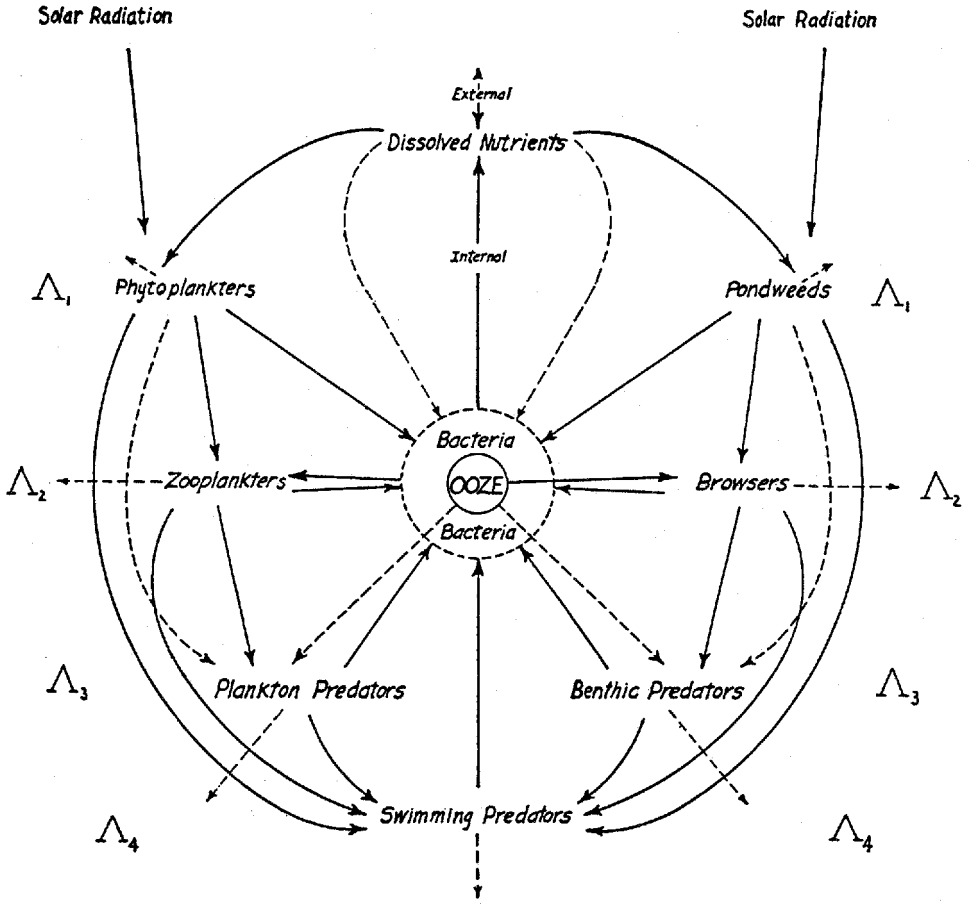
To Keep Every Cog and Wheel:

Regulatory and Conceptual Background for Managing the Fishes of Jasper National Park

David W. Mayhood



Part 1 of a Fish Management Plan for Jasper National Park

Freshwater Research Limited

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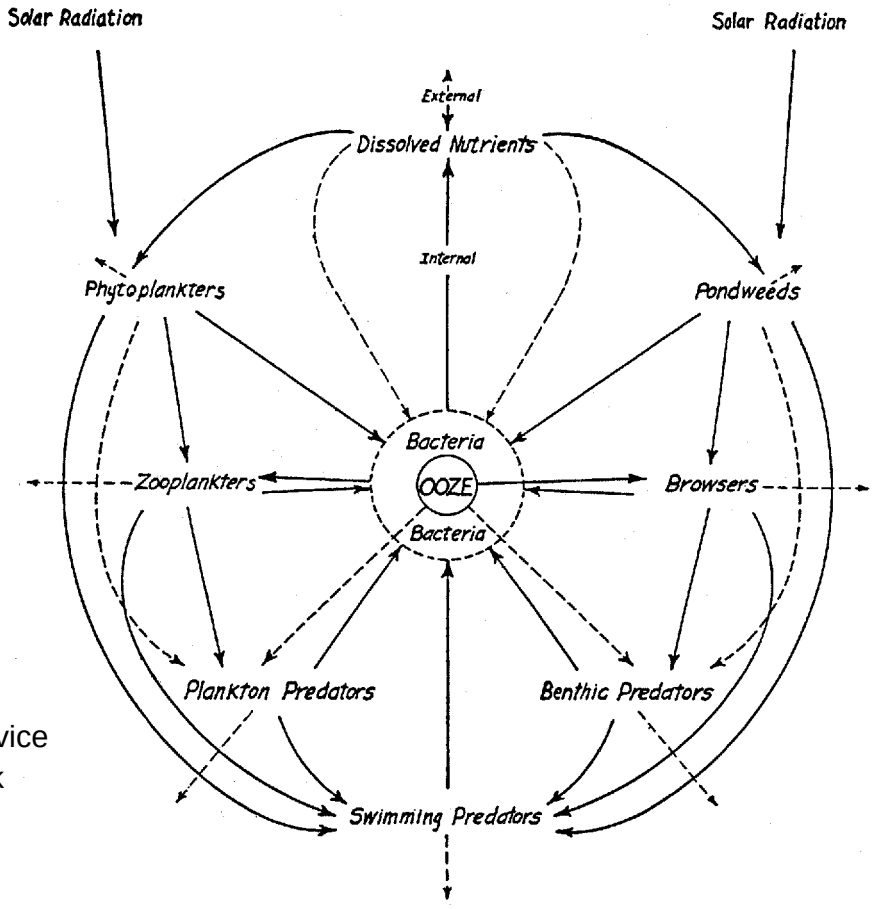

Prepared for
Canadian Parks Service
Jasper National Park
Jasper, Alberta

Part 1 of a Fish Management Plan for Jasper National Park

September 1992

Cover & Title Page. An infinitesimal fraction of the innumerable cogs and wheels making up the ecological machinery of Jasper National Park: R. L. Lindeman's classic generalized food-cycle relationships for a typical lake (Lindeman 1942:208). This digram is a highly schematic, extremely simplified representation of some of the crucial ecological processes in many park lakes (most of our high lakes lack the pondweed element shown in the digram). Each labelled element in the lake could be replaced with a list of several to dozens of species, many of them with separate ecologically distinct life history stages. Each species and stage plays a unique ecological role. Each may also function somewhat differently in different water bodies. Inputs to the system from outside the lake (the external label at the top of the picture) typically result from cycles and relationships at least as complex than this one. Inlet streams, for example, each have ecological machinery that carries out the same functions of production, consumption and decomposition, and the operation is somewhat different in each. Likewise, outputs from the lake (the dotted arrows leaving the circle) enter into similarly complex ecological cycles within the larger ecosystem of the park and its surrounding area. Finally, the entire mechanism continually changes: individuals vary, populations adapt, species evolve, communities wax and wane, succeeding one another. Maintaining the ecological integrity of JNP means maintaining the structure and function of this infinitely complex integrated mechanism: keeping every cog and wheel together and functioning, allowing natural change to take its course.

ABSTRACT

I reviewed the National Parks Act, the Green Plan, current and proposed Canadian Parks Service Policy documents, the Jasper National Park Management Plan, and national and regional directives on sport fishing management

1. to identify and describe the purpose and objectives of the national parks of Canada in general, and of Jasper National Park in particular;

2. to reconcile where necessary, and to the extent possible, conflicts and inconsistencies in the regulatory documents so that they provide clear guidance to the plan; and

3. to introduce the principal scientific and park management concepts that most appropriately would address the objectives revealed by the regulatory documents.

The *primary* purpose of Canada's national parks is to protect the landscapes and ecological integrity of natural areas of Canadian significance representing the major natural environments of Canada. The primary purpose of Jasper National Park is to protect the landscapes and ecological integrity of the lands and waters within its borders, specifically a representative cross-section of the eastern Rocky Mountains natural area. It follows that the primary goal of fish management in JNP must be to ensure that the ecological integrity of the park's natural fish resources (the native fishes and their habitats) is maintained.

The landscapes and ecological integrity of the national parks, including those of Jasper National Park, are protected for a purpose: so that people can learn about and enjoy them as examples of natural areas of Canadian significance representing the major natural environments of Canada. Jasper National Park is protected so that people can learn about and enjoy a representative example of the eastern Rocky Mountain natural area. Appropriate uses of the park are those that enable people to learn about and enjoy the park *in that context*, provided that those uses do not damage the landscape or disturb the integrity of the parks' ecosystems. Thus, an important *secondary* goal of fish management planning for JNP is to ensure that park users can experience the fishes and their habitats in appropriate ways. In particular, people must have opportunities to learn about and enjoy the fishes and their habitats as integral parts of this representative eastern Rocky Mountain natural area.

The reasons in principle for maintaining biodiversity were examined to justify the primary purpose of national parks. Utilitarian reasons include maintaining the ecosystem services humans require to survive. We employ national park ecosystems as undamaged models of the ecosystems we use more intensively, so that we can restore

and maintain the intensively-used systems more effectively. Many people see intrinsic value in the existence of all species, and would consider human-induced extinction immoral. By helping to protect ecological integrity and biodiversity, national parks address this perceived moral imperative to help prevent extinctions. Perhaps most importantly, there is strong cultural and aesthetic value in protecting and maintaining species and ecosystems in their wild, natural state.

Conservation biology is an emerging discipline concerned with maintaining biodiversity and ecological integrity. It is the approach most appropriate for managing the fishes and their habitats in Jasper National Park for the purpose of ensuring that the ecological integrity of the park's fish stocks and their habitats is maintained. In national parks, maintaining ecological integrity means allowing ecosystems to remain intact and self-maintaining, their full complement of organisms interacting among themselves and with their environment in a manner unchanged by humans.

It is recognized that the ecological integrity of Jasper National Park undoubtedly is irretrievably damaged to some extent already. Fish management will have to be directed toward restoring and maintaining ecological integrity as closely as possible, given the circumstances. Major problems of fish conservation to be addressed include conserving genetic diversity; identifying, interpreting and maintaining stock structure within native fish populations; restoring and conserving the ecological integrity of natural aquatic ecosystems; and preventing or reversing the cumulative effects of small individual environmental insults.

The constraints placed on angling in Jasper National Park by the requirements for conservation were briefly examined. They include

1. a generally more restrictive attitude toward sport fishing in national parks by the public and professionals;

2. a requirement that no native stock be depleted to below self-maintaining levels;

3. a requirement that no native stock be altered by exploitation or management;

4. a requirement that no other native component of natural aquatic ecosystems be damaged as in (2) or (3);

5. a requirement that a full complement of native fish stocks and aquatic ecosystems be retained in an unaltered state as benchmark or reference resources; and

6. a requirement that any unique stocks (native or not), aquatic ecosystems or components of aquatic ecosystems be protected in an unaltered condition.

More detailed summaries of these points are available in the Discussion of each major section, and in the Summary and Conclusions at the end of the document.

ACKNOWLEDGEMENTS

I am grateful to the Project Advisory Committee (D. Donald, P. Galbraith, M. Gilmour, C. Hunt, P. Wiebe), and especially to Project Manager J. Taylor and Acting Project Manager W. Bradford, for lively discussions on issues in this report, and for providing information, documents and support when it was most needed. The recent work of D. Schindler, S. Lamontagne, A. Paul, P. Leavitt and B. Parker in Banff and Jasper parks convinced me to expand the section on conserving aquatic ecosystems. This volume has been greatly expanded from the draft version to respond to certain review comments and suggestions on Parts 2 and 4. H. Johnson and D. Palmer helped with literature searches. This report was prepared under Canadian Parks Service contract number KJP-01290.

The views expressed herein are mine and are not necessarily shared by the Canadian Parks Service or the Project Advisory Committee. Any errors are mine.

CONTENTS

INTRODUCTION

Jasper National Park (JNP) encompasses 10,878 square kilometres containing over 800 lakes and hundreds of miles of running waters, many of them home to significant stocks of fish, both native and introduced. These fishes and the habitats supporting them are a major and integral part of the greater Jasper National Park ecosystem. In addition, the fish populations support one of the largest sport fisheries in the Canadian national parks system. These valuable resources are presently being managed under the general provisions of the National Parks Act, a diverse set of policy documents, and an overall park management plan, but without benefit of a comprehensive fish management plan.

In November 1989, Jasper National Park engaged Freshwater Research Limited to develop "a well thought-out fisheries management plan … to provide long term protection for this valuable yet highly vulnerable resource" (Terms of Reference, p. 3). The ultimate goals of the project are to produce a longterm fish management plan that

1. "is consistent with existing legislation, policies and directives;

2. "is consistent with an advanced level of thinking regarding the protection/use of the Park's fish resources as reflected by the philosophies/techniques and recommendations set forth at the recent CPS Aquatic Management Workshop [Harvey et al. 1989];

3. "represents a conservative strategy where knowledge gaps are evident;

4. "balances a high degree of protection with a reasonable amount of consumptive use;

5. "is sympathetic to the ecological integrity of individual water bodies; and

6. "has a non-consumptive philosophical base" (Terms of Reference, p. 6).

This report (Part 1) is the first in a series of four that together propose such a fish management plan for Jasper National Park. The plan itself (Part 4) constitutes a proposal by Freshwater Research Limited to JNP that requires both review by the public (who are invited to make comments and suggestions), and approval by the Canadian Parks Service and its responsible Minister. Parts 1 to 3 are the supporting background documents upon which Part 4 is based.

The purpose of the present volume is to determine what the goals of fish management in the national parks are intended to be, and what conceptual approaches to meeting

those goals are appropriate.

More specifically, the objectives of this volume are

1. to describe the legislation and policies guiding fish management in the national parks of Canada in general, and in Jasper National Park in particular;

2. to reconcile where necessary, and to the extent possible, conflicts and inconsistencies in the regulatory documents so that they provide clear guidance to the plan; and

3. to introduce the principal scientific and park management concepts that most appropriately would address the objectives revealed by the regulatory documents.

This report is designed to meet these objectives.

THE REGULATORY ENVIRONMENT

Legislation: The National Parks Act (1988)

Fish conservation and sport fishing in Jasper National Park are governed primarily by the National Parks Act as amended in 1988, and by the National Parks Fishing Regulations. Other regulations under the Act, such as the General Regulations and Water and Sewer Regulations, are peripherally relevant. The Fisheries Act and other Acts and their regulations bear on fish and fishing in the park, particularly on pollution and other forms of aquatic habitat damage. Finally, Canada has international obligations for fish conservation in Jasper National Park, both as a signatory of the World Charter for Nature (United Nations 1982), and by virtue of Jasper's status as part of a World Heritage Site (UNESCO 1972). This analysis, however, will be limited to the National Parks Act.

Section 4 of the National Parks Act states the general purposes of the national parks.

"The National Parks of Canada are hereby dedicated to the people of Canada for their benefit, education and enjoyment, subject to this Act and the regulations, and the National Parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations."

While this paragraph might be legitimately interpreted in several ways, in general "use without impairment" is clearly the guiding principle. Fish resources in national parks, therefore, may be used provided they are not damaged.

The Act implicitly recognizes sport fishing as an acceptable activity in national parks, at least in principle, and makes specific provision for protecting fish and their habitats. Section 7(1) states:

"The Governor in Council may, as he deems expedient, make regulations for

"(a.1) the protection of the flora, soil, waters, fossils, natural features, air quality and cultural, historical and archaeological resources;

"(b) the protection of fauna, the taking of specimens thereof for scientific or propagation purposes and the destruction or removal of dangerous or superabundant fauna;

"(c) the management and regulation of fishing; and the protection of fish, including the prevention and remedying of any obstruction or pollution of waterways".

Where conflicts between resource use and resource protection arise, the Act clearly and explicitly directs that protecting the resource comes first. Section 5(1.2) states:

"Maintenance of ecological integrity through the protection of natural resources shall be the first priority when considering park zoning and visitor use in a management plan."

The "ecological integrity" of fish resources must be maintained, whatever use is made of them. No uses are exempt.

Policy: The Green Plan (1990)

In 1983, the United Nations General Assembly established the World Commission on Environment and Development (WCED). The Brundtland Commission, as it came to be called (after its chairman), was given the tasks of re-examining the critical problems of development and environment on the planet, and of formulating realistic proposals for action by the world community. The Brundtland Commission's final report, *Our Common Future* (WCED 1987), proposed a plan of action based on a concept termed *sustainable development*. By sustainable development the Commission meant *development meeting the needs of the present without compromising the ability of future generations to meet their own needs* (WCED 1987:8).

Canada's Green Plan (Government of Canada 1990) is this country's most tangible endorsement of the Brundtland Commission report. It is Canada's sustainable development plan, detailing what the concept means to the Canadian Government. The Green Plan constitutes Canada's most fundamental policy on environment and development. It is a commitment of the entire federal government, not just of Environment Canada (Government of Canada 1990:19), and contains extensive provisions for monitoring compliance.

The many areas in which the Green Plan affects fish management planning for Jasper National Park are described below. Page numbers refer to the Green Plan document (Government of Canada 1990) unless noted otherwise.

Basic Principles

The Green Plan cites seven principles upon which the Government of Canada bases its efforts to secure both a safe and healthy environment, and a sound and prosperous economy (pp. 15-18). Because the Green Plan is a commitment of the entire federal government, these principles are expected to be applied to fish management planning in Jasper National Park.

Respect for Nature. "Nature has an intrinsic value that exceeds its worth in the marketplace. It supports a diversity of life on the planet and is essential to our well-being." Because human actions can wreak serious, irreversible, yet frequently unpredictable damage on the environment, we must be prudent, erring on the side of protecting the environment (p. 15).

The Economy-Environment Relationship. "The well-being of Canadians is dependent on the health of both our environment and the economy." We must meet our environmental goals in ways that promote economic prosperity; for example, by setting clear, fair and consistently-applied rules for the use of environmental resources. In meeting environmental goals, we must make use of market forces and allow industry as much flexibility as possible. We must provide for our country's environmental and economic future by investing in science, education and technology, viewing the challenge of protecting the environment as an economic opportunity, not a constraint (p. 15).

