THE BOREAL FOREST, CREE-OJIBWA FORAGING AND ADAPTIVE MANAGEMENT

Bruce Winterhalder
University of North Carolina at Chapel Hill

Abstract: By choice and partly by necessity, native peoples in the Canadian middle north retain much of their traditional economy, including widespread use of local renewable resources. Ecological studies of boreal forest ecology and Cree-Ojibwa foraging behaviors suggest that three types of understanding will facilitate analysis and management of the native boreal forest economy: i) populations of fauna fluctuate strikingly on several time scales, and they are widely scattered over a shifting mosaic of small-scale patches; ii) Cree-Ojibwa hunting and trapping strategies can be quite effective and sometimes are systematically patterned by a logic which accords generally with optimal foraging theory; and iii) the principle of ''adaptive management'' developed by Holling and his colleagues fits boreal ecology and Cree-Ojibwa foraging practices, and could well guide planning by boreal forest peoples.

In this paper I consider the continuing impact of development on a small community of Cree-Ojibwa speaking people living in the boreal forest of northern Ontario. I am especially concerned with the nature of their environment, their adaptations to that environment, and with planning concepts compatible with this human-ecological system. I write as an anthropologist who spent a year living in a small community with these people, studying their use of local resources (Winterhalder 1977). Like many anthropologists I am uncomfortable with development planning. Therefore, let me begin cautiously, with a definition and a carefully delineated context for my discussion.

First, I see development as a deliberate and organized form of a long-standing process: power, technology, knowledge and values are projected across political, socio-cultural or economic (class) boundaries with the effect of changing people's lives and surroundings. Development is pervasive and rarely neutral; either religion or construction may be helpful or harmful but not, commonly, inconsequential.

Second, residence of the Cree-Ojibwa within one of the affluent western industrial democracies makes them a somewhat anomalous example of peoples usually envisioned when development is discussed. Development is something done in Latin America, Africa or Asia. I will therefore address the comparison of the Cree-Ojibwa case to ''underdevelopment'' elsewhere, and will suggest that it is apt.

Third, I do not view my comments as recommendations to the Cree-Ojibwa people, nor to persons who have assumed responsibility ''on their behalf.'' The Cree-Ojibwa have an extraordinary sense of themselves and their situation. I will try to make some important and useful observations, but I do not mean to mistake my possible insights for their interests.

I will proceed as follows: As background I will allude briefly to the historical development of the Cree. I will indicate how their present-day situation is and is not comparable to that of other third-world peoples. I will discuss briefly attitudes towards development assessment in Canada, and the place of local renewable resources in the present-day and future economy of northern peoples. This background will justify my definition of development, my sense of optimistic urgency with respect to this subject and the contemporary Canadian north, and my subsequent focus on renewable resources.

My main argument has three parts: i) the nature of the boreal environment and its description; ii) long-standing Cree-Ojibwa strategies for use of renewable boreal resources and their analysis; and iii) the compatibility of these ideas with the concept of "adaptive management" (Holling 1978).

Background

By the definition given above, the Cree-Ojibwa have undergone development throughout the historical period (Bishop 1974; Ray 1974; Rogers 1982). Commercial activity of the fur trade was first, augmented later by missionaries and finally by federal and provincial authorities. Development occurred in directions and at a pace set by external forces, whether corporate, ecclesiastical, or governmental (SCC 1977). There were transformations, but their impact ought not to be overstated. The early fur trade was built on an infrastructure of traders operating primarily as an extension of Indian skills and subsistence activities. Many of the goods traded were implements (e.g., firearms, snare wire, traps) that furthered the abilities of native peoples in their own lifestyles. Missionary activity was largely benign, in part because of Anglican monopoly and limited success. And, even if misconceived or badly implemented, government efforts (with the exception of treaties) were essentially the service industries of a liberal democratic society. The material culture of the Cree-Ojibwa has changed greatly, the nuclear family has grown in importance at the expense of extended family groups, and village life now prevails over life in the bush. But social and religious beliefs persist, as does the use of local resources in a native economy. Edward Rogers, an ethnographer with over 25 years experience in the region, puts it this way:

> ". . . The fact remains that for all that the Indians of northern Ontario and adjacent Manitoba have had to endure at the hands of Euro-Canadians in their endeavors to assist the native people and in the face of changing environments, the Indians have not become assimilated into Western society. Fundamentally, they remain Ojibwa and Cree in spirit and in outlook. And, most likely they will continue to be themselves well into the foreseeable future" (Rogers 1982).

Current Socio-economic Situation

Discussion of the Cree-Ojibwa in terms more commonly applied to third world peoples requires some justification. The Science Council of Canada has summarized the situation this way:

> ". . . The political economy of Canada's north has most of the characteristics of an underdeveloped country: extremely high birth rates; declining mortality rates; relatively low incomes; extreme variations in income levels from the highest to the lowest; heavy reliance on imports; little local industry; preponderance of natural resource-based industry; a low level of political development, and so on . . ." (Rea 1976, quoted in SCC 1977).

Historically, products originating in the north have generated wealth elsewhere:

> ". . . The profits from the fur trade and from whaling were earned in the markets of Europe and America and they generated secondary activity only in France, England and southern Canada. Only a fraction of the profits were returned to the Indians and Eskimos. The mining industry has also taken its profits out of the Northwest Territories, and the oil and gas industry will do the same . . ." (Berger 1977).

Capital investment in the north buys equipment and materials in southern Canada (SCC 1977). Not least important, in their confrontations with southern culture and development proposals native peoples deliberately have sought guidance in the recognition that they have the political economy of a colonized people (Watkins 1977).

