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SUSTAINABLE DEVELOPMENT, SCIENTIFIC RESEARCH AND ECOLOGICAL AREAS

First Edition

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ABSTRACT

There are many reasons for protecting ecological reserves, ranging from utilitarian to aesthetic. The objective of this paper is to summarize the case for one utilitarian value: scientific research. We are all dependent for our survival and standard of living upon the biological resources of our planet, and scientific research is necessary to ensure the sustainable use of these resources. Ecological reserves provide undisturbed sites essential for this scientific research. It therefore follows that renewable resource management benefits significantly from the existence of ecological reserves. Reserves have at least three important roles in science. They provide control areas with minimal disturbance as reference points for study of disturbed systems. They also provide areas where long term research can be conducted without risk of interruption. As research on protected sites grows, they provide the opportunity to conduct research in areas with a solid base of already existing data. Only a very small subset of Canadian ecosystem types is currently protected within ecological reserves, and remaining remnants of natural systems are being rapidly lost. While trained personnel, research funds, and research facilities are all accepted as essential foundations for scientific research, ecological reserves should be recognized as an important fourth component. Reserve administrators can increase the scientific use of reserves by (1) increasing the number of ecological reserves, (2) considering accessibility in both site selection and management and (3) building a data base on each reserve. The scientific community can participate by (1) lobbying for increased rates of aquisition, (2) ensuring that existing reserves are used in ongoing or planned research and (3) providing scientific data for the selection and management of reserves.

INTRODUCTION

There are many reasons for creating systems of ecological reserves, ranging from utilitarian to cultural (Hilts, 1986). The utilitarian view is that ecological reserves are created to be used, and that uses such as education, scientific research, and genetic conservation should be emphasized. The objective of this report is to document the utilitarian view that ecological areas are important for scientific research, and to provide some examples from Canada. Since the value of scientific research itself is often not generally appreciated, I begin by documenting the utilitarian value of biological research. Once these two cases have been made, I conclude with some thoughts on how the connection between systems of ecological areas and the advancement of scientific research can be strengthened.

Utilitarian arguments have strict limitations because they do not present the total value of ecological reserves. Reserves are not protected solely for use, but because they possess a unique intrinsic value, a trait they share with great works of art. Ecological reserve systems, like museums, universities, art galleries and libraries, provide both individuals and societies with an added context and depth to their existence. No other justification may be necessary, but a clear understanding of the utilitarian view (and its limitations) is essential for presenting the total case for ecological reserves.

THE VALUE OF RENEWABLE RESOURCES

The physical, economic, social and psychological well-being of human beings is ultimately dependent upon the resources provided by planet earth. Many of these resources are, in principle, renewable, with the potential to sustain well-being far into the future. Table 1 shows the estimated value of such renewable resources to the Canadian economy. Social and psychological well-being are much more difficult to quantity, but one aspect of this is human involvement with wildlife and wildlife related activities. A recent study by the Canadian Wildlife Service found that in one year (1981), 83.8 percent of the population engaged in wildlife related activities (Table 2) and spent an estimated $4.2 billion while doing so.

The World Conservation Strategy (IUCN, 1980) recognizes these relationships and proposes three goals for maintaining sustainable development: (1) maintenance of ecological life support systems, (2) preservation of genetic diversity and (3) maintenance of sustainable utilization. Scientific research is important for achieving all three of these goals. For example, scientific research is necessary to determine the degree to which essential life support processes (e.g. water purification, oxygen production, regulation of climate) are altered by human activities. As well, scientific research into the design and management of nature reserves is important for maintaining genetic diversity. Here I will concentrate on the most utilitarian goal, the maintenance of sustainable utilization.

THE RELATIONSHIP BETWEEN SCIENTIFIC RESEARCH AND SUSTAINABLE UTILIZATION

Human history provides many examples of the decline and loss of potentially renewable resources (Ehrlich and Ehrlich, 1983). A striking Canadian example was the collapse of Great Lakes fisheries, including the extinction of Atlantic Salmon and virtual elimination of species such as Lake Trout (Christie, 1974). Only 7 percent of Canada's land base supports agriculture, but approximately 10,000 ha of this land are lost to non-agricultural uses annually (Pollard & McKechnie 1986). There is growing evidence that Canada's extensive forests are now being over harvested (Science Council of Canada, 1983); Keating, 1983; Pollard & McKechnie, 1986). On a global scale, one of the most recent examples is the deterioration of the grazing system in the Sahel area of Africa which has led to widespread famine. Sinclair and Fryxell (1985) convincingly argue that this situation has resulted from overgrazing a system where historically a balance had existed between cattle and vegetation.