Efficient Use of Resources. All environmental resources are limited in some way. We must value them at their true worth, using them frugally so that we live off the interest without depleting the capital. For example, we should not exploit fish stocks more rapidly than they can replenish themselves. To encourage efficient use of resources, we must adopt the rule that the polluter or user pays (p. 16).

Shared Responsibility. "No single government or industry, however large, and no individual, however committed, can tackle our environmental problems alone. The responsibility for finding lasting solutions rests with all Canadians" (p. 16).

Leadership. "Governments are trustees of the environment on behalf of the people. They are responsible for establishing the framework of laws and regulations that control access to the environment." The Government of Canada will show leadership on environmental matters, nationally and internationally (p. 17).

Informed Decision-Making. "To make wise decisions about the use of our environment, we must know and understand the physical world and its ecosystems, and the interrelationships between the natural environment and the economy. Informed decision-making requires high-quality environmental science, education and information." But we cannot rely solely on experts for the solutions to environmental

problems. Because Canadians are to be called upon to change their behaviour toward the environment, we must ensure that the public can be directly involved in deciding what those changes will be (pp. 17-18).

We Must Think, Plan and Act in Terms of Ecosystems. We live in a complex and integrated environment, in which all creatures including humans interact with, and depend upon, each other. The increasing number and complexity of environmental issues demand that we adopt an integrated approach (p. 18).

The Role of Canada's National Parks and Their Fishes

The specific provisions in the Green Plan that most clearly circumscribe fish management in Jasper National Park are found in the section entitled *Our Special Spaces and Species* (pp. 79-90). It is here that the role of the national parks in overall federal environmental policy is described, and the policy on wildlife (including fishes) as an ecological resource is detailed.

The Green Plan makes protecting our country's rich biological diversity a major goal, recognizing an international responsibility to do so. For example:

"As plant and animal species disappear throughout the world at an alarming rate, people and governments are beginning to recognize a responsibility for maintaining the planet's biological diversity. Negotiations are under way under the auspices of the United Nations Environment Program and other international organizations on a convention on the conservation of biological diversity. Canada supports this concept, and will support international efforts to sign such a convention before the end of 1992" (p. 86).

"Canada's rich biological diversity must be a major component of our legacy to future generations. It represents a significant proportion of the world's biodiversity, provides millions of Canadians with highly valued recreational opportunities and forms the basis of many subsistence and recreation-based economies" (p. 79).

*"To exercise its responsibility to ensure biodiversity, Canada must secure the future of its own wildlife species" (*p. 85).

Under the Green Plan, the country's national parks (among other "special places") are intended to be protected from major pressures of human development. They are seen as fulfilling a dual role of

- "*preserv*[ing] *important landscapes from the forces of change that accompany the economic activities of humans",* and

- "*conserving our biological diversity by protecting wildlife habitat"* (p. 79).

The national parks are expected eventually to protect about three percent of Canada's total land area representing all the major terrestrial natural regions, up from about 1.8 percent now (pp. 79-80). But the plan recognizes that merely setting aside land is not enough. It therefore commits the federal government to

- *"developing an enhanced resource management program involving applied studies for ecological integrity and regional integration;*

- *" supporting staff training in natural resource protection; and*

- *"promoting the concept of parks as 'living' scientific laboratories and models of sustainable development management"* (p. 81).

In addition, the federal government commits itself to adopt the Federal Policy on Wetland Conservation. This policy will include protection of wetlands on federal lands such as national parks, and provisions for making wetland conservation "a fundamental goal of all federal land use decisions" (p. 82).

The Green Plan deals at length with sustaining the country's wildlife as part of its international responsibility for protecting biodiversity. In this context the term "wildlife" is clearly intended to mean all "wild life", i.e., not only large game mammals, but all wild living things, including fishes. It notes, however, that "migratory birds, particularly waterfowl, continue to show declines", that 175 species of mammals, birds, reptiles, fishes and plants are "known to be at risk", and that "about 10 species are added to the list each year" (p. 83, cf. pp. 84-85). Loss and degradation of habitat, overharvesting, poaching, disease and toxic substances are identified as the reasons for Canada's wildlife populations being under considerable stress (p. 83).

The Green Plan recognizes that despite ongoing efforts to protect wildlife, more must be done, including protecting non-game species. The Plan emphatically declares:

"The federal government intends to meet, head on, the challenge of maintaining and enhancing the health and diversity of Canada's wildlife. Helping wildlife populations to survive and flourish must become a national effort, involving all levels of government and the public at large." (p. 84).

The Green Plan outlines a National Wildlife Strategy to begin addressing its wildlife protection goals. Based on a policy adopted by Wildlife Ministers across Canada in 1990, the federal government commits itself to the following measures affecting fish management in Jasper National Park (in addition to those intended to protect wildlife habitat in "special spaces" like national parks, described above).

- Wildlife research programs will be strengthened, focusing on ecological and toxicological research, especially in cooperation with colleges and universities (p. 84-85).

- Populations of both endangered and non-endangered species will be directly increased by undertaking recovery programs for many particular species at risk, by undertaking cooperative programs with universities and environmental nongovernmental organizations, by managing federal lands "appropriately to meet protection and recovery needs", and by developing recovery programs for all threatened and endangered species under federal jurisdiction (p. 85).

- An integrated cooperative program to protect and conserve wildlife habitat beyond the boundaries of the national parks will be undertaken with other governments and the private sector (p. 87).

Other Relevant Provisions

Many other provisions of the Green Plan bear upon fish management planning in Jasper National Park. Under the heading Life's Three Essentials — Clean Air, Water and Land (pp. 27-60), the Green Plan makes a major commitment to "virtually eliminate" discharges of persistent toxic substances into the environment (p. 43). This is a fishery management issue in Jasper because of recent evidence of pulpmill toxins in migratory fishes collected from the Athabasca River just outside the park (Part 3). The federal government has undertaken to link sources of of toxic substances with their ultimate impact on the environment (p. 47); thus the fish management plan must consider the potential for contamination of park fish stocks from this source. In this connection, the Green Plan promises a joint federal, provincial and territorial government environmental impact study on the cumulative effects of existing and proposed developments in the Athabasca River Basin, as recommended by the Alberta-Pacific Environmental Impact Assessment Review Board (p. 37).

The Plan commits the federal government to improve water science in Canada. This undertaking is part of a larger commitment to a five-year environmental science and technology action plan that emphasizes "an integrated, ecosystem-based understanding" (pp. 39, 149).

The initiatives for sustainable fisheries under the heading Sustaining our Renewable Resources (pp. 61-78) in the Green Plan deal primarily with commercial fisheries, especially marine fisheries. There are some provisions that are applicable to fish management in the national parks, however. For example, the Green Plan commits the federal government to develop a national policy for sustainable fisheries by 1992 (p. 75). The role of national parks fish stocks in this policy remains to be defined, but the function assigned to national parks overall in federal environmental policy (described

above) suggests possible limited roles in research, education and model recreational fisheries.

Under the heading Global Environmental Security (pp. 97-129), the Green Plan refers to the major economic and social stake Canada has in obtaining action by the world community to clean up the global environment. To effectively influence events, however, this country must set an example of good environmental stewardship. We must show that we are willing to take difficult decisions ourselves if we expect others to do the same.

"We must recognize that to exert influence and act on the international stage, we must first have our own environmental house in order: that is, we must practise at home what we advocate abroad" (p. 123).

For example, Canada vows support for protecting the world's biodiversity (p. 86, quoted under the heading The Role of Canada's National Parks and Their Fishes, above), so it must take effective action to protect biodiversity at home.

Many of the commitments made under the general heading Environmentally Responsible Decision-Making (pp. 131-158) apply to fish management planning for Jasper National Park. This portion of the Green Plan calls for

- consulting and joint planning on environmental matters among federal and provincial governments, aboriginal peoples, non-government organizations, industry and the general public (pp. 131-140);

- "providing accurate, timely and accessible environmental information to Canadians" (p. 141);

- developing Canada into an environmentally literate society through improved environmental education, specifically including (among other approaches) development of environmental training plans appropriate for specific target audiences, and support for partnership activities designed to increase understanding of specific issues (p. 145-146);

- supporting new science, specifically research designed to provide an ecosystem-based understanding of environmental problems, and with an ensured strong federal scientific presence (pp. 147-149); and

- using strong environmental laws, together with market-based approaches where appropriate, to protect the environment (pp. 153-158).

Finally, the Green Plan emphasizes that Canada's goal is to respond quickly and effectively to environmental emergencies (p. 165). Management planning for the fish resource in Jasper must include provisions for such response.

The Green Plan declares that "Federal operations must be exemplary in meeting and frequently exceeding all regulations and standards as well as being compatible with provincial and international environmental objectives" (p. 159). The Government of Canada intends to lead by example in all of its operations affecting the environment, thus it intends that its fish management plan for Jasper National Park should meet the highest standards for managing the resource in a national park context.

Policy: Canadian Parks Service Current Policy (1979)

The Canadian Parks Service[1] (CPS) interprets its mandate for fish conservation and sport fishing in numerous policy, planning and management documents. The policy document specifically guiding the overall activities of CPS is the Parks Canada Policy of 1979 (Parks Canada 1983). This policy is somewhat out of date due to recent changes in the National Parks Act (1988) and the Green Plan (1990). It is currently being revised (see below). At the time of writing the 1979 Parks Canada Policy (Parks Canada 1983) is the policy governing CPS activities, except where there are clear contradictions between it and the Act or the Green Plan. In the following review under this heading, page numbers refer to the Parks Canada Policy (Parks Canada 1983) unless noted otherwise.

Overview

The Parks Canada Policy was written to guide all of the agency's responsibilities, which include a mandate to protect a wide variety of cultural and historical resources of national value in addition to the national parks. The writers of the policy document acknowledged that the intended purpose of the resources under Parks Canada's jurisdiction has changed substantially over the years, and is continuing to change. They saw the contemporary role of Parks Canada as "protect[ing] outstanding natural areas and historic places of Canadian significance across the country" (p. 2), recognizing that our special places have significance transcending not only our borders but our traditional economic values.

"… by preserving wilderness tracts and historic resources we are asserting our collective belief that there are special places whose importance transcends their immediate contribution to our gross national product. This is a responsibility not only

1 The body responsible for Canada's parks has been variously named Parks Canada, Environment Canada — Parks, and Canadian Parks Service in recent years. I have adopted the names as they are used in the source documents, but all refer to the same agency.

to future generations of Canadians but also to all mankind as part of international heritage efforts" (p. 2).

"Recent international developments also have implications for Parks Canada's policies. Canadians are beginning to appreciate that protecting heritage resources is part of their international responsibility "(p. 4).

The overall objective for the agency, defined in its program policy, is

"to protect for all time those places which are significant examples of Canada's natural and cultural heritage and also to encourage public understanding, appreciation and enjoyment of this heritage in ways which leave it unimpaired for future generations." (p. 7)

Parks Program Policy

The Parks Program Policy describes how Parks Canada intends to meet its objective, placing priority on resource protection over use. Some examples follow.

under the heading "Program Objective":

"Certain places representative of Canada's natural and cultural heritage are of importance to all Canadians. These special places should be given the highest degree of protection and managed for the benefit of all Canadians within a national system so as to leave them unimpaired for future generations." (p. 7);

under the heading "Protecting Natural and Cultural Resources":

"Parks Canada will make protection of heritage resources its primary consideration.

"Ecological and historical integrity are Parks Canada's first considerations and must be regarded as prerequisites to use. Protection of heritage resources is fundamental to their use and enjoyment by present and future generations." (p. 8)

It is worth noting that this latter statement, in establishing ecological integrity as taking priority over use, foreshadows by nine years the "ecological integrity" clause (Section 5(1.2)) of the National Parks Act as amended in 1988.

under the heading "Outdoor Recreation":

"Parks Canada will provide opportunities for outdoor recreation within the Parks Canada system as means for present and future generations to understand and enjoy heritage resources in ways consistent with protection of these resources.

"Parks Canada's primary concern is to protect and present heritage resources of national significance. Thus public demand for outdoor recreation opportunities in a particular locality is not justification for Parks Canada's participation…..

"Certain outdoor activities offer a valuable means for enjoying and understanding heritage resources. Parks Canada will encourage those outdoor recreation uses which are directly associated with, and dependent on, heritage resources subject to requirements for resource protection, visitor safety and protection of the rights of other visitors. Within these constraints a variety of activities will be offered in different seasons." (p. 10)

This last section also describes some other conditions that must be met to justify any proposed uses of fish resources.

National Parks Policy

Objective

The national parks are only one element of the overall federal parks program. The particular role the national parks are intended to fulfill in that larger program is set out in the Parks Canada Objective for National Parks (p. 28), which is

"to protect for all time representative natural areas of Canadian significance in a system of national parks, and to encourage public understanding, appreciation and enjoyment of this natural heritage so as to leave it unimpaired for future generations."

The meaning of this objective is enlarged upon in the Background to the National Parks section of the document (p. 27).

"National parks are a means of preserving in a natural state areas which are representative of the major natural environments of Canada. … They offer a range of opportunities to learn about and enjoy the natural environment. In order to enable the continued protection of these areas, it is necessary to ensure that visitor activities do not result in harmful changes to ecology or to the appearance of the landscape."

. . . . . .

"On the international level, Canada's national parks are an important component of a world-wide endeavour to protect outstanding natural areas. Within Canada, the national parks are part of a family of parks and wildlife areas administered by different levels of government and designed to serve various public needs. Within this Canadian family of parks, the national parks are distinct because they are natural areas of Canadian significance, because they are protected by federal legislation and

because they are financed by and dedicated to all Canadians.

"There are many benefits of national parks. Some are intangible such as the knowledge that future generations will be able to appreciate wilderness areas of untouched natural beauty. Others are more tangible, such as the enjoyment of visiting national parks across Canada. There are also benefits which can be measured in terms of jobs created and tourism industry development. Furthermore, national parks are ecological benchmarks for research into natural processes and into the relative effects of man on lands outside national parks. For all these reasons, Canada has a responsibility to protect these special places and to encourage public appreciation now and in the future."

Section 1.0 of the the National Parks Policy (p. 28) is more specific in describing the purpose of national parks.

"National parks are intended to protect representative examples of the diversity of Canada's landscape and marine areas for the benefit of present and future generations. To this end, Parks Canada has divided Canada into 48 natural regions, of which 39 are terrestrial and 9 are marine. Each of these natural regions should be represented in the system of national parks."

The section continues on, describing in considerable detail how parks will be chosen to represent the 48 natural areas of Canadian significance.

Fish Management

Much of the National Parks section of the Parks Canada Policy document outlines more specific policies affecting the protection, use and management of fish resources. For example, it describes the zoning system used by the Canadian Parks Service to define broad classes of use appropriate to various parts of each park, and to assist "… in managing the tension between use and preservation" (p. 30). It defines five zones, and describes in very general terms the intensity and types of use to be allowed in each. Uses of fish resources within any zone must meet the broad criteria set for that zone.

National Parks Policy specifies that

"Natural resources within national parks will be given the highest degree of protection to ensure the perpetuation of a natural environment essentially unaltered by human activity", and *"… will be protected and managed with minimal interference to natural processes to ensure the perpetuation of naturally evolving land and water environments and their associated species."*(p. 31)

It excludes resource extraction from the national parks:

"National parks are special areas which are protected by federal legislation from all forms of extractive resource use …." (p. 30),

but makes an explicit exception to permit sport fishing as a "traditional extractive activity":

"Certain traditional extractive activities will be permitted in the following circumstances:

. . . . . .

"iv) Controlled sport fishing of naturally regenerating populations of native species will be permitted." (p. 32)

In passing, it is worth noting that this paragraph, by referring specifically to "native" species, fails to explicitly permit fishing for introduced or exotic species — presumably an oversight. In any case, use of the fish resource through sport fishing is conditional:

"All such activities will be subject to the requirement to protect the ecosystems and maintain viable populations of fish and wildlife species." (p. 32)

Even though sport fishing is explicitly permitted, protecting the resource is paramount.

Other National Parks Policy statements on resource management deal with non-native organisms and extirpated native species.

"Non native species of plants and animals will not be introduced into a national park and, where they exist, efforts will be made to remove them." (p. 32, Section 3.2.8).

"A species of plant or animal which has been native to, but which is no longer present in the park area, may be reintroduced:

i) if the effect on other plants and animals is acceptable; and
ii) if such action is compatible with park objectives; and
iii) if such action does not pose serious problems for neighbouring land uses." (p. 32, Section 3.2.7)

Both of these statements are important to fish management in Jasper National Park, where many exotic species of fish and even aquatic invertebrates have been introduced to park waters, and where there is reason to believe that certain native fish stocks have been introgressed, seriously reduced, or perhaps even extirpated (Part 3).

National Parks policy makes outdoor recreation activities subject to measures protecting resources:

"Parks Canada will provide for a variety of outdoor recreation opportunities which are a means for park visitors to enjoy and understand the park's natural environment and which are consistent with the protection of park resources." (p. 33, section 4.1.1)

"Parks Canada will regulate the amount, kind, time and location of outdoor recreation activities using the zoning plan and other management actions to protect parks resources or to ensure visitor safety and enjoyment." (p. 33, section 4.1.5)

Although research is seen as essential for managing national parks

"Parks Canada will encourage and conduct research into natural phenomena, public needs, visitor use and impacts so as to contribute directly to the identification, selection, establishment, protection, development, interpretation, planning and management of national parks" (p. 35, section 5.1),

and research not directly related to managing national parks is viewed as a permissible use

"Other research in national parks which will enhance understanding of natural processes and/or enjoyment of natural areas will be authorized:

i) when use of a national park environment is essential; and

ii) when such research is undertaken or sponsored by a qualified individual or organization" (p. 35, section 5.2),

research in national parks is subject to controls to protect natural resources, and therefore is seen as secondary to resource protection:

"Research activities and facilities within national parks will be controlled by Parks Canada to protect natural resources." (p. 35, Section 5.3)

The Parks Canada Policy document unequivocally places priority on protecting park resources, including fish, above all other uses. Even where a specific exception is made in the "non-extractive use" policy to allow sport fishing, this exception still is subject to the condition that the ecosystems must be protected and "viable populations" maintained.

