This is especially relevant years after the clearcut, during the stem exclusion stage of forest succession when structural diversity is typically the lowest (Hansen and others, 1991; Parminter, 1998).

5 This includes Weyerhaeuser Company and International Forests Products – two of the largest tenure holders within the study area. For more information, see http://www.weyerhaeuser.com/ and http://www.interfor.com/

P R I N C I P L E 8

Incorporate ecological restoration of degraded landscapes, stands and sites into forest management

Rationale

In some areas, logging and logging-related activities have degraded the ecosystem integrity and biological diversity of the forest and its aquatic resources (e.g., loss of soil productivity[1] or stability and loss of habitat for old-growth dependent species through simplification of forest structure) (Scientific Panel, 1995). Ecological restoration[2] can re-establish lost forest structure and the processes and functions that maintain and enhance biodiversity and forest productivity (Society for Ecological Restoration, 1996; Slaney and Martin, 1997). It is possible to integrate ecological restoration as a key component of forest management where past practices left ecologically degraded areas. For example, the structural complexity of forest stands can be increased during thinning operations by creating gaps, thinning at variable densities and retaining hardwoods. In many cases, however, restoration can simply mean leaving the forest to restore itself (Hammond and others, 1996).

Ecological restoration is not the solution for maintaining functional ecosystems. Since ecological restoration is a young art and science, considerable uncertainty exists about how fully restoration can recreate environments degraded by ecologically inappropriate forest practices (Slaney and Martin, 1997). Forest managers must therefore focus on preventing losses of biodiversity and ecosystem integrity, rather than on their restoration.

Best practices

Management Triggers in the Late-Successional and Riparian Reserves of National Forests

The United States Department of Agriculture (USDA) Forest Service has developed a set of management triggers for silvicultural activities in the Late Successional Reserves and Riparian Reserves of the Pacific northwest, particularly in the range of the Northern Spotted Owl (USDA and USDI, 1997). Management triggers are landscape-level characteristics that prompt forest managers into conducting appropriate management activities that meet the goals of the Aquatic Conservation Strategy[3] and Late-Successional Reserves[4]. In essence, the use of management triggers incorporates ecological restoration into forest management by recognizing areas in need of attention and modifying management accordingly. Appropriate management activities are specific to seral stage. Forest managers are presented with a range of appropriate treatments so they can select the most appropriate following site-specific assessment of the area in question.

Examples of management triggers include areas with: long-term productivity issues, dense and uniform conifer stocking, a species mix inappropriate for the growing potential of the site, or areas with Aquatic Conservation Strategy needs (e.g., degraded instream habitat or excess sedimentation). Each management trigger is associated with management criteria (or objectives) that help integrate site conditions, the successional pathways appropriate for a given site and desired future conditions. For example, the management criterion for areas with long-term productivity issues is to restore soil productivity. The appropriate management activities are silvicultural treatments to add nutrients to the soil, such as "fall and leave," recruiting snags and closing roads.

Current Practices

Watershed Restoration Program

Ecological restoration on the north and central coast of British Columbia is limited to watershed restoration. The Watershed Restoration Program, founded in 1994 and funded by Forest Renewal British Columbia (FRBC), is the primary program for watershed restoration in B.C. (Slaney and Martin, 1997). Its goals are to restore and protect fisheries and aquatic resources, to increase knowledge and tools for restoration and watershed management, and to provide employment opportunities (WRP, 1999). More specifically, the technical objectives of this organization are to reduce sediment flows from hillslopes to streams, to re-establish natural patterns of water drainage, and to replace lost features of stream channels that affect stream stability and the availability of habitat for commercially valuable or endangered fish stocks (WRP, 1999).

Watershed restoration in coastal British Columbia receives considerable funding from FRBC. For example, the Pacific Region[5] received $158 million for watershed restoration from 1994 to 1999 and $25.6 million is scheduled for the years 2000/2001 (FRBC, 2000). The majority of funding for watershed restoration goes to road deactivation or rehabilitation, i.e., culvert installation or replacement, to reduce the risk of sediment loading into streams. The remainder is used for habitat restoration projects, revegetation of streambanks and hillslope stabilization. FRBC funds are often spent in partnerships with industry to provide training and education for forest workers, and to cover the cost of labour and equipment needed for watershed restoration.