Scientific research has three essential roles to play with respect to such problems. First, scientific research can help avoid such problems by determining the biological limits on sustainable utilization. Second, scientific research is necessary to manage the resource to increase the potential utilization over time. Third, when resource stocks are already depleted, research is necessary for rehabilitation.

A recent report by the Advisory Board on Ecological Reserves in Québec (Conseil Consultatif sur les Réserves Ecologiques, 1986) stresses these relationships. They note that in order to predict the future behavior of ecosystems, we must have a sound understanding of the chain of cause and effect as it applies to ecosystems. This understanding can only be gained through scientific research. If we cannot predict behavior and ensure sustainable use, then society will be faced with the enormous costs of restoration. In some cases the damage may be irreversible, making it all the more important to prevent deterioration in the first place.

The importance of conservation research appears to be widely recognized among the general public. A recent poll in Québec, conducted by the Ministry of Higher Education, Science and Technology, examined attitudes to scientific research and technology. More than two-thirds (69.3%) of the 1,050 individuals polled felt that there should be increased funding for research on environmental matters, as opposed to 1.8% who thought funding should be reduced. In contrast, less than one-quarter of those polled favoured increased research in aviation or robotics (Crelinsten, 1985).

THE RELATIONSHIP BETWEEN SCIENTIFIC RESEARCH AND ECOLOGICAL RESERVES

There are four essential foundations for the scientific study of renewable resources. Three are trained personnel, research funds and research facilities. The fourth is a system of protected natural areas.

The most important value of ecological areas is that they provide controls, or undisturbed areas, against which we can measure the effects of human perturbations. Consider the following questions: What is the rate of loss of soil fertility in Canada's prairies? What is the effect of sport fishing on the decline of Lake Trout? What are the effects of hunting on the population size of moose? How does whole-tree harvesting in forestry influence soil fertility? Each of these questions has important implications for maintaining the productivity of a renewable resource. Each can best be answered by comparison with similar areas where agriculture, fishing, hunting or forestry does not occur. The very value of a natural area lies in the fact that it hasn't been subject to human manipulation. The longer an area has been free from human disturbance, the more value it has. Only when all major ecosystem types in Canada are represented within a comprehensive system of ecological reserves can we be assured that future generations of scientists will be able to confidently answer such important questions.

A striking example of the role of such control areas is provided by the famine in the Sahel region of Africa (Sinclair and Fryxell, 1985). It is widely assumed that the famine here was caused by drought, and a massive international relief program has been based on this assumption. However, in the middle of the denuded and famine-stricken area there is a 1000 km^2 green patch. This is an area which was maintained with a more traditional rotational grazing system - in effect, the original migration system previously practiced in the Sahel. This area was green even though it received the same rainfall as the surrounding denuded areas. This "control" plot illustrates that the denudation of the landscape, and resulting famine, resulted from overgrazing.

In Canada, major areas of landscape are being altered by clearcutting, aerial spraying with herbicides, cultivation, and urbanization. Like the green patch in the Sahel, ecological reserves will soon be the only "control" areas left where we may guage the impacts of these far-reaching and long-term alterations of the Canadian landscape.

In the 1975 Presidential Address to the British Ecological Society, G.C. Evans (1976) reviewed a century of development in ecological research and concluded that probably the most important aspect of the conservation of ecosystems is this preservation of biological systems to meet needs as yet unforseen. He added "Conservation is often presented as if it represented a clinging to the past: not so, what we are engaged in preserving is opportunities for the future" (italics mine).

Ecological reserves also provide protection for long term ecological research. Most important questions require scientific studies lasting over many years. If the study is initiated on private land, or crown land not designated for protection, changes in land ownership or land use may disrupt the experiment before results are obtained. To give but one example, a team from my lab has used the wetlands of Axe Lake in Muskoka, Ontario, as a model system for wetland conservation for nearly a decade. Nearly 20 publications on wetland ecology and conservation have resulted. While we carefully maintained contact with local landowners, in the fifth year of our work I received a phone call from an irate landowner telling me I had 24 hours to get my experiments off his land before he called the police and arrested us for trespassing! Needless to say, one cannot move long term experiments around a lake easily, if at all. The landowner, it turned out, had been given lies about our activities (for reasons too complex to explain here), and retracted his request the next day -- but one decision by one person based upon false information could have ruined longterm experiments and the tens of thousands of dollars invested in them.