However, it is worth noting the differences as well. The Cree-Ojibwa live within a democratic state, scientifically sophisticated, affluent by world standards, and with an existing and highly developed industrial and agricultural base outside of their region. To a greater degree than elsewhere, the knowledge and funds exist to assist autonomous Cree-Ojibwa attempts to reach an accommodation with the dominant society, one that preserves their lifestyles and environment.

Development Assessment and Renewable Resources

The recent Canadian public experience with northern development has been dominated by one extended event: The Mackenzie Valley Pipeline Inquiry, also known as the Berger Inquiry (Berger 1977; Gamble 1978). Less visibly but concurrently, the Science Council of Canada drafted a set of reports on northern development and science (SCC 1977). Each of these reviews, and more recently Freeman (1981), has recorded the insistence of native peoples and the arguments of other experts that traditional resources such as game, fish and fur will continue to have a prominent role in the native economy of the north. Usher's (1981) conclusions are probably the most trenchant: continued use of these resources by Indians and Inuit is economically rational and a subsistence necessity because native peoples are and will continue to be marginal participants in the affluent industrial economy that surrounds them. In other words, the continuity of a native economy has gained widespread recognition.

To summarize, the Cree-Ojibwa and their boreal environment have been undergoing relatively slow endemic change and small-scale development by outsiders in the form of traders, churchmen and government agents for several hundred years. They have accommodated to some degree, but have remained Cree-Ojibwa — to a substantial degree in and of the boreal forest. In terms of population and economy their present situation is similar to that of third-world peoples. Like those people, they and the forest now face large-scale development projects initiated elsewhere and profitable elsewhere; like those people they continue to rely heavily on a local economy of renewable resources.

Environmental Analysis

I now turn to the central concerns of this paper. Indian peoples yet have and wish to retain much of their indigenous culture and economy. Successful pursuit of this resolve requires that all sides exercise a sound understanding of the renewable resources available to the Cree-Ojibwa, the effective ways of using them, and the management and planning methods compatible with the ecological practices of the Cree-Ojibwa and the nature of their boreal environment.

My first topic is shortcomings in standard environmental descriptions. Environmental assessments typically contain a description of the setting, an inventory of the natural resources and comments on how their numbers are likely to be affected by the proposed development. This type of characterization has its counterpart in the writings of ecological anthropologists, and the drawbacks are the same. The environmental descriptions in such studies are normative. Soils are described, climate is summarized by annual or monthly mean rainfall and temperature, vegetation is characterized by biome-level description, and a list of flora and fauna is provided. The environment is presented as a static background, portrayed by averaging statistics.

I want to emphasize (full discussion in Winterhalder 1980) that information in this form has limited utility. It is incompatible with theories for analyzing human adaptation; it misleads about the nature of ecosystems; and it provides little practical guidance in understanding the persistence or failure of human ecological systems as these are affected by local ecological events and processes.

The north is a particularly good example of a variable environment. Perhaps because of its vast size and lack of vistas, it suggests monotony. Its streams are sluggish; its vegetation dwarfed. But this appearance of homogeneity and timelessness is deceptive. As it affects the Cree-Ojibwa forager for example, it is a landscape vibrant with activity (see Winterhalder 1983a; papers in this volume), presenting a dramatic and, importantly, unusually well-documented, case of what is probably common to most natural environments: 1) dynamic patterns of spatial heterogeneity in the landscape and in dispersion of animal populations, and 2) recurrent fluctuations in the population density of flora and fauna. These fluctuations are more or less weakly synchronized because of the interlocking effects of food chains and overlapping responses to environmental factors such as climate and fire. They are more or less regular in their pattern. In its effect on a forager, this type of environment defies characterization and understanding in normative terms. Variability and range, rather than averages, are central to the functioning and persistence of these human populations, to the study of ecological adaptation, and to an attitude capable of effective management.

The Optimal Foraging Approach

My second concern is the analysis of foraging, the gathering or hunting of non-produced resources. I am interested in the rationality of this kind of productive activity. Microeconomics can illuminate the behavior of a firm operating in a market, given basic assumptions like profit maximization, knowledge of market conditions and the like. If we take seriously the proposition that the Cree-Ojibwa wish to continue a lifestyle which includes using renewable game resources of the boreal forest, then we have to come to a comparable understanding of the rationality of foraging. One set of concepts which can contribute to this goal, optimal foraging strategy models, guided my study of Cree-Ojibwa ecology (Winterhalder 1977; 1981a,b).

This work had a narrow focus, the attempt to analyze systematically the foraging behaviors of a Cree-Ojibwa, harvesting food-producing resources found in the boreal forest. I used theory from evolutionary ecology (Schoener 1971; Pyke *et al.* 1977; Winterhalder 1981a). It is based on the observation that individuals who improve their performance of basic life tasks relative to time and energy investment will be more adapted. In this case the optimization assumption is as follows: human foragers will develop behaviors which allow them to achieve the highest possible net rate of energy capture while foraging. The last part of this statement, 'while foraging', is worth emphasis. It circumvents the assumption that hunter-gatherers attempt simply to maximize resource use. The optimization principle is fully compatible with behaviors which attempt to minimize the time required to obtain a fixed and perhaps rather limited quantity of resources. The models which give an operational form to this principle are fairly simple; they are general and meant to be realistic but not quantitatively precise (Levins 1966).

The Models

Most organisms select their diet from a variety of potential food sources. The diet breadth model (MacArthur and Pianka 1966; Pyke *et al*. 1977) attempts to specify which and how many of those resources an optimal forager will take in different circumstances. The forager is assumed to randomly encounter prey. He or she decides which and how many of the encountered types to pursue. Resources are ranked by their net value relative to handling and pursuit costs. As more of the types encountered are pursued, average search cost per unit pursued decreases; average pursuit and handling costs, on the other hand, increase because the diet is expanding to include those types less desirable or more difficult to capture. These opposing trends can be used to identify an optimal diet, that set of prey which will give the maximum net rate of energy intake.