Policy: Canadian Parks Service Proposed Policy (1991)

The Canadian Parks Service (CPS) recently released a draft policy document for public review (Canadian Parks Service 1991). The proposed policies would supplant those of 1979 described above (Parks Canada 1983). The new policy paper makes no direct reference to the Green Plan, but is marked with the Green Plan logo, so presumably it was designed to implement the Green Plan policies. It is intended also to make parks policy conform with new legislation, most importantly the National Parks Act amendments of 1988.

I will describe proposed policies having implications for fish management in Jasper National Park to indicate current CPS thinking on how park resources in general should be managed. Page numbers refer to the draft policy document (Canadian Parks Service 1991) unless noted otherwise.

Overview

In addition to the natural heritage resources, (national parks, heritage rivers and national marine parks), CPS is responsible for many cultural resources of national significance, including historic sites, historic canals, heritage buildings, heritage railway stations and any cultural resources within the natural heritage lands. The agency views its program as providing "examples of Canada's highest order of land stewardship, reserves of biological and genetic materials, wilderness areas, ecological benchmarks, areas where essential ecological processes and life-support systems are maintained, important examples of built environment preservation, and non-consumptive economic alternatives to more resource depleting activities." The agency uses the broad terms *heritage areas* or *heritage resources* to refer collectively to all of the resources for which it has responsibility (p. 8).

The proposed overall objective of the Canadian Parks Service is stated as follows.

"To fulfil national and international responsibilities in assigned areas of heritage recognition and conservation; and to commemorate, protect and present, both directly and indirectly, places which are significant examples of Canada's cultural and natural heritage in ways that encourage public understanding, appreciation and enjoyment of this heritage in a sustainable manner" (p. 14).

Program Policy (Proposed)

The program policies outline in general how the CPS intends to meet the objective

cited above. In the proposed policy document, these program policies are defined to deal with both the natural and cultural resources for which the agency is responsible. How the program policy will be applied specifically to national parks is outlined in the next section, National Parks Policy (Proposed).

The proposed policy places protection of ecological and historical integrity jointly above all other uses.

"Protection and preservation of ecological and historical integrity will be given the highest priority in the acquisition and management of heritage places and resources by the Canadian Parks Service, and in every application of policy they are paramount. ….

"Ecological and historical integrity will provide the foundation for public use, understanding and enjoyment. The protection and conservation of heritage resources are fundamental to their use by present and future generations" (p. 15).

Many specific proposed program policies provide for using, learning about, planning for, managing and otherwise dealing with heritage resources. These provisions emphasize conservation, preservation and protection themes, or are conditional upon resources being protected, in keeping with the primary goal of protection implied by the heritage resources designation. Some examples are listed below.

under the heading "Understanding, Appreciation and Enjoyment"

"The Canadian Parks Service will make appropriate opportunities available for the public to experience Canada's heritage in those natural and cultural settings which it manages, so that present and future generations can understand and enjoy heritage resources in ways consistent with protection of those resources." (p. 15).

"A range of opportunities will be provided which satisfy a significant cross section of visitors. Appropriate visitor activities will be those that are related to the heritage themes and character of the setting, and do not disturb the cultural or ecological integrity of heritage resources." (p. 16).

"Some of Canada's most significant tourism attractions are … part of the system of heritage areas administered directly by … CPS. Maintaining the integrity of these special places is vital to their tourism value as well as to the CPS mandate." (p. 16)

under "Research, Planning and Management"

"Research activities will be managed in ways that ensure the protection and presentation of heritage, as well as public safety and enjoyment" (p. 16).

"Management plans will identify critical park, canal, and site values for protection…" (p. 17).

"The Canadian Parks Service will meticulously implement the Federal Environmental Assessment and Review Process (EARP)" (p. 18).

under "Roles and Relationships"

"On behalf of the Government of Canada, the Canadian Parks Service will assume the lead role it has been given in fulfilling Canada's international responsibilities for the protection and presentation of places representative of the world's natural and cultural heritage" (p. 19).

"…the CPS contribution [to conservation and sustainable use strategies] *will be made by maintaining ecological integrity in national parks…"* (p. 22).

These policy statements show that the CPS intends to protect the integrity of heritage resources under its jurisdiction above all other uses. The document continues on to give other specific guidance for appropriate heritage resource uses, planning and management in its proposed program policies.

National Parks Policy (Proposed)

Objective

The national parks form only a part of the overall program of the Canadian Parks Service. The role of the national parks in the program is defined by the CPS objective for national parks:

"To protect for all time representative natural areas of Canadian significance in a system of national parks, and to encourage public understanding, appreciation and enjoyment of this natural heritage so as to leave it unimpaired for future generations" (p. 29).

This proposed objective for national parks is identical to that currently in place. The intended role of the national parks is elaborated further, both in the Background to the proposed policy, in detail under the heading "The National Park System", and in various other sections. Under Background:

"National parks protect major natural environments representative of the heritage of all Canadians.

. . . . . .

"The establishment alone of national parks will not ensure their continued protection. In varying degree, park resources will always be subject to external influences and the effects of previous land use practices. Natural processes are dynamic and will change a park's character over time. Such changes will be fitting and representative if natural processes are permitted to prevail. However, representativeness will be lost if human activity and development generated from outside or inside a park become the dominant processes of modification." (p. 28)

Under Section 1.0, "The National Park System":

"National parks protect representative examples of the Canadian landscape. To this end, the Canadian Parks Service has identified 39 terrestrial natural regions across Canada, each of which warrants representation in the national park system. Within each of these regions, the identification of areas which include the greatest diversity of representative biological, geological and physiographical themes is being completed. Potential national parks are selected from among these ' natural areas of Canadian significance'." (p. 29)

Under Section 2.0, "Management Planning", the prime objective of protecting the ecological integrity of the parks is specifically recognized.

"… [management] *plans will: specify the type and degree of resource protection and management needed to assure the ecological integrity of the park ….*

"The 1988 amendments to the National Parks Act state that the maintenance of ecological integrity must be the first consideration in management planning." (p. 31)

. . . . . .

"In the preparation of a management plan, the maintenance of ecological integrity through the protection of natural resources will be the first priority when considering zoning and visitor use." (p. 32)

Under Section 3.0, "Protecting and Managing Natural Resources":

"Management for park purposes differs markedly from that of other lands, where effort may be directed toward modifying or controlling nature, producing crops or extracting natural resources. Within national parks, effort is directed at protecting natural heritage by maintaining the environment in as natural a state as possible. This goal has far-reaching implications in that many concepts and practices which are relevant or essential to successful resource management on other lands are inappropriate in national parks." (p. 33).

"… the activities of modern society and phenomena such as climate change hold the prospect of profoundly altering Canada's natural environment. National parks will become increasingly important in national and international efforts to maintain biodiversity and genetic resources." (p. 34)

These and many other direct statements in the draft document clarify the intended purpose of national parks. As in the current policy, Canadian national parks are intended to protect and maintain landscapes and their ecosystems representing the major natural regions of the country, retaining all of their parts and processes in their intact, natural state (i.e., in a state unmodified by man), to whatever extent that may be possible. In addition, they are intended to be part of worldwide efforts to maintain biodiversity and genetic resources.

It is also the object of national parks to "encourage public understanding, appreciation and enjoyment of this natural heritage", but only in such fashion that leaves the parks "unimpaired for future generations". To remain unimpaired by visitor use, the Act requires that ecological integrity (ecosystem "intactness") be maintained. Significantly, in both the proposed and the current policy, it is *not* an objective of national parks to provide for any visitor uses other than those advancing "public understanding, appreciation and enjoyment" of the parks' natural landscapes and ecosystems.

Fish Management

How the objective for national parks will be met is described in detail under numerous headings. Several relate directly to fish management. Under Section 3.1, "Resource Protection" (p. 34):

3.1.1: "*Ecosystems will be given the highest degree of protection to ensure the perpetuation of natural environments essentially unaltered by human activity.*"

3.1.2: "*The ecological integrity of the resources in national parks will be protected through the elimination of threats and, wherever possible, existing uses which compromise this integrity.*"

Other paragraphs under this heading commit CPS to prevent, eliminate or minimize pollution, ensure compliance with the National Parks Act and Regulations, and consult the public in developing park regulations.

In Section 3.2, "Resource Management" (pp. 34-35), several specific principles are listed that apply to fish management. The guiding principle is the first:

3.2.1: "*Ecosystems within national parks will be managed with minimal interference in natural processes.*"

Later sections reveal that the "minimal interference" envisioned is scientifically-based active management. Active management will be permitted in certain instances, as when manipulation is required to restore already altered natural processes and ecological integrity; when significant natural or cultural resources must be protected; or when it is

clear that natural processes will have serious adverse effects on neighbouring lands or risk to major park facilities, public health or safety. Fire, indigenous insect infestations and avalanches are cited as examples of natural processes that may be actively managed for these reasons. If and when active management is used, it will duplicate natural processes as closely as possible, and be carefully monitored.

Other sections under the Resource Management heading set policy for dealing with transboundary concerns, scientific research, non-native species, and native species restoration that are relevant to fish management planning for Jasper National Park. CPS will establish *cooperative resource planning programs* with adjoining jurisdictions to deal with shared natural resources (applicable to migratory fishes in the Athabasca and other rivers). *Basic scientific research* contributing to the protection and understanding of ecosystems will be encouraged, including use of the parks as benchmark ecosystems. All reasonable efforts will be made to prevent *non-native species*, or those "modified by biotechnology" (presumably genetically altered organisms), from being introduced into the parks, and where they exist, to eliminate or contain them. *Extirpated but indigenous organisms* may be reintroduced if suitable habitat exists in the park and there will be no negative effects on the park or surrounding lands.

Finally under the heading of Resource Management, specific policies for aquatic resources are listed. These are presented in their entirety below.

3.2.9: *"High priority will be given to the identification and full protection of unique and significant representative aquatic ecosystems, and to the provision of opportunities for benchmark research on, and interpretation of, aquatic ecosystems.*

"Where fish populations can sustain some harvest without impairing resources, angling may be permitted. Regulations will be conservatively based on ongoing stock assessments and will conform to the principle that angling is part of an overall aquatic resource program involving public education, recreation and resource protection.

"Fish stocking will be discontinued except where necessary to restore indigenous fish populations which have been adversely affected by habitat modification."

Section 4.0 of the proposed policy, "Public Understanding and Enjoyment of National Parks" (pp. 35-39), provides a rationale for why and how the "public understanding, appreciation and enjoyment" part of the parks' objective is to be achieved. The two introductory paragraphs to the section (p. 35) make the point that it is "crucial to the continued protection and enjoyment of existing parks, and to the completion of the national parks system", that the public understand and support the reasons for which they were set aside. For this to happen, people must be able to experience the parks in some way. Opportunities for experiences must be provided with "care and imagination", to meet the protective obligations of the Act. Provided that these

obligations are met, the experiences may be direct (e.g., visits) or vicarious (e.g., through books, films, articles and photographs).

Other parts of Section 4.0 provide more specific considerations related to how park fishes should be understood and enjoyed. Under 4.1, "Visitor Activities" (p. 36), the policy emphasizes that visitors with a wide range of interests and skills be provided for, subject to protecting the parks' ecological integrity, and that "marketing techniques" be used to plan visitor use and evaluate the quality of visitor experience. Under 4.2, "Information and Interpretation" (pp. 36-37), the policy proposes "to provide the public with interesting and enjoyable opportunities to observe and interpret" the resources of the parks, to provide information and interpretation of resource management issues inside and outside the parks, and to involve "informed individuals, professionals, and interest groups" in preparing and presenting programs and events. Section 4.3, "Visitor Services and Facilities" (p. 37), specifies that "services and facilities will be directly related" to providing understanding and enjoyment of park resources.

The following fish management philosophy emerges from this analysis. First, the integrity of the parks' ecosystems will be be given the highest degree of protection such that they remain essentially unaltered by human activity, to whatever extent that may be possible. In this way it is hoped to maintain the parks as representative benchmarks of natural Canadian landscapes and ecosystems. Active management may be used to restore natural processes and ecological integrity where they have been altered, and rarely to protect certain unusually valuable park resources. In managing fishes, for example, non-native species will be actively prevented from becoming established in the parks, and where they have become established, all reasonable attempts will be made to eliminate or contain them. Stocks of indigenous fishes will be restored to the extent possible where they have been extirpated. Otherwise, *minimal interference* is the principle of management and use. High priority is given to identifying, protecting and understanding both unique and representative aquatic ecosystems. In support of protecting the natural ecosystems of the parks and completing the parks system, people must be able to experience and enjoy park resources, including fishes. It is in this context that angling may be permitted — as part of an overall program of public education, recreation and resource protection.

Policy: Jasper National Park Management Plan (1988)

On a local level, the Jasper National Park Management Plan (Canadian Parks Service 1988) presently guides policy on fish conservation and fishery management. Provisions for fish conservation and management in the Jasper National Park Interim Aquatic

Resources Management Guideline (Antoniuk 1984) are intended to be supplanted by the fish management plan being developed here.

The purpose of Jasper National Park, as one of the so-called "Four Mountain Parks", is to

"… protect a representative cross-section of the eastern system of the Canadian Cordillera — the Rocky Mountain natural region — for the appreciation, understanding and enjoyment of present and future generations of Canadians and other visitors" (Canadian Parks Service 1988:5).

The specific objectives for protecting and preserving park resources include:

> *"a) To protect and preserve the natural resources and processes occurring within … Jasper…;*
>
> *"b) To provide the highest level of protection or, where appropriate, preservation of resources and processes that are:*
> *i) nationally or internationally significant;*
> *ii) unique, rare, or endangered;*
> *iii) good examples of the natural resources and processes occurring in the Canadian Rocky Mountains; and*
> *iv) important in retaining the park's wilderness character"* (Canadian Parks Service 1988:7, section 1.4.2).

The plan defines its first principle of resource management as follows:

"Resource protection will take precedence over visitor use and facility development where conflicts occur. Visitor use will be managed to safeguard natural and cultural resources, as well as the aesthetics of the park. Park resources will be managed on an ecological basis; cooperating and coordinating resource management with the other parks in the four park block, and with provincial and private interests managing adjacent lands. A high priority will be placed on protecting unique, sensitive, rare or endangered plant and animal species; and habitats of limited distribution and extent, without which certain species could not occur" (Canadian Parks Service 1988:16).

Sport fishing and fish management policies are set in the following guidelines in the plan.

"Viable native fish populations in the park will be maintained. Appropriate sport fishing locations and strategies for maintaining fish populations will be identified in a fisheries management plan. The limited stocking of road accessible lakes may continue as a fisheries management strategy.

. . . . . .

"The park protects the headwaters and upper reaches of many streams which flow through provincial lands. The Canadian Parks Service will work cooperatively with provincial agencies in the management of fish populations in these streams" (Canadian Parks Service 1988:39–40).

"Sport fishing is an accepted traditional activity. The primary consideration in managing sport fishing will be the protection of aquatic ecosystems and the maintenance of viable native fish populations. Efforts will be made to increase the public's understanding of the fishing regulations and to provide realistic expectations of fishing opportunities in the park" (Canadian Parks Service 1988:92).

Policy: Directives (1981, 1986)

Parks policy on fish management and sport fishing is expanded upon in two directives, one national in scope, the other applicable to the Western Region. Both directives are now partly out of date due to changes in the National Parks Act in 1988. They would also be superceded by some provisions in the proposed new Canadian Parks Service Policy, if or when it is formally adopted.

Parks Canada Guideline 4.4.1 (Parks Canada 1981), sets the national guidelines for sport fishery management, introducing some important policies specific to the topic. In particular, it directs that populations of both native and "established" exotic fish populations be managed for "sustained yield" (Guideline 1). It also stipulates that exotic fish species will not be stocked in national parks; that waters not stocked prior to, or in, 1980 will not be stocked after that time; that only species native to the particular water body will be stocked in that water body; that any fish stocked will be certified disease-free stock; and that all stocking programs will be reviewed during preparation of management plans with a view to phasing them out (Guideline 4). Finally, the directive states that damaged fish habitats should be rehabilitated where feasible, but that manipulating habitats to enhance sport fishing is prohibited (Guideline 5).

Western Region Directive WRD #63 (Parks Canada 1986) sets sport fish management guidelines for the Western Region. It states

"The broad objective for fisheries management in Western Region is to protect the aquatic ecosystems, maintain viable indigenous fish populations and provide limited recreational fishing opportunities to Park visitors" (p. 2, section 4(a)).

This directive introduces a new rationale for stocking:

"Stocking of indigenous species to reduce fishing pressure on natural fish populations will continue to be a tool of Park's (sic) *fisheries managers where monitoring has shown this to be necessary" (*p. 2, section 4(f)).

It also states an important preservation goal of fisheries management in Western Region parks:

"Endangered, threatened, rare and unique aquatic species and their habitats will be identified and protected" (p. 3, section 4(i)).

WRD #63 emphasizes the importance of fish resource monitoring to detect changes and guide management, and designates standard techniques to be used for this purpose.

Discussion

The National Parks Act as amended in 1988 provides the legal basis for all fish management in the park, and as the law of the country takes precedence over policy where there is a conflict. The Act declares that the national parks are intended for the "benefit, education and enjoyment" of the people of Canada, and are to be maintained and used in such a way as to leave them unimpaired for future generations to enjoy. The overall guiding principle of the national parks, then, is "use without impairment."

Provision is made under the Act for regulations for the protection, management and use of the parks' natural resources, including fishes. In particular, fishing in the national parks is permitted implicitly by the Act. A new and potentially powerful section of the Act, the "ecological integrity" clause (5(1.2)), explicitly directs park managers to protect the ecological integrity of park resources as a precondition of their use. Thus fishing is legally permissible only provided that this activity does not damage the parks' ecological integrity. The ecological integrity clause also helps to clarify the purpose of national parks. Because such prominence is given in the Act to maintaining ecological integrity, maintaining the ecological integrity of the lands and waters they enclose must be a major purpose of the national parks.

The several policy documents reviewed help to better define the purpose of the parks and the appropriate goals of fish management in them. The broadest of the policy treatments is the Green Plan. The Green Plan is Canada's response to the United Nations' call for global sustainable development, describing what sustainable development means to Canada, and how this country intends to attain it. It is a commitment of the entire federal government, including the Canadian Parks Service. The Green Plan primarily envisions the national parks as

1. preserving important landscapes from changes due to human economic activities, and

2. conserving biological diversity.

