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THÈSES CANADIENNES SUR MICROFICHE

NAME OF AUTHOR *NOM DE L'AUTEUR* [illegible]

TITLE OF THESIS *TITRE DE LA THÈSE* [illegible]

UNIVERSITY *UNIVERSITÉ* University of Alberta

DEGREE FOR WHICH THESIS WAS PRESENTED *GRADE POUR LEQUEL CETTE THÈSE FUT PRÉSENTÉE* Master of Science

YEAR THIS DEGREE CONFERRED *ANNÉE D'OBTENTION DE CE GRADE* 1978

NAME OF SUPERVISOR *NOM DU DIRECTEUR DE THÈSE* Dr. D. Gill

DATED/*DATÉ* 24 April 1978 SIGNED/*SIGNÉ* [illegible]

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THE UNIVERSITY OF ALBERTA

THE POTENTIAL FOR WILDERNESS RECREATION IN A SAND DUNE ENVIRONMENT IN NORTHEAST ALBERTA

by

WILLIAM ADAM NIELSEN

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF GEOGRAPHY

EDMONTON, ALBERTA

SPRING, 1978

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled THE POTENTIAL FOR WILDERNESS RECREATION IN A SAND DUNE ENVIRONMENT IN NORTHEAST ALBERTA submitted by William Adam Nielsen in partial fulfilment of the requirements for the degree of Master of Science in Geography.

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Supervisor

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Date 6 April 1978

The natural, undeveloped landscape of this active dune complex and lakeland area in northeast Alberta may provide opportunities for future wilderness recreation experiences. 1 August 1976.

To my sister Ann.

ABSTRACT

This study presents a detailed examination of the recreational potential of a sand dune region in northeast Alberta. The 200 km² study area contains an 18 km² active dune complex, stabilized transverse, parabolic and blowout dunes, and numerous lakes. Landforms caused by continental glaciation are also present.

The active dune complex is the largest in Alberta. A number of environmental factors have combined to maintain the activity of this dune complex, including extensive deposits of glacial outwash sands, a warm, dry local climate, and an extremely flammable plant cover that is often ignited by lightning. As such, the active dunes are not only a product of wind, but of a combination of local climatic and biological conditions acting on a sandy substrate.

The active dune complex is surrounded by jackpine-lichen woodland. This vegetation type has 2 well developed strata - a low density tree stratum dominated by jackpine and a ground cover dominated by foliose lichens. In contrast to the parklike woodland, 2 other vegetation types, mixedwood and wetland, are areally less significant but add floral diversity and create important wildlife habitats.

The many lakes of the area have clear, potable water, sandy shorelines and shallow off-shore areas. Furthermore, they support an interesting shoreline

vegetation, a variety of migratory avifauna and large fish populations, and should therefore provide valuable water-based facilities for future recreationists.

The wildlife of the study area is a wilderness population including such rare species as bald Eagle, Osprey, Pileated Woodpecker and Sandhill Crane. Pest species, common in man-altered ecosystems, are noticeably absent.

Constraints to recreational use are the delicate lichen ground cover, the highly flammable jackpine-lichen woodland, erosional problems associated with an aeolian landscape and negative effects of human contact with wildlife. Potential conflicts with black bears, which are numerous in the region, is a major concern.

The sand dune area is wilderness having a variety of natural features conducive to wilderness recreation. However, there are severe environmental constraints to the use of this area. Therefore, prior to recreational development of any kind, a management program should be designed, possibly along the lines of a special ecological reserve, an ecological reserve area, a wilderness area, or family wilderness park. These alternatives stress preservation of the unique sand dune complex while providing a broad range of management possibilities.

ACKNOWLEDGEMENTS

Completion of this research would have been impossible without the cooperation of a number of people and institutions, whose help I gratefully acknowledge. I especially thank my advisor, Dr. Gill, the Department of Geography, The University of Alberta, who helped in many ways. Professor Murphy, Chairman, Department of Forest Science, The University of Alberta, and Dr. Jackson, the Department of Geography, The University of Alberta, also provided helpful criticism throughout the study.

Particular thanks are due to L. H[illegible]tie and B. Sims of Ekistic Design Consultants Ltd., Edmonton, for many hours of discussion and comment concerning development in northeast Alberta and the place of recreation in that development. I thank M. Dumais, T. Lee, D. Lindsay and M. Ostafichuck, of the Department of Botany, The University of Alberta, for verifying plant identifications. W.E. Roberts, Curator, Museum of Zoology, The University of Alberta, kindly identified the problematical fishes and amphibians.

I gratefully acknowledge I. Wilson and the cartographic staff of the Department of Geography, The University of Alberta, who prepared the thesis graphics.

Special thanks go to all the staff of the Boreal Institute for Northern Studies, The University of Alberta, for their many kindnesses. Anita, Donna and Gerlinde were especially kind and helpful. I thank my friend and field assistant John Walker. To Pye, Jade and Jesse go my love and thanks.

Finincial support was provided by Environmental Planning and Research Services, Research Secretariat, Alberta Environment, and by 2 grants-in-aid from the Boreal Institute for Northern Studies, The University of Alberta. Partial funding was also provided by the National Research Council of Canada (Operating Grant No. A8700 Gill).

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CHAPTER 1

INTRODUCTION

Outdoor recreation is an important part of Alberta's social, economic and environmental makeup. A diversity of physiographic regions, fortunate geographical location and variety of exceptional scenery and natural features have provided the opportunity for the development of 5 national and 49 provincial parks within Alberta. Located in most areas of the Province, these Parks were designed to protect the natural condition of the landscape while providing a variety of recreational opportunities to local, regional, national and international visitors.

Coupled with development of outdoor recreation facilities, an expanding Provincial economy and increasing social pressures of urbanized society have led to the growing popularity of many types of outdoor recreation including the seeking of wilderness experience. Every year, increasing numbers of people have the desire and the means to enjoy nature in its unaltered condition in relative solitude. But the limited size of existing facilities and the increasing number of visitors is pushing the human density in wilderness areas above desirable levels (Lesko and Robson 1975). For example, the number of overnight isitors at wilderness campsites in Banff National Park ·reased from 1,000 to 14,000 per season between 1963 and (Superintendent's Annual Report 1963 - 1973). The consequences of crowding and overuse have been deterioration of the land-based resource and a lower quality of recreational experience. Generally, the most extensive environmental impact occurs near major trail-heads, campsites and special scenic attractions.

The results of increased demand for a low-density (extensive) type of recreation facility in the Province have been two-fold: an increase in efforts to plan and manage existing facilities and inventories to identify additional recreation resources.

1.1 Managing Existing Outdoor Recreation Facilities

Managers and park officials are attempting to control deterioration of the landscape through management and protection of natural resources. Strict controls are being imposed upon the numbers of visitors and activities allowed. Environmental conditions are being monitored at campsites and other high use areas, while interpretive and educational programs are being developed as positive ways to enable man to recreate in harmony with the natural (and often delicate) wildland areas of Alberta. Success in these attempts will reduce the amount of disturbance to the natural environment and thus will ultimately benefit man.

1.2 Resource Inventories to Identify New Recreation Areas

Undeveloped areas of the Province are being investigated by Alberta Provincial Parks for their potential to supply alternative opportunities to existing recreation facilities. Currently, Kananaskis Valley, the grasslands of SE Alberta, the Lakeland area (encompassing Cold, Seibert and Touchwood Lakes) and Kakwa Falls in the Peace River area are being assessed for a wide range of recreational opportunities.

This thesis examines the sand dune region of northeast Alberta to assess yet another exceptional area of the Province and its potential for wilderness recreation. The region contains superlative scenic, geologic and surface features associated with continental glaciation and the geomorphic agent, wind; especially fascinating is a large, actively moving sand dune complex, unique in the Alberta landscape. These natural features may provide the resources for a future wilderness recreation facility. Analysing the wilderness recreation potential is important at this time, before alternate (and perhaps environmentally harmful) development occurs.

CHAPTER 2

WILDERNESS, WILDERNESS RECREATION AND SAND DUNE ENVIRONMENTS-A LITERATURE REVIEW

The intent of this chapter is to establish a rationale for the present sand dune study in terms of wilderness and wilderness recreation. Although it will be shown that wilderness is a cultural concept, characterized by dynamic societal attitudes, additional factors are required to assess recreation potential and management alternatives for the sand dune area.

2.1 The Concept of Wilderness

The term wilderness has become increasingly popular in the last decade to describe certain physical and biological environments and their characteristic fauna and flora within a specific geographic region (for example the Canadian North, the Rocky Mountains, the tall grass prairie). References to these locations have stressed environmental conditions; natural, roadless areas (United States Department of Agriculture 1973), an area undisturbed by man, a place where animals may be viewed in their natural habitat, areas usually containing examples of unique, exceptional landform features - decidedly a human point of view.

Wilderness has not always been viewed in the positive. Societal attitudes toward the value of wilderness have undergone a variety of changes over the last 2 centuries. These have been outlined by Nash (1976). He pointed out that the biblical concept - a treeless wasteland - was the foundation for the first, formal dictionary definition (Johnson 1755). Johnson wrote "wilderness is a desert; a tract of solitude and savageness" (Nash 1976:3). Wilderness, for the early colonizers of North America, was wild land to be feared, a land to conquer and to rid of wild beasts.

Near the end of the 19th century, as large tracts of land were altered to serve the needs of a rapidly expanding population and industrial complex, people began to realize that retention of the natural landscape had social value. Some proponents of a conservation ethic at this time were voicing preservationist ethics. For example, Henry Thoreau (1893) assessed wilderness to be the source of vigor, inspiration, and strength ... the essential raw material of life. He argued that these psychological benefits could not be attained in a man-made industrial setting.

In the early 20th century, Aldo Leopold became a major opponent of Johnson's early concept of wilderness as a wasteland. For Leopold (1925) wilderness was a wild, roadless area where those who were so inclined could enjoy primitive modes of travel and subsistence. He described wilderness as a resource, one having physical and psychological benefits for mankind.

Recently increasing demand for and participation in wilderness recreation activities has led to competition for wildland resources, resulting in a variety of allocation and management problems. The major concern of today's wilderness advocates is that natural environments are quickly disappearing in the face of other resource demands such as forestry, pipeline construction, coal exploration, agriculture and more intensively developed recreation areas.

For example, in Canada, northern residents have stressed the cultural and ecological importance of retaining wilderness areas in the face of pressures to develop oil and gas resources. Berger (1977:30) summarizing their attitudes, stated simply that "wilderness is a non-renewable resource" and remarked that because Canada has the last true wilderness areas in North America we will have to be very careful when deciding upon development priorities. The implications for preservation of wilderness resources are, in the final analysis, for human benefits. "Wilderness constitutes an important - perhaps an invaluable - part of modern-day life; its preservation is a contribution to, not a repudiation of, the civilization upon which we depend" (Berger 1977:30).

2.2 Wilderness Recreational Carrying Capacity

Implicit in the previous discussion of wilderness is the need to understand the environmental characteristics of a proposed wilderness recreation area, its resistance to change from man's activities in combination with an understanding of wilderness recreationists, and the demands of future users for that particular environment. These factors have been combined into an operational framework known as recreational carrying capacity.

Recreational carrying capacity is a level of use which an environment can sustain, beyond which irreversible damage will occur and quality recreation experiences can no longer be provided. The carrying capacity concept, now an accepted planning and management tool, was first proposed by Wagar (1964). He analysed the carrying capacity problem in terms of (1) the impact of the recreational environment on people, (2) the impact of people on the recreational environment, and (3) management procedures to modify these reciprocal impacts. He concluded that an analysis of the human as well as the ecological and management considerations must go into administrative decisions to limit recreational use.

Expanding upon Wagar's original concept, Lime and Stankey (1971) proposed that carrying capacity, in a management framework for wilderness recreation facilities, has 3 basic components: a managerial component, a cultural or user component, and an environmental and locational component. These factors are not independent considerations but are closely interwoven.

.2.1 Wilderness Areas Require a Management Framework

As wilderness is a natural resource it embodies a cultural concept, rather than an ecological one (Kroening 1977). Therefore, wilderness recreation implies cultural perception of a particular environment. Yet acceptable types and rates of man-induced environmental change, perceptions and quality standards are constantly changing in response to a dynamic social environment.

For example, during the late 1950's and early 1960's, increasing demand for and use of wildlands for recreation, coupled with other demands to utilize renewable and non-renewable resources, resulted in declining environmental quality in many areas. A direct result was conflict between advocates of wilderness preservation and other resource users. As a result, researchers, planners and managers of wilderness recreation areas required a legal guideline, a standard upon which to base resource allocation decisions.

The first legal (and most often accepted) definition for wilderness in North America (The United States Wilderness Bill 1961) defined wilderness to be "an area where the earth and its community of life are untrammelled by man, where man himself is but a visitor who does not remain...1 retaining its primeval character and influence, without permanent improvements or human habitation...". The bill stressed that wilderness "appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticable" (Lucas 1973:150-51).

In Alberta there currently exist 3 legislative mechanisms by which wilderness areas can be preserved and which provide objectives for subsequent management plans. They are:

1) The Alberta Wilderness Act (1971)
2) The Provincial Parks Act (1974)
3) The Alberta Historical Resources Act (1977).

These legal mechanisms can be used to outline a variety of management alternatives for the sand dune area and thus are discussed in Chapter 7.

From the terms outlined in the United States Wilderness Bill, it appears that the overriding goal of wilderness management is to permit natural ecological processes to work within a fairly large, unoccupied area. Yet, once a recreation area has been created, ecological problems will always appear. Thus, wilderness recreation areas require management. The amount of use an area can receive without deterioration is dependent upon the declared management objectives for that site and the degree of 'naturalness' it is felt necessary to preserve. Burden and Randerson (1972:440) explain:

> ...the same area might have a series of carrying capacities; a low level of recreational use which would preserve a rare, sensitive species, a higher

> one which would preserve an acceptable degree of flowering of a ground species, a higher one again which would preserve a complete grass cover, and yet a higher level in which a complete grass cover was dependent on artificial fertilization, seeding and watering. These considerations lead us to define carrying capacity as the maximum intensity of use an area will continue to support under a particular management regime without inducing a permanent change in the biotic environment maintained by that management.

Therefore, managers of wilderness recreation areas are concerned with making choices; how much land to allocate, to what uses, and for whom, are common management questions. Managers must employ the basic data gathered in the inventory stages to determine:

1) Types of facilities suitable to the given resource base

2) Priorities for use

3) Costs of maintaining the desired levels of environmental quality set in a complex and dynamic social context.

Managers are charged with balancing the utilitarian benefits and costs with the cultural benefits and costs by developing evaluation techniques for alternate proposals and land use plans.

The impinging of social values upon the resource by determining use types begs understanding of ecosystem function and structure and human wants and needs. Management concerns should be framed in a holistic or ecosystematic way. (Spurr 1966, Odum 1971 and Heinselman 1973 discuss the ecosystem aspects of resource management with expertise.) It is the task of the resource manager to follow the lead of modern ecological analysis and use the many research findings to decide on a best use. A systems plan can include many important factors affecting future demands for specific recreation opportunities on a regional scale and should be the starting place for development in new areas.

The unpredictable nature of demand for recreation facilities forces managers to adopt flexibility in plan designs. But there is a need for more human research and public participation in the management process to overcome problems of planning on the basis of supply oriented research.

2.2.2 <u>The Wilderness Recreationist</u>

Since the Outdoor Recreation Resource Review Commission (ORRRC) reports were published (1962), and especially since the USDA Forest Symposium (1971), planners for recreation facilities have realized that more needs to be known about the types of people that are recreating, what motivates them to travel to wildland areas from their comfortable urban environments, how they perceive the natural environments, what their attitudes are to facility design, imposed regulations and opportunities provided, and most importantly, what [illegible]xpect from an outdoor recreation experience. As a result, a great deal of research has been conducted into the human aspects of recreational demand. Aspects of this research dealing with wilderness recreation are discussed below.

The research into social carrying capacity provides information on user attitudes, motivations and perceptions. These studies have been conducted mostly in wilderness areas, notably in the Boundary Waters Canoe Area of the Superior National Forest (Lime 1972; Lucas 1963,1964a,1964b,1964c,1965; Stankey 1971,1972,1973; Wagar 1974, and in the numerous mountain wilderness areas of Western North America (Merriam 1963, Merriam and Ammons 1968, Hendee et al. 1968, Shafer 1969, Godfrey and Peckfelder 1972).

Typically, managers have operated on the assumption that increasing use results in declining environmental quality and therefore, declining quality of the recreational experience (Frissell and Stankey 1972). Researchers have determined that types of uses and numbers of users are as important, and in some cases more important, than pristine environmental conditions. In the Boundary Waters Canoe Area, Lucas (1964a) found that canoeists objected to encountering other visitors more than did motorboaters and motor canoeists. Canoeists therefore defined carrying capacity not only in terms of numbers of people but also in types of use. Stankey (1971) found carrying capacity to be a function not only of the level and type of use encountered but also the place and timing of encounters, and the behavior of visitors. Visitors wanted to camp out of sight and sound of other parties, but most reported their satisfaction did not decline substantially until they met more than 2 or 3 parties a day.

The social structure and the motivations that influence wilderness recreation are also being studied as necessary input to understanding social carrying capacity. Researchers have attempted to identify underlying motives of wilderness recreationists so that planning can meet actual needs and understood demand (Catton and Hendee 1968, Harry and Hendee 1968, Hendee et al. 1968, Hendee and Mills 1968, Hendee 1969, 1970, and Hendee et al. 1971). By using questionnaire surveys, they identified wilderness recreation values which include:

1) A natural environment where no vehicular access is possible

2) A need for management to protect the natural state, but management must be inconspicuous

3) A heavy demand for water based recreation (most relevant to the study area)

4) A need for a remote, sanctuary-like environment.

These results point out basic needs for any wilderness recreation area. To further identify the various user types engaged in wilderness recreation, survey methods were developed. Catton and Hendee (1968) analysed questionnaire results and summarized much of the knowledge about wilderness users to that time. They determined that, generally, wilderness users:

1) Are strongly opinionated

2) Are highly educated, have high incomes and are members of professional or managerial employment groups

3) Are motivated by a desire to escape from the artificiality of contemporary urban environments to a refreshing contact with natural settings

4) Express truly social behavior. Only a small minority expressed the desire to be completely alone in the wilderness

5) Acquire values leading to such use during youth. The increasing numbers of parents that are taking their children into wilderness areas are instilling values for life, securing demand for future wilderness facilities

6) Are not 'purists'. Purists demand unchanged (by man) natural environments and belong to organized conservation groups where their preferences are likely to be heard. Most users allow, or even desire, minor facility development (trails, campsites, fire pits, etc.)

7) Do not realize that many of their actions jeopardize the maintenance of an untarnished wilderness resource. This finding implies the need for better education concerning user activities and, more immediately, stricter controls by management while educational programs are developed and administered.

The results of social aggregate studies identify a need to provide a diversity of recreation opportunities (Burch and Wenger 1967). Further, the aim is to place outdoor recreation within a broader socio-cultural context.

Very recent criticisms of research into the modern wilderness recreationists' preferences, motivations and attitudes have been summarized by Thorsell (1977:24). He stated:

> ...wilderness vacationers range from sensitive and dedicated wilderness purists to inexperienced city-oriented funseekers. The majority of users fall in the middle range,the typical wilderness vacationer.

He continues:

> The contemporary user is not travelling by himself, nor does he wish to be alone in the backcountry. Solitude is not rated as an important reason for his wilderness visit. Instead, the wilderness user is on a short excursion with select friends to enjoy primitive travel and the delights of wandering in open wild country - a sort of recreation consumership. He is not in the wilderness to commune with nature as Thoreau or Grey Owl did, nor is he there to encounter and explore nature in all her moods. Rather, today's wilderness vacation is recreation-oriented as much as it is nature-oriented.

He concludes that:

> Most wilderness users want a taste of the outdoors but only penetrate and savour it briefly at the margin (95 percent of all backcountry trail trips in Banff Park in 1967 occurred within five miles of the highway). The user stays only long enough to reach his destination, record the image on film, and return to the car. The whole trip scarcely allows time for any study of nature. The main motivations are a wish to visit a nature-dominant landscape and a desire to escape civilization.

Implications of changing user perceptions of wilderness, and the necessity for changes in management response, are evident in areas of education, environmental design, landscape aesthetics, research, and in the broader definition of the role of parks in our society (Thorsell 1977:26). Understanding the human variable in the paradox of wilderness recreation will require continued research into the expressed needs of wilderness recreationists. Wilderness parks are important not only for preservation of habitat but also as harbingers of the evolving environmental ethic. As Krieger (1973) noted, "we will have to realize that the way in which we experience nature is conditioned by our society - which more and more is seen to be receptive to responsible interventions".

The demand for new wilderness areas will likely increase, perhaps as a by-product of wilderness-oriented education and as the trend continues toward greater environmental awareness. Knowledge of wilderness skills and an increasing desire for solitude in a natural setting may reduce the present managerial and environmental costs but will require retention of large areas of undisturbed, natural environments.