If managers are waiting for the conclusions from such experiments, valuable time is lost in implementing a management strategy - time which may lead to further deterioration of the natural resource. When long term studies are undertaken, each additional year of data enhances the value of a natural area. If a site is then destroyed, the potential for future measurements documenting natural processes is forever lost. As such natural areas become increasingly scarce, scientific advancement is increasingly hampered.

A third consideration is that scientific research itself enhances the value of a natural area. When inventories have been completed, when experiments have been conducted, when long term data sets have been collected, these in themselves provide a resource for future generations. The value of sites increases as the accumulated data increases. Areas which have been extensively studied need to be included within a reserve system to provide a foundation for future research. This need for long term studies in ecological areas was emphasized by Likens (1983), in the Address of the Past President of the Ecological Society of America, who concluded that rigorous and uninterrupted long-term studies of ecosystems are a "national treasure".

EXAMPLES OF THE VALUE OF ECOLOGICAL RESERVES TO SCIENTIFIC RESEARCH

There are two difficulties with measuring the value of specific ecological areas to conservation research. First, there has been a lack of protected areas for ecological research, so that many productive scientists have had to, by necessity, work outside of protected areas. Second, it is difficult to measure "value" precisely. To deal with the first problem, I have included case histories of areas which have not been legally designated as protected ecological areas, (e.g. Sable Island) but which at least have had a documented history of scientific use. To deal with the second problem, we may consider number of scholarly papers produced as a measure of scientific value, since scholarly papers are the principal method for disseminating the results of scientific research.

ALGONQUIN PROVINCIAL PARK

The Wildlife Research Station in Algonquin Provincial Park, Ontario, is in a 30 square mile area established in the early 1940's, and now included within a much larger "North Algonquin Primitive Zone". Since research began on the site in 1945, at least 200 refereed papers, 28 doctoral theses, 53 master's theses, as well as book chapters and scientific reports, have resulted from research at this station. These studies dealt with topics ranging from the biology of biting insects to the control of moose disease. An independent audit of the station concluded that "... The Wildlife Research Station is an almost priceless asset to field biology, not only in Ontario, but in Canada as a whole ... Scientists who earned their Ph.D. ... at the Wildlife Research Station have gone on to leading positions in universities and government agencies" (B. Falls, unpublished manuscript).

POLAR BEAR PASS

The high Arctic Research Station at Polar Bear Pass has, over the past 15 years, yielded more than 100 scientific publications on arctic ecology. These have ranged from the biology of breeding waterfowl, to studies of wolves and muskox through to basic inventories of the distribution of insects and plants (Gill, 1985).

DELTA MARSH

Two research stations have been actively involved in scientific research in the Delta Marsh in Manitoba. The Delta Waterfowl and Wetlands Research Station has produced a stream of scientific studies on waterfowl ecology and management since 1939. More than 400 scientific papers have covered topics including feeding ecology of ducks and effects of water level changes on praire marshes (Delta Waterfowl Research Station, 1976). Nearby, the University of Manitoba Field Station has contributed an additional 150 scientific papers, as well as 40 M.Sc. and Ph.D. theses on related topics (J. Shay, pers. comm., 1986). Both of these stations thus are actively training future generations of scientists as well as producing scientific data.

SABLE ISLAND

The isolation of this sandy island off the east coast of Nova Scotia has produced a distinctive flora and fauna, attracting scientific interest for more than a century (Zimlicki and Welsh, 1975). Published studies on Sable Island have covered botany (10 papers), zoology (50 papers) and geology (40 papers). Its isolation and strictly delimited animal populations have made it an ideal site for important research in the population dynamics and breeding biology of birds and mammals.

BRITISH COLUMBIA

With Canada's largest number of ecological reserves, British Columbia has a growing list of research publications from scientific studies in ecological reserves. Topics have included the breeding biology of coastal birds, the ecological characteristics of saline lakes, fish evolution, and Sea Otter biology (British Columbia Ecological Reserves Program, 1986).