In other words, this is the role of the parks in Canada's sustainable development policy. It must be a principle role of fish management in the national parks as well. As will be shown below, both goals are essential parts of maintaining ecological integrity, so are consistent with Section 5(1.2) of the National Parks Act.

Other provisions of the Green Plan described at length above are applicable to various degrees. Among the most appropriate, given the role of the parks, are the basic principles of respect for nature (i.e., recognizing the intrinsic value of nature, requiring that we must be prudent, erring on the side of protecting the environment) and ecosystem-based planning. The fish management plan for Jasper National Park must recognize that the fish stocks being managed have an intrinsic value that exceeds their marketplace value, and it must incorporate an ecosystem approach to planning and management.

Canadian Parks Service Policy, both current and proposed, agree on the fundamental purpose and objectives of the national parks. Both place national parks in a larger context of protected heritage resources having national and international value. The role of the national parks in this system is to protect *natural areas of Canadian significance* representing the major *natural* environments of Canada. This is a more precisely defined role than those described in the Act or the Green Plan, but is fully compatible with them.

It is evident that, as integral parts of these major natural environments, the native[2] fishes and their habitats must be protected. More to the point, it is evident that protecting native fishes and their habitats must be the *principle objective* of fish management in the national parks, because protecting these particular natural areas, specifically the ecological integrity of these areas, is the sole defined purpose of the national parks.

Although CPS policy consistently gives priority to protecting natural resources, it emphasizes that the parks are protected for a purpose. Park natural resources are protected so that park users may enjoy, benefit from, and learn about the parks' natural environments, provided that these resources remain adequately protected. Regarding fishes, angling is singled out as an appropriate use of the resource, provided that the resource is not impaired, ecosystems are protected, and populations remain viable.

The proposed CPS Policy on fish management diverges from the current policy in important ways. The current policy allows angling of self-maintaining native fish populations as a "traditional" activity, granting an exception to the general policy

2 By definition, introduced fishes are not part of natural environments.

against allowing extraction of park resources. Interpreted literally, it would prevent angling on self-maintaining non-native fish populations, a decidedly unsupportable position. The present policy takes no explicit position on fish stocking, but the general prohibition against introducing non-native species could be interpreted as severely restricting the practice. This is especially true considering the stated intention of the policy to perpetuate a park environment essentially unaltered by human activity.

In contrast, the proposed CPS Policy simply states that angling may be permitted, subject to conservatively based stock assessments, and conforming to the principle that angling is part of an overall aquatic resource program of public education, recreation and resource protection. The proposed policy also bans stocking (restoring indigenous stocks is permissible), and places a high priority on identifying and fully protecting "unique and significant representative aquatic ecosystems". Although worded somewhat differently, both policies specify that non-native species are to be prevented from becoming established in the park, and any that have become established are to be removed or contained.

Of the two, the proposed policy concerning fish management is more consistent with the purpose and objectives of national parks identified above. Unlike the present policy, the proposed policy considers fish management and its techniques as means of addressing the purpose and objectives of the national parks, rather than as ends in themselves, largely unrelated to park objectives.

The Jasper National Park Management Plan interprets the role of JNP in the national parks system as protecting a representative cross-section of the eastern Rocky Mountain natural region. It specifies that the park is intended to preserve and protect natural resources and natural processes that are nationally or internationally significant; unique, rare or endangered; representative of the natural region; or important in retaining the park's wilderness character. These objectives clearly apply to fish management in the park. Sport fishing is permitted explicitly on the basis that it is a traditional activity (and therefore an exception to the general prohibition on extractive use). As always it is conditional on the fish populations and their habitats being adequately protected.

The Policy Directives deal almost entirely with selected details of sport fishing management, especially stocking, and generally do not conflict with the current CPS Policy document. They appear to treat sport fishing as an end itself, rather than as one means of meeting the objectives of the parks. They are seriously out of date, however. Several of their provisions, especially those regarding stocking, clearly conflict with the ban on stocking in the proposed CPS Policy. They also conflict with the Green Plan objective of conserving biodiversity in national parks, and probably contravene the ecological integrity clause of the Act.

I draw the following conclusions from this analysis. Canada's national parks are intended to protect the landscapes and ecological integrity of natural areas of Canadian

significance representing the major natural environments of Canada. That is their *primary* purpose. The primary purpose of Jasper National Park is to protect the landscapes and ecological integrity of the lands and waters within its borders, specifically a representative cross-section of the eastern Rocky Mountains natural area. It follows that the primary goal of fish management in JNP must be to ensure that the ecological integrity of the park's fish resources (the fishes and their habitats) is maintained.

The national parks, including Jasper National Park, are protected for a reason. Their landscapes and ecological integrity are protected so that people can learn about and enjoy them *as examples of natural areas of Canadian significance representing the major natural environments of Canada.* Jasper National Park, for example, is a natural area of Canadian significance protected so that people can learn about and enjoy it as a representative example of the eastern Rocky Mountain natural area. Appropriate uses of the park are those that enable people to learn about and enjoy the park in that context, provided that those uses do not damage the landscape or disturb the integrity of the parks' ecosystems. Thus, an important *secondary* goal of fish management planning for JNP is to ensure that park users can experience the fishes and their habitats in appropriate ways. In particular, people must have opportunities to learn about and enjoy the fishes and their habitats as integral parts of this representative eastern Rocky Mountain natural area.

Many questions remain. What precisely is ecological integrity? What is biodiversity? Why are they important? What approaches to protecting them are available? How can fishes and their habitats be enjoyed without damaging ecological integrity? These and other related matters are discussed in the next section.

CONCEPTUAL BACKGROUND

While the national parks legislation, policies, and park management plan are unequivocal in calling for a fish management plan that places resource protection above all else, they are not at all precise about what exactly needs protection and what degree of change, if any, would be tolerable. For example, what degree of change due to visitor use would constitute damage to ecological integrity? In terms of protecting the fish resource, what is the appropriate "fish unit" to preserve? Is it the ecosystem, community, species, population, or some other level of organization? Various documents refer to preserving "biodiversity," "ecosystem integrity", "native species", "viable populations" or "self-sustaining populations". The terms are seldom defined, yet their precise meanings are by no means obvious. Of course, these words were not necessarily intended to be used in an exact technical sense; usually they were not written for technical people. But fish management is a technical business. We need to think clearly about what we want to achieve with fish management in Jasper National Park, so we must have clear definitions.

In this section I try to define more precisely the general intentions revealed in the regulatory documents to help set achievable goals for the fish management plan. To do so, I discuss some of the more important concepts that are particularly relevant to protecting fish resources in national parks, and that must be incorporated into the final fish management plan itself (Part 4).

What is Ecological Integrity?

"Ecological integrity" is a widely used phrase in biological conservation, often in connection with statements of the goals or objectives of conservation efforts. Despite this, it is rarely defined. For instance, the 1988 amendments to the National Parks Act require the Canadian Parks Service to give first priority to maintaining "ecological integrity" in planning for visitor use (see Legislation:…, this report). The term is not defined in the legislation, nor in the current park policy document which apparently first applied it as a principle in managing national parks (Section 1.1, Protecting Natural and Cultural Resources, Parks Canada 1983:8)

The meaning of ecological integrity as it applies to Canada's national parks is crucial to this project because of the legal requirement to maintain it in planning for visitor use. Legally and logically, we need a workable definition of the term to establish the goals and objectives of a fish management plan for Jasper National Park. For these reasons I will consider the matter in detail.

What Others Think

To help it meet the law, the Canadian Parks Service funded a literature survey to discover specifically what "ecological integrity" means. Although the authors of the resulting report provided what they called "a commentary on definitions of ecological integrity, together with a review of relevant literature" (Serafin et al. 1989:1), they actually found "no unambiguous definition of ecological integrity" in the literature (ibid. p. 13), and did not offer one of their own.

The Society for Conservation Biology held a symposium in 1989 on ecological integrity. Few participants offered definitions of the subject, and those that were presented were surprisingly weak. In his contribution, Karr (1990:245) defined the related term *biological integrity* as "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition and functional organization comparable to that of natural habitat of the region". For *ecological health,* Karr (1990:245) stated that "a biological system — whether it is a human system or a stream ecosystem — can be considered healthy when its inherent potential is realized, when its condition is [relatively] (sic) stable, its capacity for self-repair when perturbed is preserved, and minimal external support for management is needed". The use of the terms "balanced", "integrated", "adaptive", "comparable", "natural", "inherent potential", "relatively stable" and "minimal" are too general and imprecise. All require definition themselves, making these attempts useless for defining what ecological integrity is as a goal of resource management in Canadian national parks. The ideas of self-maintenance and of "natural" species composition and community function, are relevant to our purpose, however.

In his symposium summation, Noss (1990b:241) observed that "when a community is dominated by native species, is relatively stable, and shows other attributes of 'health', it is often said to have integrity". Again, the use of the terms "relatively stable" and "attributes of health" render this definition too imprecise for our use. The concept of native species, however, is unambiguous in the case of inland fishes, and is an improvement over the "natural" species composition of Karr (1990:245). Noss (1990b:243) went on to imply that the concept of ecological integrity had to protect native species, allow species composition to change with time, and maintain "structural and functional integrity" of ecosystems.

The Canadian Parks Service (1991:113) recently suggested that "maintenance of ecological integrity" be defined as "managing ecosystems in such a way that ecological processes are maintained and genetic, species and ecosystem diversity are assured for the future." This definition also is too imprecise. For example, the "ecological processes" idea needs more precise definition because even the most severely damaged ecosystems still have functioning ecological processes — often more (or more active)

processes than undamaged ones, in fact. Likewise, some genetic, species and ecosystem diversity will always be present except in the most extreme case: where there is no life at all. The definition fails to provide a meaning for ecological integrity that is unambiguous and at least theoretically attainable.

A Proposed Definition

It is possible to arrive at a definition of ecological integrity by working from widely-accepted meanings of the two separate words. Ecology has been defined as "the study of the interactions among organisms and between organisms and their physical environments" (Ehrlich 1986:12; Ricklefs 1973:11 used a similar definition). The ecology of a place thus reasonably may be defined as the set of interactions among organisms, and between organisms and their physical environments, in that place. Integrity is, in the present context, a state of wholeness and soundness, as in being complete and unimpaired (The Random House Dictionary 1978:470, The Concise Oxford Dictionary 1990:616). A minimal definition of ecological integrity, then, is "a state in which exists the complete, unimpaired set of interactions among the organisms of a place, and between its organisms and their physical environment."

The real problem for the Canadian Parks Service comes in setting limits to the definition to make it an achievable goal. In particular, what constitutes impairment, or put another way, what baseline should we use to measure deviations from ecological integrity?

Consider the hypothetical example of a paved highway constructed through a forest. One may conceive of the highway having a complete, though small, set of organisms that interact fully with each other and with their physical surroundings. The highway has an ecology. On its own terms, the highway also has ecological integrity. Should the highway be dug up and the forest allowed to reclaim the right-of-way, the integrity of the highway ecosystem would be lost. Of course, ecologists are used to considering the problem of a highway constructed through a forest from the forest's point of view. Considered as a replacement of the forest, the highway is ecologically impaired, and the ecological integrity of the forest has been lost. Whether ecological integrity exists in any situation depends on the basis of comparison. The appropriate basis of comparison depends upon the purpose for which the comparison is made.

The purpose assigned to Jasper National Park by the Canadian Parks Service (1988) was discussed previously (The Regulatory Environment, this volume). Jasper Park is intended to protect the natural resources and processes representative of the Canadian Rocky Mountains, as well as those natural resources and processes that are unique, rare or endangered, or are important in retaining the park's wilderness character. In a national park context, natural can be taken to mean "as formed by nature without human intervention" (The Random House Dictionary 1978:596), or "existing in or caused by nature; not artificial" (Concise Oxford Dictionary 1990:790). To avoid a

circular definition the reference to nature should be removed, giving “formed without human intervention; not artificial.”

The appropriate basis of comparison for judging ecological integrity in Jasper National Park, then, is the state of the park's natural resources and processes in the absence of human intervention. *The ecological integrity of Jasper's fish-bearing ecosystems will have been maintained if they remain unaltered by human activity; that is, are self-maintaining, with their full complement of organisms interacting among themselves and with their environment in a manner unchanged by humans.*

There are some important corollaries of this definition. First, aquatic ecosystems in which ecological integrity has been maintained will hold only native stocks, because ecosystems with introduced stocks by definition have been altered by humans. Second, ecological integrity must be restored where it has been destroyed, otherwise it would not be maintained as required by the Act: maintenance implies restoration (repair) once damage is detected. Third, maintaining ecological integrity requires that ecosystems be allowed to change without the intervention of humans. Changes such as succession, adaptation and evolution are natural processes integral to healthy ecosystems.

Some Objections

Some significant objections can be raised to the concept of ecological integrity so defined. For example, humans have been part of the Jasper ecosystem perhaps for thousands of years (Part 3, Section II), so it would be illogical to speak of maintaining the integrity of Jasper's ecosystems in the absence of humans. It also may be argued that ecological integrity as defined here is unattainable in Jasper National Park, where we know that already there have been human-induced changes in aquatic ecosystems at least during the present century (Sections II and III, Part 3), and where we cannot be sure what the ecosystems would be like had they not been altered by humans. In fact, present human-induced changes in the ecology of the planet as a whole render absurd from now on the idea that ecosystems can exist completely uninfluenced by humans.

In dealing with these and similar problems, some have emphasized the obvious: that humans inevitably influence nature, are a part of nature and in that sense are natural (e.g., Callicott 1990, 1991). It is a short step then to reason that everything humans do therefore is natural[3]. This approach, if adopted, has potentially devastating consequences not only for national park ecosystems, but the global ecosystem. It may be rebutted this way.

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3 I want to emphasize that Callicott does not do this, although some of his words taken out of context come close (Callicott 1991:26-27). It is simply a consequence of the view he presents that must be dealt with.

"According to this 'law-of-nature' view …, which is frequently invoked to support specific management recommendations, intensive management and alteration of national parks or other areas is natural because humans are a part of nature and all of their actions follow the laws of nature. That argument, of course, can be used to rationalize any management decision, which makes the concept trivial and useless …. Few would agree that it is natural to destroy the life support systems of our planet" (Anderson 1991:348).

Others have tried to incorporate humans into the concept of ecosystem integrity by considering an ecosystem natural if the impact of humanity is no greater than that of any other single biotic factor (Reid and Miller 1989:68). There is a logical problem with this idea as well: there are many ecosystems in which a single species (termed a keystone species) naturally has a disproportionate influence on the entire ecosystem. In the chaparral ecosystems of California, for example, coyotes appear to be responsible for maintaining intermediate predators in check, thereby allowing a large variety of ground-nesting birds to persist that otherwise would be extirpated (Soulé et al. 1988). As discussed below (Conserving Aquatic Ecosystems), trout in mountain lakes probably often take on the role of keystone species. Native North Americans probably acted as a keystone species in many ecosystems (Dobyns 1989), perhaps being responsible for the extinction of much of the North American megafauna at the end of the Pleistocene (the case for and against is summarized by Pielou 1991:254-261). To consider humans as a natural part of ecosystems, then to place an arbitrary limit on the extent to which they may influence ecosystems and still be natural, is inconsistent and …, well, unnatural.

A Resolution

Some argue that humans differ fundamentally from other organisms in their relationships with ecosystems. Nature operates automatically, and other organisms function instinctively within it; humans do things consciously, by design (e.g., Rolston 1979, in Anderson 1991:348). Whether this is entirely true is debatable. But on this basis, it is at least logically possible (though practically impossible) to isolate humans from natural ecosystems, and to speak of maintaining ecological integrity in the absence of human intervention.

Dasmann (1984:668, referring to some of his earlier work) made the following helpful distinction. Some humans live *in* local ecosystems and are part *of* them. These people are born, live and die in that ecosystem or group of related ecosystems, obtain all of their needs from it, and are limited by its constraints. Such people can truly be said to be a part of an ecosystem — part of nature in the conventional sense. They are "ecosystem people."

In contrast are "biosphere people." Biosphere people do not draw their support from any single ecosystem, but from many. They can draw their sustenance from the planet's entire capital of life through the global economy. Biosphere people can bring great amounts of materials and energy to bear to exploit any one ecosystem, but crucially they are not limited by that ecosystem. When the resources of one ecosystem are exhausted, biosphere people are able to exploit the remainder of the biosphere to meet their needs.

Dasmann saw these two types as representing the extremes of a continuum in ways of relating to the land rather than two discrete types of culture. He urged that all people who live in an area and call it home must have similar rights and be given equal consideration in protected areas planning and management. The critical criterion, he suggested, was not whether the people are indigenous, but whether their ways of life are compatible with the goals of conservation.

There must be few if any "pure" ecosystem people remaining. Virtually all humans are to some extent biosphere people. And to the extent that they are biosphere people, humans *are* fundamentally different from other organisms in their relationship to nature. They *can* theoretically (though again, not practically) be isolated from selected natural ecosystems. It *is* theoretically reasonable to speak of maintaining ecological integrity in the absence of human intervention in the case of biosphere people.

There remain the practical problems. How can ecological integrity so defined be maintained where human-induced changes have already been made, where we do not know what the ecosystems would have been like had they not been altered by humans, and where human-induced global environmental disturbances unavoidably will have an effect?

The answer of course is that it can't. There are *degrees* of naturalness, however: some states of the ecosystems are more natural than others (Rolston 1990, Anderson 1991). In theory, it is possible to evaluate and even to quantify the degree of naturalness (Anderson 1991). Practical, ethical, cultural and aesthetic reasons for attempting to maintain ecosystems as nearly as possible to an unmodified condition are described elsewhere in this volume (Why Protect Biodiversity?, Protected Areas and Conservation). Even those who stress the need to intervene in and actively manage ecosystems for human benefit can recognize great value in maintaining as many protected area ecosystems as we can in as natural a state as we can (e.g., Callicott 1990:19).