2.2.3 The Environmental Component

Most relevant to this study are the environmental conditions in the sand dune area that will determine the recreational carrying capacity and thus management policies should the area be developed as a wilderness recreation facility. Basic components of any land-based wilderness ecosystem have been outlined by Chubbard and Ashton (1969) to be:

1) Geology and soils (as they affect drainage and vegetation; for example, fertile soils are able to withstand high levels of use and maintain a more satisfactory ground cover than nutrient-poor soils)

2) Topography and aspect (as they affect soil erosion and microclimatic influence on the flora and fauna)

3) Vegetation (its ability to tolerate varying intensities of recreational use)

4) Climate (as it influences length of season available for a given recreational use and ecological conditions in the area)

5) Water

6) Flora and fauna (especially where they are the basis for the recreational use of an area).

Many of these components are important in sand dune environments as the following review of literature indicates.

2.2.3.1 Sand Dune Environments

During decades of work by many researchers, an abundance of literature concerning sand dunes and dune environments has accumulated. Two disciplines, geomorphology and ecology, have displayed special concern for these landscapes "because of the simplicity of landforms and their interesting assemblages of organisms" (Hermesh 1972:4).

Some of the interests lie in identification of the dynamics of the processes involved in dune activity. Major themes of research include the effect of wind on dune shape (Bagnold 1941), the role of vegetation in dune formation (Cowles 1899,1901,1911; Enquist 1932, Cooper 1958, Olson 1958, Wagner 1964, Hermesh 1972), and the relationship of climate to dune activity (Hack 1941, Odynsky 1958).

2.2.3.1.1 Sand Dune Geomorphology

Bagnold classified dunes under true desert conditions while studying "the free interplay of wind and sand, uncomplicated by the effects of moisture, vegetation or of fauna..."(Bagnold 1941:xii). Using wind tunnel experiments to determine the movement patterns of sand grains and relating these physical principles to actual dune formations in the desert, he discovered that, "instead of finding chaos and disorder, the observer never fails to be amazed at a simplicity of form, an exactitude of repetition and a geometric order unknown in nature on a scale larger than that of crystalline structure". However, these open desert dunes differ in morphology from those influenced by moisture and vegetation. The latter types are the concern of the present study.

2.2.3.1.2 Vegetation-Landform Relationships in Sand Dune Environments

Many researchers have studied the ecological relationships of wind, vegetation and sand movement. One of the earliest of these was Henry Cowles. Over a period of 12 years (1899-1911) he analysed vegetation-dune relationships to determine "the order of succession of the plant societies in the development of a region, [in order to] discover the laws which govern the panoramic changes" (Cowles 1899:95). He concluded that order and stability increases in dune environments with time and the absence of disturbance. Recurring disturbance produces a cyclic transformation of stages of vegetation-landform relationships.

This concept of dynamics in natural ecosystems is a dominant theme in much of today's environmental research. Perhaps no topographic form exhibits such rapid change and instability as a sand dune, and it therefore offers a rare opportunity to study the interrelations of vegetation and landform processes under the most dynamic of conditions.

Vegetation has been studied as an agent of dune geomorphology. One of the first to record the ability of plants to influence dune formation was Cowles (1899) who stated "A plant which...has the power to hold its position and keep the sand from being blown away is commonly called a sand-binder. In this connection it may also be called a dune-holder" (Cowles 1899:192). The significance of this observation is that plants may not only initiate dune formation but also have a major influence on the ultimate morphology of a dune system.

In a recent ecological study of dune environments in northern Saskatchewan, Hermesh (1972) determined that vegetation-landform relationships have resulted in 5 major dune shapes; transverse, rolling, longitudinal, parabolic and blowout. He concluded that such variations in dune morphology are related to the life forms of the associated vegetation; that transverse dunes are associated with shrubs and trees, rolling dunes with grasses and herbs, while longitudinal dunes lack vegetation. The building, maintenance and final destruction of many dunes is therefore a cyclic phenomenon dependent on changes in several interacting factors, including their plant cover.

2.2.3.1.3 Dune-Climate Relationships and the Northeast Alberta Sand Dune Area

Enquist (1932), Cooper (1958) and Odynsky (1958) suggest that reviewing conditions under which dunes are currently forming can lead, through cautious extrapolation, to the reconstruction of dune forming climatic patterns. In the only published research on the climate of the active dunes of northeast Alberta, Odynsky (1958) reports that the alignment of stabilized transverse dunes represent effective dune-forming winds in harmony with present wind directions. He also identifies 3 cycles of dune-forming winds (and therefore climatic regimes) for the study area. This research is discussed in Section 4.2.4.3 in relation to the present aeolian landforms of the study area.

2.3 Recreational Interest in Sand Dune Environments

Sand dune environments have been developed for a broad range of recreation opportunities. Pinery Provincial Park (Ontario), Leadbetter Point State Park (Washington) and Good Spirit Lake Provincial Park (Saskatchewan) are 3 examples. A fourth area, the Athabasca sand dunes (Saskatchewan) is being proposed for a national park.

Pinery Provincial Park is situated southeast of Lake Huron and is important for large stabilized and semi-stabilized forested dunes, a rare regional example of pristine forest, a 7-stage successional continuum of dune vegetation (including many rare plant species). Four wilderness areas (including interpretive trails) and a number of nature reserves have been created within the park with consideration of the areas' pristine states, their vulnerability to immediate disturbances and the uniqueness of their species complement (Gibbard 1970). The recreational opportunities are mainly for wilderness activities while stressing interpretive values.

Leadbetter Point State Park is in a coastal marine accretion zone and exhibits diverse and distinct natural processess contributing to "incomparable aesthetic value" (University of Washington 1975:9). This sand dune peninsula was assessed to be extremely sensitive to uncontrolled recreational activities in the sense that "a delicate and intricate balance exists between sand, vegetation, wind and water...a change in one [factor] can drastically affect the others" (University of Washington 1975:16). Recreational opportunities range from preserved natural areas in the most dynamic seaward locations, to intensively developed sites in the forest on the eastern portion of the area. Landform-vegetation relationships and aesthetics are stressed as prime attractions for recreational use.

The Good Spirit Dunes at the southeast end of Good Spirit Lake are "a unique and fascinating feature in eastern Saskatchewan...ideal locations for the study of natural history since they dramaticallly illustrate the delicate inter-relationships among soil, water, plants and animals" (Saskatchewan Department of Natural Resources 1973:2). The park is developed as an interpretive facility emphasizing dune formation, vegetation-dune relationships and plant successional stages.

Currently, the Athabasca Sand Dunes of Saskatchewan are being studied for recreational values. In this context the "region is of [national] scientific importance because of (1) its unique geomorphology, namely the occurrence of extensive inland sand dunes and ventifact covered ridges; (2) its unique flora consisting of relict populations of arctic, boreal and northern Great Plains species; (3) the great evolutionary significance of the high level of biological endemism [plants unique to that area]" (Argus 1969:6). (Also see Argus 1970, Hermesh 1972, Mondor 1973, Rowe 1973, Rowe and Hermesh 1974.) The emphasis for this, Canada's largest active sand dune area, is to preserve geographical, geological, biological and scenic features for the benefit, education and enjoyment of the people of Canada (Mondor 1973).

2.4 Summary

Sand dune environments appear to have many resources consistent with today's wilderness philosophies and recreational needs. Their varied and dynamic array of landform, vegetation, wildlife and aesthetic factors are well suited to development as natural, wildland areas. However, all the above examples stress the need to restrict user activities to preserve the delicate dune environments. In this light, the purpose and scope of this study is to analyse the environment of the study area in the context of possible management alternatives f wilderness recreation development and use.

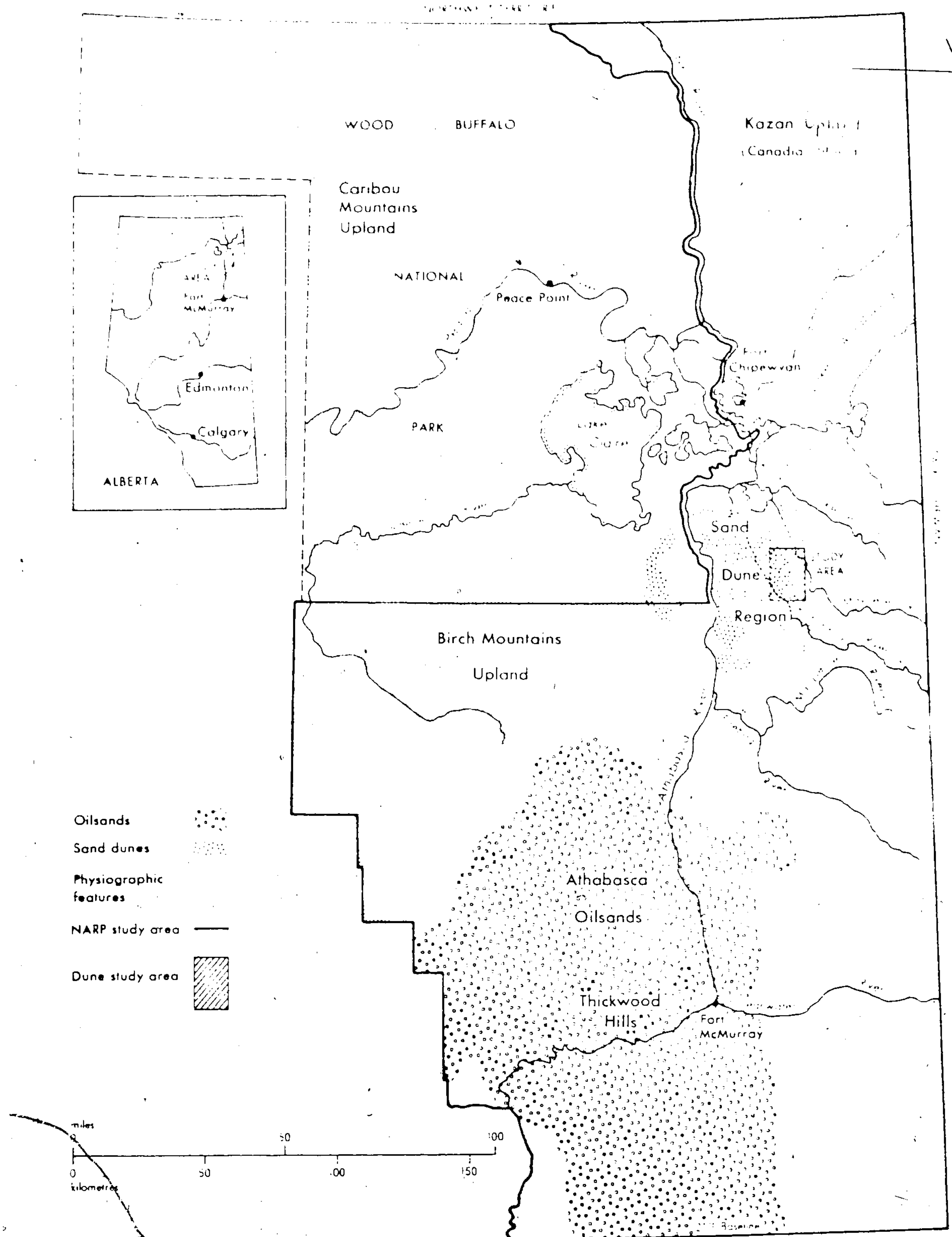
CHAPTER 3

THE RESEARCH PROJECT

.1 The Northeast Alberta Region

Recent improvements in the technology for extracting oil from the Athabasca Oil Sands have led to plans for major developments by the petroleum industry in northeast Alberta. This region (Figure 3.1) will continue to experience population growth, urban expansion, development of transportation infrastructures and auxiliary industrial development as a result of industrial exploitation of the Oil Sands.

Reducing the impact of industrial development on the human and natural environment requires a thorough knowledge of all facets of the region. Information must be gathered to provide data for planning development and reclamation of oil sands extraction areas, transportation and communication infrastructure and new urban areas. The initial concern of researchers involved in baseline studies in northeast Alberta is to secure accurate data so that a



Sources: Modified after NARP (1976) and the Atlas of Alberta (1969)

Figure 3.1 The northeast Alberta region

rational evolution of development will occur.[1]

Industrial and economic growth will result in an expanding regional population requiring the development of many new facilities, including space for recreation. Rapidly increasing demand for recreation facilities requires an evaluation of new areas capable of meeting a variety of demands. As Perloff and Wingo (1962:34) aptly state:

> Many activities have special resource requirements to be met by the native endowment of a facility. Mountain climbing needs mountains; but even hiking needs a natural endowment of topography, flora, and fauna to absorb and stimulate the hiker. Each activity has its own requirements which must be met by facilities before the activity can be carried out. The nature of these requirements is an important link between those activities which people are likely to want and those which can be provided.

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[1] Ekistic Design Consultants Ltd., Edmonton, prepared the Northeast Alberta Regional Plan (NARP 1976) which summarizes the many factors that will influence the formulation of an optimal, regional development pattern for northeast Alberta. It provides preliminary information on the resource base of this region.

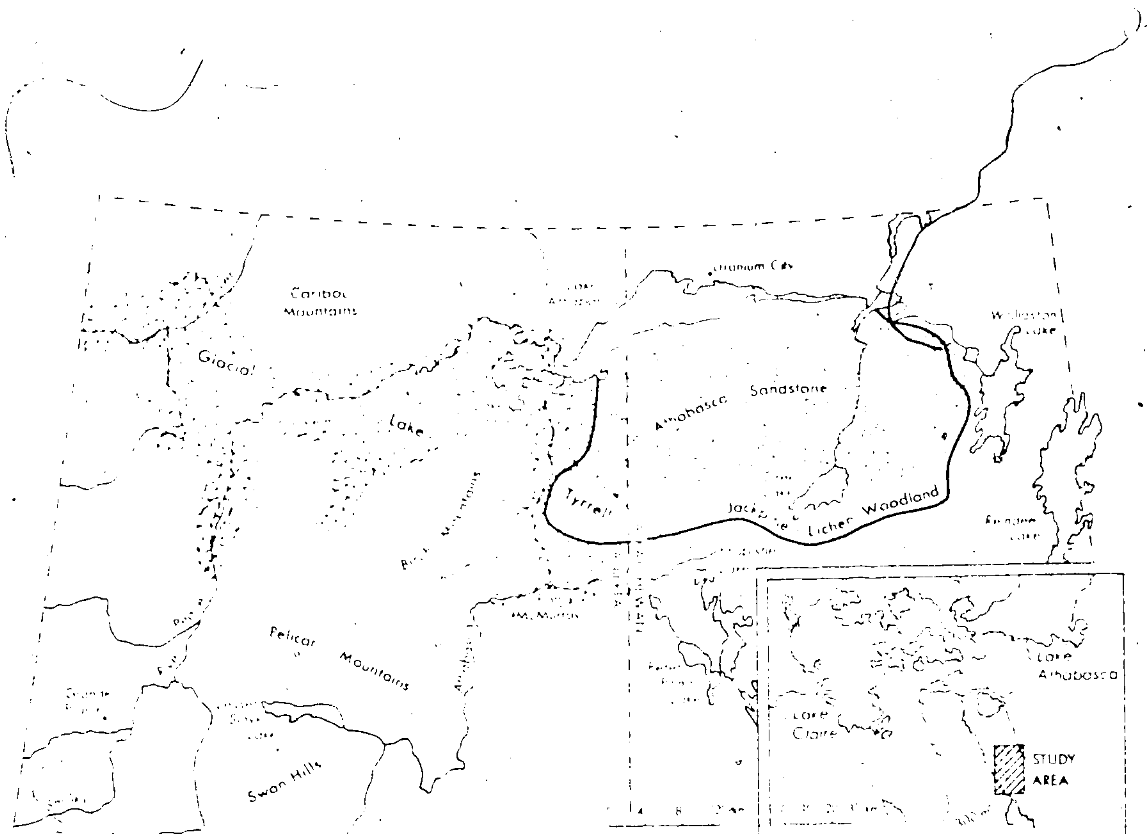
A second major study currently under way in the northeast Alberta region is The Alberta Oil Sands Environmental Research Program (AOSERP). AOSERP is a 10 year, $40 million multi-disciplinary research project undertaken by the governments of Alberta and Canada, and is designed to provide the scientific and technological knowledge for both levels of government and industry to use in environmental planning and protection within the Athabasca oil sands region. Areas of research include; geology, meteorology, hydrology, botany, wildlife, aquatic fauna, forestry, land use and sociology.

These projects, and others that are likely to follow, will facilitate planning decisions by identifying the complex (and often conflicting) demands of industry, government and local residents.

Wilderness recreation requires a large area of relatively undisturbed natural environment, a special or even unique blend of physical characteristics -- topography, vegetation and wildlife, and an opportunity to hike through and camp in a diversity of landscapes in relative solitude.

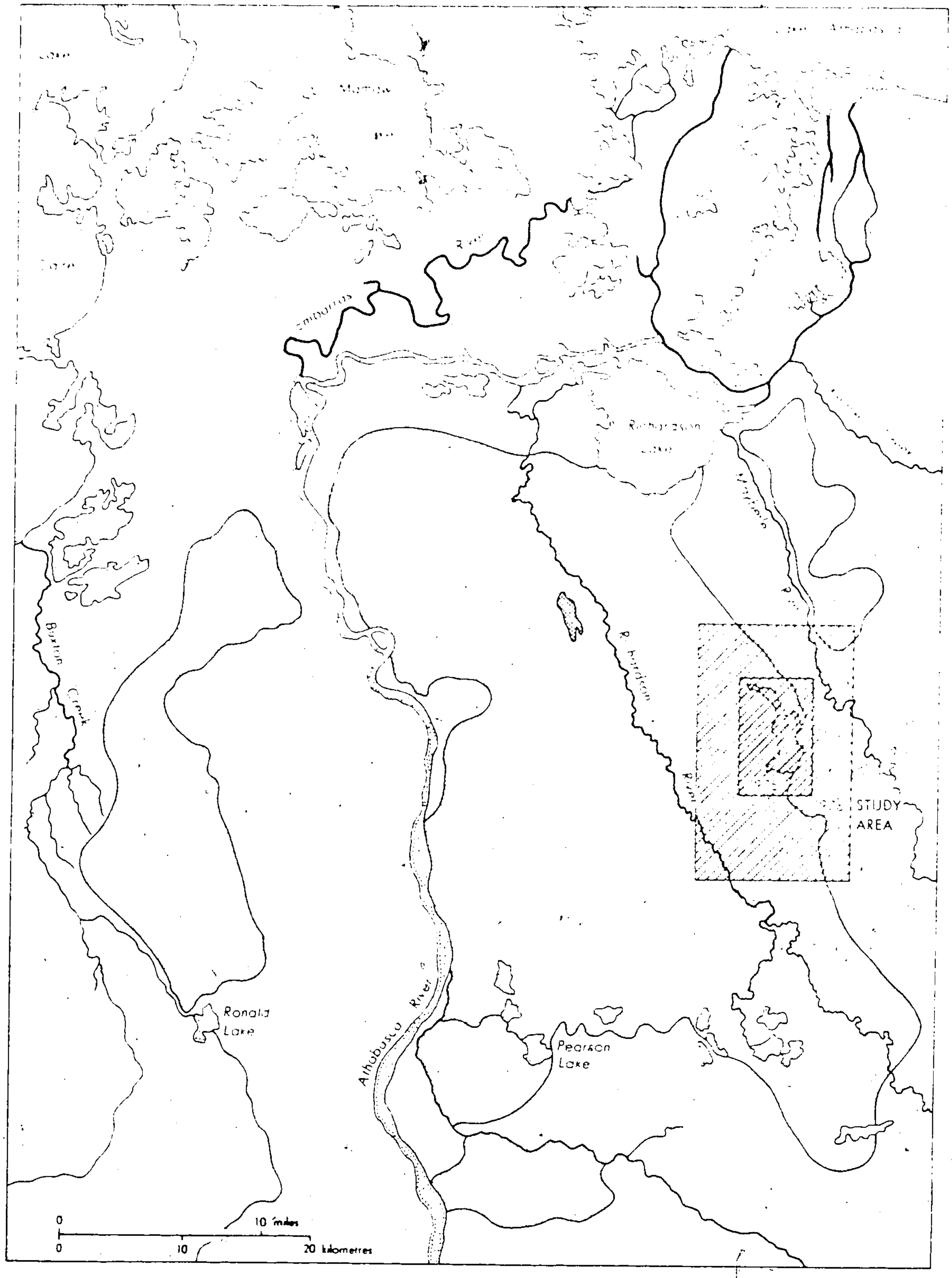
Northeast Alberta (Figure 3.1), a region almost as large as Vancouver Island, contains large areas of undeveloped natural landscape and offers a variety of wilderness recreation opportunities. These include: the vast plain encompassed by Wood Buffalo National Park; the Canadian Shield with its myriad lakes; the forests and lakes of the Birch Mountains Upland, Caribou and Thickwood Hills; the complex and dynamic ecosystem of the Peace-Athabasca Delta; and major tributaries of the Mackenzie River system, the Athabasca, Peace and Slave Rivers.

Another potential wilderness recreation area in northeast Alberta (noted briefly in the Northeast Alberta Regional Plan 1976), is a region of sand dunes, lakes and glacial landforms (Figures 3.2,3.3). This area contains a number of features ideal for wilderness recreation, including isolation from developed areas, and a rich and diverse landscape composed of topography, vegetation and wildlife largely undisturbed by man's activities.