Terrestrial Ecosystem Restoration Program

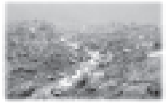
FRBC is developing a Terrestrial Ecosystem Restoration Program (TERP) (Holt, 2000). This program focuses on terrestrial ecosystems, recognizing that the aquatic focus of the WRP does not include the large number of terrestrial species impacted by forestry activities. The proposed strategic goal of TERP is to restore the capacity of ecosystems to provide the natural diversity of processes, habitats and species where these have been significantly impacted by past forest practices (Holt, 2000). This goal will be addressed by recreating forests that more closely resemble those developed through natural disturbance processes, reducing significant trends in ecosystem simplification, restoring selected terrestrial ecosystems, and focusing restoration attempts on projects with the most rapid response time. Unfortunately, funding for this initiative is only $50,000 in 2000/2001 for Ecosystem Restoration Pilot Projects in each of FRBC's six funding regions (FRBC, 2000)[6].

Areas of uncertainty

What are appropriate targets for restoration? Typically, restoration projects attempt to restore sites to a set of reference conditions, i.e., a set of conditions that reflects the ecosystem composition, structure and function found within an area's natural range of variability[7] (Swanson and others, 1994; Moore and others, 1999). In theory, characterizing reference conditions should take into account *all* ecosystem components, i.e., organisms, structures, biogeochemical cycles, disturbance processes, etc., as well as the way these components vary over different temporal and spatial scales. Only through such thorough characterization can we ensure that all influencing factors are considered in setting the reference conditions (Moore and others, 1999). This is difficult because many of these factors are poorly understood or difficult to measure.

Should we restore processes or structure? If a set of reference conditions can be established, how we achieve those conditions is open to debate. For example, it may be possible to characterize reference conditions for a given site through analyses of historic records and TEK of similar undisturbed sites and findings of other researchers. Do we then seek to restore the processes (e.g., fire) that generated the reference conditions (e.g., by prescribed burning) or the forest structure that reflects the reference conditions (e.g., by silvicultural manipulations) (Stephenson, 1999)?

Where is the balance of benefits of "active" versus "passive" restoration? In some cases, degraded sites will regain lost structure and function if given enough time, i.e., through passive restoration. When do the benefits of more costly active restoration outweigh the benefits of simply letting the forest restore itself?



NOTES TO PRINCIPLE 8

1 Interestingly, logging has also increased the productivity of certain sites, as measured by woody biomass (Kimmins, 1996).

2 Ecological restoration is defined as the process of assisting the recovery and management of ecological integrity, which includes a critical range of variability in biodiversity, ecological processes and structures, regional and historical context and sustainable cultural practices (Society for Ecological Restoration, 1996).

3 See the section regarding the Aquatic Conservation Strategy of the Northwest Forest Plan on page 39.

4 The goal of Late-Successional Reserves is to protect and enhance conditions of late-successional and old-growth forest ecosystems, which serve as habitat for late-successional and old-growth related species, including the Northern Spotted Owl (USDA and USDI, 1994).

5 The Pacific Region covers the Lower Fraser Valley to the mid coast and the Queen Charlotte Islands and Vancouver Island.

6 More information is available at: http://www.forestrenewal.bc.ca/pubs/

7 The assumption is that the conditions of a site needing restoration have been degraded beyond this natural or historic range of variability.

PRINCIPLE 9

Acknowledge uncertainty and monitor the ecological consequences of forest practices

Rationale

Given the complexity and dynamic nature of forest ecosystems over time and space, forest practices based on the principles in this report could have unforeseen and possibly negative consequences for the ecological sustainability of the forests in the study area. Uncertainty is an inherent part of managing dynamic, complex and interconnected natural systems (Walters and Holling, 1990; Ludwig and others, 1993). Since applying these principles requires implementing non-traditional and innovative practices that have uncertain ecological consequences, as well as unknown operational, social and economic ones, it is important to monitor the effectiveness of different forest practices in meeting ecological, operational, social and economic management objectives (Pojar and others, 1999).