The point is that *now,* as the definition proposes, we should allow some representative ecosystems, such as the greater Jasper ecosystem, to be self-maintaining, with their full complement of native organisms interacting among themselves and with their environment in a manner unchanged by humans. We cannot return to some "original", natural, prehuman condition that likely did not exist, but now we can perhaps allow ecosystems to maintain themselves and evolve without our intervention. In many

specific cases park ecosystems have remained essentially unchanged by humans, and we can let them continue to evolve that way. In some cases we know or can discover the essential features of the unaltered state of a modified ecosystem, and can intervene (or withdraw intervention) to return the ecosystem to its natural condition. In other cases returning the ecosystem to its natural state may not be possible. We might then intervene either to move it closer to an unmodified condition, or to prevent it from diverging even more from its natural state. In such cases we will have to accept some loss of ecological integrity.

These various situations have to be evaluated on their individual merits. The Canadian Parks Service cannot be expected to do the impossible to fulfill its purpose, only to do the best it can under the circumstances. As a practical matter in Jasper National Park, ecological integrity is an ideal to be striven for, rather than a goal that can be fully achieved: attainable in many aquatic ecosystems, but probably not so in the waters of the park as a whole. The problem is not so much with the concept of ecological integrity or the purpose of the park, but with the condition of the park as we now find it.

Conservation Biology: What and Why

As pointed out above (The Regulatory Environment), the Canadian Parks Service has been assigned the job of protecting the landscapes and maintaining the ecological integrity of representative natural areas of national significance in a system of national parks. It is the principal job of the national parks to preserve and protect natural ecosystems and their components. They are to be protected so that people may learn about, enjoy and benefit from them as examples of natural areas of Canadian significance. The first of these goals, the preservation and protection of natural ecosystems and their components, is the special domain of the emerging discipline of conservation biology.

Conservation biology is that branch of science concerned with maintaining the biodiversity of the planet; that is, retaining the variety of the world's organisms, their genetic diversity, and their complete set of interactions among themselves and with their surroundings. It is concerned with retaining the composition, structure and function of the world's ecosystems (Noss 1990a:356-357). Conserving biodiversity means retaining the full variety of everything from genes, populations and species to communities, ecosystems and landscapes, and with maintaining the full complement of processes and interactions at all of these levels. It is therefore the goal of conservation biology to maintain ecological integrity as I have defined it above.

Conservation biology is an applied science, the application of classical scientific methodology to the conservation of biological diversity (Murphy 1990:203). As in other scientific disciplines, alternative hypotheses are first developed based on existing data. Each of these hypotheses then is rigourously tested against new experimental data designed to exclude them. Hypotheses are reformulated based on the new data, Finally, testing and reformulation are repeated as necessary. The hypotheses may look a little unusual, as when it is hypothesized that some protective action will maintain a population above its minimum viable size. Likewise, experimental testing may take the form of monitoring rather than active manipulation.Still, the criteria of scientific inquiry can be met.

Conservation biology has been called a crisis discipline[4], in the same sense that emergency medicine, firefighting and policing are crisis disciplines. The reason is not difficult to divine. Current rates of extinction of the Earth's species, mostly due to human activities, have been variously estimated at from 2 to 11 percent per decade, or a loss of one-quarter of all the Earth's species by the year 2015 — a rate of species destruction unmatched since the Cretaceous Era 65 million years ago (Reid and Miller 1989:37-39, Ehrlich and Wilson 1991:759-760). These are extinctions at the species level alone. A similar litany could be sounded of the losses of whole biological communities or ecosystems. A listing of all the variously endangered populations of organisms must be infinitely worse yet.

Among the fishes, the group of organisms of particular interest in this report, Reid and Miller's very preliminary and incomplete accounting lists 464 species endangered and vulnerable worldwide. Although more than half of these (250 species) are endangered in a single tropical lake, there is little reason to be complacent about our own problem. A recent partial listing for North America describes 292 full species as endangered, vulnerable. rare, indeterminate or extinct (Williams and Miller 1990). The American Fisheries Society's Endangered Species Committee lists 103 fishes endangered, 114 threatened, and 147 of special concern in Canada, the U.S. and Mexico (Williams, et al. 1989; includes subspecies). That is a total of 364 fishes currently known to be in trouble in our corner of the planet alone. Three genera, 27 species and 13 subspecies have become extinct in North America over the last 100 years (Miller et al. 1989:22), 10 of them in the last 10 years (Williams et al. 1989:2), one of those at the very birthplace of our first national park (Renaud and McAllister 1988, Miller et al. 1989:28). The overall Canadian record at last count is this: four of our fishes are now extinct, two more are extirpated (present elsewhere but no longer in Canada), three are endangered, 10 threatened, and 34 vulnerable (Munro 1992:24).

The toll among other major groups of earthlings is as bad, and often worse. The term "crisis" too often is glibly applied. In describing the loss of biological diversity on Earth, it is entirely appropriate.

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4 aptly described as one in which "limited information is applied in an uncertain environment to make urgent decisions with sometimes irrevocable consequences" (Maguire 1991:123).

Why Protect Biodiversity?

Conservation biology can be thought of as the biology of scarcity and diversity (Soulé 1986a, 1986b). When organisms or their habitats become scarce, conservation biologists are called in. What in effect they are asked to do is to maintain biodiversity. We don't want to lose a species, we don't want to lose a habitat, because the resource will become simplified, less diverse. As I argue below (What is Ecological Integrity?), reduced biodiversity constitutes damage to the integrity of ecosystems. As stewards of the ecological integrity of our national parks, the Canadian Parks Service must *by law* concern itself with maintaining biodiversity. This is the most immediate practical reason for protecting biodiversity in Jasper National Park.

Unfortunately, the reasons for maintaining biodiversity *in principle* are not explained in the National Parks Act, nor in any of the Canadian Parks Service policy documents reviewed for this report. It is not always obvious to people why maintaining biodiversity should be so crucially important as to take priority over all other park uses, especially such self-evidently gentle and appropriate park uses as sport fishing. It is critical that resource users and resource managers alike understand and accept the reasons for conserving biodiversity so that they will support, implement and imaginatively defend a fish management plan based on the concept.

I will attempt to present some of those reasons now. In doing so I have not tried to present an exhaustive list, only to provide a variety of arguments that I personally have found useful in thinking about the issue. Others will accept, reject or modify them, or develop reasons of their own for conserving biodiversity.

Utilitarian Reasons [5]

Biodiversity is of direct practical importance to humanity in that much of our food, medicines and industrially useful products are derived from wild organisms (Reid and Miller 1989). Ultimately all of our food and about 75 percent of our medicines are derived from wild species, yet only a small fraction of all species are presently used by us (Hoffman 1991:4). Although most of the world's food now is supplied by about fifteen plant species (Frankel and Soulé 1981:180), wild plants offer considerable opportunities for the development of new crops — if not driven to extinction first. Furthermore, they offer the possibility of discovering new drugs (many important drugs already have been isolated from wild plants) and supplying new industrial needs (Reid and Miller 1989:22-30). A similar case can be made for preserving all types of

5 Others (e.g.; McAllister 1991, Hoffman 1991:4-5) have considered arguments under this heading in separate categories: utilitarian to refer narrowly to natural products useful to humans, and biosphere or ecosphere support to refer to the ecosystem processes we must have to live. Both types seem to me to be utilitarian arguments.

organisms, including fishes.

Clearly the economic value of preserving biodiversity must be enormous. How enormous?

"The value of biodiversity is the value of everything there is. It is the summed value of all the GNPs of all countries from now until the end of the world. We know that, because our very lives and our economies are dependent upon biodiversity. If biodiversity is reduced sufficiently, and we do not know the disaster point, there will no longer be any conscious beings. With them will go all value — economic and otherwise" (Norton 1988:205).

Is Norton right? Let us consider the ecological utility of conserving biodiversity.

We humans are animals. As such, we rely ultimately on the ecosystems of the Earth for all of our life needs. Ecosystems are made up of many individual species, each of them having particular functions in the system, each unique from all the others, all interacting with each other to make a functioning whole. Species in turn are the sum of the genes and gene complexes that are exchanged and interact to produce them. Ecosystems and their member species have been likened to integrated service networks, the parts of which need to be conserved to conserve the whole (Reid and Miller 1989:3). Habitats and ecosystems must be maintained to conserve species, and species must be conserved to maintain habitats. Genetic diversity must be preserved to maintain species. All these elements need to be conserved to maintain the vital ecological services keeping us healthy and alive.

On a global scale the consequences to us of failing to maintain biodiversity vary widely, depending upon the extent and details of the losses in question. Numerous examples are provided in recent publications on conservation and biodiversity (Wilson and Peter 1988, Western and Pearl 1989, Reid and Miller 1989). They literally range from virtually no practical effect at all as far as we can tell (in the case of single extinctions of certain local populations), to major benefit (no more smallpox!), to perhaps a catastrophe for humanity on the scale of a nuclear winter caused by the total cumulative damage to biodiversity (e.g., Ehrlich 1988:25). "One thing we know", it has been said: "If we lose enough species, we will be sorry. The guessing game is really Russian roulette. Each species lost without serious consequences has been a blank in the chamber. But how can we know before we pull the trigger?" (Norton 1988:205).

It is fair to point out that most of the predicted severe global consequences *for humanity as a whole* of failing to maintain biodiversity have to do with damage to ecosystems outside of Canada. This is because Canada is not a centre of biodiversity. Most of the Earth's species and critical land ecosystems are found in the tropics, especially in tropical rain forests (Reid and Miller 1989), and losses there are expected to have proportionately large effects on the larger ecosystem of the planet.

But Canada is a big place, and its ecosystems form a large part of the biosphere, even if they are considerably less diverse than tropical rain forest ecosystems. It is likely that our temperate ecosystems are suffering biodiversity losses proportionate to those in the tropics, and these losses are probably occurring as rapidly (Moyle and Williams 1990). Also, temperate ecosystems already may be more degraded than tropical ones because relatively more of the temperate region is being intensively disturbed (Hughes and Noss 1992:11). We too have a large international responsibility to maintain our biodiversity. If with all of our advantages we do not protect the biological diversity under our jurisdiction, we can have little hope of influencing the mostly disadvantaged countries controlling the tropical rain forests to protect their biodiversity for our benefit.

Conserving biodiversity is critically important for all countries, including Canada, and for our local human communities, for other than global reasons. Our seas, seacoasts, hills, skies, mountains, rivers, grasslands, tundras, valleys, lakes, forests, muskegs and marshes are not only the actual *places* that we live, they are our homes, providing us with our local, national and continental ecosystem services (Ehrlich and Wilson 1991). Our rivers and lakes, for example, provide us with drinking water and sewage treatment, fish to eat and fish for recreation. These ecosystems have to work right for *us* to work right. They will not work right, however, if we damage their component species, the habitats of their species or the genetic integrity of their species.

In using and maintaining Canada's ecosystems, perhaps our most serious problem is that we cannot even begin to fully predict the consequences of damaged biodiversity. For this reason we should be extremely careful about making any irreversible changes to our ecosystems, their species, and the genetic integrity of those species. A well-known proponent of this view was Aldo Leopold, the great American forester, wildlife manager and conservationist. Stated with characteristic eloquence in *Round River* (Leopold 1966:190), his words are the source of the title for this report.

"The outstanding scientific discovery of the twentieth century is not television, or radio, but rather the complexity of the land organism. Only those who know the most about it can appreciate how little is known about it. The last word in ignorance is the man who says of an animal or plant: 'What good is it?' If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering."[6]

This is probably the most readily understood and easily supportable reason "to keep every cog and wheel" in the representative natural areas of Canadian significance that

6 I may be guilty of a kind of subliminal plagiarism: Pister (1985:12) quoted this phrase in explaining his first sudden insights into the value of conserving the rare desert fishes. See Rowe (1989, 1990) for a thoughtful critique of the mechanistic view implied here.

are our national parks. We may need, out of ignorance, to risk a certain amount of damage to the ecological integrity and biodiversity of the country simply to get on with the business of living. We use our national parks, however, primarily to protect representative examples of our major natural ecosystems from that sort of damage so that we have models for restoring the ecosystems we use more intensively.

Several other examples of the utilitarian benefits of conserving biological diversity in the particular case of fish are presented in "Problems of Fish Conservation", in this volume.

Ethical Reasons

Some hold that our wild species and ecosystems need to be protected for their own sake; they have intrinsic value.

The Norwegian philosopher Arne Naess (1986:505) offered the following analogy.

"We experience good old friends as values in themselves on a par with ourselves, and we do things for their sakes as naturally as for our own. Our friends may be useful to us, but that is not all. Why shouldn't this also apply to other living beings than humans?"

Naess (1986) referred to work he has done in Scandinavia showing that the great majority of ordinary people believe our fellow organisms on this planet have intrinsic value, apart from their possible value to us, and should be conserved for that reason alone.

The idea that all living things have intrinsic value, that is, value apart from that we ascribe to them for our benefit, is the foundation of the so-called Deep Ecology and Animal Rights movements. A basic tenet of the Deep Ecology Movement is that all living things have the right to exist, and that we have no right to bring about their extinction. Furthermore, the right of any one type of organism to life is no greater that that of any other (Nations 1988:79). If species have an inherent right to exist, it is immoral of us to cause their extinction. The basic philosophy of many in the Animal Rights Movement is similar, except that believers in animal rights apply the ethic to individual animals.

There are logical and practical problems with this view as a general proposition. One logical problem is this: the good of the species as a whole is rarely, if ever, compatible with the interests of individual organisms (Hargrove 1989:231). Which takes precedence, and why? This is a critical issue in conservation, where often entire rare taxa are threatened with extinction by the proliferation of individuals of an abundant introduced species. In such cases the introduced individuals may have to be eliminated if the rare taxa are to survive.

Thompson (1990) examined some of the logical problems at length. She considered popular proposed systems of environmental ethics based on intrinsic value, and argued that they fail certain essential tests of any ethical system, criteria which she termed consistency, non-vacuity and decidability. She demonstrated that what is of value in these schemes was arbitrarily determined (therefore inconsistent), that applying the proposed criteria of value consistently included virtually everything as valuable (failing the test of vacuity), and that consequently there was great uncertainty in deciding what is and is not of value (failing the test of decidability). Why, she might argue in response to Naess' question quoted above, should the inherent right to exist be extended arbitrarily only to *living* things? Why not rocks? If we include rocks, why not machines? In fact, why not include all things? And if we believe all things have an inherent right to exist, that all things are inherently of equal value, then what guidance does such an ethic give us?

Practical problems arise where humans themselves are on the edge of existence. Nations (1988:79) makes the point tellingly:

"When human activities drive one of our fellow species to extinction, I consider that a betrayal of our obligation to protect all life on the only planet we have."

He goes on to say, however:

"I have never tried to tell a Latin American farmer that he has no right to burn forest for farmland because the trees and wildlife are as inherently valuable as he and his children are. As an anthropologist and as a father, I am not prepared to take on that job."

But for practical purposes these objections are largely beside the point. As noted above (re Naess 1986), many in human society *do* consider, however arbitrarily, that all living things have the inherent right to exist, and that is enough to justify to *them* the protection of biodiversity (e.g., see discussion of The Green Plan, this volume). Their ethic is hardly alone in holding arbitrary views as to what is of value.

Other ethical reasons for conserving biodiversity have been advanced that do not rely on a belief in the intrinsic value of all living things. If conserving biodiversity can be supported on other grounds, it would be unethical not to do so (McAllister 1991). In arguing against environmental ethics based on intrinsic value, Thompson (1990:150,159-160) supported such an alternative ethic. She held that some things (e.g., wildlife, natural ecosystems, etc.) are valuable and should be preserved because our lives and our conception of ourselves will be enhanced in a spiritual sense if we learn to appreciate them for what they are, and if we learn to live with them in harmony. Like the ethic implied by the utilitarian arguments for conserving biodiversity, this is a human-centred, subjective ethic. It is the basis for the cultural and aesthetic arguments for conserving biodiversity discussed below.

Cultural and Aesthetic Reasons

"We are remodeling the Alhambra[7] *with a steam-shovel, and we are proud of our yardage."*(conclusion to *The Land Ethic*, Leopold 1966:263)

With this one arresting metaphor, Aldo Leopold perfectly encapsulates one set of cultural and aesthetic arguments for protecting biodiversity. The biosphere is an infinitely intricate, endlessly complex, surpassingly beautiful edifice. To damage it is to wreck a work of inestimable cultural, spiritual and aesthetic significance. It is the ultimate in philistinism, a heinous act of vandalism or willful stupidity.

Some measure of what biodiversity might mean to our society aesthetically and culturally is revealed in our art and literature. Bruce Littlejohn (1989) showed that Nature figures prominently in Canadian history, arts and letters, that it is so prominent as to be of our very essence as Canadians. If we surrender wilderness, he argued, we surrender much of what distinguishes us as a people (Littlejohn 1989:19).

Margaret Atwood (1972) demonstrated a striking, quintessentially Canadian feature of our literature, including our "Nature" literature: the prominence of victim themes. "Stick a pin in Canadian literature at random", she wrote, "and nine times out of ten you'll hit a victim" (Atwood 1972:39). She identified four "victim positions": (1) denying that one is victimized, (2) recognizing that one is a victim, and acquiescing, (3) recognizing that one is a victim, but refusing to acquiesce, and (4) being a non-victim. Those in the latter category either never were victims, or have overcome victimization.

These positions can be seen as proceeding in order from least desirable to most desirable. If one is being victimized, it is better to recognize the fact, then it is better to do something about it than not, but best of all is either not to be victimized or to have overcome the oppression. Culturally speaking, a society in which there is no victimization, no oppression, is culturally preferable to others in which there is. Lack of oppression can be considered as one measure of cultural maturity in a society.

If we accept the proposition that the literature of a nation reflects with reasonable accuracy the cultural attitudes of its citizens, Atwood's literary analysis tells us a great deal about our society's attitudes toward Nature. She presented several examples in our "Nature" writing of the first three victim positions. Our writers (and by implication we general members of Canadian society) have been especially fond of the Position Two idea that humanity has no hope against the power of Nature (or more recently that Nature has no hope against the abuses of humanity). Significantly, she did not refer to

7 The spectacularly intricate, lace-like and extraordinarily delicate architecture of the Alhambra Palace in Granada, Spain, marks the ultimate stage of refinement of Moorish architectural style: "… the visible counterpart of all the wonders of *The Thousand and One Nights*" (Janson 1977:229-231).

any Position Four examples of Canadian Nature writing. Apparently we, as represented by our writers, have been unable to conceive of a world in which neither humanity nor Nature oppresses the other (as of 1972).