Various factors with a potential influence on foraging can be carried into this model by observing how they would affect prey ranking, search costs, or pursuit costs. Searching foragers, those spending relatively large amounts of foraging time looking for prey, will be dietary generalists. Pursuing foragers, those spending relatively more time in pursuit, will be specialists. Increased abundance of high ranked prey types reduces search time and leads to specialization. Behaviors or technologies which improve pursuit efficiency should cause the diet to expand; those which increase the efficiency of searching should cause it to contract. Finally, a prey type not worth harvesting when rare is not worth harvesting even if it suddenly becomes abundant. In effect, whether or not an item is included in the optimal diet is independent of its own abundance and depends only on its rank and the abundance of items of higher rank.

Foraging movement is the subject of another of these models, the marginal value theorem (Charnov 1976; Charnov *et al*. 1976). It considers a patchy or heterogeneous habitat, and predicts when a forager should leave the patch under current exploitation in order to search out another, unharvested one. There are travel costs between patches, food is encountered and harvested within patches, and within each patch the rate of food intake is "depressed" as foraging occurs. Prey are depleted, dispersed, become alerted and therefore wary or evasive, or become simply more difficult to locate as the easier to find items are taken. In these circumstances, the optimal forager leaves the patch under exploitation when the marginal capture rate drops to the average capture rate for the habitat. The organism that remains beyond this time has an immediate rate of harvest which is below what it could expect if it moves on.

The Horn model (Horn 1968; Wilmsen 1973) considers settlement pattern in relation to resource distribution and density. It assesses the geometric distance from a foraging group to food locations. If resources are predictably and evenly dispersed, then the more efficient pattern is regular dispersion of small forager social units. In contrast, if the available resources are clumped together and move unpredictably throughout a large range, then the optimal strategy is aggregation of the foraging population at the center of that range. The ability of humans to directly exchange information about resource location enhances the value of central place aggregation.

A related model indicates that moderately dense, predictable and evenly distributed resources create conditions which lead to the evolution of territoriality (Brown 1964; Dyson-Hudson and Smith 1978). Territories arise because the benefits of exclusive use outweigh the costs of defense. Once a territory is established it creates circumstances more favorable to long-term conservation because the forager is assured of the delayed benefit of short-term restraint.

Refuging (Hamilton and Watt 1970) or central place (Orians and Pearson 1979) foragers are defined by a pattern in which the forager makes an outward trip, forages, and then makes a return trip to a home base with captured prey. In this case, diet choices must consider the costs of prey search and pursuit, and also radial travel to and from the foraging locations (Orians and Pearson 1979). Although details of the optimal solutions vary with modifications in the assumptions, a general pattern is evident: as radial travel time increases the optimal diet breadth progressively is restricted to prey species of higher value, and the optimal load for the return trip increases in size.

With central place foraging one expects some depletion of prey close to the settlement. Faced with such depletion, the optimal forager will increase radial travel distance whenever the cost is offset by the greater richness of the more distant locales. Thus, if prey and habitat are used optimally, local depletion is to some degree self-correcting. The lower the travel costs, the greater will be the evenness in use of successive habitats surrounding a settlement.

Finally, a paper by Morrison (1978) makes a related point about central place foraging. In circumstances like those affecting the Cree-Ojibwa, the optimal search path of a forager attempting to locate randomly distributed prey is one in which the predator makes few turns. An unexpected corollary of this pattern indicates that this search pathway is not one expected always to find the prey nearest to the central place (Morrison 1978, p. 931). This reduces the impact of localized depletion around a settlement. As with the previous models, travel costs have an important impact on this strategy.

Cree Foraging

In my fieldwork (Winterhalder 1981b, 1983b) I traveled with Cree foragers, noting time and energy investments, foraging tactics and choices, knowledge of animal behavior, and the game captured. These trips, and others recorded in less detail through conversation with returning hunters, were mapped on airphotos in order to measure distances and placement relative to the vegetation mosaic. I intentionally worked with proficient hunters. In this village snowmobiles were used to travel to hunting areas, but not to pursue game, a practice prohibited by game regulations and impeded by the deep, soft snows of the bush. Small outboards were used for travel during open water periods.

In analyzing diet breadth I originally predicted that the low density and high dispersion of boreal forest resources would mean relatively high search times and consequently generalized hunting strategies. In fact, Cree-Ojibwa foragers often set out for only one or a few species. With snowmobiles, search efficiency, subsidized with fossil fuels, was high enough to account for the narrow diet observed. I had not anticipated the effects of transportation on search velocity. However, 15 years ago, snowmobiles and outboards were not in widespread use, and the prediction of more generalized hunting is supported by informants' statements, early ethnographies, and by commentary by northern anthropologists (Winterhalder 1981b; 1983b). The optimal diet breadth model seems to give us insight into the causes of changing Cree-Ojibwa foraging practices.

Qualitative observations of Cree foraging also give support to the marginal value theorem. When muskrat were shot as they sat on the new ice lining river coves, only the more readily available animals were taken in each location before the forager moved on to the next population concentration. Foragers say that hare snarelines in a particular place generally are abandoned for more favorable spots before they cease to be productive (for other instances see Winterhalder 1983b).

With respect to settlement, an original pattern of dispersed family hunting groups is widely documented for the eastern boreal forests, as is the recent change to more permanent and larger settlements (Rogers 1963; additional references in Winterhalder 1983b) with economic and government inducements. In an environment of fairly evenly dispersed resources the original pattern corresponds to that predicted by the Horn model. However, the shift to nucleated settlements occurred roughly coincident with the introduction of bush planes and outboards (snowmobiles came later), which gave the Cree-Ojibwa continued access to large areas of surrounding land, including traditional hunting and trapping ranges. The Horn model accurately characterized the original situation; the loss of foraging efficiency with settlement was somewhat offset by improved transportation, if at a high monetary cost (Berkes 1981a).