As mentioned previously, adaptive management provides a framework for managing resources in an uncertain environment. Adaptive management allows rigorous learning by framing forest practices in the context of an experiment, i.e., through the use of replicates and controls (Walters and Holling, 1990; Bormann and others, 1994; Scientific Panel, 1995). This requires setting explicit management objectives that can be monitored with clear environmental indicators to determine whether forest practices meet management objectives (Walters and Holling, 1990; Bormann and others, 1994). Environmental indicators of sustainable forest practices should be easy to measure, cost effective, adaptable to changing conditions (e.g., time and forest age), scientifically sound, based on known ecological relationships and related to management goals (Smith and others, 1999; B.C. Ministry of Environment, Lands and Parks, 2000b).

Best practices

Effectiveness Monitoring Program of the Northwest Forest Plan

The USDA Forest Service has begun an Effectiveness Monitoring Program (EMP) to assess whether the goals of the Northwest Forest Plan[1] are being met (Mulder and others, 1999). Still in the design and implementation stage, this program focuses on ecological monitoring of the status and trends of "priority resources:" late-successional forests, Northern Spotted Owls, Marbled Murrelets and aquatic and riparian ecosystems. This ambitious and innovative monitoring plan seeks to institutionalize and integrate habitat-based monitoring into the day-to-day activities of several regulatory agencies at various levels of bureaucracy. The EMP also seeks to establish a basis for future monitoring of other important resource issues (e.g., socioeconomic, and "survey-and-manage" species).

The emphasis of the EMP is on prospective monitoring, i.e., on providing an early warning of environmental change before irreversible losses occur. The program focuses on a set of indicators that highlight cause-and-effect relationships between effects on ecosystem functioning and stressors or threats. Conceptual models based on ecology illustrate the pathways between the stressors and the ecosystem effects and provide reliable, early warning signals of change. These early warnings establish "prompts" for management intervention and have clear connections to the decision-making processes of forest management.

The EMP focuses on the pattern and dynamics of habitat structure, relying on the notion that habitat is a suitable and pragmatic surrogate for predicting wildlife abundance and distribution. The assessment strategy for collecting habitat data emphasizes both remote sensing and ground-plots to allow inferences about habitat at a range of spatial and temporal scales. By focusing on habitat-based monitoring, the designers of the EMP see the following advantages: a more cost-effective approach than directly monitoring many species, a foundation of existing forest inventory programs on which to build, and a move towards an ecosystem-based approach that is more anticipatory than the current retrospective approach to ecological monitoring (Mulder and others, 1999).

Current Practices

Adaptive Management Pilot Projects

Adaptive management is very limited in current forest management of the study area. However, in 1995 the B.C. Ministry of Forests initiated a review of the principles and potential of adaptive management (B.C. Ministry of Forests, 2000). Several small-scale pilot projects for adaptive management were begun throughout B.C. The goal of these projects is to evaluate adaptive management and demonstrate the range of issues to which it can be applied. The pilot projects rely on the cooperation and support of participants ranging from the B.C. Ministry of Forests (Districts, Regions and Headquarters); the Ministry of Environment, Lands and Parks; the forest industry; and non-government organizations. The pilot projects in the study area include:

1. **Grizzly Bear Habitat – An Adaptive Management Approach for Integrating Grizzly Bear Habitat Requirements and Silvicultural Practices in Coastal B.C.:** The primary goal of this project, initiated in 1992, is to develop silvicultural systems that provide Grizzly forage over the entire rotation of a managed stand, while at the same time producing high quality timber.

Its main objective is to evaluate the effect of varying the size of forest openings and the numbers of trees per cluster on the light environment of a plantation, as well as the effects on the species composition and productivity of the plants that provide forage for Grizzly Bears.

2. **Lagins Creek Silvicultural Systems Trial:** The objective of this pilot project is to test the performance of clearcut and group-selection harvesting methods in the Queen Charlotte Islands Forest District (B.C. Ministry of Forests, 2000). This ongoing project created small patch cuts averaging 0.34 hectares to compare regeneration performance with clearcut sites. Future monitoring of windthrow, riparian habitat impacts, water quality impacts and wildlife impacts is planned.