NATIONAL PARKS

Research in national parks currently covers topics ranging from studies of the causes of erosion through to the effects of fire on vegetation (Nelson and others, 1986). These studies dealing with fundamental issues in the management of landscapes are supplemented by other research including ecology of caribou and breeding biology of threatened bird species.

UNITED STATES

The value of reserves to science has been specifically investigated in the United States. A 1963 study by the American Association for the Advancement of Science found that over 2,000 scientific studies had been carried out within protected ecological areas (American Association for the Advancement of Science, 1963). Three of their conclusions were (1) that a great deal of research is being done in natural areas, (2) that natural areas form an indispensable research facility for a number of scientific disciplines and (3) that every effort should be made to expand the natural area system in the U.S. to make it more serviceable as a research facility. In particular, they noted that "the acquisition of such "outdoor laboratories"is fully as appropriate a use for public funds as is the building of cyclotrons, radiotelescopes, or physiology laboratories" (p. 8). The United States has since created a series of experimental ecological reserves. The initial system contained 71 sites at 67 locations throughout the United States (Lauff and Reichle, 1979). It must be emphasized that this system emphasizes scientific research and thus is supplementary to the national system of reserves maintained by agencies such as the Nature Conservancy and National Park Service.

ENHANCING THE SCIENTIFIC VALUE OF ECOLOGICAL AREAS

Given the importance of ecological areas and scientific research for implementation of the World Conservation Strategy, there is an obvious need for cooperation between practicing scientists and those who administer ecological reserves. Two goals can be recognized: the establishment of completed reserve systems, and the use of these systems by scientists. Let us briefly review the existing situation in Canada, and then consider how scientists and reserve administrators can co-operate to attain these goals.

THE STATUS OF ECOLOGICAL RESERVES IN CANADA

Tachereau (1985) provides a thorough review of the current status of ecological reserves (and related protected areas) within Canada. The basic conclusion is that while the system is slowly improving, it is still critically inadequate. Many important regions of Canada are still not represented within ecological reserves or similar protected zones. The Lands Directorate of Environment Canada is completing an ecological classification of Canada based upon ecological characteristics such as vegetation, land form, soils and drainage (Rubec and Wiken, 1983; Wiken, 1986). This system recognizes over 5,900 ecodistrict land units, which can be combined into approximately 195 landscape ecoregions, or 15 ecozones. To represent this complex array of land unites spanning an entire continent, Canada currently has approximately 150 reserves. All but 30 of these are in one province, British Columbia (Tachereau, 1985). This should be contrasted with Great Britain, with a much smaller land base, and much higher population density, where the Nature Conservancy Council currently protects 197 National Nature Reserves (more than 150,000 hectares) and 4,497 Sites of Special Scientific Interest (more than 1.4 million hectares) (Nature Conservancy Council, 1985). In Great Britain there are many other agencies protecting other natural areas such as local conservation trusts, the Royal Society for the Protection of Birds, and the Royal Society for Nature Conservation.

The marine situation is even less satisfactory, although the recent publication of a National Marine Parks Policy by Environment Canada (1986) is a positive step. This document recognizes 29 marine regions, none of which is currently protected within a marine national park.

RESERVE ADMINISTRATORS AND THE SCIENTIFIC USE OF ECOLOGICAL AREAS

An important first step to encourage scientific use is to get on with the act of creating ecological reserves. Until a reserve system exists, scientists will have to continue working on an ad hoc basis in areas which are accessible, even if there is no guarantee that these areas will be available in future years.

Goldsmith (1983) and Beechey (1986) have provided a review of the criteria for selecting ecological reserves. If scientific use is desired, then accessibility of reserves is particularly important. Perhaps some sites should be designated near universities precisely because of the potential for research use. Given that some forms of research do alter the system under study, some jurisdictions may also wish to consider having a class of research reserves. These might even be paired with adjacent reserves being strictly protected against any perturbation. If a relatively large area is designated, providing a small field station would greatly enhance the potential of the site for university research. Nearly all of the above examples of research in ecological areas are associated with a field station.
By expanding and organizing the data being collected in ecological areas, their value to scientists would also be increased. Most scientific research is funded for three year intervals. This does not permit researchers to spend much time collecting baseline data, nor to set up long term monitoring. By completing vegetation descriptions and check-lists, reserve administrators can ensure that valuable baseline data is already available. Long area monitoring programs, such as those for acid rain or water chemistry, could be associated with ecological areas to expand the baseline data further. This has already occurred in the United States where standardized meterological measurements are planned for Long-Term Ecological Research (LTER) sites (Greenland, 1986). If all such information were assembled into a national registry with easy access, scientists could quickly determine whether a site was available to answer a specific scientific question.