I do not have the data to closely assess the predictions concerning radial game depletion, or search path and turning. In the small community (about 100 people) that I studied, localized game depletion was not perceived as a problem, and the distribution of moose kills, for which I have evidence, did not suggest that it was. Search pathways regularly took people far from the village and made few turns.

Overall, in the instances cited here (Winterhalder 1981b), Cree-Ojibwa foraging corresponds rather well to the predictions of optimal foraging models. This suggests that the models provide insight into the rationality of foraging behavior, and a guide to efficient ecological practice. Exceptions, such as aggregated settlement pattern, can be explained by alternative causes and their effects investigated.

Evolutionary ecology theory illuminates foraging, but the practice of foraging and especially its dynamics require detailed information on the variables actually incorporated into the model and decisions. Here the type of dynamic environmental analysis mentioned above is essential.

The boreal forest is vast, but only a small portion of it is productive for the forager. Species used by the Cree are associated with vegetation habitats that make up only 28 per cent of the landscape; if the large areas of open water not used for fishing are excluded, then only about 10 per cent is used intensively. The favorable locations are small patches, randomly distributed, and by virtue of disturbance and succession, always shifting. Mobility is essential, and considerable experience goes into acquiring familiarity with a hunting area. Each trip reappraises that information as once favorable areas become less alluring to game through succession, and as disturbances such as fire create newly attractive habitats.

The temporal dynamics are equally important. Fluctuations of population density by season or longer periods are dramatic. These density changes plus seasonal alterations in visibility, snow and water conditions, and other factors which affect encounter rates give a highly dynamic quality to the search component of the diet breadth model. Similar environmental conditions impart flux to pursuit costs, and hence the ranking of prey species. Taken together, those spatial and temporal factors directly influencing foraging decisions are unstable and nonrecurrent on the scale of a forager's lifetime. The environmental elements of foraging are always novel, even if the guiding strategies persist.

It is impossible in a paper to portray the skill of a proficient Cree-Ojibwa forager. While the optimal foraging rules themselves may be rather simple, adroit application is demanding. The effective environment changes rapidly, in multiple ways, and with significant degrees of unpredictability. Among the major adaptive skills of a Cree-Ojibwa forager are: observational sensitivity to the state of the ecosystem and its likely changes; the ability to evaluate simultaneously and selectively many environmental factors which will affect foraging decisions; and flexible responses. Foraging is the application of simple rules in a complex and skill-demanding setting.

One commonly hears that western technology has disrupted the lifeways of the Cree-Ojibwa or other hunters; that a flannel shirt from Sears and a Winchester shotgun inevitably compromise this subsistence pattern. There may be cases in which this is true, but the Cree-Ojibwa have adopted Euro-Canadian technologies and other developments without altering their underlying strategies of harvesting forest resources. Optimal foraging models help to demonstrate the continuing proficiency and rationale of their hunting and trapping efforts even, for instance, as they take fewer species. The latter is not evidence of ''disengagement'' from their forest habitat; rather it is a predictable response of an optimal forager living in a certain kind of new technological context.

Foraging Management

Foraging models help to identify aspects of foraging behavior which are systematic and efficient. These should not be impeded if effective use of renewable game resources is to be encouraged. And, the models can aid in understanding the impact of effective game exploitation on the environment. However, use of this information requires that we overcome western myths about socio-cultural evolution, progress and our hunting ''heritage'', and the western experience of hunting as a sport (a leisure activity, with qualities enhanced precisely because they are the opposite of occupational pursuits).

Usher (1981) has provided a penetrating analysis of the first problem, that of the prevailing attitudes toward hunters. Western attitudes suggest that foraging production is an anachronism, to be preserved only as a romantic lifestyle preference or cultural legacy. Hunters are predators, and not very good ones, being limited by privation, natural processes and immature technologies. This view allows neither for efficient use nor effective management by foragers of their resources. If given a technological edge, these hunters will presumably overcome the dominance of nature and destroy the resource base. All of these conceptions deny that foraging is an important socio-economic activity, with rational as well as meaningful virtues. All are flawed.

Foraging strategy analysis is one aspect of an alternative and more enlightening view. It highlights the systematic nature of foraging, and it does so with clear implications for management. For instance, foraging harvest is most efficient when the hunter takes that set of game identified by the optimal diet breadth model. Game regulation categories which contravene these groupings will impede effective use of renewable resources and thwart skilled foraging practices. Separate management and regulations for categories like "big game", and "waterfowl" might be an example. In given conditions the optimal diet may include some species from each of these groups. Or, to give a more specific example, since the harvest of an organism depends on its "ranking," innovations in species-specific capture technologies should be a more effective way of controlling or directing harvest toward an under-utilized species than would be increasing its population.

The marginal value theorem suggests that the effective hunter moves from patch to patch without fully exploiting and hence depleting each location. Habitat heterogeneity not only enhances game diversity and productivity (Rowe and Scotter 1973), but reduces forager impact in given locations. Practices such as fire control or lumbering which reduce habitat patchiness will have a negative impact in this respect, and may also reduce the resilience of the human ecological system (Roff 1974; May 1975; Smith 1972).

The Horn model shows that growth of Cree-Ojibwa settlements decreases foraging efficiency. This same pattern risks uneven use of resources, with depletion adjacent to the populated area and underuse in the hinterlands. Effective policy here would encourage the proliferation of small settlements. Central place models and those relating to optimal search pathways suggest that only the most valuable game will entice foragers far from their villages, unless radial transportation costs are low. If even harvest of resources in the bush and near to settlements is desired (Fuller and Hubert 1981; Berkes 1981a), then use of snowmobiles and bush planes should be encouraged, perhaps through subsidy.