Sources: Atlas of Alberta 1969; Department of Mineral Resources, Saskatchewan (1972); Rowe (1972)

Figure 3.2 Environmental features associated with the formation of the northeast Alberta sand dunes



Fixed dune fields

Active dune fields

Figure 3.3 The northeast Alberta sand dune region

3.1.1 Formation of the Northeast Alberta Sand Dunes

The following environmental features in combination appear to be responsible for the formation of the sand dunes of northeast Alberta:

1) The Athabasca Sandstone geologic formation extends from Saskatchewan into northeast Alberta south of Lake Athabasca (Figure 3.2)

2) This major outcropping of sedimentary bedrock was glacially scoured during the Wisconsin glacial period, which provided a local abundance of sandy till

3) During deglaciation (which began approximately 10,000 B.P.), this material provided a source for the deposition of extensive sand and gravel outwash plains, and in glacial Lake Tyrrell, lacustrine sands (Taylor 1958). After deglaciation and the lowering of lake levels, the unvegetated sands were reworked by wind into an extensive dune system (Figure 3.2, insert; Figure 3.3)

4) Although no wind data are available for the study area, direction can be inferred from interpretation of the active aeolian features; the presently active transverse dunes of the active dune complex are oriented NNW-SSE reflecting effective summer winds from the WSW. To the southwest of the dunes region are several major uplands (Figure 3.2) with elevations up to 850 m (550 m higher than the study area). These uplands in combination create a significant

rainshadow; in the western mid-north, rainshadows are best developed northeast of topographic highs because prevailing winds during summer are from the southwest (Eley 1977). This rainshadow effect results in the dunes area receiving less summer precipitation than any other portion of northeast Alberta (Mann 1977). For example, the May-September precipitation in the Birch Mountains (Figure 3.2) is 342.9 mm while at Richardson Tower, 15 km south of the study area (Figure 4.9), precipitation for the same period is only 256.0 mm, or 34 % less (Table 4.1)

5) The dune sands, outwash sands and gravels and other coarse glacial deposits that overlie the Athabasca Sandstone have created excessively drained, submesic soils which are occupied by drought-tolerant jackpine-lichen woodland (Rowe 1972). Figure 3.2 illustrates that the distribution of this vegetation type is closely correlated with the Athabasca Sandstone from which the soils of the jackpine-lichen woodland were origi[illegible] derived. The southwest lobe in the distribution of this vegetation type (Figure 3.2) is located on the sands of the northeast Alberta dune system (Figure 3.2, insert)

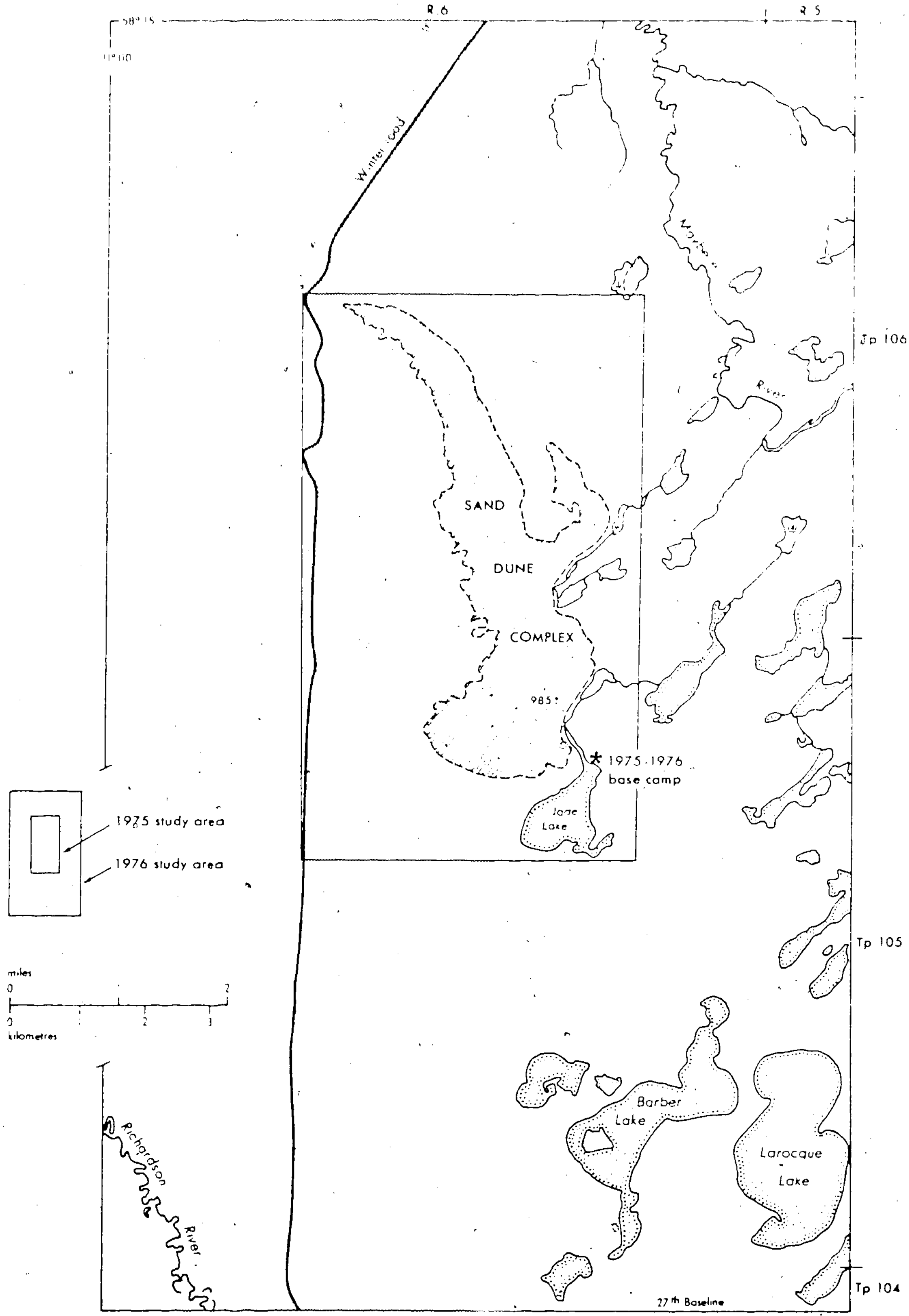
6) During dry periods, which are usual for this region, jackpine-lichen is one of the most flammable of all vegetation types, and is thus subject to recurring wildfires (Section 4.3.1.1.2). Reduction in forest cover together with occasionally strong winds has aided the movement of sand

7) The combination of dry sandy substrate, semi-arid local climate, recurring forest fires and wind has resulted in a range of sand dune features, a number of which remain active (Plate 1).

3.1.2 The Sand Dune Region of Northeast Alberta

The sand dune region of northeast Alberta covers an area of approximately 3000 km² (Figure 3.3). It is bordered on the north by the south shore of Lake Athabasca and the adjacent delta complex, on the east by the Saskatchewan border, on the west by the Athabasca River, and on the south by township 103. A variety of dune types have been identified in this area including parabolic, transverse, blowout and longitudinal. They are now stabilized by vegetation except for 2 large active patches (Figure 3.3; Plate 2).

The study area, located 170 km NNE of Fort McMurray and 24 km south of Richardson Lake, is bounded on the east by the Maybelle River, on the west by the Richardson River, and on the south by the 27th baseline (Figure 3.4). The field area contains the largest active dune complex in Alberta, a variety of stabilized dunes, a varied mosaic of plant communities, and 3 large lakes, providing a representative sample of the environmental resources and ecological constraints that should be considered by planners of future land use in the sand dune region (Plate 3).



Source: NTS base map 74 L/2 1:50 000

Figure 3.4 Generalized map of 1975-1976 study area

3.2 The Research Problem

The central problem of this thesis was to obtain sufficient biophysical baseline data to determine the potential of the sand dune environment for use as a wilderness recreation facility. There were two important factors to consider:

1) The biophysical environment of the land-based resource

2) The constraints imposed by these natural conditions on use by recreationists.

As practically no published research is available to identify the environment of the sand dune area, the first step in this study was to complete an extensive environmental inventory. Once this baseline information was recorded, more site-specific analyses were conducted to determine the susceptibility of the area to disturbance from natural and human sources.

3.3 Research Objectives

To assist problem analysis, 4 specific research objectives were established:

1) Inventory the environmental and ecological conditions of the study area (Chapter 4)

2) Assess the recreational resources of the sand dune area (Chapter 5), consistent with current philosophies on wilderness recreation as identified by the existing

literature (Chapter 2)

3) Analyse the environmental constraints to the development of the dunes region for wilderness recreation (Chapter 6)

4) Examine the environmental effects of recent human use in the study area as an indicator of environmental carrying capacity (Chapter 6).

3.4 Research Methods

3.4.1 Library Research

As a first step in compiling an environmental inventory I surveyed the literature relevant to the study area and to wilderness recreation.

3.4.2 Field Work

3.4.2.1 Field Trip 1

The initial field work (25-27 February 1975) was a reconnaissance trip to the active dune area to record various aspects of winter environmental conditions. Emphasis was placed on choosing an ecologically representative study area, on observing environmental conditions during winter and on recording winter wildlife activity.

3.4.2.2 Field Trip 2

During spring 1975 preliminary landform and vegetation base maps were prepared from 1:3333 1951 panchromatic air photographs, and a summer reconnaissance field program was planned.

The 1975 field period lasted from 3-23 August. During this time I conducted e[illegible]usive ground truthing for air photo interpretation and mapping of geomorphic features, soils, vegetation distribution and wildlife habitat. More than 400 35 mm ground and aerial color slides were taken of the area to assist in mapping, data analysis and planning the 1976 field season.

The results of the 1975 reconnaissance field work provided a good general knowledge of the study area which facilitated the preparation of the 1976 field agenda.

3.4.2.3 <u>Field Trip 3</u>

Based on the first broad classifications of surficial geology, landforms, vegetation and water resources, a more detailed field sampling program was conducted during June and July 1976. Fifteen transects were selected (Figure 4.1) to ensure that each of the previously identified features would be sampled and that representative sites within the study area would be examined.

Quadrats 10 m^2 were set out at 50 sample sites along the 15 transects to complete the ground truthing of previously mapped information, to inventory plant species and wildlife presence, to record evidence of wildfire surface erosion, and to assess the susceptibility of the landscape to human disturbance.

3.4.3 Air Photo Interpretation

Available photographic coverage for the study area is limited to 1951 panchromatic air photos (scale 1:3333; reference numbers 160 5802, 160 5803A and 160 5804) and panchromatic photo mosaics (scale 1:63,360; reference numbers 74 L/2 and 74 L/3). The quality and resolution of this photography is poor but interpretation and mapping were aided by:

1) Reconnaissance aerial investigations in February and August 1975

2) Use of equipment and assistance from personnel at the Canada Centre for Remote Sensing, Edmonton. Photo interpretation equipment used included a Jena/Zeiss Interpretoscope, a 15X zoom stereoscopic interpretation unit used for scanning, height finding and scale correction between photographs, a Bausch and Lomb Zoom Transferscope, used to transfer photographic interpretation onto a base map and mirror and lens stereoscopes.

Following the 1976 field research, mapping was refined from 35 mm air and ground color slides on 1:50,000 base maps.

3.4.4 Inventory of the Physical Environment

Six major components of the physical environment were investigated:

1) Climate and weather
2) Bedrock geology
3) Physiography
4) Surficial geology
5) Soil
6) Water resources

3.4.4.1 Climate

Climatic information was obtained from published materials, from general field observations and from interviews conducted with northern climatologists.

3.4.4.2 Bedrock Geology

Information on bedrock geology was compiled from Bayrock (1969, 1970, 1972) and from field investigations.

3.4.4.3 Physiography

The Atlas of Alberta (1969) provided information on the regional physiography of northeast Alberta.

3.4.4.4 Surficial Geology

Information on the surficial deposits was compiled from the 1:250,000 surficial geology map by Bayrock (1972 - sheet 74 L), published and unpublished reports, air photo interpretation and field work.

A Brunton compass was used to verify orientation of landforms, originally drafted from air photographs, and to measure slope angles. At each of the study sites a soil pit was dug and sand grain-size, homogeneity, and orientation was compared with currently active dune sands to determine previous aeolian activity.

3.4.4.5 Soil

Soils information was obtained from the Alberta Soil Survey of the Department of Soil Science, The University of Alberta, the Alberta Research Council, and from field mapping based on soil pits which were dug at each of the 50 sample sites. Soil was mapped according to guidelines in the System of Soil Classification for Canada (Canada Department of Agriculture 1974). These classifications were modified after discussions with members of the Alberta Ecological Society (AES) and the Department of Soil Science, The University of Alberta.

Soil pH measurements were made in the field using a portable Hellige-Truog Soil pH Test Kit. Samples were all taken at 10 cm below the surface. No soil pH was recorded for the wetland community types. Soil moisture classes (Table 4.6) were qualitatively determined, based on work by Krajina et al. (1962).

3.4.4.6 Water Resources

Evaluation of water resources included assessments of water quality, fish populations, shoreline conditions (slope, vegetation and other beach conditions) and hazards for float plane landing.

Aspects of water quality investigated included temperature, dissolved oxygen and pH using the following procedures:

1) A YSI model 42 SC Telethermometer was used to obtain two daily sets of air and water temperatures. A set of readings consisted of air temperatures at base camp 30 m from the shore of Jade Lake[1] (Figure 4.4, Location 7), and water temperatures 5 m from shore at a 30 cm depth. Readings were recorded at 0900 and 2100 during 3-23 August 1975, together with a brief summary of local weather conditions at times of recording (Appendix 8.5)

2) Dissolved oxygen and pH readings were taken in Jade, Larocque and Barber Lakes. Dissolved oxygen was obtained by using a modified Azide-Winkler method with drop count titration while a Hach test was used to determine water pH. A Rawson's nomogram was used to calculate the oxygen saturation levels from dissolved oxgyen and water temperature data.

Fish populations in Jade Lake were assessed in two ways:

1) Angling from a canoe was used to determine the fishing potential. Species caught and size (length, girth and

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[1] Only Barber and Larocque Lakes are officially named. I named the others to facilitate discussion in this thesis.

weight) were recorded

2) Specimens were gathered from the numerous schools of fry in the near-shore waters and later identified at The University of Alberta (Appendix 8.2).

Assessments of shoreline conditions and hazards for float plane landing were made during aerial reconnaissance and from a canoe.

3.4.5 Inventory of the Biological Environment

Vegetation and wildlife were assessed from published literature, air photo interpretation, aerial reconnaissance and field research.

3.4.5.1 Vegetation Classification and Mapping

Initial vegetation classification and mapping was completed after the 1975 field trips and interpretation of 1951 air photographs. During the 1976 field work, the phytosociological methods of the Zurich-Montpellier school (Braun-Blanquet 1932) as modified by Krajina (1961) and Gill (1971) were applied.

During the 1975 field reconnaissance, I noted that abrupt changes in the distribution of surficial geology, soil types and soil moisture resulted in readily observable changes in the distribution of vegetation. These changing site characteristics, coupled with identification of the species composition of separable plant communities, were employed to identify the major vegetation types. Refined mapping and classification of vegetation resulted from the analysis of data gathered at 50 sample sites (Table 4.6). At each site, 10 m^2 plots were placed in nodal locations judged to be typical of the previously mapped vegetation types. Visual estimates of percent cover (species significance) were made for each species in each of the tree, shrub, herb, moss and lichen layers according to the criteria in Table 3.1. A further assessment was made at each site based on the critera of cover, habitat characteristics, walkability, aesthetics, and susceptibility to disturbance from human use.

Table 3.1 The Species Significance Scale Showing Cover Range for Each Value

RANKING	SPECIES SIGNIFICANCE	
	Qualitative Value	Quantitative Coverage (% of plot)
+	Single or rare occurrence	Negligible
1	Occurring seldom	Negligible
2	Rare	Up to 5
3	Common	6-10
4	Occurring often	11-20
5	Occurring very often	21-35
6	Abundant	36-50
7	Abundant	51-75
8	Very abundant	76-95
9	Very abundant	96-100

The more common plant species were identified in the field, while less common or problematical species were collected and identified at the Botany Department, The University of Alberta (additional information on species identification is given at the end of Appendix 8.1). Voucher specimens are stored at the Department of Geography, The University of Alberta.

3.4.5.2 Fire Research

Fire history information and data on the ecological effects of fire were collected using the following procedures:

1) Fire records were searched at The Alberta Forest Service, Edmonton, for the period of record 1958-1976

2) Four fire sites of different ages (1975,1963,1906 and 1826) were identified from fire records, air photo interpretation and field reconnaissance An area burned during 1-4 July 1976 was added during 1976 field investigations

3) These 5 fire locations were investigated to determine probable cause of fire, the extent of the burn, successional aspects of the vegetation (species compositon of each stratum was recorded and compared with similar data from the other 4 fires), habitat characteristics, and recreational qualities (walkability, species diversity, aesthetics, interpretive qualities)

4) An evaluation was made at each location concerning the

possible ecological advantages or disadvantages of fire to use by recreationists.

3.4.5.3 Wildlife Observations

Information on wildlife was gained through standard field observations made along the 15 line transects. Methods of observation included:

1) Identification from sightings

2) Interpretation of field signs (scats, dropped antlers, cratering, tracks and evidence of browsing and grazing)

3) Collection of specimens (aquatic vertebrates).

I also conducted interviews with wildlife biologists, AES field staff and others familiar with the area. Information sources leading to the completion of a species list are given at the end of Appendix 8.3.

3.4.6 Historical Documentation

Archival research dealing with the study area and vicinity was carried out at 5 locations.

1) Ekistic Design Consultants Ltd., Edmonton

2) Long Range Planning Branch, Alberta Provincial Parks, Edmonton

3) Alberta Research Council, Edmonton

4) Alberta Forest Service, Edmonton and Fort McMurray, Alberta

5) Northern Forest Research Centre, Edmonton.

Interviews were conducted with people

knowledgeable about the history of the area and aware of current and projected developments in northeast Alberta that might affect the study area.

3.4.7 Surface Erosion Research

Information on surface erosion was recorded during line transect work. Location of erosion (with respect to landforms), its cause, and implications for use of the sites by recreationists were recorded.

3.4.8 Campsite Studies

Two aspects of campsite potential were studied, physical site capability and disturbance from human use.

3.4.8.1 Physical Capability of Lakeside Locations for Campsite Use

An environmental capability rating system (Lesko 1973) was employed to assess the campsite potential of 9 locations near Jade and Larocque Lakes. The rating system is based on the evaluation of 9 ecological factors:

1) Degree days above 5.5° C
2) Mean annual water deficit
3) Shrub cover
4) Grass cover
5) Slope and total ground cover
6) Depth of rooting
7) Thickness of the Ah soil horizon

8) Thickness of the forest floor (LFH layers)

9) Soil texture and drainage.

These factors were then assessed according to the numerical scale developed by Lesko (1973:6-9). Also, a qualitative evaluation of recreation potential was made at each location based on scenery, location in relation to water bodies, shoreline conditions (swimming, boating access) and the availability of firewood.

3.4.8.2 Disturbance From Human Use at 3 Sites on Jade Lake

Of the locations evaluated for campsite capability (Section 3.4.8.1), 3 sites had been used previously. A comparative analysis of environmental impact on these sites was completed. The sites (Figure 4.4) included:

1) A 1973 research basecamp (site 7)

2) My 1975 winter basecamp (site 1)

3) My 1975-1976 summer basecamp (site 3).

The impact analysis followed metnods outlined by Lesko and Robson (1975:7-10). Briefly, these methods include:

1) A plant community survey (Section 3.4.5.1) before impact. At sites 1 and 3 I recorded the vegetation in the area around the campsites and assumed it to be representative of site conditions before use

2) A capability rating of the campground vegetation for recreational use (Lesko 1973)

3) Visitor impact on the site was evaluated using a scale

developed by Willard and Marr (1970).

3.4.9 Testing the Resistance of Vegetation to Trampling

Channelling of use gives rise to a more intensive pressure than would be experienced if the pressure was distributed over a larger area. A path may therefore be an indicator of the type of change that would occur in an area if the pressure throughout the area increased. Hence a path may be viewed as an expression of areal response collapsed into a linear form (Peters 1972:19). This idea can be used effectively in the research area because of the relative homogeneity of ground cover throughout the jackpine-lichen woodland.

During the 1975 reconnaissance field wor[illegible] observed that when dry, the ground cover in jackpine-lichen stands is very fragile, extremely flammable and slow to recover after disturbance. To analyse the susceptibility of this ground cover to trampling, game and human trails were analysed. Trail experiments were designed after techniques used by Wagar (1964), Burden and Randerson (1972), Peters (1972) and Cordes et al. (1975).

3.4.9.1 Game Trails

Red squirrel (Tamiasciurus hudsonicus) and black bear (Ursus americanus) trails are ubiquitous in the study area. A representative 5 m segment of each type of game trail was selected for analysis of trampling impacts. The following measurements were then made in the order given:

1) Trail width (width of the disturbed area)

2) Vegetation. Species significance was recorded for the ground cover adjacent to the impact area (Section 3.4.5.1). Species growing on the trail were recorded

3) General site description. A brief note was made of the site conditions including amount of organic litter on the path, the walkability of the path surface and the degree of shading.