This is not a healthy attitude. If a society without victims is our aim, we need somehow to arrive at Position Four in our relationship to Nature to achieve a culturally mature society. Put tritely, we need to live in harmony with Nature; thus implicitly we need to conserve biodiversity. A commitment to conserving biodiversity is essential to achieving cultural maturity — in Canada and everywhere else.

I suspect that concerns of culture and aesthetics are strongly held, and are the prime reason most people have for wanting to conserve biodiversity. Utilitarian reasons are later advanced to justify these views, apparently in the belief that they are "objective" and therefore supportable. Cultural and aesthetic concerns in contrast seem to be seen as mere sentimentality, and therefore worthless.

They are only worthless if human aspirations are of no value. If for example we as Canadians decide among ourselves that we wish to protect biodiversity in national parks because our natural ecosystems are beautiful to us, that is as good a reason as any to do so. No supplementary economic, ecological or ethical reasons are required; a collective expression of our aesthetic sensibilities and wishes is enough.

Do cultural and aesthetic arguments for conserving biodiversity have any audience among the principal users of freshwater fish resources, the anglers? Emphatically, yes. One need only browse through some of the recent western fishing publications to be convinced of the truth of this statement. Butler and Maw (1985) devoted large parts of their book on fishing the mountain parks to species that are "useless" to anglers, to fishwatching, catch-and-release, and questions of environmental ethics, all cultural and aesthetic subjects of little or no apparent utilitarian value. Recent popular treatments of native trout of western North America (Smith 1984, Trotter 1987) are rife with value judgements based solely on the perceived aesthetic and cultural appeal of these fishes, implicitly arguing for their protection on those grounds. Van Tighem (1988) urged conservation of native Athabasca rainbow trout apparently based largely on their aesthetic qualities (their beauty and "nativeness"). Studies of Alberta angler preferences show that fishermen highly value the opportunity to fish for wild native species of trout in East Slopes streams (Radford and Wiebe 1975; Dunn 1986, 1987). It is difficult to imagine a utilitarian reason for this view among anglers, and the investigators did not attempt to find one. Aesthetic and cultural reasons, however, are obvious: native trout are attractive, increasingly rare ties to an historic Alberta wilderness now vanishing, tenuous remnants of a squandered natural heritage (Mayhood 1989).

Protected Areas and Conservation

For all of the above reasons and more, some parts of the Canadian landscape have been set aside as protected areas in various forms (Eidsvik 1989). To develop further the idea of maintaining ecological integrity in selected ecosystems, we turn now to the role of national parks in conservation.

Protected areas such as national parks and nature reserves are major conservation tools. While distinctions may be made between the two, Allin (1990:3) considered both national parks and nature reserves as denoting "… any system of land tenure or zoning designed primarily to protect biogeographical or ecological resources of national or international importance and to preserve them in, or restore them to, a regime characterized by minimal interference in natural processes." Nature reserves are regions removed from the development stream for the purpose of perpetuating natural conditions (Pyle 1980). They are intended "… to maintain, hopefully for perpetuity, a highly complex set of ecological, genetic, behavioural, evolutionary and physical processes and the coevolved, compatible populations which participate in these processes" (Frankel and Soulé 1981:98). Nature reserves are distinguished from game parks and zoos by being sufficiently large and self-regulating that they do not require routine husbandry of the individual organisms. By these criteria, Canadian national parks are intended to function as nature reserves (The Regulatory Environment and What is Ecological Integrity?, above; Eidsvik and Henwood 1990:77-78), whatever the variety of utilitarian, ethical, cultural and aesthetic reasons for protecting them may have been (Eidsvik 1989).

An effective program to conserve the biodiversity of a nation ideally would include large, self-sustaining protected areas in all of its major biogeographic regions. These protected areas could take a variety of forms depending on the availability of land, the extent of past and present disturbance, and their social and political context (Reid and Miller 1989, Soulé 1991). To the extent possible, however, they should be selected to protect "… representative samples of the biological regions, ecosystems, natural communities and species of the country. …. An optimal parks system must strive to save all the parts without exception" (Ugalde 1989:146); i.e., to keep every cog and wheel.

Canada's system of protected areas is intended to come as close as possible to this ideal. As of 1990[8], federal, provincial and territorial protected areas of all types comprised about 5.5 percent of Canada's landmass (Eidsvik and Henwood 1990:68), with an eventual goal of placing 12 percent under protected area management (Government of Canada 1990:79). National parks now protect about 1.8 percent of our lands; ultimately, they are to protect representative samples of all 39 terrestrial natural regions comprising a total of three percent of Canada's land area (Eidsvik and Henwood 1990:68, Government of Canada 1990:80).

8 new parks recently added will alter slightly some figures in this paragraph.

National parks and nature reserves are not sufficient in themselves to conserve the biodiversity of most nations. This is because few if any protected areas now existing are likely to maintain all of their biodiversity over the long term: they are simply too small and isolated from each other (Wilcox 1980, Frankel and Soulé 1981, Schonewald-Cox 1983). Opportunities for establishing new protected areas are repidly diminishing even in some parts of Canada (Eidsvik.1989:44). Furthermore, all are affected by the general deterioration of the global environment. There are at least two important implications of these facts.

First, protected areas must be part of a larger comprehensive strategy to conserve biodiversity. This strategy must include a commitment to conserve biodiversity outside the boundaries of protected areas. Given the present extent of ecosystem damage, there also must be a comprehensive program of restoring already-damaged ecosystems within and beyond the boundaries of protected areas. In this work, protected areas must serve as models, as refuges and as sources of organisms for reintroduction.

Second, given the already inadequate size of most or all protected areas, these areas must be reserved as much as possible for protecting biodiversity if they are to serve their conservation role. In this respect the figures for protected areas in Canada discussed above are deceptive. They include large areas that cannot by any means be considered protected for conservation purposes. For example, they include several town-size urban areas on or within their boundaries. They also include major highways, railways, communications corridors, dams, reservoirs, forestry operations and innumerable tourist developments of all kinds, all of which have conservation impacts far beyond the physical spaces they actually occupy.

Most of the 1271 Canadian protected areas (540,047 km^2) listed by Eidsvik and Henwood (1990:64,68) are tiny. The modest average size, 425 km^2, is still misleadingly large because of the mathematical influence of a half-dozen mostly northern national parks 10,000-45,000 km^2 in area, and a similar number of relatively large provincial parks. Certainly there are examples of relatively small protected areas serving an invaluable conservation role (Reid and Miller 1989:70-78), but their ability to do so in the long term is doubtful. Finally, the protected areas in southern Canada are heavily used for recreation. Most of the provincially protected areas are managed primarily as recreation areas; their conservation mandate is secondary at best.

In attempting to conserve Canada's biodiversity we must do the best we can with what we have. Most of our protected lands are small and compromised for conservation purposes, but that is what we must work with. This fact simply reinforces the argument that what resources we do hold in protected areas must be managed maximally to conserve biodiversity. As previously noted, this is effectively the stated priority for the national parks under the National Parks Act, Green Plan and national parks policy documents.

Problems of Fish Conservation

I will not attempt to deal with all of the known problems affecting the conservation of fish resources in this section. Most of these — such as habitat destruction, overexploitation, pollution — are now fairly well recognized by resource managers and the general public, and I will say no more about them at this stage. I want to concentrate instead on aspects of fish conservation that may be less widely understood, but are important to consider in managing fishes and their habitats in Jasper National Park. These are (1) conserving the natural genetic diversity of fish, (2) the stock concept, (3) conserving aquatic ecosystems, and (4) preventing the insidious damage caused by cumulative environmental impacts.

Conserving Genetic Diversity

Traditionally the practice of fisheries management has been dominated by population ecology and population dynamics; the genetics of the populations being managed usually has not been considered. The reasons for the lack of attention to genetics are various, and have been reviewed by Allendorf et al. (1987). It suffices to note that the negative effects of this bias are now becoming recognized, and have led to numerous recent studies, symposia (e.g., Berst and Simon 1981) and a ground-breaking book on population genetics and fish management (Ryman and Utter 1987a). Among the negative effects of genetic neglect are poor performance of introduced fish resulting from using inappropriate stocks (Kincaid and Berry 1986), lost opportunities for genetically improving exploited fish populations (Simon 1986), degraded quality of hatchery stocks (Allendorf and Phelps 1980) and lost genetic diversity from species important in commercial and sport fisheries (Marnell 1986). The latter, loss of genetic diversity, directly concerns the development of a fish management plan for Jasper National Park because of its significance in biological conservation.

Significance of Genetic Diversity for Fish Conservation

The total gene complement and the way it is organized defines a species and gives it its unique characteristics. When gene combinations are lost, as when a stock is extirpated, the species is diminished. Because greater genetic variation provides greater raw material for natural selection to operate upon, loss of genetic diversity reduces the ability of a stock or entire species to adapt to changes in the environment. Ultimately, the loss of adaptability must lead to inability of a taxon to form new species.

Meffe (1986) called loss of genetic variation the central problem in conservation genetics, because it erodes evolutionary flexibility, leads to a poorer match of organism to environment, and increases the probability of extinction. He cited three conservation goals in managing endangered fishes that apply equally to less threatened species: (1)

maintaining viable populations (=avoiding extinction), (2) maintaining the capacity of fish populations to adapt to changing environments, and (3) maintaining the capacity for continued speciation.

Allendorf and Leary (1986) reviewed evidence showing that genetic diversity in individuals (heterozygosity) usually confers greater fitness (in terms of survival, disease resistance, growth rate, developmental stability) on individuals in a wide variety of species. They concluded that the loss of individual genetic variation (greater homozygosity) would be expected to make threatened and endangered species more vulnerable to extinction, and reduce the evolutionary potential of species.

More recent studies tend to confirm the general conclusion that greater heterozygosity in individual fish usually is associated with various measures of improved fitness (Liskauskas and Ferguson 1990, 1991, and literature cited therein). It also shows that the relationship is complex in some cases. Greater individual heterozygosity may confer greater fitness only at certain life history stages or for a particular sex, may not confer greater fitness in at least one species, and occasionally is associated with measures of decreased fitness (Beacham and Varnavskaya 1991, Liskauskas and Ferguson 1991).

These studies have concentrated on measures of fitness in individual fish, the assumption being that individual fitness affects population processes. Of more immediate importance for conservation, however, is the actual effect of heterozygosity on population-level processes. Leberg (1990) tested directly the effect of reduced heterozygosity on experimental mosquitofish populations under field conditions. He found that a 25% decrease in heterozygosity caused a 56% decrease in population size, demonstrating that the actual effects of genetic variation on population processes can be pronounced. Genetic variation should be preserved for its immediate benefits in maintaining the viability of populations, as well as to retain their evolutionary flexibility.

Losses of Genetic Diversity in Fish

Genetic diversity in fish may be lost in at least four ways.

Extirpation. Genetically distinct stocks may be extirpated by a variety of mechanisms, so that any genetically-determined traits unique to the stock are lost forever. This has been the fate of 3 genera, 27 species and 13 subspecies of freshwater fishes driven to extinction over the last century in North America (Miller et al. 1989). A count of the number of distinct stocks lost must be very much larger.

Extirpation of stocks living under ecologically marginal conditions may have particularly serious consequences. It has been argued that such stocks are important contributors of genetic diversity to stocks in more benign habitats, and thus have high

adaptive significance to the species as a whole (Scudder 1989).

Stocking. Genetically homogeneous stocks are often introduced widely and in very high numbers. Introduced fish are commonly derived from small numbers of precursors taken from a single population (e.g., Allendorf and Phelps 1980, Gyllensten and Wilson 1987:311). This in itself is likely to produce a source stock with reduced genetic diversity. If these fish are retained as a hatchery broodstock, inbreeding, genetic drift and selection for adaptedness to hatchery conditions can further reduce genetic diversity (Allendorf and Ryman 1987). When the fish are then stocked widely and in large numbers to replace lost native stocks, genetic diversity of the species is reduced in the wild. Paradoxically, heterozygosity is reduced even when stocking is used to replenish or enhance the very populations from which the brood fish were derived (supportive breeding, Ryman and Laikre 1991).

The fate of westslope cutthroat trout in Alberta provides an example of the problem. The source of all westslope cutthroat trout for stocking in numerous Alberta provincial and federal waters for the past decade or more has been a single stock currently residing in Job Lake. This stock was introduced into Job Lake from Marvel Lake, and into Marvel Lake from a now extirpated population in the Spray drainage (Rawson 1947, P. Wiebe, personal communication). The stock shows very low genetic diversity (McAllister et al 1981, Carl and Stelfox 1989). Pure native populations of westslope cutthroats have been eradicated from most of their indigenous habitats throughout Alberta (Mayhood 1989, 1991, unpublished data), so that this distinctive East Slopes fish is now represented in the province largely by a single genetically-uniform stock. The problem undoubtedly has been compounded by maintenance stocking from the same source (supportive breeding, in effect) in many lakes.

Introgressive Hybridization. Genetic diversity of fish species is reduced when introduced fish of the same or closely-related species hybridize introgressively with wild stocks. Fishes are unusual in the animal kingdom in that species within the same genus are often able to produce reproductively viable hybrids. When these hybrids repeatedly mate among themselves or with the parental species, the genes of the once-separate species become thoroughly intermixed to form a “hybrid swarm”. The genes of the introduced species are said to have been introgressed into the gene pool of the native species. Introgressive hybridization also occurs when two genetically distinct populations of the same species are allowed to freely interbreed (Campton 1987), as when a non-native or hatchery stock is introduced into waters containing native stocks of the same species.

It may not be obvious that introgression represents a loss of genetic diversity, or that it is damaging. In fact, as Nelson and Soulé (1987) explain, the introgressed population is genetically more diverse than either one of the parent populations. The problem is that the genetic diversity of the parent populations separately is greater than that of the introgressed population. Once introgressed, the original separate parental gene pools are gone forever. At the extreme, entire species might be lost through introgression.

Allendorf and Leary (1988:181) have warned that continued stocking of rainbow trout throughout western North America could homogenize all western trout into a single taxon (they dubbed it, tongue only half in cheek, *Salmo ubiquiti*).

Introgression may break up combinations of coadapted genes, so that particularly important gene combinations giving a population its local adaptedness are lost. Allendorf and Leary (1988:181-182) discuss the negative effects of this and other types of outbreeding depression on several types of organism.

Reduced fitness from intraspecies introgression in wild populations has been difficult to demonstrate because introgressed individuals until recently have been difficult to recognize. With the widespread use of biochemical genetic techniques, examples are appearing more frequently in the literature. For example, Philipp (1991) demonstrated that introgressed largemouth bass populations (northern × Florida subspecies) showed reduced survival and growth in comparison to the pure northern subspecies stock. Gharrett and Smoker (1991) found first-generation hybrids between even- and odd-year pink salmon from the same home stream were more variable in size than their genetically pure parents. Second-generation hybrids in their study returned to the spawning stream in lower numbers and showed increased bilateral assymmetry (a measure of developmental instability) relative to pure parental stock.

While some studies have shown improved performance of hybrid fishes in some respects (e.g., Ferguson et al. 1988, Johnson et al. 1988), such results need to be interpreted cautiously. It is possible that overall fitness is reduced even though a hybrid shows improved performance in some characteristics. First generation hybrids in particular may show increased performance simply because coadapted gene complexes from both parents remain intact (Krueger and May 1991:72). With introgression, disruption of these complexes is inevitable in the long term. Nevertheless, it appears that "the major danger of introgression is the homogenization of the many divergent evolutionary lineages and the loss of important and potentially valuable locally adapted populations" (Allendorf and Leary 1988:182).

Exploitation. Fishing can reduce genetic diversity. In a review of the topic, Nelson and Soulé (1987) identified from the literature three fishing processes that reduce genetic diversity. These might be termed successional exploitation, nonselective genetic erosion, and genetic selection.

Successional exploitation is the tendency of fisheries to successively remove species and stocks according to their desirability. Typically, the larger, later-maturing species higher on the food chain are fished preferentially and are reduced or even eliminated, followed by successively smaller and/or earlier-maturing species. Subpopulation stocks (see The Stock Concept, this volume) are especially susceptible to this process because they often go undetected. They are eliminated successively in order of their susceptibility to the fishing method and their reproductive capacity (Larkin 1977). The losses represent losses in genetic diversity, and are a particular case of extirpation

described above.

Nonselective genetic erosion operates when a population or stock is reduced by fishing below some critical point where self-reinforcing effects tend to drive it to extirpation. Nelson and Soulé (1987:349) cite several examples. If the effective population size is reduced low enough, say below 50, inbreeding depression becomes a serious problem of this type. Such small populations tend to lose alleles by random chance, so become genetically less diverse.

In contrast to the abundant evidence for the loss of genetic diversity represented by species and stocks extirpated by fishing (see Successional exploitation …, above), *genetic selection within* stocks of fish due to fishing pressure has proven difficult to demonstrate. This is because the necessary data are extremely difficult to collect (Nelson and Soulé 1987:355, Allendorf et al. 1987:13). Many important changes in fish populations that have accompanied fisheries exploitation may be either environmentally or genetically induced, and distinguishing between these causes requires genetic knowledge of the fished stocks that is seldom available.

A few instances of apparent genetic selection within stocks were briefly described by Allendorf et al. (1987:13) and Nelson and Soulé (1987). Other examples have since become known (Pain 1990, cited by Macdonald 1991:45), and experimental approaches may provide additional examples in future (McAllister et al. 1992). Nelson and Soulé (1987) believed the few known examples could well represent a common phenomenon that is difficult to observe, rather than one that is genuinely rare. Allendorf et al. (1987:12) concurred, stating flatly that "all populations of fish that are included in a sport or commercial fishery will inevitably be genetically changed by harvesting."

The Stock Concept

The concept of the "stock" offers a way of effectively addressing the problems discussed in the previous section.

What is a Stock?

Stock (as a noun) is a general term widely used in fishery management to refer to biologically meaningful management units (Ryman and Utter 1987b:ix). Within that broad sense, however, it takes on at least three different meanings, two of them commonly used and of long standing. It is necessary to distinguish clearly among these to make the term useful for present purposes.

In one sense, stock simply means the supply or quantity of fish subject to a fishery, and does not necessarily refer to biologically related fish. It is in this sense for example,

that we refer to Atlantic groundfish stocks, or sportfish stocks in a lake or river.