Ecological models suggest that conservation is more likely if conditions allow the conserver to realize the benefits of short-term restraint. Usher (1981) and Berkes (1981b) have also suggested that restriction of native hunters to traditional hunting ranges would allow customary conservation practices to operate more effectively.

Finally, good hunting conditions are unpredictable and ephemeral. Hence an effective hunter requires considerable flexibility in the timing of his or her work. Subsidiary activities such as wage labor should be organized so as to provide for this. And, although the boreal forest is vast, only a limited proportion scattered in small patches is good foraging habitat at any given time. The location of these patches is always in flux, due to factors like fire. Large areas contain small, scattered opportunities which are elusive unless the forager has experience within a region. This provides another argument for continuity of association between foragers and home ranges, and it highlights the need that these ranges be large.

What about the impact of optimal foraging patterns on the game itself? Several of these models identify circumstances in which game conservation is consistent with maximally effective exploitation. This may seem to be a paradox, but in a patchy environment the most efficient forager leaves some animals, a potential breeding population, in each patch. An optimal forager from a central place does not necessarily devastate resources close to home and ignore those further away. In the absence of population-wide regulations, resources used by one or few foragers within a territory are more likely to be "managed" for long-term harvest. Conversely, in an environment without strong spatial heterogeneity, the diet breadth model may suggest a circumstance where more deliberate practices might be needed. Resources which are ranked highly will be pursued whenever encountered. Moose or beaver might be examples. Depletion is more likely in this instance, and deliberate conservation more necessary. Similarly, costly radial travel to distant locations will lead the optimal forager to concentrate on game with the highest value, to the neglect of other species.

In effect, ecologically sound practice requires quite different perceptions of and regulations for subsistence and sport hunters. Sport hunting rules operate by impeding the effectiveness of the predator. This is compatible with the goals of sport hunting and game management, but probably not appropriate for the native population in the north (Wilkinson 1981). In some instances, subsistence hunting rules should be designed to maximize the effectiveness of the forager. This is compatible with the goal of subsistence hunting. But more important and what I want to stress, there are circumstances in which it can be compatible with management of game with only minimal guidance. To those for whom hunting is an occupation, controls designed for recreation management frustrate effectiveness, and will impede retaining a lifestyle based on renewable resources. A Cree-Ojibwa informant, chafing under diligent observation of restrictions on the use of snowmobiles to pursue game, made this comment (see also Usher 1981):

> ". . . We do not tell all of those bureaucrats in Toronto that they have to write everything with pencils, that they cannot use typewriters to do their work. Why can't we use snowmobiles to do our work?".

Berkes (1981b) has stated a similar position, calling it management by self-regulation and design. Design works by "establishing criteria to govern . . . [a] process so that the desired result will occur more or less automatically [and] without further human intervention", as opposed to regulation, which works through rules imposed from the outside and close policing. Berkes argues that the design approach will find greater acceptance in the native communities and hence has greater likelihood of being effective. Such a system would work through customary law and the traditional adaptive practices of the Cree, "keeping in mind that these practices may be under considerable stress at a given point in time."

Usher (1981) has made observations which complement these. He suggests that the hunting economy has continuity and rationality; its essential qualities persist. Usher takes concepts of political economy and mode of production to identify some of those qualities. I have used optimal foraging theory to identify other attributes of foraging rationality. Our conclusion is the same: technology and material culture may change, but as a mode of production and a strategy of foraging, the native economy persists:

> "What is important about wildlife to native people is not simply that it is of cultural or aesthetic importance, but that it is the obvious, and indeed the only possible basis, in the Arctic and subarctic, for the maintenance of the social relations that characterize the traditional mode [of production]" (Usher 1981).

To summarize, optimal foraging strategy models can illuminate the economic and ecological rationality of foraging adaptations. The models discussed here generally were supported by field studies (see also Smith 1980). This is one approach challenging notions which are dismissive of the continuity and importance of foraging economies; Usher's political economy analysis is another. The models show the systematic and predictable nature of foraging decisions even in an environment as complex and unstable as the boreal forest. Hence, their use is important to the effective management of foraging economies.

And, they illuminate the circumstances in which conservation is incidental to efficient exploitation, in which management can occur by internal design rather than external regulation.

Adaptive Management

The boreal resource environment is dynamic and unpredictable; non-normative conceptualizations are needed to properly characterize its effective qualities. Optimal foraging models can help identify decision rules that the Cree seem to follow in their efficient use of those resources, and can suggest specific management practices. There is need for a comprehensive statement about ecological management, a philosophy or theory for implementing these insights. This brings me to the concept of adaptive management (Holling 1978; Walters and Hilborn 1978).

Ecosystem Behavior

Until recently, images of natural ecosystems have been dominated by analogies based on community succession or organismal development. A biotic community was viewed as a homeostatic, equilibrium-preserving assemblage of species with a composition and physiognomy determined by stable edaphic and climatic factors. If disturbed by some external agency, this community would quickly pass through predictable states to regain its former equilibrium, the "climax". Further, disturbance was the exception; environments were ahistorical. More recent views note that succession does occur, but viewed over the long term an ecosystem is more often characterized by change than by equilibrium, and by internal as well as external disturbances. Many of the changes appear to be unpredictable in their timing and magnitude; others unexpected. The boreal forest is a good example, in its post-glacial climatic and biogeographic history, in the flux of its vegetation mosaic, and in the fluctuations of its fauna (see Holling 1973; Botkin and Sobel 1975, for other examples).