3.4.9.2 Trampling Experiments

Four trails were assessed to quantify the resistance of the ground cover to human trampling. Two trails, 1 from the 1975-76 base camp to the garbage pit (trail 1) and the other from camp to Jade Lake (trail 2) were used under a spectrum of summer weather conditions at random times by a total of 5 adults and 1 child. The 3 methods used to analyse the game trails were repeated for trails 1 and 3. Trails 3 and 4 were the sites of simulated trampling experiments.

3.4.9.2.1 Simulated Trail Trampling

Two simulated trail experiments were conducted on the lichen ground cover under dry (trail 3) and wet (trail 4) conditions.

The following methods were used to quantify trampling impacts on dry ground cover:

1) A 25 m X 25 cm length of terrain was selected having a homogeneous ground cover in a typical mature jackpine-lichen community

2) A 100 m tape was placed along the long axis of the trample plot

3) Four line-transects were established at the 5, 10, 15 and 20 m locations perpendicular to the long axis. Trail width was defined as a 25 cm wide linear disturbance

4) Vegetation was sampled along each transect as in .evious trail assessments

5) A trampling unit was established to be 1 return pass over the plot length. Trampling intervals were 0,5,10,15,25,35 and 50 units

6) Time lapse black and white photographs of the plot were taken after each trampling interval using a tripod mounted, 35 mm Pentax camera

7) Relative humidity at the lichen-air interface was recorded using a Bendix model 566 aspirated psychrometer

8) The site was described after successive trampling intervals.

For wet ground vegetation the experimental procedures were the same as in the dry ground vegetation except trampling was conducted after a period of 36 hours of rain. Site conditions were again recorded 20 days after the experiment when the ground cover had dried.

3.5. Conceptual Framework of the Study

There are no established techniques for conducting an inventory of wilderness potential, which necessitated the design of a conceptual framework for this study. This framework follows the ecosystem model of Tansley (1935), who formulated the idea of an ecosystem as a combination of the biotic and abiotic environment to form one inseparable unit.

The ecosystem concept is further elaborated by Mueller-Dombois and Ellenberg (1974) for use in environmental analysis and is called the Combined Approach. This approach identifies the ecosystem components for use as indicators of more hidden site factors. They stress the need to evaluate the environmental components in a holistic, interdependent way. In this study, environmental factors were analysed simultaneously in an attempt to develop a holistic, systematic approach.

CHAPTER 4

ENVIRONMENTAL INVENTORY

> Any site is composed of many factors--above, below, and at the ground--but all these factors are interrelated, and have achieved some sort of balance, whether it be static or one that is moving toward another equilibrium.
>
> Because of the complexity of parts and their intricate patterning together, we find that each site is in some measure unique. While it may fit into some general classification, it will have a flavor, an essence, of its own. The words site and locality should convey the same sense that the word person does: a complexity so closely knit as to have a distinct character, a complexity worthy of interest and even affection (Lynch 1962:15).

4.1 Introduction

The primary objective during inventory was to identify the environmental components of the study area most relevant to the potential development of the sand dune region for wilderness recreation.

Although every attempt was made to consider the study area as an interracting system, compartmentalization was necessary to allow collection, organization and analysis of data. The classification developed consists of three major categories, physical environment (4.2), biological environment (4.3) and human environment (4.4).

4.2 Physical Environment

For the purpose of inventorying the physical environment the study area was divided into three regions based upon readily distinguishable physical characteristics:

1) The active sand dune complex

2) The kame and kettle features to the east of the active dune complex.

3) The more recently stabilized dune areas north, west and south of the active dune complex (Figures 4.2, 4.3).

4.2.1 Climate

Generally, the regional climate of northeast Alberta is similar to that of central Alberta, although it does experience somewhat more severe winters and a shorter growing season. According to climatic data recorded at Fort McMurray airport over the past 27 years, the northeast region has a cold, snowy, forest climate (Koppen classification Dfc) with a large annual range of temperatures. The summer is short and relatively cool. Frost free days range from 80 - 100 (Atlas of Alberta 1969:15).

The most relevant climatic data available for the study area are recorded at Keane, Richardson and Birch Mountain forestry towers (Figure 4.9). Their recording periods are May through September, providing a good indication of summer climate. Winter weather information for the tower areas is estimated by Atmospheric Environment Service using data from Fort McMurray and Fort Chipewyan. Due to their distance from the study area and their

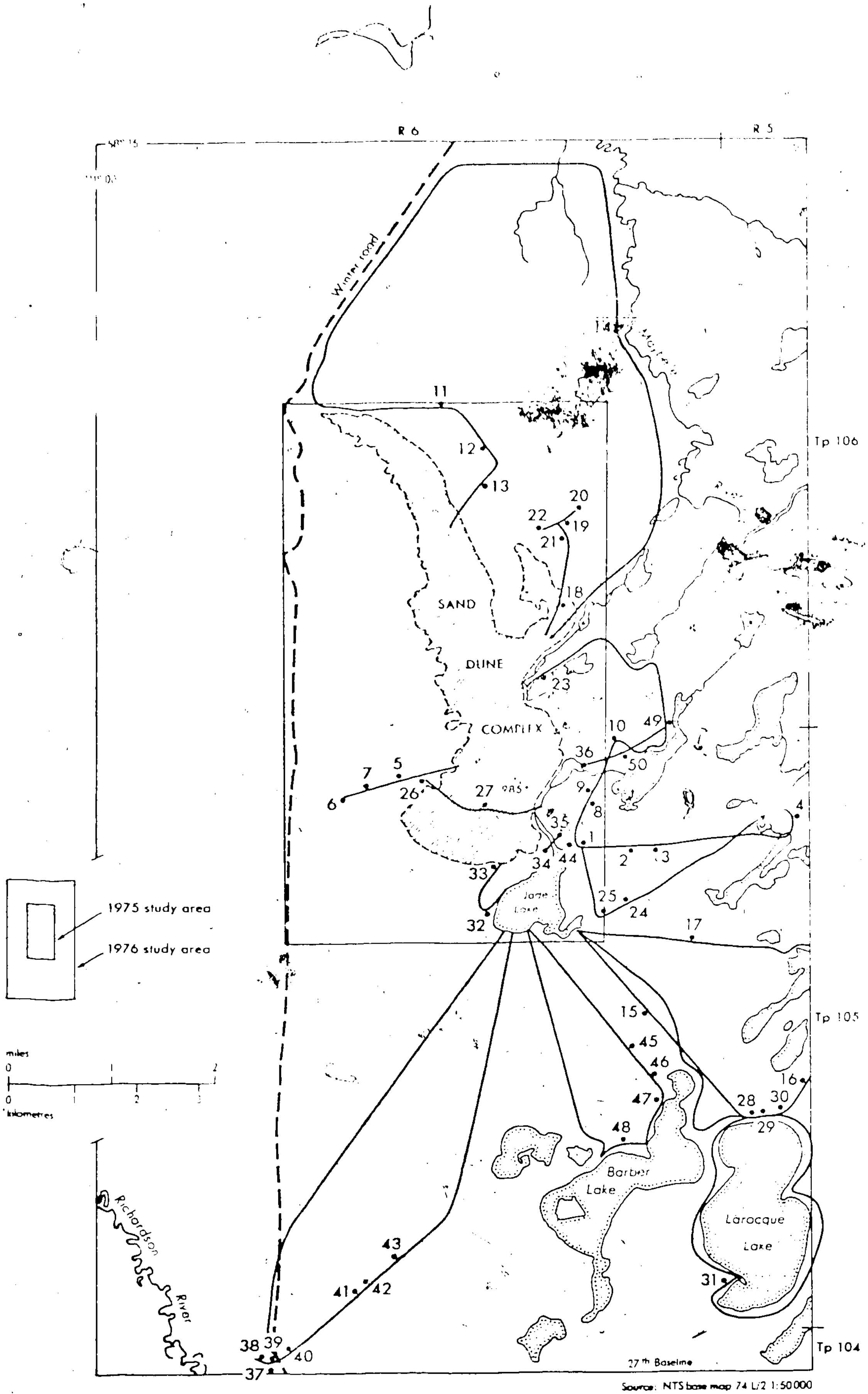
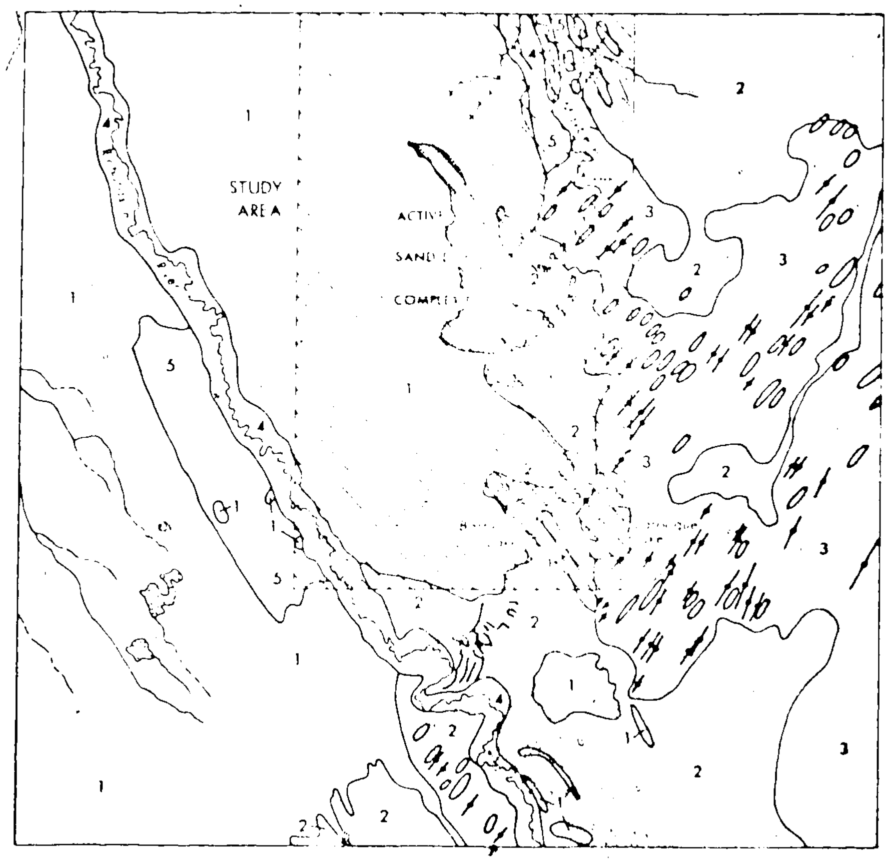


Figure 4.1 Location of transects and sample sites of the 1976 study area



Source: Surficial Geology, Fort Chipewyan, NTS74L

miles 0 5

0 5 10 kilometres

1 Aeolian sand dunes, sand in sheet and dune form
2 Ice contact deposits
3 Glacially overridden outwash sand and gravel
4 Stream alluvium
5 Outwash sand
Drumlin
Glacial fluting

Figure 4.2 Surficial geology of the study area

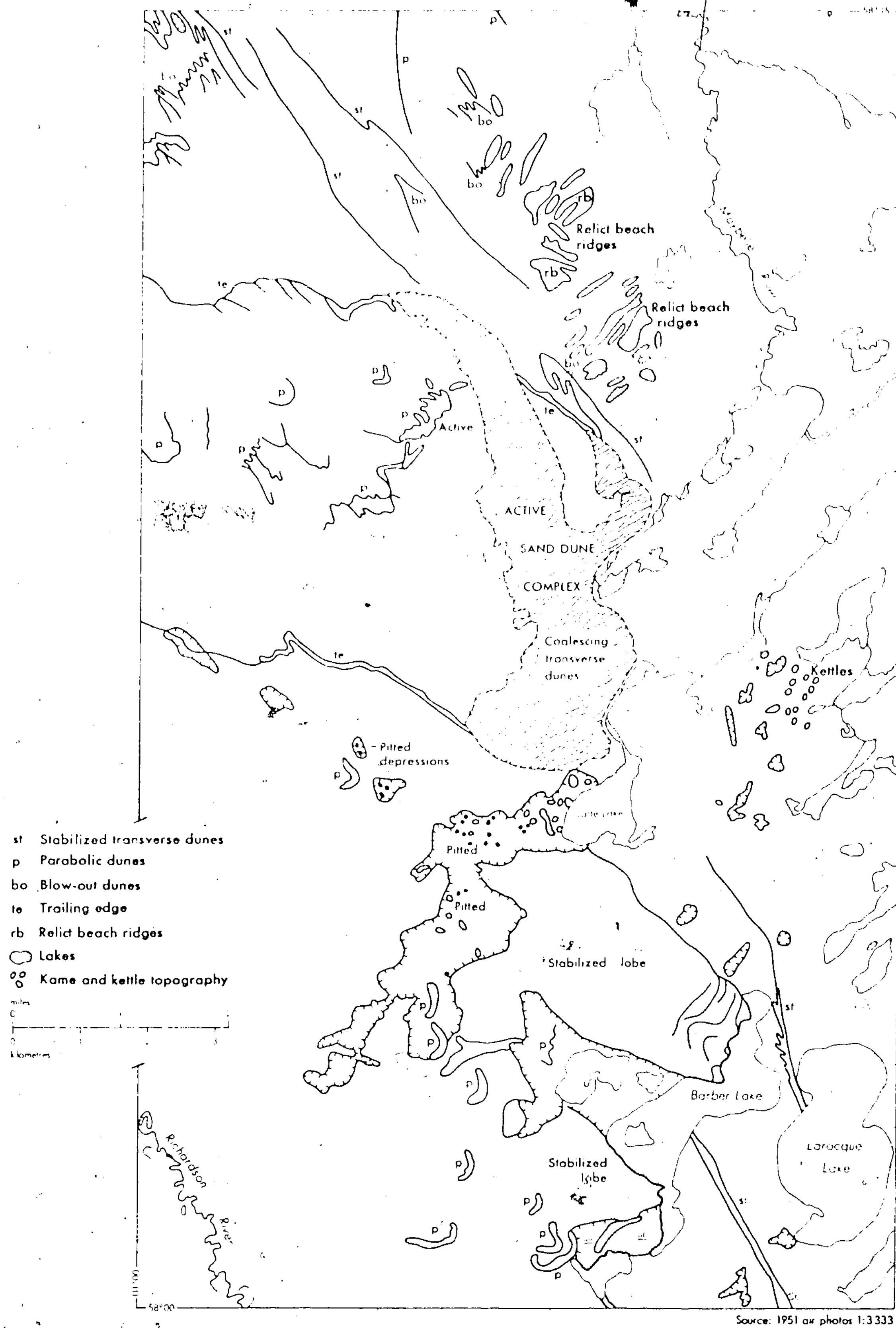


Figure 4.3 Landforms of the study area

topographic locations (Fort McMurray in a river valley and Fort Chipewyan on the north shore of Lake Athabasca), the data are only an estimate for the winter climate of the study area.

Alberta Forest Service has published average monthly precipitation data and normal maximum temperatures for the Keane and Richardson forestry stations (Tables 4.1 and 4.2). Temperature and precipitation for the period October - April have been noted by Lovatt (1975) (Tables 4.3 and 4.4). Only general information on prevailing winds is available for the study area (Lovatt 1975) along with a brief summary of local summer weather conditions during August 1975 (Appendix 8.5).

As given in Section 3.1.1, the summer climate of the study area is affected by regional physiography and prevailing southwest winds. The Birch Mountains and other uplands (Figure 3.2, Plate 2) located to the southwest of the study area create a rainshadow effect. This lee climate reduces precipitation, lowers the relative humidity, and results in a warmer, drier summer climate in the dune region.

In a general way, the 1975 information on daily wind directions (Appendix 8.5) support this hypothesis. Wind direction on sunny, warm days were S, SW and W while rain-bearing winds were predominantly N, NE and E. The rain-bearing winds could have moved around topographic features (such as the Birch Mountains) or advanced southward

Table 4.1

Average Monthly Precipitation at 4 Forestry Towers[1] in the Athabasca Forest of Northeast Alberta, May to September, 1963-1970 (mm).

Station	Elevation (m)	May	June	July	August	September	Total	% Summer ppt > Study Area
Birch Mountain	854	40.6	55.9	109.2	68.6	68.6	342.9	34
Thickwood	604	35.6	68.6	114.3	68.6	101.6	388.7	52
Keane	457	45.7	61.0	55.9	45.7	48.2	256.5	base level
Richardson	304	40.6	45.7	76.2	58.4	50.8	256.0	

Source: Stashko, E.V. 1971. Precipitation means. Alberta Forest Service Publication. pp. 9, 32.

[1] Figure 4.9

Table 4.2

30-year Normal Maximum Temperatures at 4 Forestry Towers in Northeast Alberta, 1931-1960 (°C).

Station	May	June	July	August	September	No. of Years
Birch Mountain	10.0	15.0	18.3	16.7	7.8	30
Thickwood	15.0	18.9	21.7	20.0	13.9	30
Keane	12.8	17.8	21.7	19.4	12.2	30
Richardson	15.0	20.0	23.3	21.1	14.4	30

Source: Stashko, E.V. 1971. Probable 30-year normal maximum temperatures. Alberta Forest Service Publication. pp. 8,9.

Table 4.3

Mean Daily Temperatures October to April at 2 Sites in Northeast Alberta 1941-1970

Station	Elevation (m)	Mean Daily Maximum Temp. (°C)	Mean Daily Minimum Temp. (°C)
Fort McMurray	370	- 4.0	- 15.6
Fort Chipewyan	219	- 8.1	- 18.9

Source: Atmospheric Environmental Services, Environment Canada (Edmonton).

Table 4.4

Precipitation Summary at 2 Sites in Northeast Alberta 1967-1973

Station	Elevation (m)	Precipitation October-April (6 year Mean) (mm)	Annual Precipitation (mm)
Fort McMurray	370	150.1	435.4
Fort Chipewyan	219	145.0	379.73

Source: Atmospheric Environmental Services, Environment Canada (Edmonton).

along the Rocky Mountains and across the vast wetland areas of Wood Buffalo National Park and the Peace Athabasca Delta gaining additional moisture. Due to the very limited nature of these data, any implications of long term climatic patterns for the study area are very tentative.

4.2.2 Bedrock Geology

The geology of the study area is described by Bayrock (1969, 1970) who indicated that granitic plutonic rocks underlie the region. No indication is given of the depth to bedrock. No bedrock outcroppings were observed. The Athabasca Sandstone formation lies to the immediate northeast of the study area (Figure 3.2).

4.2.3 Physiography

The study area is located within the Athabasca Delta Plain physiographic region (Atlas of Alberta 1969), approximately 70 km south of the exposed edge of the Canadian Shield. It lies between the Kazan Upland and Athabasca Plain to the north and east, and the Birch Mountains Upland to the southwest (Figure 3.1).

4.2.4 Surficial Geology

Four major classes of surface deposits are recognized in the study area:

1) Glacially overriden outwash sand and gravel
2) Ice contact deposits

3) Aeolian sand in sheet and dune form
4) Stream alluvium.

4.2.4.1 Glacially Overriden Outwash Sand and Gravel

Glacial deposits within the area (Figure 4.2) record only the advance and deterioration of the most recent glacial stage, the Wisconsin. Bayrock (1962) states that there is no evidence of multiple glaciations in the study region. During stagnation of the Keewatin ice sheet approximately 10,000 years B.P., drumlins, glacial flutings and outwash were deposited (visible to the east of the advancing dune complex - Figure 4.2).

The SW direction of glacial advance is indicated in the alignment of fluted and drumlinized sands and gravels underlying ice-contact deposits. Flutings are well developed and in places east of the study area they grade into drumlins. Drumlins are well shaped and mantled by a layer of large boulders (Bayrock 1969, 1970). Boulders and glacial debris mantling the soil surface were recorded at site 4 (Figure 4.1).

4.2.4.2 Ice Contact Deposits

The zone bordering on the east side of the active dune patch is comprised of a complex of kames and kettle holes (composed of sand, gravel and boulders). This is a transition zone between the actively moving and stabilized dune formations to the west, and the fluted and drumlinized region to [illegible] east. The area is mantled by a thin to moderately thick layer (30 cm - 1 m) of aeolian sand (Plate 4).

4.2.4.3 Aeolian Sand in Sheet and Dune Form

Aeolian sheet and dune sands derived from nearby outwash deposits cover a large area south of Lake Athabasca and the adjacent delta complex, from the Saskatchewan border in the northeast to the margin of the Birch Mountains in the southwest (Figure 3.3). Dunes are well developed but most have been stabilized by jackpine-lichen woodland. Some individual NW - SE trending dunes reach an amplitude of 30 m, reflecting effective dune forming, postglacial winds from the SW (Odynsky 1958).[1]

Six dune types and landforms modified by aeolian

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[1] From airphoto interpretation of aeolian landforms in northeast Alberta, an historical climatic reconstruction has been proposed (Odynsky 1958). Based on the relationship of effective winds to dune orientation, and previous landscape configurations (especially lake positions), Odynsky identified 3 cycles of climatic conditions that occurred. These cycles are inferred from 1) the stable transverse dunes of the northeast, indicating effective winds quite similar to those at present , 2) blowout and parabolic dunes in the northeast and hairpin types attached to the fixed transverse dunes, indicating dune forming winds from the SE, and 3) presently active, coalescing transverse dunes, effective wind direction from the WSW. From my investigations of air photos and field checking of stabilized dunes, a fourth cycle is proposed. The two stable dune lobes bordering on the west shores of Barber and Jade Lakes appear to have advanced under the influence NW winds. These dune complexes are now stabilized by jackpine-lichen woodland (Figure 4.7).

activity were mapped from air photos (Figure 4.3):

1) Stabilized transverse dunes
2) Parabolic dunes
3) Blowout dunes
4) The active dune complex (coalescing transverse dunes)
5) Trailing edges of the active dune complex
6) Relict beach ridges.