In another sense, stock is used loosely to mean any group of fish related by common ancestry at the species level, but not necessarily accorded taxonomic distinction. In this sense, for example, we may refer to coastal and inland rainbow trout stocks, which are distinct geographically and genetically, but have no formal taxonomic distinctiveness. Both of these senses are specific applications of common English usage (e.g., The Concise Oxford Dictionary 1990:1199).

Fish biologists continue to use stock in both the above senses, but have added narrower definitions recently. For example, stocks of fish have been formally defined as "intraspecific group[s] of randomly mating individuals with temporal or spatial integrity" (Ihssen et al. 1981:1839). The authors of this definition admit that it characterizes an ideal that is only approximated by the common usage of the term. They defend it as a model against which actual groups of fish proposed as stocks can be evaluated. A more readily understood, but still more restricted variation of this definition of stocks might be "more or less reproductively isolated subpopulations differentiated by time or location of spawning" (Nelson and Soulé 1987:347). In other words, Nelson and Soulé restrict their definition of stocks to groups of fish *within a population* that spawn in different places, or in the same places at different times, and show a high degree of fidelity to their spawning group. This definition is more precise, but requires a new term for other entities now commonly recognized as stocks.

For this project I have adapted the definition of Ihssen et al. (1981:1839), defining a fish stock as *any group of fish showing some degree of reproductive isolation from all other groups within the species*. This definition allows several levels of stocks to be identified, depending on the degree of reproductive isolation. At the largest scale there are groups such as the inland and coastal rainbows mentioned above that might be termed geographic stocks. Geographic stocks include, but are not limited to, races and subspecies. At the smallest scale are the subpopulation stocks of Nelson and Soulé (1987:347), within which members freely interbreed, and among which there is at least some degree of reproductive isolation. Also covered are the many hatchery stocks or strains that are almost wholly artificial. This definition lacks the satisfying unambiguous precision of that of Nelson and Soulé, but has the great advantage of accommodating the common usage both in everyday English and in the fisheries community. The ambiguity can be resolved when necessary by using adjectives to clarify what level of stock is meant (e.g., geographic stock, subpopulation stock, the Wampus Creek stock of rainbow trout). In reality the various types of stocks lie on a continuum, differing only in the degree to which they are reproductively isolated.

Significance for Conservation

The great value of the stock concept lies in its recognition of biologically significant structure within species and populations. In consequence of the island-like nature of

inland aquatic habitats, fish species are subdivided into separate geographic groups more or less reproductively isolated from each other. These separate groups inevitably diverge over time under the influence of differing environmental conditions and simple chance. The result is geographic stocks of a single species differing among themselves in various biological properties. Whether these properties are or are not visually recognizable or taxonomically significant, they may be highly significant genetically and ecologically.

Similar biologically distinct groups often occur within single populations of fish (e.g., numerous papers in Berst and Simon 1981). These are subpopulation stocks. They can arise in a variety of ways, but to remain in existence they must maintain some sort of reproductive isolation from one another. They may spawn in different places, or in the same place at different times, or conceivably in the same place at the same time but only with other members of their own group. At other times the stocks may intermingle or segregate, and they may use the same resources or partition them in some fashion. Even though there may be some gene flow among the stocks, the restricted interbreeding, and in some cases the differences in the environments used by each, can permit the development of distinct differences in biological characteristics among them. Where no genetic differences have been detected, they may yet be shown to exist: present biochemical genetic methods used to distinguish fish stocks sample only a small proportion of the genome. And even if genetic differences truly do not exist among them, subpopulation stocks provide the conditions of reproductive isolation allowing genetic differentiation in future.

Good fish management practice would dictate that such biologically distinct subpopulations be managed as separate entities. Nehlsen et al. (1991:5) quoted Rich (1939), an early advocate of stock-based fisheries management, to explain this point, and I reproduce his words here. Note that Rich's use of the word "population" matches the definition of stock used in the present document.

"In the conservation of any natural, biological resource it may, I believe, be considered self-evident that the population must be the unit to be treated. By population I mean an effectively isolated, self-perpetuating group of organisms of the same species regardless of whether they may or may not display distinguishing characters and regardless of whether these distinguishing characters, if present, be genetic or environmental in origin. Given a species that is broken up into a number of such isolated groups or populations, it is obvious that the conservation of the species as a whole resolves into the conservation of each and every one of the component groups; that the success of efforts to conserve the species will depend, not only on the results attained with any one population, but upon the fraction of the total number of individuals in the species that is contained within the populations affected by the conservation measures."

Differences Among Stocks

Hatchery stocks have been widely compared, and provide an indication of the kinds of biologically important differences that can arise among stocks. While at least one study found no differences of management significance among several hatchery strains of rainbow trout (Hudy and Berry 1983), many others have disclosed them in rainbows and other salmonid species. Some of the differences found include differences in growth (Braun and Kinkaid 1982, Cone and Krueger 1988), yield to fisheries (Braun and Kinkaid 1982, Moring 1982, Fay and Pardue 1986), survival (Braun and Kinkaid 1982, Fay and Pardue 1986, Fraser 1989), migratory tendency (Moring 1982, Cone and Krueger 1988), spawning success (Fraser 1989), habitat use (Mesa 1991), handling tolerance (Cone and Krueger 1988, McGeer et al. 1991), feeding behaviour (Mesa 1991), agonistic behaviour (Mesa 1991), predator avoidance (Johnsson and Abrahams 1991), tolerance to salt water and low pH (McGeer et al. 1991), disease resistance (McGeer et al. 1991) and morphology (Swain et al. 1991). The differences have been found among hatchery stocks (growth, yield to fisheries, migratory tendency, resistance to handling, tolerance to salt water and low pH, disease resistance), between hatchery and wild stocks (growth, survival, spawning success, habitat use, agonistic behaviour, morphology), between hatchery stocks and their hybrids with wild stocks (survival, spawning success), and between wild stocks and their hybrids with hatchery stocks (predator avoidance). When several hatchery stocks are compared simultaneously, individual stocks tend to show a distinctive set of responses (Fay and Pardue 1986, McGeer et al. 1991). Furthermore, the nature and degree of differences among hatchery stocks can vary among environments (Fay and Pardue 1986).

Many other studies show biologically important differences among natural wild stocks similar to those found among hatchery stocks. For example, Rosenau and McPhail (1987) reported differences in inherited agonistic behaviour between two separate lower Fraser River coho populations. Three separate stocks of pygmy whitefish exist in Chignik Lake, and two in each of Aleknagik and Naknek lakes, Alaska, differing in habitat occupied, morphology, meristic characters, ecology and life history (McCart 1970). Two types of lake whitefish exist in the Yukon, sometimes within the same lakes, differing in morphology, meristics, feeding ecology and habitat occupied (Bodaly 1977). McPhail (1992) described a sympatric pair of morphologically identifiable stickleback stocks in a British Columbia lake — one a littoral benthic forager, the other a plankton feeder living in the open water. Crossman (1990:1811) observed that muskellunge homing to different spawning areas also had different home ranges in summer in Stony Lake, Ontario. Three morphologically, behaviourally and genetically distinct stocks of brown trout coexist in Lough Melvin, Ireland, each spawning in separate locations (Ferguson and Taggart 1991). Numerous other examples are mentioned in the Species Accounts (Part 3, Section III), and are described in the literature (e.g., many papers in Berst and Simon 1981, and references therein).

The subtlety of critical differences between stocks can be astonishing. Swim-up fry of a lake-dwelling stock and a genetically-distinct stream-dwelling stock of Montana Arctic grayling both have a strong tendency to swim downstream during the first 10 days after emergence (Kaya 1991). Beyond about 18 days post-emergence, however, the stream-stock grayling develop an increasing tendency to hold position in a current, whereas the lake-stock grayling maintain their tendency to move downstream. The change in behaviour by the stream stock appears to adapt it for permanent stream residence. This may be a crucial feature of the only remaining stream stock of Montana grayling. Retaining this stock conceivably could determine the success or failure of efforts to restore this fish to its native streams.

The Stock Concept in Jasper National Park

Biologically significant stock differences clearly are widespread and diverse among fishes. But is the stock concept relevant to managing the fishes of Jasper National Park?

In Jasper Park, most fish populations are apparently small and often isolated in island-like habitats (lakes, ponds and widely-dispersed streams, many interrupted by waterfalls[9]). It is precisely this insular nature of the park's fish habitats that leads to stock development, by partially or totally isolating groups of fish from each other (Philipp et al. 1986). As well, Jasper may have been colonized postglacially by fishes from as many as four separate refugia, each of which may have held distinct geographic stocks. Evidence of separate stock development in Jasper fishes, and reasons for expecting to find more, is presented at length in Part 3.

The worth of the stock concept as the basis for fish management in Jasper National Park is partly psychological. There is, for example, a persistent misconception that it is permissible to plant hatchery fish in park waters provided these fish are native species (Parks Canada 1981, 1986; Antoniuk 1984). Management under the stock concept forces everyone concerned to recognize that this is a dangerous fallacy. The job of the park is to preserve native stocks of fish as part of its legal requirement to maintain ecological integrity (see What is Ecological Integrity?, this volume). Hatchery stocks are not native stocks. Typically they are very different, often less viable stocks, even though they may be of a species native to the park.

The role of Jasper National Park is to protect and retain the full biological diversity of the park. Planting hatchery *stocks* or non-native *stocks* of fish *species* native to the park in Jasper waters could destroy native stocks through introgression or displacement

9 Impassable barriers such as waterfalls effectively separate stocks above and below them, even though there is substantial one-way gene flow from the upstream stocks to those below (Ryman and Ståhl 1981:1566-1567, Northcote and Hartman 1988).

(it almost certainly has done so in the past; see Part 3), and thus reduce the biological diversity of the native fish resource. If the stock concept is not adopted, we will continue to ignore distinct stocks, and may lose them, thus failing to preserve the biological diversity of the park as required by its legislation and policy.

Conserving Aquatic Ecosystems

Elsewhere in this report (What … is Conservation Biology?, What is Ecological Integrity?) I discussed the need to conserve all levels of biological diversity, from genes, populations and species to ecosystems and landscapes. From these discussions it should be evident that the integrity of ecosystems cannot be maintained without maintaining the integrity of their aquatic communities, including the integrity of any native fish stocks they may hold; neither can one conserve the integrity of fish stocks without conserving the integrity of ecosystems of which they are a part.

Resource managers and many in the general public are aware of the second of these concepts. They understand that the environment of fishes must be protected to properly protect the fish themselves. They also understand, at least in broad terms, what sort of environmental protection is necessary to protect fishes. In other words, there is a general sensitivity to, and broad understanding of, ecology from the fish's point of view, so to speak. This concept is well treated in readily-obtainable standard fishery management texts (e.g., Lackey and Nielsen 1980, Nielsen and Johnson 1983, Schreck and Moyle 1990, Sigler and Sigler 1990, Meehan 1991, Hunter 1991), therefore I will not treat them here.

The first-mentioned concept is perhaps less well understood. Although the idea that fishes can profoundly influence the aquatic environment is not new, it is only recently that it has begun to receive a lot of attention from biologists (Northcote 1988). It is a topic of some importance to maintaining the integrity of natural ecosystems in national parks. Examples are presented below to illustrate the possible implications of this concept for fish conservation and management in Jasper National Park.

It is well documented that fish can have a marked effect on the structure and function of aquatic ecosystems. For example, Anderson (1971) observed that rainbow trout and brook trout stocked into some fish-free mountain lakes in western Canada eliminated larger species of crustacean zooplankton. Later the same author reported that *Hesperodiaptomus,* a large predaceous crustacean zooplankter, decreased or disappeared and rotifers increased in abundance concomitantly in some mountain lakes where fish were introduced (Anderson 1977). A large dark-pigmented cladoceran zooplankter, *Daphnia middendorffiana,* was seldom found in lakes bearing fish, and fairy shrimp (Anostraca) never occurred in lakes with fish in them (Anderson 1980). Discussing his results, Anderson (1980:639-640) described how trout stocked into a fishless lake might produce a permanent shift in zooplankton community structure even though the trout might eventually disappear from the lake.

Such a permanent change in fact has been observed in Snowflake Lake, Banff National Park. Trout introduced into that lake soon eliminated large crustaceans (*Hesperodiaptomus arcticus* and *Daphnia* sp.), and the zooplankton became dominated by small species (Anderson 1972). Recent observations, paleolimnological and experimental studies show that *H. arcticus* has not since returned even though trout disappeared from the lake years ago, and that the elimination of *H. arcticus* probably caused the plankton community to change to small species of zooplankton and phytoplankton (D. W. Schindler and colleagues, in preparation).

Different fish species, even when closely related, can have different effects on ecosystems. In a survey of 320 mountain lakes in western Canada, Anderson (1980) observed that cyclopoid copepods (rather than *Hesperodiaptomus*, as in fishless lakes) tended to be the dominant invertebrate predators in lakes holding introduced brook trout and/or rainbow trout. In the few lakes in which *Hesperodiaptomus* and brook trout or rainbow trout coexisted, the trout populations were usually sparse. In contrast, *Hesperodiaptomus* commonly occurred in lakes holding cutthroat trout.

Pronounced influences of fish on aquatic ecosystems are not restricted to plankton communities, or even to lakes. Or, for that matter, even to aquatic organisms.

In Shield lakes of Quebec, Magnan (1988) found that brook trout populations were less productive, shifted from eating benthic to eating zooplanktonic organisms, and underwent morphological changes in lakes where they had to compete with white suckers or creek chub. He also observed that the shift in feeding habits of brook trout in the presence of creek chub produced changes in the structure of the zooplankton community in which the proportion of large species declined and that of the small species increased.

Healey (1984) concluded from a review of fish predation on aquatic insects that benthic invertebrates in ponds and lakes generally increase and decrease in abundance in response to changes in the abundance of their fish predators, and that there was evidence that fish predation plays an important role in structuring the insect community of ponds and lakes. Studies published subsequently have tended to confirm these conclusions, showing that fishes can severely reduce (and even eliminate from some habitats) certain benthic invertebrates, change their distribution and alter their behaviour in lakes (Luecke 1990) and streams (Cooper 1987).

In contrast, Wellborn and Robinson (1991:2520-2521) stressed that benthic invertebrate prey communities experienced with fish predation often show little or no effect of fish predation; inexperienced prey communities show more pronounced effects when exposed to fish predation. Despite their argument to the contrary, they did cite a number of studies in which even experienced prey communities show significant responses to predation, pointing out however that predation affected only abundance, not species composition. A study published at about the same time (Martin et al. 1991)

showed that fishes had a rather large effect on a dragonfly population experienced with fish predation. Effects included a reduction in individual growth, strong selective cropping of large individuals, strong depressing competitive effect by small fish on young-instar nymph abundance, and a shift from a single-year (univoltine) to a two-year (semivoltine) life history.

The relationships among fishes, other aquatic vertebrates and aquatic invertebrates may be both subtle and complex, and do not necessarily involve competitive or predator-prey interactions. For example, harlequin ducks on the Maligne River at the Maligne Lake Bridge in spring appear to be consuming aquatic invertebrates kicked up by redd-building rainbow trout, an introduced species in that drainage (J. Taylor, personal communication). What are the implications to the ducks of this change in behaviour? Are they now exposed to more human disturbance? (The bridge is a busy place.) How does it affect critical aspects of their breeding biology? Except for some investigations of bird and mammal predation on fish (e.g., White 1927, Matkowski 1989 and references therein, Reinhart 1987 and references therein), interactions among fishes and other aquatic vertebrates, semiaquatic or nonaquatic organisms appear to have been little studied to date. They may be important, however, especially in the context of maintaining the ecological integrity of national park ecosystems.

The foregoing have been examples of a “top-down” view of the place of fish in freshwater environments (Northcote 1988), showing the effects fish can have on aquatic ecosystems. Northcote extensively reviewed the literature these types of effects, and concluded that fish can profoundly influence other aquatic ecosystem processes, including those types noted above. His conclusions are summarized in Table 1. Note particularly that the effects found sometimes have been substantial, subtle, complex, far-reaching, surprising and probably unpredictable from a basic knowledge of fish life history and biology. Few knowledgeable fish biologists would immediately suspect, for example, that their stocking of fish in a fishless lake might reduce the transparency of the water.

But fishes are not only aquatic animals, they are integral parts of food webs that extend out of the aquatic environment into terrestrial portions of ecosystems. Several mammal and reptile species, as well as numerous species of birds, rely partly or mainly on fish for food (The Study Area:Wildlife, Part 3). For example, grizzly bears heavily utilize cutthroat trout and change their local distribution in response to differences in cutthroat trout spawning runs in Yellowstone National Park (Reinhart 1987). Fishes also conceivably compete for food with nonaquatic organisms. They might do this by consuming larvae and adults of flying insects eaten also by bats, swallows, dippers and various other aquatic birds and mammals, spiders and other nonaquatic invertebrate predators. In the case of piscivorous fish, they may compete by consuming fish preyed upon also by other piscivorous vertebrates.

It is evident from the foregoing discussion that it is dangerous to attempt to manage fish stocks separately from the ecosystems of which they are a part. Fishes are

important parts of ecosystems, often acting as keystone species, and manipulating fish stocks in such cases inevitably will affect the structure and function of those ecosystems in some way. The findings suggest that manipulating fish populations has a high probability of producing large, unpredictable, undetected and often unwanted results unless based upon a thorough understanding of the ecosystems of which the fish are a part.

Cumulative Environmental Impacts

In park resource management, "environmental impact" means the negative effect of some change in the environment on a resource the park is intended to protect. "Cumulative impact" is the total accumulated effect of all environmental changes on the resource.

The concept is an important one. It holds that, while individual impacts may be small in themselves, the overall impact of all environmental changes affecting the resource taken together can be significant. Moreover, successive environmental changes may damage a resource not only in an additive way, but in complex ways that are difficult to predict beforehand and difficult to measure after the fact. This is because biological processes are rarely linear over wide ranges of conditions, but typically have thresholds beyond which they fail to operate or break down entirely. Where a resource is near a threshold, a small change can drive it over the edge.