SCIENTISTS AND THE SCIENTIFIC USE OF ECOLOGICAL AREAS

Scientists have three important roles to play in relation to ecological areas. The first is to continue to actively support the establishment of a national system of ecological areas. Scientific organizations could become more active in lobbying for such a system; as an example Table 3 lists the scientific societies which comprise the Biological Council of Canada.

Individual scientists can also, where possible, ensure that their work is carried out within existing reserves. The immediate advantage is that continued use of the site can, under normal circumstances, be assumed. Arbitrary decisions by landowners or developers are unlikely to damage on-going research and cripple long term work. More importantly, the legacy left to future generations of scientists will be more than a series of papers in journals: it will be a series of papers which refer to natural systems likely to be available to future researchers. There is certainly an altruistic component to this, if not an obligation to one's own discipline, but there is also a strong component of self-interest. Future generations of scientists will have to make increasing use of ecological areas. Given the choice, future workers are most likely to use the work of those scientists who today had the foresight to carry out their research in such areas. The value of studies in ecological areas is likely to increase steadily with time, and be out of all proportion to their present value.

Lastly, scientists can participate in research which helps to maintain the value of ecological areas. Most research has components which provide insights into natural area management, and many studies specifically persue management oriented questions. Scientists can ensure that their work contributes to the continued protection and wise management of ecological areas.

CONCLUSION

A principal objective of this paper was to document the importance of ecological reserves for scientific research. While this is by no means the only, or even the best, argument for setting up ecological reserve systems, it is one which needs to be articulated.

It might be argued that in fact the priorities should be reversed. Given the breadth of arguments for creating a system of ecological areas (e.g. Hilts, 1986), one might argue that the real issue is how scientific research can contribute to the management of reserves. There is already a growing scientific literature on this topic. Whether we should emphasize "preservation in the aid of research" or "research in the aid of preservation" will depend upon circumstances. Certainly they are symbiotic and mutualistic.

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TABLE 1. Value of Renewable Resources to the Canadian Economy as Measured by Standard Economic Indicators. Values for tourism are unavailable in spite of their obvious importance.

Renewable resource	Gross domestic product[a] (millions of dollars)	Export Value[b] (millions of dollars)
Agriculture	9,186.6	10,970
Forestry	2,321.4	15,563
Fishing	611.5	1,000
Hunting and trapping	29.9	not available
Tourism	equivalent figures not available	

[a] 1983 data. Source: Statistics Canada. Gross domestic product is defined as the Gross National Product + wages + interest + profits paid to foreigners less foreign factor incomes paid to Canadian residents.

[b] 1983 data. Source: Statistics Canada.

TABLE 2. The Value of Wildlife to Canadians, Estimated by Participation in Different Wildlife Related Activities in 1981 (Filion and others, 1983).

Wildlife Related Activity	Percent of Population
Indirect[a]	83.8
Non-consumptive[b] (residential)	66.8
Non-consumptive[c] (trips)	19.4
Hunting[d]	9.8

[a] includes reading, visiting zoos, purchasing wildlife art, watching wildlife films.

[b] includes feedings, watching, photographing wildlife near home or cottage.

[c] trips or outings taken specifically to encounter wildlife.

[d] does not include trapping.

TABLE 3. Scientific Societies Which Make up the Biological Council of Canada.

Name	Membership	Newsletter
Canadian Botanical Association	400	CBA Bulletin
Canadian Council of University Biology Chairman	50+	____
Canadian Phytopathological Society	380	Newsletter, Canadian Journal of Plant Pathology
Canadian Society of Environmental Biologists	400	CSEB Newsletter
Canadian Society of Microbiologists	800	CSM Newsletter
Canadian Society of Plant Physiologists	370	CSPP Newsletter
Canadian Society of Zoologists	700	CSZ Bulletin
Entomological Society of Canada	900	ESC Bulletin
Genetics Society of Canada	650	GSC Bulletin