4.2.4.3.1 Stabilized Transverse Dunes

Stabilized transverse dunes are located east, north and south of the active dune complex (Figure 4.3). They result from post glaci winds similar in force and direction (WSW) to these presentl moving the coalescing transverse dunes of active dune complex (Odynsky 1958). Five examples o this dune type were measured and found to have a long axis direction of 330° and an asymmetric profile. The lee slopes are steeper (28° - 32°) and shorter (10 - 15 m) than the more gently sloping (14° - 16°) and longer (35 - 40 m) windward slopes.

4.2.4.3.2 Parabolic Dunes

Parabolic or u-shaped dunes are long, scoop-shaped parabolas of sand with arms tapering upwind (Hack 1941, Smith 1946, Fernald and Nichols 1953, Jennings 1957). They are formed in association with a heavier vegetation cover than that of transverse dunes, without which uld probably assume the transverse form. A small of available sand is also associated with this dune type. Variations of this type (shown in Figure 4.3) were recorded in the jackpine-lichen woodland (Figure 4.5). These dunes are unstable (susceptible to wind erosion) as evidenced by the incipient parabolic dune marked 'active' on Figure 4.3. The position of these dune types indicates effective winds from the NNW (about 320°).

4.2.4.3.3 Blowout Dunes

Odynsky (1958) states that migrating sand in an elongated blowout dune is in constant struggle against the growing vegetation. Sand is deepest at the more advanced portion of the blowout dune because it is here that the surrounding vegetation is most rapidly and efficiently eliminated and a sand source provided. Elongated blowouts can be observed in conjunction with stabilized transverse dunes in the northeast portion of the study area (Plate 3). There, blowouts resulted from dune-forming winds blowing from the SSE (about 160°). Numerous small blowout areas occur along the revegetating windward edge of the active dune complex where vegetation is stabilizing the sand surface but is constantly being disturbed by wind erosion.

4.2.4.3.4 Active Dune Complex (Coalescing Transverse Dunes)

The active dune complex, approximately 7 km long and 2.5 km wide, is the largest active sand dune in Alberta.

It is composed of a number of coalescing transverse dunes migrating eastward as a single unit (effective winds about 290°).[1] From field observations at a number of sites along the advancing (precipitation) edge, I estimate that the active complex is moving at a [illegible] of approximately 1 m/year.

Individual transverse dunes vary greatly in size, shape and height. The highest and largest dunes (heights to 35 m) occur along the eastern margin of the dune complex where it meets the jackpine-lichen woodland and lakes. At this point dune movement is slowed by the forest, while vegetation becoming established on the lee slopes adds to the dune building process and thus to the wave amplitude (Section 4.3.1.5).

4.2.4.3.5 Trailing Edges of the Active Dune Complex

Two trailing edges (Figure 4.3), readily identified on air photos, describe the north-south extent of the dune complex, its point of origin, and direction and path of past movement. The trailing edges lead WNW, back to the east bank of the Richardson [illegible]ver, where it is assumed the active dune complex originated. The edges are generally 7 km

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[1] Bagnold's (1941) observation that transverse dunes are unstable is illustrated by a number of examples in the active dune complex. Many variations of transverse dunes are present, from near parabolic to crescent shaped barchans.

apart, 10 m wide and 2-3 m high. The meandering pattern along the length of these trails is probably a response to variations in the direction of past dune moving winds and differences in the ability of obstructions to retard or change the direction of movement. The general direction of movement is 105-110°.

4.2.4.3.6 Relict Beach Ridges

Low (to 1 m in height), elongated ridges are located in the northeast portion of the study area (Figure 4.3). In general, these features are arcuate (around a centre to the NW) in contrast with the linear, NE-SW oriented ice contact landforms to the SE (Figure 4.2). On air photos, the l[illegible]cape encompassing these ridges seems smoother and more [illegible] rolling than the [illegible] rugged, angular kame and k[illegible]le topography, theref[illegible] [illegible]ing the appearance of a previously [illegible]ter-worked surface. Ta[illegible]r (1958) and Bayrock (1969, 1970) note that after recession of Wisconsin Glaciation, Lake Athabasca was much larger and covered the surrounding terrain to elevations up to 90 m above present water levels. NW-SE oriented blowout dunes are associated with these ridges (effective winds SE). Thus, it appears that these landforms are previous [illegible]orelines of Lake Athabasca that have been eroded by wind to form the present aeolian features.

4.2.4.4 Stream Alluvium

The alluvial deposits of the Richardson and Maybelle Rivers are predominantly sand. The floodplains exhibit typical alluvial features of low-gradient rivers such as stream meanders, oxbow lakes, meander scrolls, and point bar deposits. At many locations along the Maybelle River, rapids and riffles occur where boulders pave the stream bed.

4.2.5 Soil

Four soil types were identified for the study area: Regosols, Brunisols, Fibrosols and Rego-Gleysols.[1] The 2 most common types are Regosols grading to Brunisols; they occur on open sand dunes and under well-drained, forested sites. (These 2 soil types are extensive in the study area and are described in Appendix 8.3.) Fibrosols develop within hummocky sphagnum bogs and under the extensive wetland areas northeast of the active dune complex.

In the depressional areas between stabilized dune ridges, and in the peat and sphagnum depressions of kettle holes and previous lake positions, soils identified as Rego-

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[1] Soil classification is based on The Canadian System of Soil Classification, Preliminary Report (Canada Department of Agriculture 1976).

Gleysols occur.

There appears to be a 4 stage genetic sequence of soil development on the well-drained portions of the aeolian landscape:

1) Regosols - active and very recently stabilized sand dunes
2) Orthic Regosols - recently stabilized dunes and aeolian sand plains (Figure 4.1 sites 45,46 and most of the area west of the active dune complex)
3) Orthic Humic Regosols - a transitional type under jackpine-lichen woodland (Figure 4.1 sites 37-43)
4) Orthic Eutric Brunisols overlying Paleosols[1] - on the oldest aeolian landscape east of the active dune complex (Figure 4.1 sites 1-3,9,11).

The oldest soil types recorded, Dystric Brunisols, occur on the kame and kettle landscape of the eastern portions of the study area.

Soil forming materials are wind and water sorted sands and gravels and outwash till. The soil is extremely porous and nearly devoid of cohesion between the grains. They are classed as well to imperfectly drained and are readily leached. Due to the limitations of the measuring method, pH was only determined to the closest 0.5.

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[1] Paleosols are developed soils that have been over-topped by mineral materials. In this example (also see Appendix 8.3), an Orthic Eutric Brunisol develcped in aeolian sand overlies the Paleosol (Plate 4).

Nevertheless, pH had a range from 4.0 to 6.5 with the most common reading being 5.5. The soils are thus acidic and low in available plant nutrients. The frequent occurrence of charcoal in the soil profiles illustrates that fire has been a recurring event. Absence of a humus layer is due to low biomass, rapid oxidation of the organic matter and recurring lightning-caused fires.

4.2.6 Water Resources

Five aspects of water resources were investigated: navigable water routes, lakes suitable for light aircraft access, water quality, campsite potential (at beach locations with sandy shorelines) and suitability for swimming (Figure 4.4). Dissolved oxygen and pH of water were sampled in several locations.

4.2.6.1 Boating

There is not an extensive network of easily navigable canoe routes. Many streams are too shallow and portages between lakes for inter-lake travel are mostly long. However, individual lakes (especially Jade, Barber and Larocque Lakes), offer excellent canoe and small boat navigation due to their clear water, irregular shorelines, sandy beaches and diverse aquatic flora and fauna.

The Maybelle and Richardson Rivers and other streams in the study area have low gradients, narrow channels, a meandering flow pattern, and occasionally,

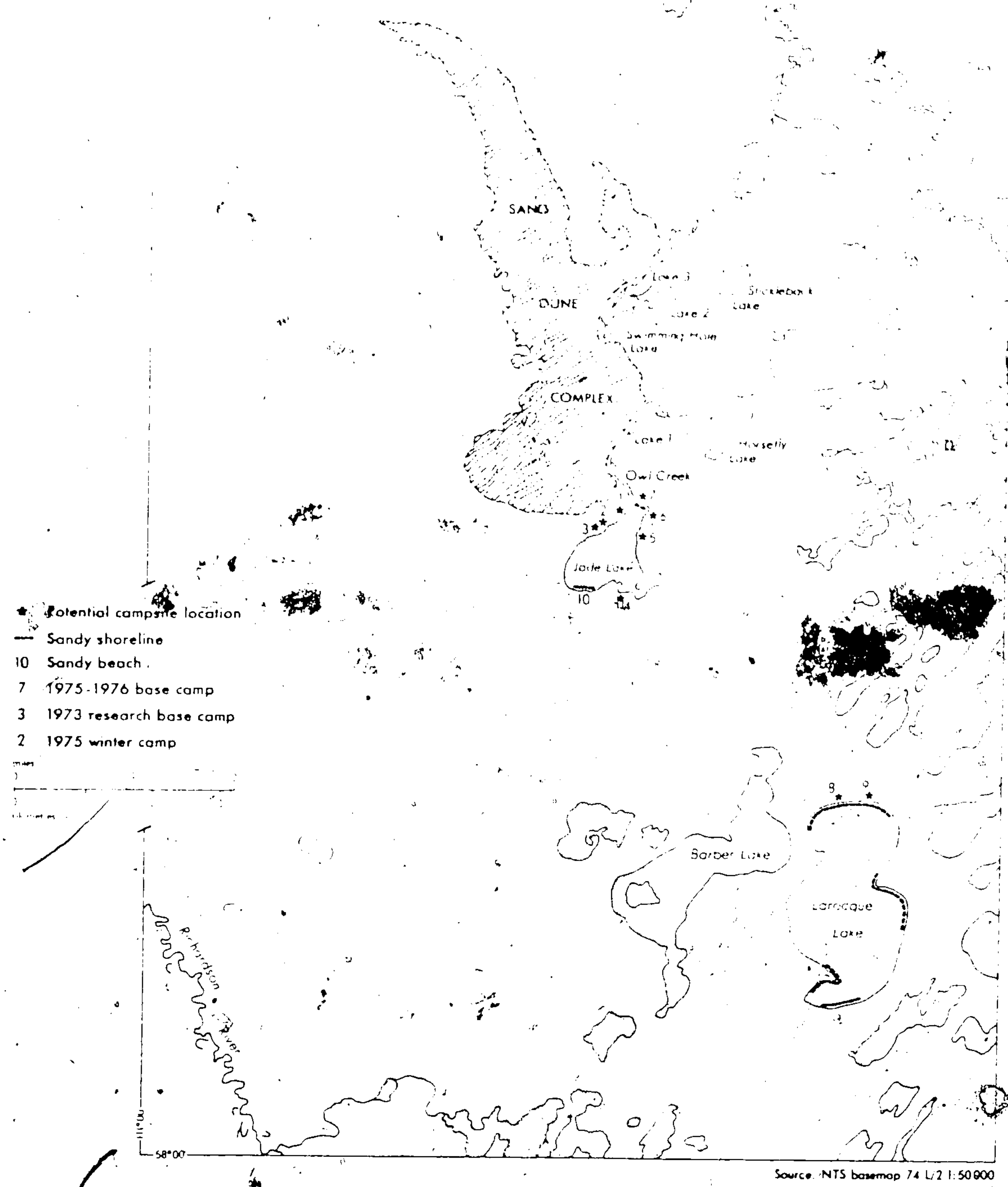


Figure 4.4 Water resources and potential campsite locations

boulder-strewn beds, and therefore have little potential as canoe routes.

4.2.6.2 Aircraft Access

Aircraft access is possible on three lakes in the study area, Jade, Barber and Larocque. I have been landed on Jade Lake in winter and summer. It is the only lake among the many small lakes along the east side of the active dune complex suitable for plane access.

4.2.6.3 Water Quality

Water in the lakes was slightly basic (7.5 to 8.0) (Table 4.5). This is normal for many lakes and rivers in the prairie provinces (Nelson 1978), but these readings appear to be high for the sand dune region, given the relatively acidic nature of the surrounding soils (Section 4.2.5). Moderately high dissolved oxygen readings (10 to 12 ppm) were plotted against recorded water temperature values (18 to 19°C) to obtain high saturations levels (106 to 125%). These high values mean that oxygen was readily available to aquatic lifeforms at time of recording (Nelson 1978). Lack of sediment and other impurities results in extremely clear and potable water throughout the study area.

Table 4.5 Water Conditions in Jade, Larocque [illegible] Lakes, Northeast Alberta

Date Sampled (1976)	Lake	Water Temp. (°C)	Dissolved Oxygen (ppm) (ave.) (n=3)	% Saturation of Dissolved Oxygen	Water pH (ave.) (n=3)
26 June	Jade	18	12.0	125	7.5
16 July	Larocque	19	11.0	117	8.0
17 July	Barber	19	10.0	106	7.5

4.2.6.4 <u>Camping and Swimming</u>

Larocque, Barber and Jade Lakes were studied to assess camping potential and suitability for swimming.

4.2.6.4.1 <u>Larocque Lake</u>

Larocque Lake (Plate 5) appears to be the most suitable lake for campsite development and water-based recreation. As the largest lake (2.9 x 1.8 km), it provides safe landing for float and ski planes under a variety of wind conditions. The arcuate northern shoreline has the longest sand beach in the study area (approximately 400 m). This and smaller sandy shorelines are mapped on Figure 4.4. Potential campsite locations have been investigated (Chapter 6).

4.2.6.4.2 Barber Lake

Barber Lake is 3.3 x 0.8 km, elongated NNE-SSW with irregular shorelines. Some sand beaches are evident on air photos but field investigations have shown them to be of poor quality (heavy growths of aquatic vegetation, and shorelines that are low and marshy or too steep for easy access).

4.2.6.4.3 . Jade Lake

Jade Lake (Plate 6) measures 1.5 x 1.0 km, and has a relatively regular shoreline and gently sloping beaches. The near-shore lake bottom is sandy and firm with sparse aquatic vegetation. There are 2 small sandy beaches (Figure 4.4, locations 7 and 10). The back-shore at the former location is not suitable for campsite development because of steep slopes (28° - 30°).

The following summary of water temperatures in Jade Lake indicates the suitability of the lakes for swimming. These temperatures should be representative of temperatures in lakes throughout the study area because they are all relatively shallow.

Lake temperatures varied little between morning and evening readings (Appendix 8.5). Temperatures ranged from a high of 21.3°C (4 August PM) to a low of 17.0°C (14 August PM).

4.3 Biological Environment

Three components of the biological environment were investigated, vegetation, wildlife and aquatic vertebrates.

4.3.1 Vegetation Classification and Mapping

Introductory information on the flora of the study area was gained from Moss (1959), Polunin (1[illegible]), Hulten (1968) and Rowe (1972). For this study, the purpose of the vegetation analysis was to identify the major community types, identify the indicator species for each and then assess the wilderness recreation qualities (walkability, aesthetics, susceptibility to disturbance from human use).

The study area is in the Athabasca south section of the boreal forest region (Rowe 1972). This vegetation is generally characterized by forests of jackpine (*Pinus banksiana*), frequently park-like in structure (Rowe 1972). Tree species also present, but of lesser significance, are larch (*Larix laricina*), white spruce (*Picea glauca*), black spruce (*Picea mariana*), aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*). This vegetation was classified into three major categories: large areas of jackpine-lichen woodland, smaller stands of boreal mixedwood, and isolated wetland vegetation types.

Further subdivision of vegetation types could have been done based on the information presented in Table 4.6

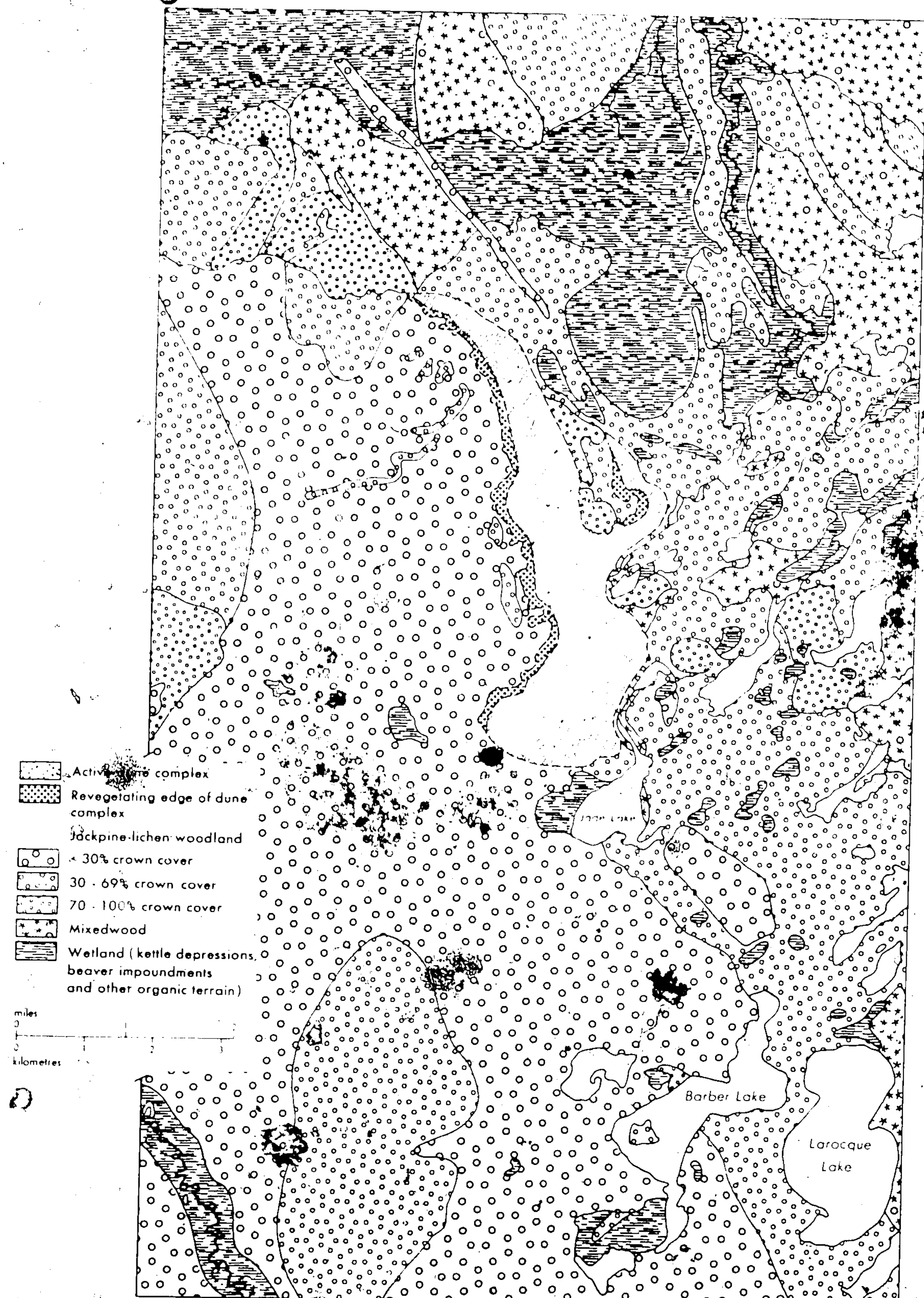
but would have been beyond the scope of this study. However, a number of important floristic distinctions are discussed with respect to recreational planning (e.g. campsite and trail locations, aesthetic considerations and water-based recreation activities), and significant physical features (most importantly, the active dune complex).

The distribution of vegetation in the study area is shown in Figure 4.5. Transect locations and sample plots are shown in Figure 4.1.

A systematic tabulation of the 143 plant species identified from the study area during 1975 and 1976 is presented in Appendix 8.1. Of the 143 species listed, 94 are vascular plants, 12 are mosses and 37 are lichens; 51 families and 102 genera are represented. This list is the first for the active sand dune area and adds to baseline information [illegible] the flora of northeast Alberta. _Cypripedium acaule_ and _Cicuta bulbifera_ are uncommon for the area and _Chimaphila umbellata_ var. _occidentalis_ appears to be the first recorded sighting for northeast Alberta (Dumais 1976).

4.3.1.1 Jackpine-lichen Woodland

The jackpine-lichen woodland type (Plate 7) has the greatest areal extent in the study area, and dominates perxeric, submesic and mesic (Table 4.6) sites west and south of the active dune complex (Figure 4.5). This type of vegetation is so classed because, of the two well-defined strata, virtually all of the species in the tree layer are



Sources: 1951 air photos 1:3333; 1955 AFS Cover Series 74 L/7 1:63360

Not shown on map are

1) Vegetation of the lee slopes and precipitation ridge

2) Shoreline communities (important for lake access from campsites, shoreline stability and aesthetics).

Figure 4.5 Vegetation of the study area

jackpine and from 60-100% of the plants in the moss-lichen layer are lichens (Table 4.6).