An example of a threshold phenomenon important in conservation biology is the minimum viable population, the smallest number of organisms that could sustain a population indefinitely. Should a population be near its minimum viable size, even a small impact could extirpate it. (This is an oversimplified description of a more complex idea to illustrate a point. Gilpin and Soulé [1986] explain more comprehensively the notion of minimum viable population.) It has been postulated that whole ecosystems may have a critical viable size as well (Lovejoy et al. 1986).

It is the threshold phenomenon coupled with the smallness of the individual impacts that makes the problem of cumulative impacts so insidious. Each small bit of damage in itself might well be insignificant, but the cumulative damage is just as real as if it had occurred suddenly from some dramatic and obvious change.

Table 1. Summary of some effects that fish can have on freshwater ecosystems, based on an extensive survey of the literature (Northcote 1988). Adapted from Northcote (1988:372).

Process	Ecological parameter affected	Mechanism and consequences
direct feeding	water transparency	① food searching stirs up bottom sediments & lowers transparency ② intense phytophagous feeding may increase transparency; reverse effects also demonstrated, depending on algal sizes grazed and extent of fertilization effects
	nutrient release, cycling	① benthic food searching increases mud-water nutrient exchange ② littoral vegetation grazing, processing increases nutrient cycling
	phytoplankton	① as in ②, water transparency ② heavy grazing commonly increases production
	periphyton, macrophytes	① strong cropping effect on biomass shown for lakes and streams
	zooplankton	① strong cropping effect on abundance especially of larger forms ② some evidence of increased production
	zoobenthos	① strong cropping effect on abundance common but not invariable in lakes and streams ② distribution & size of fish feeding causes marked seasonality in effects ③ production often increased in lakes but not so in streams
selective predation (by size, visibility, motility)	phytoplankton	① shifts in relative abundance of algal size and species composition
	zooplankton	① shifts in relative abundance of species reduces algal grazing efficiency and water transparency ② changes in clutch size and maturation timing
	zoobenthos	① heaviest predation on large body-size forms affects their cover selection, activity patterns & reproductive behaviour (both lakes & streams)

continued…

Table 1. concluded

Process	parameter affected	Mechanism and consequences
selective predation (continued)	nutrient release	① shift to smaller body size (zooplankton) increases nutrient release
excretion	nutrient release	① liquid release provides quick, patchy availability ② faeces release provides slow, patchy availability after remineralization ③ epidermal mucus release increases iron availability to algae via chelation
decomposition	nutrient release	① carcass remineralization provides slow, patchy release
migration with excretion/de-composition	nutrient enrichment	① transport of excreta or body decomposition products from high nutrient to low nutrient regions (sea to inland waters, stream lower to upper reaches, lake layers)

An especially apt example of devastating cumulative environmental impact on a fish under park protection is given by Renaud and McAllister (1988). The Banff longnose dace, *Rhinichthyes cataractae smithi,* was endemic only to the Cave and Basin Hotspring in Banff National Park. Beginning in the 1880's and extending to the present day, a succession of environmental insults were visited upon the population, including the construction of bath-houses, introduction of 10 exotic species of fish, pollution by a variety of agents, reductions or complete stoppages of flow, and successive damming and draining of its pond habitat. The population disappeared sometime between 1925 and 1971, succumbing to introgression by the widespread subspecies *R. c. cataractae.* Renaud and McAllister (1988) believed that the introduced exotics and interrupted flows were the most important factors causing the decline of the population. Impacts from the other environmental changes could not have been positive either. Once the population of *R. c. smithi* was reduced, it then became especially vulnerable to introgression when it was exposed to a population of *R. c. cataractae* from the adjacent Bow River.

Catastrophic changes in the environment appear to be rare. Cumulative impacts must account for the great majority of changes witnessed in fish stocks and aquatic ecosystems. It is therefore critical that the issue of cumulative impacts be addressed in managing fish resources in Jasper National Park.

There are two important implications of a commitment to prevent cumulative environmental impacts in national parks. Both are a consequence of the legal requirement to maintain the ecological integrity of park ecosystems.

First, there are *no minor environmental impacts* in national parks. Because it is the goal and legal requirement of the national parks to maintain ecosystems in a condition unmodified by human intervention (What is Ecological Integrity?, this volume), every deviation from that condition is unacceptable. Even if an unnatural change is judged acceptable or unavoidable for some reason, at some point the cumulative damage from repeated acceptable/unavoidable changes *will* be unacceptable. How to deal with this problem in a realistic way is considered in Part 4.

Second, because national parks are intended to maintain ecosystems in their natural state, *it is the natural condition* of the ecosystem that must be used as the baseline against which cumulative impacts are measured, not any presently existing, partially damaged condition. Determining what the natural condition of the fish stocks and their ecosystems are (or might have been) is one of the principal objectives of Part 3. Approaches to determining the natural condition where it is presently unknown is taken up in Part 4.

Sport Fishing and Fish Conservation

The review of the regulatory environment in the first section of this report showed that protecting the fish resource is intended to take priority over all other uses of that resource in Canada's national parks. The discussion in the second section thus far has centred on certain concepts particularly relevant to conserving fish and their ecosystems within a national park setting. Here I outline how these concepts constrain sport fishing, the present major use of fishes in Jasper National Park, taking into account current views on angling within national parks in general. This and related questions are considered in more detail in Parts 2 and 4.

Current Views on Angling in National Parks

Reconciling aquatic conservation and sport fishing has been a continuing concern within the Canadian Parks Service, and has been addressed in two recent documents (Harvey et al. 1989, Schiefer 1989).

Approximately 100 Parks Service personnel, interested academics and professionals attended a workshop on management of aquatic resources in national parks in November 1988, and published the proceedings with a list of recommendations (Harvey et al. 1989). It is not clear how the recommendations were decided upon, but it appears there was some attempt to arrive at a consensus among the participants, so the recommendations provide valuable insight into the views of a significant body of thoughtful people with experience in the field. Several of the recommendations are relevant to fish management in Jasper National Park.

Symposium participants in general recommended that sport fishing *as a consumptive use* be discouraged or prohibited within national parks, although there was said to be no clear consensus on this point. For example, it was recommended that sport fishing not be considered a traditional activity under section 3.2.11 of National Park policy, because the general intent of park policy is that resource harvesting be discouraged or prohibited (Recommendation 1, Sport Fishing). Instead, it was recommended that sport fishing be managed as an "in-park experience" (Recommendation 3, Sport Fishing) or "park activity/experience" (Recommendation 1, Recreation and Interpretation). Consumptive use was not clearly defined, but appears to mean use as domestic food as opposed to being part of an in-park experience (Recommendation 3, Sport Fishing). Participants recommended that stocking be phased out (Recommendation 5, Sport Fishing), but again there was said not to be consensus on the issue. In particular, one participant argued that numerous Jasper National Park lakes had unique characteristics that rendered a "no-stocking" policy untenable in that special case (D. B. Donald, memorandum to D. Harvey, 23 December 1988).

Workshop participants seemed to favour uses that in some forms are incompatible with sport fishing. Several recommendations urged greater protection for the fish resource or aquatic ecosystems (Recommendations 2, 3, 6, Sport Fishing; 2, 3, 4, 6, Traditional/ Commercial/ Native Harvesting; 1, 4, 5, Internal and External Threats to Aquatic Systems; 2, Research and Monitoring) and greater emphasis on public education and interpretive use of aquatic resources (Recommendation 2, Sport Fishing; 8, Internal and External Threats to Aquatic Systems; 3, 7, 8, 11, 12, Recreation and Interpretation). Use of national park waters as benchmark ecosystems was also recommended (Recommendation 2, Sport Fishing; 6, Internal and External Threats to Aquatic Systems).

One of the symposium recommendations proposed using catch and release regulations as a management technique for sport fishing, though again there was said to be no clear consensus in support (Recommendation 4, Sport Fishing). Schiefer (1989) later addressed the matter in detail in a review of information on North American catch/release management. The results of his review suggest that catch/release management of sport fish might meet the conservation objectives of the Canadian Parks Service, might dramatically improve fishing quality and might be popular with most anglers. He indicated that, based on experience elsewhere, most resistance to the technique probably would come from resource managers rather than resource users.

At least two constraints on sport fishing are revealed in this brief examination of views on angling in national parks. One is that there is a significant body of opinion favouring nonconsumptive use of fish resources in national parks. The other is that there is at least one management approach that shows some promise of successfully treating sport fishing in a nonconsumptive way.

Conservation Constraints on Angling and Fish Management

By law and policy, sport fishing may be pursued within national parks only to the extent that it does not damage the resource. In terms of conservation, damage means any loss of diversity, broadly defined, that would reduce viability, adaptability or ability to evolve of any *stock* of indigenous fish. Damage also means any loss of diversity that would affect aquatic ecosystems in the same way.

What this means in precise terms will have to await detailed consideration of each ecosystem (lake, stream) and fish stock. Some general answers can be given now, however. First and most obviously, no indigenous stock can be permitted to be reduced to a size that can no longer maintain itself. Second, no indigenous stock can be genetically altered by angling or sport fish management. Third, no other indigenous component of aquatic ecosystems can be subjected to either of these conditions as a result of angling or sport fish management. Fourth, a full complement of indigenous stocks and aquatic ecosystems must be retained in an unaltered state as benchmark or reference resources. Finally, any unique stocks (indigenous or not), aquatic ecosystems or components of aquatic ecosystems must be protected in an unaltered condition.

These are stringent restrictions, but they are necessary to meet the requirements of the National Parks Act and national parks policy. Schiefer's (1989) review suggests that in principle sport fishing realistically might be conducted without breaching them, and there is reason to believe they will be supported by those charged with managing fish resources and by sport fishermen (Harvey et al. 1989, Schiefer 1989).

Discussion

Historically, fish managers in the national parks of Canada manipulated populations and habitats to maximize sport fishing opportunities in park waters (Part 2). This approach has been de-emphasized more recently because it is clearly contrary to the overall conservation mandate of the national parks, but it has not been totally abandoned. At least since 1979 it may have been defended on the grounds that sport fishing has been explicitly exempted from the general prohibition against consumptive use; however the analysis of relevant legislation and policy shows that protection of the resource *always* takes precedence over visitor use (The Regulatory Environment, this volume). For this reason the approach and techniques of conservation biology, not those of fishery optimization, are the appropriate basis for fish management in national parks.

In general terms, the field of conservation biology is concerned with maintaining the full variety of the world’s life, from its genetic diversity to the complete set of

interactions among its organisms and the physical environment; in other words, with retaining the composition, structure and function of the ecosphere (Noss 1990a). In this sense it takes on the function of quality control. Good quality control involves at least two things: (1) making some evaluation of risk (the consequences and probability of failure), and (2) responding *in a conservative manner* to minimize the risk. In terms of Jasper National Park, for example, conservation-oriented fish management will first have to consider what a contemplated form of visitor use might do to the ecological integrity of the park, and then evaluate the possible magnitude of any damage. It will then have to estimate the likelihood of that damage happening, and propose highly conservative ways of minimizing the risk, in all cases erring on the side of protecting ecological integrity.

It is this need to minimize risk of damage to ecological integrity that distinguishes the conservation approach to fish management from the fishery optimization approach. If your principal goal is to minimize the risk of damage to ecological integrity, any evidence of a threat to ecological integrity is likely to weigh heavily in your management decisions. In contrast, if your goal is to provide an optimal sport fishery, you are prone to demand stronger evidence of a threat to ecological integrity, or even proof that damage actually will occur.

This difference in point of view accounts for the frequent accusations of bias and subjectivity levelled against conservation biologists by sport fishery managers and others (Callicott 1991:22). In reality the standards of proof are the same on both sides; it is the evaluation of risk that differs. It is true but beside the point that the critics of conservation biology are equally guilty (if that is the term) of bias and subjectivity by virtue of their different point of view. The question to be answered is: which point of view is appropriate to the purpose? The goal assigned to fish managers in Jasper and other Canadian national parks is to maintain ecological integrity above all; therefore the conservation biology approach is the appropriate basis for fish management in this case.

SUMMARY & CONCLUSIONS

The overall guiding principle of the national parks of Canada is "use without impairment." The primary purpose of the parks is to protect the landscapes and ecological integrity of representative natural areas of Canadian significance. They are protected so that people can learn about and enjoy them in that context. That is their secondary purpose. Appropriate uses, therefore, are those that allow people to learn about and enjoy the parks as representative natural areas without damaging their landscapes or disturbing their ecological integrity. Allowing any such damage or disturbance would defeat both purposes. For example, the primary purpose of Jasper National Park is to protect a representative portion of the eastern Rocky Mountains natural area in Canada. It is protected so that people can learn about and enjoy it as a representative example of that natural area, provided that they do no damage to its landscapes or ecological integrity.

Fish management in Jasper National Park therefore must first be directed toward maintaining the ecological integrity of the park's fish stocks and the ecosystems of which they area a part. It then must provide suitable opportunities for people to learn about and enjoy the fishes. Appropriate uses will be those that allow people to learn about and enjoy the park's fish stocks as parts of a representative eastern Rocky Mountain ecosystem, and that do not disturb the ecological integrity of that ecosystem.

In the context of Canada's national parks, maintaining ecological integrity means retaining natural ecosystems in a state unaltered by human activity; that is, keeping them self-maintaining, with their full complement of native organisms interacting among themselves and with their environment in a manner unchanged by humans. Maintaining ecological integrity requires that ecological integrity be restored where it has been destroyed, because maintenance implies restoration where necessary. Maintaining ecological integrity also requires that ecosystems and their components be permitted to change without the intervention of humans. Changes such as succession, adaptation and evolution are natural processes integral to healthy ecosystems.

It is obvious that maintaining ecological integrity so defined can never be fully attained in Jasper National Park, or probably anywhere else on earth. It can be approached more or less closely, however: some ecological states are more intact than others, just as some states are more natural than others. In national parks, ecological integrity as defined here is a worthwhile ideal to be striven for, even if ultimately it cannot be completely attained. It serves as a guide to give direction to management action, and a standard against which the success of a management program can be measured.

Conservation biology is the discipline now emerging to deal with maintaining biodiversity and ecological integrity. It is an applied science, employing classical

scientific methodology[10] (though sometimes in novel ways) to solve conservation problems. As such, it is an appropriate approach for managing fishes in national parks. Conservation biology recognizes as valid numerous reasons for protecting biological diversity and ecological integrity, including utilitarian, ethical, cultural and aesthetic reasons.

Reasons in all of these classes have been used to justify Canadian national parks as protected areas. But whatever the justification, our protected areas must serve a central role as part of an overall comprehensive strategy to conserve biodiversity beyond their boundaries. To do so successfully, they must serve as models of undamaged ecosystems, as refuges and as sources of organisms for reintroduction elsewhere. Their ability to serve these functions is compromised by the isolation and generally small size of most protected areas, which will render them ineffective for conservation in the mid- to long term, and by their present uses which are often inimical to conservation. Opportunities to establish new protected areas also are near an end. Accordingly, it is critical that what resources we still hold in protected areas be managed maximally for conservation purposes.

To maintain the ecological integrity of native park fishes, it is necessary to conserve their genetic diversity. Genetic diversity must be protected not only to maintain the ability of park fishes to to adapt and evolve, but simply to maintain viable populations. Avoiding losses of genetic diversity requires that populations not be extirpated, especially those living in marginal habitats, because those populations are likely to be major contributors to the genetic diversity of the species as a whole. It also requires that the widespread introduction of genetically uniform stocks be avoided, that introgressive hybridization be prevented, and that any selective effects of exploitation, which are little known but suspected to be significant, be curtailed.

The stock concept, the idea that any group of fish showing some degree of reproductive isolation from all other groups within the species is the appropriate fish management unit, offers a way of dealing effectively with the problems of conserving ecological and genetic diversity in fish. Whether they are geographic stocks or subpopulation stocks, the integrity of each such unit needs to be maintained. This is because biological differences among stocks are varied and widespread. Though they may at times be subtle, stock differences reflect a high degree of adaptedness in the stock to the native environment, so have great value for conservation. The stock concept is an especially suitable basis for fish management in Jasper National Park because of the strongly subdivided, insular nature of aquatic habitats within it, which tend to promote stock development, and because Jasper waters may have been colonized by distinct geographic stocks from four or more glacial refugia.

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10 (1) alternative hypothesis development based on existing data (2) rigourous testing of these hypotheses against new experimental data designed to exclude hypotheses (3) reformulation of hypotheses based on the new data (4) testing and reformulation repeated as necessary

Fish pose special problems for conserving the ecological integrity of aquatic ecosystems. This is because fish often appear to act as keystone species, playing a large role in maintaining the essential structure and function of many aquatic ecosystems. For this reason, changes in fish stocks have potentially large, often surprising and sometimes unpleasant consequences in aquatic systems. In addition, their role and influence extends outside of aquatic environments into terrestrial ecosystems. These relationships have been little studied and are largely unknown, but may be important in maintaining the ecological integrity of the park as a whole.

Perhaps the most insidious threat to ecological integrity, and ultimately perhaps the least tractable, is the cumulative effect of small, apparently insignificant instances of environmental damage. While each instance of damage may well be insignificant, the overall effect of all such changes can be calamitous. Successive environmental changes may damage ecological integrity not just in an additive way, but in complex ways that are difficult to predict beforehand and difficult to measure after the fact. This is because biological processes are seldom linear over wide ranges of conditions, but typically have thresholds beyond which they fail to operate. When an organism or ecological function is near a threshold, one more small environmental impact can have catastrophic consequences. This means that effectively there are no minor environmental impacts — in national parks or anywhere else. To maintain ecological integrity in national parks in the face of cumulative environmental impacts, it is essential to use the natural, unmodified state as the standard against which environmental damage is assessed, not some presently existing, already damaged state.

Sport fishing poses obvious problems for maintaining ecological integrity in national parks. Strong debate has been engendered among park managers, academics and the public as to how to resolve the issues. A less consumptive and manipulative approach emphasizing angling as part of an overall park experience was favoured by some at a recent conference convened to deal with such problems. There is no consensus as yet. The priority requirement to maintain ecological integrity helps to set the limits on sport fishing. This requirement dictates that no native fish stock be fished below its minimum viable population size, that no native stock be genetically changed by angling or fish management, that no natural ecosystem or component thereof can be so altered, that a full complement of native stocks and aquatic ecosystems be retained in an unaltered state as benchmark resources, and that any unique stocks, ecosystems or components thereof must be fully protected.

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