B.C. Ministry of Forests Forest Sciences Program

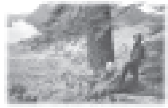
The mission statement of the Forest Sciences Program is to "provide innovative solutions to high-priority forest resources management problems in British Columbia and to seek opportunities to advance resource stewardship based on sound scientific principles, so that Ministry responsibilities under the *Ministry of Forests Act, Forest Practices Code of British Columbia Act, Forest Act, Range Act* and other related statutes can be fulfilled" (B.C. Ministry of Forests, 2000). The Research Branch in Victoria is an integral part of the Forest Sciences Program, along with the Regional Forest Sciences Group in each Forest Region. These researchers strive to provide a sound scientific basis for forest practices and policy decisions through research in forest productivity, ecology, soil science, wildlife biology, hydrology, tree genetics, fisheries, and growth and yield. More than 55 scientists and technicians from the Research Branch work in Victoria, regional and district offices and research stations. Another 40 scientists and technicians work in the Regional Forest Sciences Groups. The Forest Sciences Program provides Forest Service staff with access to in-house scientific expertise, timely advice and applied research capability to address current forest resource management issues, anticipate future problems and strive towards long-term stewardship and sustainability (B.C. Ministry of Forests, 2000).

Areas of uncertainty

How do we monitor biodiversity?

It is necessary to monitor biodiversity to understand how it is affected by forest management. This requires quantification of a fundamentally multi-dimensional concept. Biodiversity cannot be reduced to a single quantifiable entity, especially given that we are still discovering what the term means and because we are limited by a lack of understanding of many different life forms in the forest (e.g., soil fauna and flora) (Purvis and Hector 2000). The resolution of this question is further complicated by the long time scales required to assess the response of forest ecosystems to perturbations (e.g., logging).

How do we incorporate monitoring into the culture of management? Planning and implementing large-scale monitoring programs and adaptive management initiatives often results in failure, mainly due to cost and institutional barriers (Walters, 1997). Much more understanding is needed about how to institutionalize adaptive management, monitoring and feedback to decision-makers.



NOTES TO PRINCIPLE 9

1 The Northwest Forest Plan is a large-scale ecosystem management plan for federal lands in the Pacific Northwest, encompassing 24 million acres (9.6 million hectares). The goals of the Northwest Plan are "to take an ecosystem-management approach to forest management, with support from scientific evidence; meet the requirements of existing laws and regulations; maintain a healthy forest ecosystem with habitat that will support populations of native species (particularly those associated with late-successional and old-growth forests), including protection for riparian areas and waters; and maintain a sustainable supply of timber and other forest products that will help maintain the stability of local and regional economies on a predictable and long-term basis" (USDA and USDI, 1994).

Conclusion

The principles outlined in this document identify three important considerations for ecologically sustainable forest management. First, forest management must consider ecological sustainability its primary objective and incorporate it into all aspects of the planning of forest practices. This requires planning in a hierarchy of spatial and temporal scales, meaningfully engaging local communities in decision-making, and incorporating ecological restoration into the culture of forest management. Second, forest management must be constrained within the limits of ecological sustainability. As an ecologically sustainable rate-of-cut is imperative, so too are acknowledgement of uncertainty and monitoring of ecological consequences of forest management. Third, we must conserve all native species and their habitats within their range of natural variability. Keystone, endangered, threatened and rare species are particularly important in this respect. Other critically important foci for conserving biodiversity and ecosystem integrity include hydroriparian areas and the maintenance of ecosystem processes and forest structure within their range of natural variability.

Adopting these principles in the design and implementation of forest practices will undoubtedly improve the chances of maintaining biodiversity and ecosystem integrity in managed forests. However, whether ecological sustainability is achieved will more fundamentally depend on how these principles are integrated with other important dimensions of sustainable forest management, i.e., the cultural, social and economic objectives for which forest managers strive. Perhaps most importantly, ecological sustainability hinges on adopting more ecologically-based philosophies and perspectives – perspectives based on the notion that humans are part of ecosystems, rather than separate from them, and on the recognition that humans are powerful ecological entities that can not only protect but also nurture biodiversity and ecosystem integrity.

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A Cut Above outlines nine principles to guide the development and implementation of ecologically sustainable forest practices in coastal British Columbia. Drafted with the help of an advisory team of leaders in the field of ecological sustainability, these guiding principles illustrate a fundamentally different approach to forest management and planning than the current industrial model. The report provides an ecological rationale for each principle, as well as examples of "best practices" drawn from existing frameworks in other jurisdictions to illustrate realistic models of how the principles can be applied on the ground. Also detailed are relevant "current practices" in British Columbia and key areas of ecological uncertainty that exist regarding each principle.

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