The tree stratum, for the majority of the sampled plots, is characterized by moderate cover values (<50%) and species significance values of 6 or less. Of the 50 sampled plots, 25 had only jackpine in the canopy.

Because of the environmental constraints (dry cool climate, excessively drained nutrient-deficient soils, recurring wildfires) the ground flora is composed mainly of lichens. This stratum has a high cover value for lichens (70-100%), especially Cladina mitis, C. stellaris and Cladonia uncialis and a diversity of less abundant lichen species. The highest number of terrestrial lichens recorded for any one sample plot was 13 (Table 4.6 plot 1).

In the more open jackpine-lichen woodland sample plots (for example Table 4.6 plots 6,17,38,43,45) lichen cover becomes patchy (Plate 8).

4.3.1.1.1 Variations Within the Jackpine-lichen Woodland Type

On some sites, changes in the values of one or more environmental factors (chiefly an increase in soil moisture or a decrease in time since fire) result in increases in bryophyte and ericoid species (Table 4.6). Cover values of mosses (especially Pleurozium schreberi and Polytrichum piliferum - plots 1,14,28) and ericoids (such as Arctostaphylos uva-ursi, Vaccinium myrtilloides and V.

Jackpine-lichen Woodland

Sample Plot Number	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]								
Soil moisture	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]		[illegible]										
Soil pH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
Number of plant species recorded	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]								
Total tree canopy cover (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]								
Total shrub cover (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]								
Total ground cover (%)	[illegible]	[illegible]	85	80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]								
Stand age (years)	72	72			64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	61		[illegible]	[illegible]									
Tree layer (>1 m)																							
Pinus banksiana	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]												
Picea mariana																							
Betula papyrifera																							
Populus tremuloides																							
Picea glauca																							
Larix laricina																							
Tall shrub layer (<1 m - >30 cm)																							
Alnus crispa														4									
Prunus pensylvanica																							
Salix spp.																							
Betula papyrifera																							
Myrica gale																							
Pinus banksiana																							
Picea mariana																							
Populus tremuloides																							
Low shrub layer (<30 cm)																							
Arctostaphylos uva-ursi	2	2	2	2		2	2		6	4	2	2	1	4	4		5	2		3	1	1	
Vaccinium myrtilloides	1			2			2		1		5	6	3	4	4						1		
Vaccinium vitis-idaea				1					1		3	3		5	4								
Chamaedaphne calyculata																							
Ledum groenlandicum																							
Pinus banksiana									1														
Empetrum nigrum															3	4		1				1	
Kalmia polifolia																							
Picea mariana																							
Prunus pensylvanica													1										
Herb Layer																							
Carex spp.																				1			
Hudsonia tomentosa	2															5		3	4	3		2	
Gramineae													2				4	1		3			
Maianthemum canadense									3		1	1	3		3								
Solidago spp.	1		1						1			1	1				2			2	1		
Eriophorum brachyantherum																							
Sarracenia purpurea																							
Aralia nudicaulis																							
Cornus canadensis											1												
Campanula rotundifolia			1			2						1					1						
Epilobium spp.									1														
Cypripedium acaule															2								
Rubus chamaemorus																							
Compositae																							
Tanacetum huronense																							

Table 4.6
Major Vegetation Types of the Study Area

. Jackpine-lichen Woodland

...le 4.6
...ypes of the Study Area

											Mixedwood							Wetland						
																		100	[illegible]	100	100	100	100	100
																				+156		128		+69
								2			6	6		1	4	1	5							
								4			5	4	4	2	4	4	2							
											6	6	1	3	5	2	5				1		3	1
																		5	5	3	4	2	5	5
													3							2	3	7	5	
		4			2	4																		
									4							2								
																		5						6
																				2				
1							5	5		6	3		5					6	6	6				
5	2		4	2	1	2			5															
			3				4	4	3	3	2		2											
								5			4	3			2	2								
								4			2	1												
																		4	4		3			4
																		3	3	2			3	
											2	3	3		3									
												3	2		4									
											1	1			1									
										2		1	2											
															1	2								
																								5
								3			2													
									3															

Table 4.6

Jackpine-lichen Woodland

Sample plot number	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]														
Soil moisture[1]	[illegible]	[illegible]	[illegible]																			
Soil pH	[illegible]	[illegible]																				
Number of plant species recorded	[illegible]		[illegible]	[illegible]					[illegible]				[illegible]					[illegible]				
Total tree canopy cover (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]		[illegible]									
Total shrub cover (%)	[illegible]		[illegible]										[illegible]		[illegible]							
Total ground cover (%)	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]																
Stand age (years)	[illegible]	[illegible]			[illegible]	[illegible]																
Moss layer																						
Pleurozium schreberi	3	2																				
Hylocomium splendens	3				2											4						
Dicranum spp.																						
Dicranum polysetum																						
Ptilidium ciliare	1				2																	
Lichen layer																						
Cladina mitis		6																			4	
Cladonia uncialis		2	3	4	3	4			1										4		4	
Cladonia gracilis			2		2	2	2	3	1										1			
Cladonia cornuta				2	3	1		3	2										1			
Cetraria nivalis		2	2	3	2	1	2	3	2	1	1		1	2					1			
Cladina stellaris	2	1	3	2	2	2	1	2	2	1	1		2	2								
Cladonia amaurocraea					2	2		1	2					1			2		3		4	
Cladonia cristatella		3		2		+	3												2	1		
Cladonia sp.			1		1	1		1	2							2		2				
Peltigera malacea	3		1						1				1	2		1		1				
Cetraria islandica				2	1	1		2			1		1	1			2					
Cladonia arbuscula													1	1								
Stereocaulon tomentosum														+					4	2		
Cladonia pleurota						+											2			1		
Cladonia rangiferina					1			2	1					1								
Cladonia crispata						2																
Cladonia chlorophaea					1																	
Cladonia phyllophora																						
Cladonia verticillata																						
Epiphytic lichens	4	+	6	3	3		+	+	3	3	3	4		5	4			2	1		1	

[1] Soil moisture: 0) Xeric; 1) Perxeric; 2) Submesic; 3) Mesic; 4) Permesic; 5) Subhygric; 6) Hygric.

[2] Species Significance Index (Cover Abundance): +) Single or rare occurence; 1) Occurring seldom, cover negligible; 2) Rare, covering up to 5% of the plot; 3) Common, covering 6-10% of the plot; 4) Occurring often, covering 11-20% of the plot; 5) Occurring very often, covering 21-35% of the plot; 6) Abundant, covering 36-50% of the plot; 7) Abundant, covering 51-75% of the plot; 8) Very abundant, covering 76-95% of the plot; 9) very abundant, covering 96-100% of the plot.

Table 4.6 (continued)

Jackpine-lichen Woodland	Mixedwood

Mixedwood							Wetland						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24	[illegible]	[illegible]	[illegible]	12	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100	[illegible]
									[illegible]		128		+69
											2		
											6		
							[illegible]	[illegible]	[illegible]		[illegible]	6	8
											3	5	6
													3
											2		3
												2	
											3		
													3
											4		
											2		
											1		

vitis-idaea - plots 8,11,18,31) in the low-shrub and herb layers were highest (<25%) in early post-fire successional stands (plot 18) and along gently sloping near-shore locations (plot 31). An increase in cover values for Polytrichum piliferum and Hudsonia tomentosa (plots 18,21,26,43) are indicators that an area was recently disturbed by fire or erosion. On recent fire-disturbed surfaces in the lee of fixed transverse dunes (plot 48) an increase in annual and perennial herbs was recorded, especially the grasses Agrostis scabra, Bromus pumpellianus and B. marginatus and the composites Solidago decumbens, S. lepida and Achillea millefolium.

At a number of sites, 2 mosses (Pleurozium schreberi and Polytrichum piliferum) increased in cover value to become nearly co-dominant with the lichen component (plots 3,5,7,25,36,40-42). These pioneer moss species appear on sites after surface disturbances such as along the winter road (Figure 4.9; plots 37,39), after wind erosion (plot 7), and in the early stages of regeneration after fire (plots 46-48). These variations in the moss-lichen cover are discussed in Chapter 6 in context of their constraints on recreational development.

Many of the older jackpine stands sampled (>70 years) have high cover values for arboreal lichens (Plate 21). Common species are Cetraria pinastri, C. halei, Hypogymnia physodes, Parmelia sulcata, Evernia mesoporpha, Usnea hirta, U. subfusca and Alectoria glabra.

They have a high aesthetic value, particularly after a rain. Whereas dry lichens are pale, brittle and appear to be dead or dying, lichens moistened by rain are pliable, rich in color, and appear to 'come alive'.

Much of the diversity in stand composition and age of the jackpine-lichen vegetation type is a result of recurring wildfire (stand ages are recorded in Table 4.6; ages were not available for plots 5,7,10,12-17,21-24,27,29,30,44). Therefore, this factor has important implications for the vegetation and wildlife of the study area.

4.3.1.1.2 The Ecological Importance of Fire in the Jackpine-Lichen Woodland of the Study Area

Fire records for northeast Alberta reveal a high incidence of lightning-caused wildfires. Of 6 locations in the Prairie Provinces tested during June - August 1956-1967, the Fort McMurray area experienced the highest mean thunderstorm-hours per month (Longley 1972:29). Many well-developed convection cells were observed over the study area during the 1975-1976 field seasons which resulted in local thunderstorm activity.

A search of fire records (which span 1958-76) and subsequent site research revealed that fire is a frequent and integral factor in the ecology of the study area.

During 1958-76, 45 fires in the study area and vicinity were reported and suppressed. Closer examination of data shows that only 8 fires occurred in the 10-year period 1958-67 while the remaining 37 fires occurred in the following 1968-76 period. (This interpretation must be viewed carefully. The increase may be due to improved detection techniques in the 1968-76 10-year period.) The most common stand age was 76 years signifying that a fire in 1900 (±2 years) was widespread over the study area. Variable patterns of fire occurrence can be related to specific weather conditions (coincident with lightning activity). All fires were lightning-caused.

The majority of fires reported were small in areal extent. Only 4 fires exceeded 200 ha including the 1963 Richardson River fire of 1150 ha. Hence, the jackpine-lichen forests are composed of a diverse mosaic of stand ages and densities resulting primarily from small, lightning-caused fires.[1]

Five fire sites were sampled which revealed distinctive successional trends, associated changes in wildlife habitat, and implications for recreation planning. Using time since fire as the dependent variable these characteristics were grouped into 4 age classes (Table 4.7). The ecological implications of each age stand are discussed

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[1] Jackpine stands develop best where fire has prepared a suitable seedbed, with exposed mineral soil and a minimum of organic matter. The maximum seeding of jackpine occurs after fires since a dry heat of at least 27°C is required to open the seed-bearing serotinous cones (Smith 1966: 143).

below.

4.3.1.1.2.1 Plant Succession Following Fire

The successional trend in jackpine-lichen regeneration after fire is characterized by rapid establishment of jackpine seedlings (7600 to 14,500/100m² - Table 4.7) (sites 46,48 Figure 4.1) accompanied by several forbs including Maiantuemum canadense and Solidago spp. Immediately after fire, many jackpine seeds speckle the ash-covered ground surface.

In the second age stand (13 years after fire), cover-abundance and species significance differed markedly from 1-year old stands. In the 13-year old stands (sites 40,41,43 Figure 4.1), the number of jackpine seedlings had declined significantly (142 to 539/100m²). Also, the percentage of bare ground had decreased with establishment of Hudsonia tomentosa, Polytricum piliferum and a number of lichens, especially Stereocaulon tomentosum, Cladonia cristatella and C. gracilis.

In the 72-year old stands (sites 1-3, 11 Figure 4.1), stand densities varied from 16/100m² (site 1) to 88/100m² (site 2). The density of tree cover and an increase in moisture availability tends to influence shrub development. Arctostaphylos uva-ursi and Vaccinium myrtilloides dominate the shrub layer in the more open stands (16-50 trees/100m²). In slight depressions with mesic soil conditions, Prunus pensylvanica and Alnus crispa

Table 4.7

Plant species and percent cover at 4 different-aged burns in the study area.

	Site reference number (Figure 4.1)	46	48	40	41	43	1	2	36	49
	Age of canopy	1	1	13	13	13	72	72	157	157
	Bare soil (%)	30	--	15	15	40	5	5	---	20
Layers	Plant species	% cover								
Tree layer	*Pinus banksiana*	3[1]	--	6	4	6	5	7	5	5
	Populus tremuloides	--	2	--	--	--	--	--	--	--
	Betula papyrifera	--	--	--	--	--	--	--	[illegible]	--
	Picea mariana	--		--	--	--	--	--	1	--
Tall shrub layer	*Prunus pensylvanica*	--	1	--	--	--	1	--	--	--
Low shrub layer	*Arctostaphylos uva-ursi*	--	2	2	1	--	1	--	2	2
	Vaccinium myrtilloides	--	--	--	--	--	3	--	+[2]	--
	Vaccinium vitis-idaea	--	4	--	--	--	--	--	+[2]	--
	Pinus banksiana (seedlings/100 m^2)	14,500[3]	7600	533	142	209	--	--	--	--
Herb layer	*Hudsonia tomentosa*	2	--	4	2	4	--	--	--	--
	Maianthemum canadense	--	5	--	--	--	3	--	--	--
	Solidago spp.	--	4	--	--	--	1	--	--	--
Moss and lichen layer	*Polytrichum piliferum*	3	--	5	7	6	3	1	5	2
	Pleurozium schreberi	--	--	--	--	--	2	1	5	2
	Dicranum polysetum	--	--	--	--	--	1	--	--	--
	Ptilidium ciliare	--	--	--	--	--	--	1	3	2
	Cladina mitis	--	--	2	2[1]	1	7	7	5	6
	Cladonia gracilis	--	--	4	2	1	2	1	2	3
	Cladonia cornuta	--	--	3	2	--	2	2	3	3
	Cladonia cristatella	--	--	7	7	1	--	--	--	1
	Cladonia amaurocraea	--	--	1	+[2]	2	1	2	5	3
	Cladonia uncialis	--	--	--	--	--	2	3	3	5
	Cetraria nivalis	--	--	--	--	--	2	2	2	3
	Cladonia rangiferina	--	--	--	--	--	1	1	5	2
	Cladina stellaris	--	--	--	--	--	2	2	--	2
	Cladonia deformis	--	--	4	--	+[2]	--	2	--	1
	Peltigera malacea	--	--	--	--	--	2	3	--	--
	Cladonia pleurota	--	--	2	1	2	--	--	--	--
	Cetraria islandica	--	--	--	--	--	1	--	--	2
	Stereocaulon tomentosum	--	--	--	--	2	+[2]	--	--	--
	Cladonia arbuscula	--	--	--	--	--	1	--	--	--
	Cladonia verticillata	--	--	+[2]	--	--	--	--	--	--
Arboreal lichens	*Usnea* spp., *Evernia mesomorpha*, *Alectoria fremontii*	--	--	--	--	--	5	4	+[2]	+[2]

[1] fire remnant, not burned

[2] trace

[3] number of seedlings, cover values not recorded.

are associated with this age stand (sites 3,16 Figure 4.1). The almost completely vegetated ground surface (95-100%) is dominated by Cladonia mitis, C. uncialis and the moss Pleurozium schreberi. Of lesser abundance, but characteristic of these stands, are a number of terrestrial lichens including Cladina stellaris, Cetraria nivalis, Cladonia uncialis, C. rangiferina, Peltigera malacea and the moss Polytrichum piliferum. In the most open 72-year old jackpine-lichen stands (site 5,6 Figure 4.1), the ground cover is patchy (<75% cover) and soil is poorly developed, shallow and xeric.

Dwarf mistletoe (Arceuthobium americanum) occurs on many jackpines in the study area, but is most evident on trees in the 72-year old stands. Certain topographic areas have a high proportion of broomed individuals, namely ridges and stabilized dune crests that are exposed to prevailing west winds. Fire controls the spread of witches broom by destroying the infected trees (Hiratsuka 197[illegible]).

Two examples of 157-year old jackpine stands were investigated (sites 36,49 Figure 4.1). The stand age and density were similar (5/100m²), but a different lichen cover occurred at each site. The oldest observed lichen cover occurred at site 36. At this location a fixed transverse dune, surrounded on 3 sides by water, created a refuge from fire. A wedge taken from a jackpine in the interdune depression adjacent to site 36 had 3 fire scars indicating previous fires in 1916, 1904 and 1876. The tree was 157 years old, suggesting that the last crown fire was in 1819. Absence of fire scars on trees on top of the dune (the refuge) indicates a 157 year absence of surface fires. Thus, the oldest lichen community is characterized by a total ground cover with a high cover-abundance of Cladonia rangiferina, C. mitis, C. uncialis and Cladina stellaris (Table 4.7). Bryophytes associated with this lichen community include equal percentages of Pleurozium schreberi and Polytrichum piliferum and lesser amounts of Ptilidium ciliare. Although the mosses were partially concealed by the 8-10 cm of lichen cover (the thickest lichen mat recorded), equal cover was noted for mosses and lichens (50% each). The high percentage of moss cover suggests a moist surface environment, another factor deterring spread of surface fires.

Site 46 (Figure 4.1) is a 157-year old jackpine-lichen stand protected to the west by a large wetland which is credited with intercepting crown fires advancing from the west and northwest. Fire scar interpretation revealed that the last surface fire at this site had occurred in 1900, advancing from the north (Plate 9). The present lichen community is dominated by Cladina mitis, C. stellaris, Cladonia uncialis, C. rangiferina, C. cornuta and Cetraria nivalis, similar to the 72-year old moss-lichen stratum. Bryophyte cover is 10% with equal percentages of Ptilidium ciliare, Polytrichum piliferum and Pleurozium schreberi. In areas close to the wetland an increase of Vaccinium *myrtilloides* occurs.

In conclusion, at least 4 ages of post-fire regeneration were identified in the study area. One and 13-year old stands are typified by numerous jackpine seedlings that develop rapidly, and these are usually accompanied by *Hudsonia tomentosa*, *Polytrichum piliferum* and *Stereocaulon tomentosum* that serve to bind the surface. The and 157-year old stands are characterized by a rapid decline in the density of jackpine and an increase in the *Cladonia* and *Cladina* dominated ground cover. This successional pattern has been noted for other locations in the boreal forest by Rowe and Scotter (1973).

4.3.1.1.2.2 Nutrient Cycling

As Smith (1966) noted, jackpine stands develop best where fire has prepared a suitable seedbed with exposed mineral soil. The ash-covered ground surface noted in the 1-year old communities provides available concentrations of calcium, potassium and phosphates similar in composition to a considerable application of fertilizer (Burton 1944). Thus, nutrients, which were previously tied up in the live biomass, are made available by fire. This influence was exemplified by the rapid growth of jackpine seedlings at sites 46 and 48 (Figure 4.1). The fire-induced nutrient recharge is of short duration and favors plants like jackpine that are able to establish quickly.

4.2.1.2.3 Fire and Wildlife Habitat

The value of jackpine-lichen communities as wildlife habitat appears to be lowest in the early stage after fire. Only [illegible] bird species were observed in the 1-year old stands.

In the 72-year old stands, abundant cone crops, wood litter, patchy lichen cover, and ericoid berry crops provide a more varied habitat which is particularly used by red squirrels, black bears and a variety of bird species (Table 4.8). Past use by caribou also illustrates the importance of this habitat age class. This is the most widespread of all the forest age classes, thus increases in man-caused fires could severely reduce wildlife habitat in the study area.

The 157-year old communities appear to have habitat qualities similar to the 72-year old habitats.

4.2.1.3 Mixedwood Vegetation Types

The mixedwood type (Plate 10) occurs principally in the eastern portion of the study area (Table 4.6 plots 4,16,30). It is classed as mixedwood because the tree stratum is composed of both coniferous and deciduous species. This vegetation type is the most diverse upland community in the study area. Structurally, the mixedwood type has 5 well-developed strata and is therefore made up of the greatest number of plant species in the study area (29,26 and 25 species in plots 35,26 and 25 respectively).

The 5 strata are made up of the following species:

1) Tree layer - the main species (listed in order of decreasing cover value) are *Pinus banksiana*, *Betula papyrifera*, *Populus tremuloides*, *Picea mariana* and *Picea glauca*.

2) Tall shrub layer - dominated by *Alnus crispa*, *Prunus pensylvanica*, *Salix* spp. and *Betula papyrifera*.

3) Low shrub stratum - dominated by *Arctostaphylos uva-ursi*, *Vaccinium myrtilloides* and *Ledum groenlandicum*.

4) Herb layer - characterized by sedges and grasses *Maianthemum canadense*, *Aralia nudicaulis*, *Cornus canadensis* and *Epilobium* spp.

5) Moss-lichen layer - the most common mosses are *Pleurozium schreberi* and *Dicranum polysetum*, and common lichens are *Cladina mitis*, *Cladonia uncialis* and *C. amaurocraea*.

Detailed species composition for each stratum is recorded in Table 4.6.

Functionally, the mixedwood type has the most developed soils (Dystric Brunisols), and were estimated to have the highest nutrient availability, the highest productivity, the greatest biomass, and create the richest ildlife habitat.