Holling (1973) and also Botkin and Sobel (1975) have developed two concepts to characterize this newer view of ecosystems. Stability refers to recovery of an equilibrium state after a disturbance. The less the fluctuation, the more rapid the return, then the greater the stability. The lynx-hare population cycles would be an example of a highly unstable system.

Resilience, on the other hand, is the ability of a system to absorb change or undergo a perturbation and yet retain the same basic relationships or configuration. It assesses the likelihood of system persistence. The lynx-hare cycle is highly resilient. Holling (1973) argues that clearer understanding and better management of ecosystem behavior will result if we shift from emphasis on stability to an emphasis on resilience.

Management

This change of view has important implications for studies of human adaptation and for the practice of environmental assessment and management. If ecosystems were globally stable they would be relatively easy to characterize, highly predictable and quite forgiving of stress and misunderstanding. The alternative implies not only that most natural systems (including those dominated by humans) tend to fluctuate unpredictably, but that they contain uncertainties and the capacity always to generate the unexpected. Incremental quantitative change can give way to qualitative transformation abruptly. These and other concepts suggest a rather thorough reformulation of environmental assessment and management practice (Holling 1978). The central question becomes how to manage when much is unknown, some things are uncertain, and the unexpected must be acknowledged as possible. Holling (1978) provides a series of explicit, practical answers to this question.

The history and characteristics of the boreal forest show it to be an environment like that envisioned in Holling's views on ecosystem uncertainty, resilience and stability. Similarly, Cree-Ojibwa foraging strategies and their use of skill and observation to meet the vicissitudes of their situation with adaptive flexibility will appear familiar to the student of Holling's views. Because their effective environment is one of uncertainty and novelty, the Cree have developed knowledge, tactics and foraging strategies which readily take into account instability and the unexpected. Cree foragers have learned and practice much of what the "adaptive manager" would propose.

This adaptive resilience extends beyond strategies for immediate harvest of renewable resources. Berkes (1981b) has described how the land tenure and ethno-ecological practices of the Cree have weathered the successive perturbations of the fur trade, the introduction of technology, growth, economic development and road construction, and although changed, have survived intact. In the face of development and other instabilities, the system has proven remarkably resilient: ". . . good resource use practices develop over time among peoples who are dependent on a particular resource. Despite various perturbations, the persistence of such resource use practices have been extensively documented. . ." (Berkes 1981b).

Recognition of how Cree-Ojibwa subsistence adaptations fit adaptive management should result not only in good ecology, but effective planning as well. Usher (1981) has listed multiple advantages of designing northern game-management on the basis of native custom and practice, "of modifying the 'idiom of management' (La Rusic 1979) in favour of something that native harvesters could recognize as congruent with their own mode of thought." Berkes' similar argument was cited earlier.

To summarize, advances in theoretical ecology and in understanding of ecosystems have converged in the idea of adaptive management. The use and development of renewable resources in the north is an ideal situation in which to apply the principles of adaptive management, in part because some of the "design" is already in place in the foraging mode of production and foraging strategies of native peoples.

Conclusions

> ". . . The development of the whole renewable resource sector — including strengthening of the native economy — would enable the native people to enter the industrial system without becoming completely dependent on it. An economy based on modernization of hunting, fishing and trapping, on efficient game and fisheries management, on small-scale enterprise, and on the orderly development of gas and oil resources over a period of years — this is not retreat into the past; rather, it is a rational program for northern development based on the ideals and aspirations of northern native peoples" (Berger 1977).

The Cree-Ojibwa have experienced slow development over several hundred years. Their response has been flexible and selective; they have resisted to the degree that much of their culture is yet intact. Their current political ability to influence the future schedule and route of their development is problematic, but tenaciously defended. There is evidence that renewable resources will continue to play a significant role in the native economy. Hence the protection and management of that economy is of great importance.

More specifically, these circumstances require: (1) an accurate appraisal of the short- and long-term dynamics of the boreal environment, its resources, and especially their spatial heterogeneity and temporal instability; (2) models which can systematically illuminate the Cree-Ojibwa foraging economy. Cree-Ojibwa hunting and trapping practices are intricate, always changing, and superficially without pattern. It takes an assumption of rationality and an appropriate body of ideas — here optimal foraging models — to find the coherence. Management policies may follow to a large extent from design already in the adaptations; and (3) a practical set of planning principles which can combine these observations on environmental properties and adaptive rationality.

The Cree-Ojibwa know these things tacitly. Ecosystem analysis and adaptation study are recognizing them explicitly and systematically. If planning can adapt, then forager, forest, and manager will gain the advantage of greater congruence.

Acknowledgements

I appreciate the guidance, comments and assistance of Sara DeGraff, Carol Goland, Eric Smith, John Yellen, and especially the people of Muskrat Dam Lake.

Literature Cited

Berger, T.R. 1977. Northern frontier — northern homeland. The Report of the Mackenzie Valley Pipeline Inquiry, Volume I. Minister of Supply and Services, Ottawa, Ontario.

Berkes, F. 1981a. Fisheries of the James Bay area and northern Quebec: A case study in resource management. *In*: First International Symposium on Renewable Resources and the Economy of the North. M.M.R. Freeman (Ed.). Association of Canadian Universities for Northern Studies, Ottawa, Ontario. pp. 143-160.

Berkes, F. 1981b. The role of self-regulation in living resources management in the north. *In*: First International Symposium on Renewable Resources and the Economy of the North. M.M.R. Freeman (Ed.). Association of Canadian Universities for Northern Studies, Ottawa, Ontario. pp. 166-178.

Berkes, F. and C.S. Farkas. 1978. Eastern James Bay Cree Indians: Changing patterns of wild food use and nutrition. Ecology of Food and Nutrition 7: 155-172.