4.3.1.3 Wetland Vegetation Types

Several types of plant communities are associated with depressional sites in the study area. These vegetation types, collectively classed as wetland communities (Plates 11,17), mostly result from the early stages of plant succession in shoaling kettle lakes (plots 22,24), and more advanced succession in shoaling kettle holes where up to 30 cm of organic buildup was recorded (plots 9,10,12,19). Wetlands also occupy the extensive lowlands of the northeastern section of the study area (plot 20). Only the indicator species were identified for the wetland communities (Table 4.6).

The dominant species in the herb layer of early successional wetland sites are Equisetum fluviatile, Juncus balticus, Sarracenia purpurea, Carex aquatilis and C. rostrata. The moss layer is dominated by Sphagnum spp. while open water areas contain Potamogeton alpinus, P. natans, P. obtusifolium and Nuphar variegatum. Generally, this vegetation has a littoral zonation from wetter (pondweed and pond-lily) to drier areas (mosses, sedges and horsetail).

Later successional stages within the wetland vegetation complex have drier site conditions (due to increased elevations of the organic terrain), have increased species diversity (Table 4.6 plots 12,19), and usually have 4 well-developed strata:

1) Tree layer - dominated by Picea mariana and Larix laricina

2) Low shrub layer - characterized by Chamaedaphne calyculata, Kalmia polifolia, and Ledum groenlandicum

3) Herb layer - common species are *Eriophorum brachyantherum* and *Rubus chamaemorus*

4) Moss-lichen layer - dominated by *Sphagnum* spp. and increasing values for foliose lichens, especially *Cladina mitis*, *Cladonia uncialis*, *C. deformis* and *C. cornuta*.

4.3.1.4 Shoreline Vegetation

A discrete vegetation type (Plate 19) occupies the margins of most lakes, ponds and streams in the study area. This band of riparian vegetation varies in width with the steepness of the shoreland (the strip narrows as the slope, and thus the soil moisture gradient, steepens). Plants characteristic of the wettest sites (emergent zone) are *Phragmites communis* and *Carex aquatilis*, succeeded upslope by a 2-10 m wide band of *Myrica gale*, *Vaccinium myrtilloides* and *Auralia nudicaulis* (Table 4.6 plot 44). On steeper slopes (20-30°) there may be an upslope zonation to *Betula papyrifera* and *Picea mariana* (Table 4.6 plots 34,35). This band of vegetation normally has a well developed lower stratum of forbs, grasses and mosses (Table 4.6).

4.3.1.5 Vegetation of the Active Dune Complex

The morphology of the coalescing transverse dunes of the active dune complex (Section 4.2.4.3.4) partially results from the interaction of wind-blown sand and sand-binding plants that modify dune shape and size. The shape of dunes in part depends on the ability of these plants to become established and maintain their position as the dunes roll over them (Cowles 1901). Plants are therefore important components of the active dune complex.

No classifiable vegetation types or consistent patterns of vegetation communities were identified for the dynamic sand and gravel surfaces of the active dune complex. Nevertheless, although cover-abundance values are low, the dunes display a diverse flora. A generalized vegetation pattern was identified for three sites:

1) The revegetating windward edge
2) The lee slopes and interdune depressions
3) The precipitation ridge.

4.3.1.5.1 The Revegetating Windward Edge

Along the western edge of the active dune complex, vegetation is establishing and stabilizing the sand surface (Plate 12). Initially, stabilization is due to the ability of *Hudsonia tomentosa* and *Empetrum nigrum* to become established under conditions of soil drought and a surface that is constantly aggrading and degrading. Moss (1959) notes that *Hudsonia tomentosa* commonly colonizes pine sand-hills and dune locations. Polunin (1959) describes *Empetrum nigrum* as growing chiefly on rather dry areas of sand or gravel that are favorably sheltered in summer and well covered with snow in winter. Similar circumstances were recorded by Hermesh (1972) in the Athabasca Dunes of northwest Saskatchewan. Two surface-binding species, the moss Polytrichum piliferum and the crustose lichen Stereocaulon tomentosum increase in abundance westward toward the forested area and the fixed dune plain (Table 4.6 plots 18,26). Rowe and Scotter (1973) also note that bryophyte species such as Polytrichum piliferum soon appear on burned-over areas or other disturbed sites.

Once the surface of the revegetating edge has been stabilized by pioneer species, jackpine and a patchy ground cover of Cladina mitis are able to establish and eventually succeed the Hudsonia-Empetrum-Polytrichum-Stereocaulon fringe.

4.3.1.5.2 Lee Slopes and Interdune Depressions

Certain plants appear to favor the sand and gravel depressions, lee slopes and crests of the coalescing transverse dunes. In some cobble depressions (Table 4.6 plot 27), high cover values were recorded for Empetrum nigrum, Hudsonia tomentosa and Polytrichum piliferum. Upslope, in the lee of some transverse dunes, dune grasses, including Agropyron smithii, Koeleria cristata, Agrostis scabra, Bromus marginatus, Calamagrostis neglecta and rarely Festuca rubra are established (Plate 13). Wherever these species are found they have the following general distribution: Agropyron smithii occupies the driest sites along the dune ridges, while Koeleria cristata, Calamagrostis neglecta and Festuca rubra dominate the more moist lee slopes, and Agrostis scabra occupies the base of lee slopes in the wettest (mesic) locations. Moss (1959) describes Agropyron smithii and Koeleria cristata as common on prairie grasslands, while Calamogrostis neglecta is common on dry slopes (Polunin 1959). Festuca rubra is also noted for colonizing sandy areas (Polunin 1959:54).

According to Hermesh (1972), most grasses growing in sand dunes are able to withstand the severe environment of an aggrading sand surface by sending out rhizomes and stems which grow to a point near the surface and then form shoots which raises the whole plant to a higher level. Other species (for example Betula papyrifera) have extensive secondary or adventitious rooting from the buried portions of the stems (Plate 14). This type of vegetation development impedes sand movement and influences the morphology and amplitude of individual dunes in the active dune complex. Occasonally, Tanacetum huronense var. floccasum, a leading dune-fixing plant in the Lake Athabasca dunes of Saskatchewan (Moss 1959), was recorded on the dune crests.

4.3.1.5.3 The Precipitation Ridge

On the east side of the dune complex, where actively blowing sand invades the forest and water bodies (Plates 15, 18), there is a large transverse dune or precipitation ridge (Cooper 1958). This ridge has a long, gentle, windward deflation slope (averaging 4.7°) and a steep lee slope (averaging 28°). Although heights up to

35 m from the base of the lee slope to the dune crest were measured, the ridge normally has a height equal to that of the adjacent jackpine forest (8-10 m).

The lee slope is partially vegetated by trees, shrubs, and a few forbs and grasses which hold sand and increase the height of the ridge.

4.3.2 Wildlife

Introductory information on the distribution and life histories of wildlife in northeast Alberta is presented by Fuller (1967), Hampson (1967), Banfield (1974) and Salt and Salt (1976). The purpose of wildlife investigations was to identify the major species present in the study area (especially those such as black bear and red squirrel that would most likely interact with visitors) and to acquire knowledge of their habitat relationships (Table 4.8, Figure 4.6).

The 101 species recorded from various sources for the study area are listed in Appendix 8.2. Eleven species of aquatic vertebrates, 75 birds and 15 mammals were observed (or their presence noted through tracks, scats, or other signs). Forty-six families and 85 genera are represented.

4.3.2.1 Black Bear

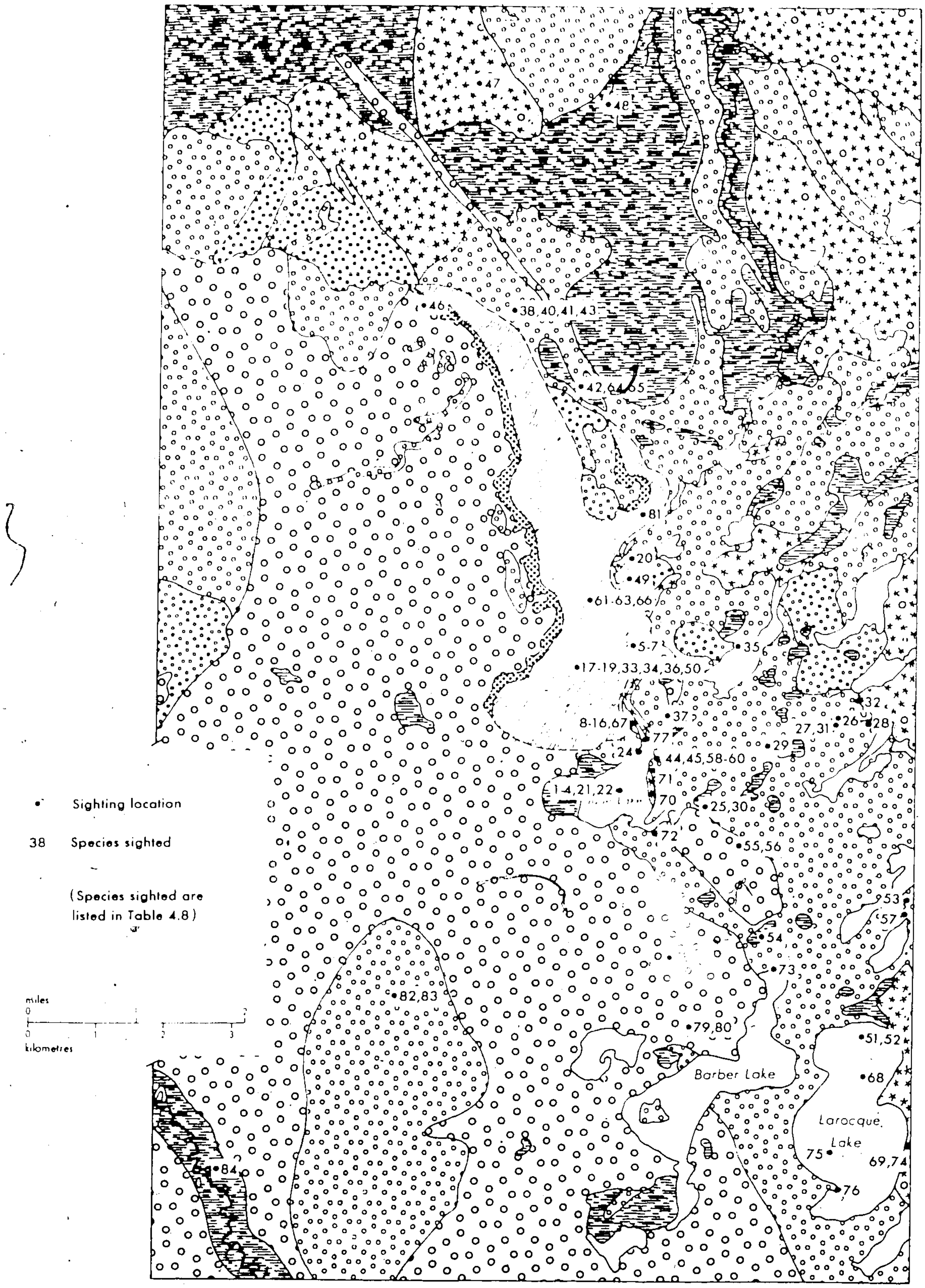
The sand dune area supports a large black bear (Ursus americanus) population. Abundant berry crops

(Figure 5.2) (in order sighted)

25 June	1	bufflehead	single male	common	Jade Lake
25 June	2	common tern	6 - 10 in flight	very frequent	active dunes
25 June	3	red-winged blackbird	1 adult male	very frequent	mixedwood wetlands
25 June	4	spotted sandpiper	1	frequent	active dunes
25 June	5	killdeer	1	frequent	active dunes
25 June	6	American robin	1 adult male	common	mixedwood
25 June	7	gray jay	6 adult males and females	very frequent	mixedwood
25 June	8	mallard	1 female on nest	frequent	Owl Creek
25 June	9	common crow	1	common	mixedwood
25 June	10	common loon	1	very frequent	Jade Lake, small kettle lake
25 June	11	chipping sparrow	1 adult male	common	mixedwood
25 June	12	song sparrow	1	common	mixedwood
25 June	13	savannah sparrow	1	common	active dunes
25 June	14	slate-colored junco	1	common	mixedwood
25 June	15	common nighthawk	2	very frequent	jackpine-lichen woodland, mi
25 June	16	common tern	2 eggs	very frequent	active dunes (sand surface)
25 June	17	wolf	tracks	rare	active dunes
25 June	18	moose	scats, tracks, browsed willows	rare fresh tracks; frequent winter scats	active dunes
25 June	19	black bear	scats, tracks	very frequent	active dunes
25 June	20	beaver	2	frequent	Swimming Hole Lake
26 June	21	red-necked grebe	2 mating pairs	common	Jade Lake
26 June	22	surf scoter	1	common	Jade Lake
26 June	23	sandhill crane	2 mating pairs	very frequent	Jade Lake
27 June	24	Canada goose	1	common	Jade Lake
27 June	25	sandhill crane	nesting pair	very frequent	kettle hole wetland
27 June	26	spruce grouse	nesting female	very frequent	jackpine-lichen woodland
27 June	27	common nighthawk	nesting female	very frequent	jackpine-lichen woodland
27 June	28	solitary sandpiper	nesting female	frequent	small lake
27 June	29	warbling vireo	1	common	jackpine-lichen woodland
27 June	30	lesser yellowlegs	1 adult male	frequent	kettle hole wetland
27 June	31	eastern kingbird	1	common	jackpine-lichen woodland
27 June	32	osprey	nesting pair with young	rare (only pair sighted)	mixedwood
28 June	33	Swainson's hawk	1 (hunting)	rare	active dunes
28 June	34	red-tailed hawk	1 (hunting)	common	active dunes
29 June	35	belted kingfisher	1	rare	Horsefly Lake
29 June	36	Franklin's gull	small flock (6 - 10)	frequent	active dunes
29 June	37	Bohemian waxwing	3 - 4	frequent	jackpine-lichen woodland
1 July	38	common crow	1	common	jackpine-lichen woodland
1 July	39	shoveler	1	common	wetland
1 July	40	boreal chickadee	3 - 4	frequent	jackpine-lichen woodland
1 July	41	ruby-crowned kinglet	1 adult male	rare	jackpine-lichen woodland
1 July	42	California gull	small flock	frequent	wetland
1 July	43	Tennessee warbler	1	rare	jackpine-lichen woodland
1 July	44	spotted sandpiper	1 adult male	frequent	Jade Lake (basecamp dock)
2 July	45	little brown bat	several	frequent	basecamp
3 July	46	caribou	dropped antler	common	active dunes
3 July	47	red crossbill	1 adult male	rare	jackpine-lichen woodland
3 July	48	sparrow hawk	1 (hunting)	rare	jackpine-lichen woodland
4	49	lesser scaup	large flock (about 50)	frequent	Swimming Hole Lake
4 July	50	coyote	1 set of tracks	common	active dunes
9 July	51	common loon	3 flocks of 40 each	very frequent	Larocque Lake
9 July	51	surf scoter	20 females, non-breeding	common	Larocque Lake
9 July	52	bald eagle	1 adult (soaring)	rare	Larocque Lake
9 July	53	northern three-toed woodpecker	1 adult female	common	mixedwood
9 July	54	sandhill crane	6 - 7 males, females, juveniles	very frequent	wetland
9 July	55	common nighthawk	1 female, nesting; 2 flightless young	very frequent	jackpine-lichen woodland
9 July	56	spruce grouse	males, females, young along transect 6	very frequent	jackpine-lichen woodland, mixedw
9 July	57	pigeon hawk	1	rare	mixedwood nea[redacted]
9 July	58	red-breasted merganser	2 (male and female)	common	Jade Lake [redacted]
9 July	59	black bear	1 yearling	frequent	jackpine-lic[redacted]
10 July	60	beaver	1 adult	very frequent	Jade Lake
10 July	61	Brewer's sparrow	nesting pair with young	common	active dunes, interdune depressio
10 July	61	chipping sparrow	nesting pair with eggs	common	active dunes, interdune depressio
10 July	62	rusty blackbird	1 adult male	[illegible]	

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] June	[illegible]	belted kingfisher	[illegible]	rare	[illegible]
[illegible] June	[illegible]	Franklin's gull	small flock [illegible]	frequent	[illegible]
[illegible] June	[illegible]	Bohemian waxwing	1	frequent	[illegible]
[illegible] July	[illegible]	[illegible]	1	common	[illegible]
[illegible] July	[illegible]	shoveler	1	common	wetland
[illegible] July	[illegible]	[illegible]	[illegible]	frequent	[illegible]
[illegible]	[illegible]	ruby-crowned kinglet	[illegible]	rare	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	frequent	wetland
[illegible]	[illegible]	[illegible] warbler	1	rare	[illegible]
[illegible]	[illegible]	spotted sandpiper	[illegible] adult male	frequent	[illegible]
[illegible]	[illegible]	little brown bat	several	frequent	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	common	active dunes
[illegible] July	[illegible]	red crossbill	[illegible] adult male	rare	jackpine [illegible] woodland
[illegible] July	[illegible]	sparrow hawk	[illegible]	rare	jackpine lichen woodland
[illegible] July	[illegible]	[illegible]	large flock [illegible]	frequent	[illegible] Lake
[illegible] July	[illegible]	coyote	1 set of tracks	common	active dune
9 July	[illegible]	common loon	[illegible] flocks of [illegible]	very frequent	Larocque Lake
[illegible] July	[illegible]	surf scoter	20 females, non breeding	common	Larocque Lake
9 July	[illegible]	bald eagle	1 adult [illegible]	rare	Larocque Lake
9 July	53	northern three-toed woodpecker	1 adult female	common	mixedwood
9 July	[illegible]	sandhill crane	6 [illegible] males, females, juveniles	very frequent	wetland
9 July	[illegible]	common nighthawk	1 female, nesting; 2 flightless young	very frequent	jackpine lichen woodland
9 July	56	spruce grouse	males, females, young along transect 6	very frequent	jackpine lichen woodland, mix[illegible]
9 July	57	pigeon hawk	1	rare	mixedwood near lake margins
9 July	58	red-breasted merganser	2 (male and female)	common	Jade Lake
9 July	59	black bear	1 yearling	frequent	jackpine-lichen woodland
10 July	60	beaver	1 adult	very frequent	Jade Lake
10 July	61	Brewer's sparrow	nesting pair with young	common	active dunes, interdune depres[illegible]
10 July	61	chipping sparrow	nesting pair with eggs	common	active dunes, interdune depres[illegible]
10 July	62	rusty blackbird	1 adult male	common	Horsefly Lake
12 July	63	olive-sided flycatcher	1 adult male	common	black spruce wetland
12 July	64	ruffed grouse	2 adult [illegible] and female)	common	edge of wetland
12 July	65	teal	2	rare	wetland depression
12 July	66	eastern kingbird	pair, adults	common	black spruce wetland
12 July	67	great horned owl	1 adult	rare	Owl Creek
16 July	68	surf scoter	2 females with broods	common	Larocque Lake
16 July	69	pileated woodpecker	1 adult male	rare	Larocque Lake (shoreline)
16 July	70	pileated woodpecker	1 adult male	rare	Jade Lake (shoreline)
16 July	71	sandhill crane	2 adults and 2 young	very frequent	Jade Lake
17 July	72	river otter	1 adult female and 3 juveniles	frequent	[illegible] Lake (abandoned beaver lod[illegible]
17 July	73	caribou	scats and cratering, past winter	rare	jackpine-lichen woodland
17 July	74	Oregon junco	6 adults, male and female	common	mixedwood
17 July	75	osprey	2 adults	rare	Larocque Lake
17 July	75	bald eagle	2 adults, 2 juveniles	rare	Larocque Lake
17 July	76	northern phalarope	flock of about 30 shorebirds	common	Larocque Lake
17 July	76	Wilson's phalarope		common	Larocque Lake
17 July	76	least sandpiper		common	Larocque Lake
17 July	76	western sandpiper		common	Larocque Lake
18 July	77	muskrat	2 adults	common	Jade Lake
23 July	78	black-backed three-toed woodpecker	1 adult	rare	jackpine-lichen woodland
23 July	79	herring gull	1 adult	common	[illegible]kpine-lichen woodland
23 July	80	common nighthawk	>50 in a flock	very frequent	jackpine-lichen woodland
25 July	81	white pelican	1 dead, found by AES on dunes	rare	active dunes
29 July	82	yellow warbler	1 adult	common	jackpine-lichen woodland
29 July	83	red-breasted nuthatch	1 adult	common	jackpine-lichen woodland
30 July	84	otter	1 adult, 3 young	frequent	Richardson River

*A complete listing of wildlife species recorded during 1975 and 1976 is included as Appendix 8.2.



Sources: 1951 air photos 1:3333; 1955 AFS Cover Series 74 L/2 1:63360

Figure 4.6 Wildlife sightings recorded in the study area during June - August 1976 including Arctostaphylos uva-ursi, Vaccinium vitis-idaea, V. myrtilloides and Empretrum nigrum, and good winter denning sites along root-bound sandy slopes, provide excellent habitat conditions. Actual numbers of black bears in the study area are not known, but judging from sightings plus numerous scats, trails, feeding sites and other signs, the study area supports a very dense population.

4.3.2.2 Red Squirrel

The most visible mammal in the study area is the red squirrel (*Tamiasciurus hudsonicus*). Abundant jackpine cone crops supported high populations of squirrels during the 1975 and 1976 field seasons. Squirrel middens (large, intergenerational winter cone caches and nest sites) are ubiquitous in the study area, especially in the forested portion east of the active dune complex.