Bishop, C.A. 1974. The Northern Ojibwa and the fur trade. Holt, Rinehart, and Winston of Canada, Toronto, Ontario.

Botkin, D.B. and M.J. Sobel. 1975. Stability in time-varying ecosystems. Amer. Nat. 109: 625-646.

Brown, J.L. 1964. The evolution of diversity in avian territorial systems. Wilson Bull. 76: 160-169.

Charnov, E.L. 1976. Optimal foraging, the marginal value theorem. Theor. Pop. Biol. 9: 129-136.

Charnov, E.L., G. Orians and K. Hyatt. 1976. Ecological implications of resource depression. Amer. Nat. 110: 247-259.

Colwell, R.K. 1974. Predictability, constancy and contingency of periodic phenomena. Ecology 55: 1148-1153.

Dyson-Hudson, R. and E.A. Smith. 1978. Human territoriality: An ecological reassessment. Amer. Anthro. 80: 21-41.

Feit, H.A. 1973. The ethno-ecology of the Waswanipi Cree; or how hunters can manage their resources. *In*: Cultural Ecology. B. Cox (Ed.). McClelland and Stewart, Toronto, Ontario. pp. 115-125.

Freeman, M.M.R. (Ed.). 1981. Proc. First International Symposium on Renewable Resources and the Economy of the North. Association of Canadian Universities for Northern Studies, Ottawa, Ontario.

Fuller, W.A. and B.A. Hubert. 1981. Fish, fur and game in the Northwest Territories: Some problems of, and prospects for, increased harvests. *In*: First International Symposium on Renewable Resources and the Economy of the North. M.M.R. Freeman (Ed.). Association of Canadian Universities for Northern Studies, Ottawa, Ontario. pp. 12-29.

Gamble, D.J. 1978. The Berger inquiry: An impact assessment process. Science 199: 946-952.

Hamilton, W.J., III and K.E.F. Watt. 1970. Refuging. Ann. Rev. of Ecology and Sys. 1: 263-286.

Hare, F.K. and J.C. Ritchie. 1972. Boreal bioclimates. Geog. Rev. 62: 333-365.

Holling, C.S. 1973. Resilience and stability of ecological systems. Ann. Rev. of Ecology Sys. 4: 1-23.

Holling, C.S. 1978. Adaptive Environmental Assessment and Management. John Wiley and Sons, Chichester, England.

Horn, H.S. 1968. The adaptive significance of colonial nesting in the Brewers blackbird *(Euphagus cyanocephalus)*. Ecology 49: 682-694.

MacArthur, R.F. and E.R. Pianka. 1966. On optimal use of a patchy environment. Amer. Nat. 100: 603-609.

May, R.M. 1975. Stability in ecosystems: Some comments. *In*: Unifying Concepts in Ecology. W.H. van Dobben and R.H. Lowe-McConnell (Eds.). Dr. W. Junk B.V. Publisher, The Hague, The Netherlands. pp. 161-168.

Morrison, D.W. 1978. On the optimal searching strategy for refuging predators. Amer. Nat. 112: 925-934.

Orians, G.H. and N.P. Pearson. 1979. On the theory of central place foraging. *In*: Analysis of Ecological Systems. D.J. Horn, G.R. Stairs and R.D. Mitchell (Eds.). University of Ohio Press, Columbus, Ohio. pp. 155-177.

Pianka, E.R. 1978. Evolutionary Ecology. Second ed. Harper and Row, New York.

Pruitt, W.O., Jr. 1958. Qali, a taiga snow formation of ecological importance. Ecology 39: 169-172.

Pruitt, W.O., Jr. 1978. Boreal Ecology. Edward Arnold, London, England.

Pyke, G.H., H.R. Pulliam and E.R. Charnov. 1977. Optimal foraging: A selective review of theory and tests. Quart. Rev. Biol. 52: 137-154.

Ray, A.J. 1974. Indians in the Fur Trade: Their Role as Trappers, Hunters and Middlemen in the Lands Southwest of Hudson Bay. University of Toronto Press, Toronto, Ontario.

Roff, D.A. 1974. Spatial heterogeneity and the persistence of populations. Oecologica, 15: 245-258.

Rogers, E.S. 1963. Changing settlement patterns of the Cree-Ojibwa of northern Ontario. Southwest J. Anthro. 19: 64-88.

Rogers, E.S. 1982. Cultural adaptations of the northern Ojibwa of the boreal forest, 1670-1980. *In*: Boreal Forest Adaptation: The Algonkians of Northern Ontario. A.T. Steegman, Jr. (Ed.). Plenum, New York. In press.

Rowe, J.S. and G.W. Scotter. 1973. Fire in the boreal forest. Quat. Res. 3: 444-464.

Schoener, T.W. 1971. Theory of feeding strategies. Ann. Rev. of Ecology and Sys. 2: 369-404.

SCC. 1977. Northward Looking: A Strategy and a Science Policy for Northern Development. Science Council of Canada Report No. 26, Ottawa, Ontario.

Smith, E.A. 1979. Human adaptation and energetic efficiency. Human Ecology 7: 53-74.

Smith, E.A. 1980. Evolutionary ecology and the analysis of human foraging behavior: An Inuit example from the east coast of Hudson Bay. Ph.D. Dissertation, Cornell University, Ithaca, New York.

Smith, F.E. 1972. Spatial heterogeneity, stability and diversity in ecosystems. Trans. Conn. Acad. Sci. 44: 309-335.

Southwood, T.R.E. 1977. Habitat, the templet for ecological strategies? J. Anim. Ecol. 46: 337-365.

Usher, P.J. 1981. Sustenance or recreation? The future of native wildlife harvesting in northern Canada. *In*: First International Symposium on Renewable Resources and the Economy of the North. M.M.R. Freeman (Ed.). Association of Canadian Universities for Northern Studies, Ottawa, Ontario. pp. 56-71.

Watkins, M. 1977. Aboriginal people and staple production: A commentary on the Berger Report. West. Can. J. Anthr. 7: 83-94.

Wilkinson, P.F. 1981. Some thoughts towards a policy for the rational use of renewable resources in the Canadian north. *In*: First International Symposium on Renewable Resources and the Economy of the North. M.M.R. Freeman (Ed.). Association of Canadian Universities for Northern Studies, Ottawa, Ontario. pp. 73-85.

Wilmsen, E.N. 1973. Interaction, spacing behavior, and the organization of hunting bands. J. Anthr. Res. 29: 1-31.

Winterhalder, B. 1977. Foraging strategy adaptations of the boreal forest Cree: An evaluation of theory and models from evolutionary ecology. Ph.D. Dissertation, Cornell University, Ithaca, New York.

Winterhalder, B. 1980. Environmental analysis in human evolution and adaptation research. Human Ecology 8: 135-170.

Winterhalder, B. 1981a. Optimal foraging strategies and hunter-gatherer research in anthropology: Theory and models. *In*: Hunter-Gatherer Foraging Strategies: Ethnographic and Archeological Analyses. B. Winterhalder and E.A. Smith (Eds.). University of Chicago Press, Chicago, Illinois. pp. 13-35.

Winterhalder, B. 1981b. Foraging strategies in the boreal forest: An analysis of Cree hunting and gathering. *In*: Hunter-Gatherer Foraging Strategies: Ethnographic and Archeological Analyses. B. Winterhalder and E.A. Smith (Eds.). University of Chicago Press, Chicago, Illinois. pp. 66-98.

Winterhalder, B. 1983a. History and ecology of the boreal zone in Ontario. *In*: Boreal Forest Adaptations: The Algonkians of Northern Ontario. A.T. Steegmann, Jr. (Ed.). Plenum, New York. pp. 9-54.

Winterhalder, B. 1983b. Boreal foraging strategies. *In*: Boreal Forest Adaptations: The Algonkians of Northern Ontario. A.T. Steegmann, Jr. (Ed.). Plenum, New York. pp. 201-241.

QUANTIFYING THE HARVEST OF NATIVE SUBSISTENCE FISHERIES

Fikret Berkes
Brock University

Abstract: A number of questionnaire-based studies have been carried out in recent years to quantify native subsistence fisheries, along with other animal resource harvests, in the Canadian north. A major problem in quantifying fish catches is that harvesters usually have difficulty remembering the actual numbers of these relatively small and numerous prey animals caught over a yearly cycle. The present study is based on actual field checks of fish harvests of native fishermen over a six-year period in one native community, Chisasibi, in James Bay, northern Quebec. The data so obtained are compared with the results of questionnaire studies conducted under the provisions of the James Bay Agreement.

The mean annual per capita fish harvest of eleven family groups was 60 kg (1975-1981) as compared to questionnaire study results in which the community-wide mean annual per capita harvest ranged from 26 kg in 1976-1977 to 82 kg in 1974-1975. On the basis of these results and other studies elsewhere in the north, the following approximations are offered. A "non-traditional" family living in a relatively large community is likely to obtain 10-20 kg fish per capita per year. A "traditional" family in the same size community is likely to obtain 50-100 kg fish per capita per year. A "traditional" family in a small community is likely to obtain 100-200 kg per capita per year. To improve the methodology of studies on native subsistence it is suggested that questionnaire surveys be combined with field work. This would help identify and confirm the species, the fishing areas, and produce data which would help verify the overall harvest estimate.

The study of resource harvesting by northern native peoples is important for several reasons. In terms of theory, the relation between hunters and animals is of interest to anthropology and ecology (e.g. Winterhalder and Smith 1981). For applied natural and social sciences, harvesting studies are important for native land and resource claims issues (Feit 1980), fisheries management (Berkes 1977), wildlife management (Feit 1973), and environmental and social impact studies of northern development projects (Berger 1977; Tester 1979; Berkes 1982).

The plan of this paper is first to provide an overview of native harvest and land use studies and to place native subsistence fisheries in perspective. Secondly, the paper presents the results of a field study on native subsistence fisheries which is discussed in some detail to provide a context for more general observations on subsistence fisheries. Thirdly, the paper includes a review of some of the questionnaire-based studies of native subsistence fisheries. Lastly, the paper offers some practical guidelines on ways in which the methodology of subsistence fishery studies may be improved.

While much of the material presented here is on the boreal zone, many studies are cited from other areas. This provides comparative information and helps emphasize the similarities rather than the differences between the boreal zone and the zones further to the north.

RESOURCES AND DYNAMICS OF THE BOREAL ZONE

Proceedings of a conference held at Thunder Bay, Ontario, August, 1982

Ross W. Wein, Roderick R. Riewe and Ian R. Methven
(Editors)

Association of Canadian Universities for Northern Studies

The organizers gratefully acknowledge generous financial support received from the following organizations:

Department of Environment, Government of Canada
Department of Fisheries and Oceans, Government of Canada
Department of Indian Affairs and Northern Development, Government of Canada
Government of the Northwest Territories
Great Lakes Forest Products
NOVA, An Alberta Corporation
Petro-Canada
Polar Gas Project
Province of Alberta
Province of Newfoundland-Labrador
Province of Ontario
Province of Saskatchewan

Cover photo by Roderick R. Riewe

130 Albert Street,
Ottawa, Canada K1P 5G4
Tel: (613) 238-3525

Deposited at the National Library of Canada
Ottawa
1983

ISBN 0-9690987-2-3