4.3.2.3 Other Mammals

Other mammals recorded for the study area are listed systematically in Appendix 8.2. Sightings were recorded of beaver (*Castor canadensis*), river otter (*Lontra canadensis*), little brown bat (*Myotis lucifugus*), masked shrew (*Sorex cinerus*) and least chipmunk (*Eutamias minimus*). Although caribou (*Rangifer tarandus*) or moose (*Alces alces*) were not sighted, numerous signs of these species occur throughout the study area.

4.3.2.3.1 Beaver

The beaver, once an abundant species in the study area (11 old beaver houses were located on Jade Lake in 1975), appeared by 1975 to have been locally extirpated by trapping. Remnants of trap sets remained near the entrance to beaver lodges. Numerous old beaver-cut tree stems and food caches were observed, but no signs of recent activity were seen. During the 1976 field season, however, two new lodges were found on Jade Lake, suggesting that beavers had migrated into the study area.

4.3.2.3.2 River Otter

This species appears to be abundant in the study area. Five sightings were recorded, one made during the winter reconnaissance trip and on 4 occasions during the 1976 field season when adults with young were observed.

4.3.2.3.3 Little Brown Bat

This species was an almost nightly visitor in the air-space over the evening campfire.

4.3.2.3.4 Masked Shrew

This species was frequently observed scurrying through the dense shoreline vegetation in front of basecamp.

4.3.2.3.5 Least Chipmunk

Very few sightings were recorded.

4.3.2.3.6 Caribou

Evidence of past use of the study area by caribou was common (dropped antlers and grazed and cratered lichen cover especially in the jackpine-lichen woodland west of the active dune complex (Plate 8). The last large migration to the vicinity is thought to have occurred during the winter of 1953 when caribou herds were reported as far south as Fort McMurray (Murphy 1976). Soper (1964) reports that woodland caribou once ranged the forest in which Syncrude's lease 17 occurs (Figure 3.1) but presently are restricted to pockets to the east and south of Fort McMurray and northwest of Lake Athabasca. He stated also that barren ground caribou (Rangifer arcticus) once extended their winter migrations as far south as Fort McMurray (Soper 1964). However, a combination of increased fires on caribou range and on migration routes related to increased human activity, plus increased hunting pressure, have forced the caribou herds to remain north of Lake Athabasca (Hawley 1975).

Only 1 caribou cratering area (Figure 4.6 site 73; Table 4.8) was observed. Effects of winter cratering by caribou on the ground cover are discussed in Chapter 6.

From field signs a number of other mammals are known to inhabit the study area. These include wolf (Canis lupis), coyote (Canis latrans) and other species listed in Appendix 8.2.

4.3.2.4 Waterfowl

The study area is heavily used by waterfowl during migration and staging periods. The sand dunes are on 3 of the 4 major North American flyways, and are immediately south of the Peace-Athabasca Delta, a most important staging and breeding area (Peace-Athabasca Delta Project Report 1972). During August 1975, hundreds of large flocks were observed flying south over the study area.

During field work, waterfowl were observed on every lake and small water body in the study area. Frequent sightings were recorded of Common Loons (Gavia immer) and Lesser Scaups (Aythya affinis), while slightly less numerous were Mallards (Anas platyrhynchos), Red-necked Grebes (Podiceps grisegena), Surf Scoters (Melanitta perspicillata), Canada Geese (Branta canadensis) and Red-breasted Mergansers (Mergus serrator) (Table 4.8).[1]

Eight non-breeding Common Loons were resident on Jade Lake during August 1975, while flocks of up to 30 were

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[1] Only the first sighting of a species in a new location was recorded. Therefore, the observed frequency (Table 4.6) does not necessarily coincide with individual sightings recorded.

observed on Larocque Lake in July 1976.

4.3.2.5 Other Migratory Birds

Three migratory bird species were often sighted during summer field work. These were Sandhill Crane, Booming Nighthawk and Common Tern.

4.3.2.5.1 Sandhill Crane

Approximately 12 Sandhill Cranes (*Grus canadensis*) were resident in the study area during August 1975. A slightly smaller population was recorded for 1976. The active dune complex was used extensively by these birds as evidenced by numerous tracks and droppings. On three occasions in 1975 the flock was sighted circling high over the open dunes. Attention was drawn by their constant chorus while in flight. On many occasions during the 1976 field work, mated pairs of Cranes with young were encountered at wetland nesting sites and on Jade Lake.

4.3.2.5.2 Common Nighthawk

The sandy surface and patchy lichen cover in the jackpine-lichen woodland provides excellent habitat for the Common or Booming Nighthawk (*Chordeiles minor*) (Salt and Salt 1976). High populations (Table 4.8 site 80) were recorded during the 1976 field season.

4.3.2.5.3 Common Tern

The most populous bird species on the active dunes were Common Terns (*Stirna hirundo*). Nests were frequently observed on the surface of the active dune complex. In July 1976, many sightings were made of young scurrying across the active sand surface.

4.3.2.6 Upland Game Birds

Abundant berry crops, especially *Vaccinium vitis-idaea*, and the availability of grit provide habitat 3 major species of upland game birds.

4.3.2.6.1 Willow Ptarmigan

In Alberta, the Willow Ptarmigan (*Lagopus lagopus*) breeds in the northern part of Jasper National Park occasionally as for south as the Tonquin Valley, but elsewhere it is only a winter visitor (Salt and Salt 1976). One large flock was observed during the February 1975 field work. From the large number of scats, snow burrows, and tracks on the exposed dune tops (where they acquire grit and wind blown seeds), and frequent observations of the previous winter's scats during the 1976 field season (especially common in the open jackpine-lichen woodland), it is clear that Willow Ptarmigan is the most populous winter upland game bird in the study area.

4.3.2.6.2 Spruce Grouse

A number of Spruce Grouse (Canachites canadensis) were sighted during the summer field seasons. Populations appeared to be higher in 1976.

4.3.2.6.3 Ruffed Grouse

Only 2 sightings were made of Ruffed Grouse (Bonasa umbellus), 1 in 1975 in the jackpine-lichen woodland (adult female and 4 subadults) and 1 in 1976 in the same vegetation type (male and female) (Figure 4.6 site 64; Table 4.8).

4.3.2.7 Raptors

A number of raptors were recorded for the study area. Populations of individual species were not large.

A pair of Bald Eagles (Halioeetus leucocephalus) with 2 juveniles, and a pair of Osprey (Pandion haliaetus) with young, were resident in the study area during 1976.

Other species sighted include Golden Eagle (Aquila chrysaetos), Red-tailed Hawk (Buteo jamaicensis), Swainson's Hawk (Buteo swainsoni), Marsh Hawk (Circus cyaneus), Pigeon Hawk (Falco columbarius), [illegible] Hawk (Falco sparvarius) and Great Horned Owl (Bubo virginianus).

4.3.2.8

Other Avifauna

A number of more common boreal avifauna were also sighted, including Eastern Kingbird (Tyrannus tyrannus), Olive-sided Flycatcher (Nuttallornis borealis), Gray Jay (Perisoreus canadensis), Common Raven (Corvus corax), Common Crow (Corvus brachyrhynchos), Black-capped Chickadee (Parus atricapillus), Northern Pileated Woodpecker (Dryocupus pileatus) and Boreal Chickadee (Parus hudsonicus). A systematic list of birds sighted is included in Appendix 8.2.

4.3.2.9 Aquatic Vertebrates

4.3.2.9.1 Fish

Investigations by Turner (1968), Bidgood (1973) and Northwest Hydraulic Consultants Ltd. (1975) provide the data available on local fish populations and this has been summarized by Renewable Resources (1975). The latter acknowledged that insufficient data are available to assign catch limits for recreational fishing. Information available to date for the study area is summarized below.

Fish populations in the Richardson River are largely unknown. However, on the basis of its physical characteristics (volume of flow, depth, and gradient), the river should be suitable for northern pike (Esox lucius) and walleye (Stizostedion vitrium). Fish populations of the Maybelle River are similarly unknown. However, sticklebacks

(Culaea inconstans), northern pike and walleye have been found in the river and associated lakes.

Information on northern pike angled in Jade Lake on 5 occasions during June-July 1976 is recorded in Table 4.9.

Table 4.9 Northern Pike Angled in Jade Lake June-July 1976

Date	Weight (Kg)	Length (cm)	Girth (cm)
30 June	1.02	53	23
5 July	0.45	47	18
8 July	1.36	61	25
8 July	1.25	57	22
8 July	1.13	54	22
17 July	1.02	52	21
17 July	0.86	~~53~~	20
19 July	0.86	46	19

The Table illustrates that sizes ranged from 1.36 kg, 61 cm to 0.68 kg, 46 cm, and these appeared from other evidence (sightings in near shore waters and fish angled but sizes not recorded) to be representative. During August 1975 I caught 2 walleye (Stizostedion vitrium). Lacking further evidence, I assumed populations to be small for this species. However, during the 1976 field season angling proved successful on every occasion (average of 4 times per week). (A systematic list of fishes identified for the study area is included in Appendix 8.2.)

4.3.2.9.2 Other Vertebrates

Only 3 species of amphibians were recorded for the study area, boreal toad (*Bufo boreus*), Canadian toad (*Bufo hemiophrys*) and wood frog (*Rana sylvatica*). All are resident in the riparian fringe.

4.4 Human Environment

4.4.1 Urban Centres and Population Growth in Northeast Alberta

A detailed description of the existing communities and population growth of northeast Alberta has been prepared by Hastie (1975) in a working document for NARP (1976) and provides the information summarized here.

Approximately 16,000 people, or 1% of the Provincial population, currently reside in northeast Alberta. Most of the population is in Fort McMurray (14,000). The remainder of the region is virtually uninhabited except for small native communities at Fort Chipewyan (1500), Fort MacKay (254) and Anzac (154) (1974 figures). Table 4.10 outlines growth projections to the year 1990.

Five oil sands extraction plants, including GCOS, Syncrude and 3 additional plants planned for construction, has been termed Scenario 1 in NARP (1976). This scenario represents a highly probable level of industrial development which is readily foreseeable by 1985 (Hastie 1975). Even if

Table 4.10 Urban Population Projections for Northeast Alberta

	Assuming Oil Sand Development Stops After Syncrude	Assuming Oil Sands Development Stops After Five Plants
1975	14,176	14,471
1976	15,704	16,226
1977	20,297	21,156
1978	20,742	22,896
1979	22,882	25,504
1980	23,432	30,260
1981	23,900	33,885
1982	24,378	35,822
1983	24,865	42,327
1984	25,362	46,321
1985	25,869	51,198
1986	26,386	56,012
1987	26,914	57,132
1988	27,452	58,275
1989	28,000	59,440
1990	28,560	60,628

Source: Hastie (1975:33).

the situation described in Scenario 1 is reached and projections for population growth are realized, human density in northeast Alberta will remain low. However, improved accessibility and increased visitation in wildland areas will demand more immediate planning decisions than increases in the regional population might justify. A major concern for the sand dune region would be the construction of a new townsite and the development of a transportation route (Section 4.4.4) to serve mining development. A townsite has been proposed for the vicinity of Bitumount fire tower, north of the Muskeg River (Figure 4.9; Mann 1977) to serve an expanding oil sand industry. Existing land use and land status in the dune region are examined next so that possible future conflicts with development for wilderness recreation may be identified.

4.4.2 Existing Land Use and Land Status in the Study Area

Currently, two economic activities, uranium exploration and fur trapping, take place in the study area and vicinity. The area is also under reservation by the Provincial government (Section 4.4.2.3).

4.4.2.1 Uranium Exploration

Records of quartz mineral exploration permits for the study area date to 1968 when National Nickle Ltd. of Calgary acquired 3 permits (Figure 4.7 Permits 82-84). Seven companies have expressed interest in the area since

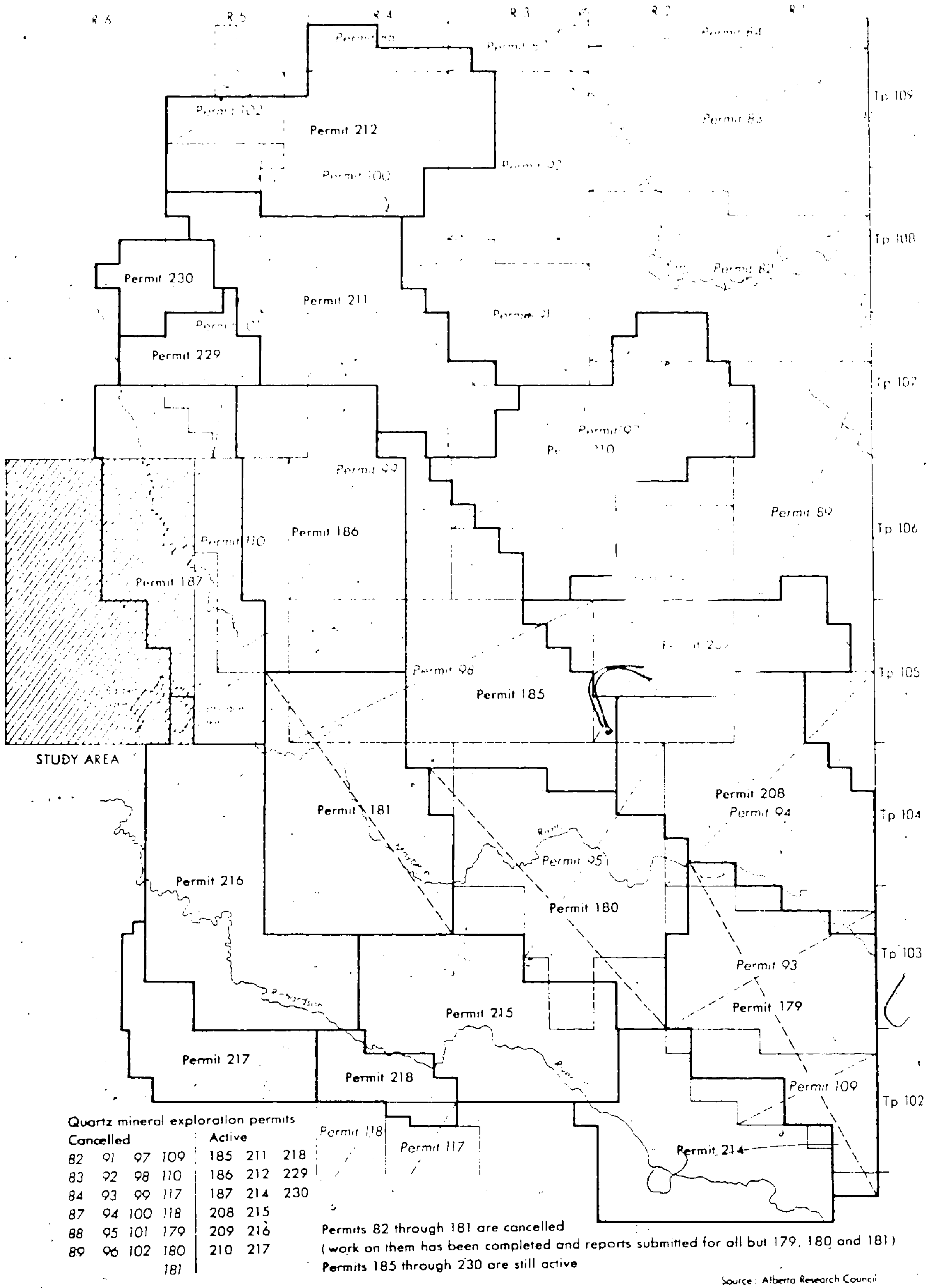


Figure 4.7 Quartz mineral exploration permits in the study area and vicinity. Permits 187 and 216 cover parts of the study area

that date (Appendix 8.4). Currently, 15 exploration permits are active in the area, 8 held by Eldorado Nuclear Ltd., Edmonton, 5 by Great Plains Development Company of Canada, Ltd., Calgary, and 2 by BP Minerals Ltd., Calgary.

During 1975 and 1976, Eldorado Nuclear conducted uranium exploration approximately 22 km ENE of the study area. Base camps were located on Archer and Paxton Lakes. No information on this exploration program is yet available.

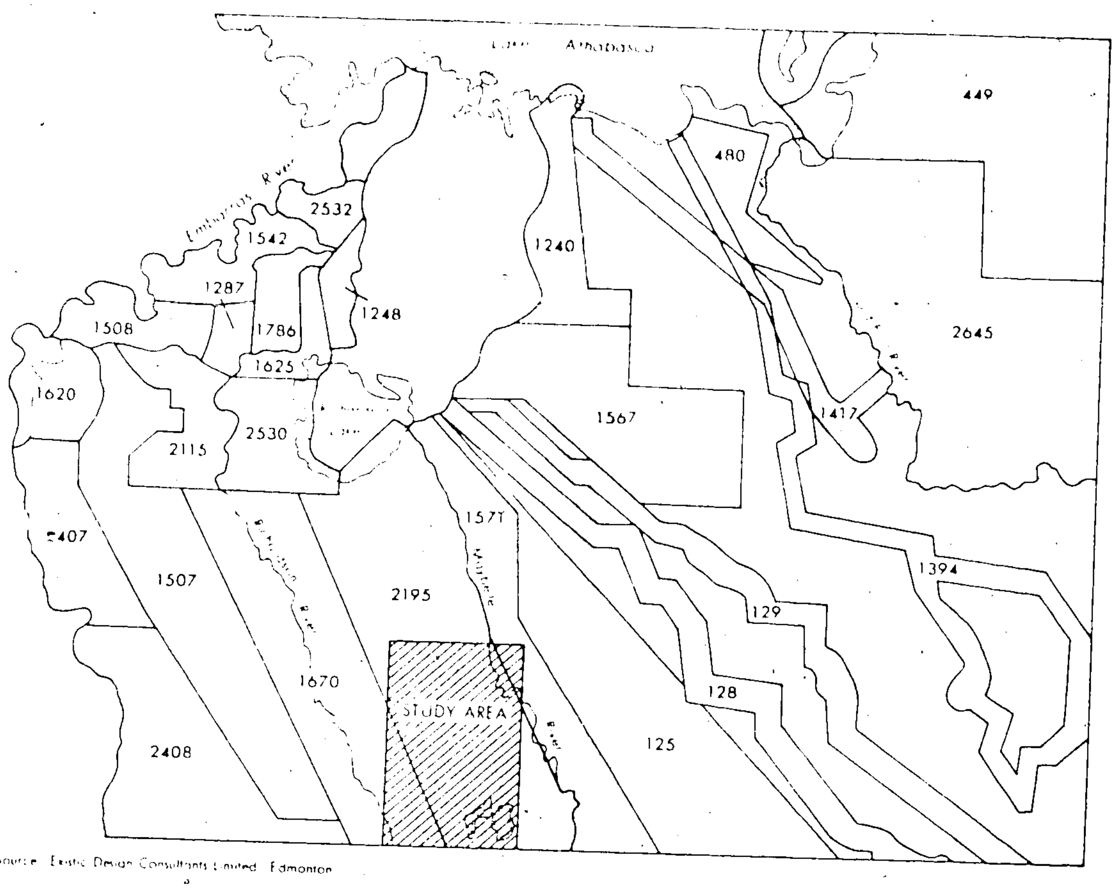
4.4.2.2 Fur Trapping

Three trapping areas, registered to Fort Chipewyan residents, are located in whole or in part within the study area (Figure 4.8). Trapping area 1571, which covers the NE corner of the study area, is currently vacant. Although the annual income from these trapping areas is relatively low (Table 4.11) the historical aspects of this activity could provide valuable interpretive material and educational benefits for future wilderness recreationists.

Certificates of registration of trapping areas convey to the holder only the right to trap on the trapping area, and do not offer the legal rights to land use that titles or leases do.

4.4.2.3 Park Reservation

In November 1973, Alberta Recreation, Parks and Wildlife (RPW) and Alberta Forest Service (AFS) placed a 5 year reservation (due to expire November 1978) on



Source: Ekistic Design Consultants Limited, Edmonton

Figure 4.8 Registered trapping areas in the study area and vicinity

Table 4.11 ...stered Trapping Areas in the Study Area

Certificate Number	Trapping Area Value	Location (Figure 4.8)
1571 (Vacant)	?	Maybelle River
2195	$ 397	Lakes in the study area
1670	$ 550	Richardson River
125[1]	$7900	Between the Maybelle River and Keane Creek

Source: Ekistic Design Consultants Ltd., Edmonton (1975)

[1] Trapping area 125 is located east of the study area between the Maybelle River and Keane Creek. The assessed value of $7,900 is the highest for any single trapping area in northeast Alberta. (The assessed value was arrived at by Northwestern Hydraulics Consultants Ltd. on the basis of data from the Fish and Wildlife Division of Alberta Recreation, Parks and Wildlife collected during 1971-1974.)

approximately 9920 ha including the active sand dune complex under study. The reservation is for conservation purposes until development alternatives can be assessed. As stated by McCammon (1978), "because there is little fear of human visitation due to its remote location, it has been a rather low priority area". Consequently, no work had been done in the reserved area at time of writing.

As the current reservation is large and non-specific, AFS staff will be researching the area during spring and summer 1978 to acquire more site-specific information with which to evaluate the more important features for future reservation and possible recreational development (McCammon 1978).

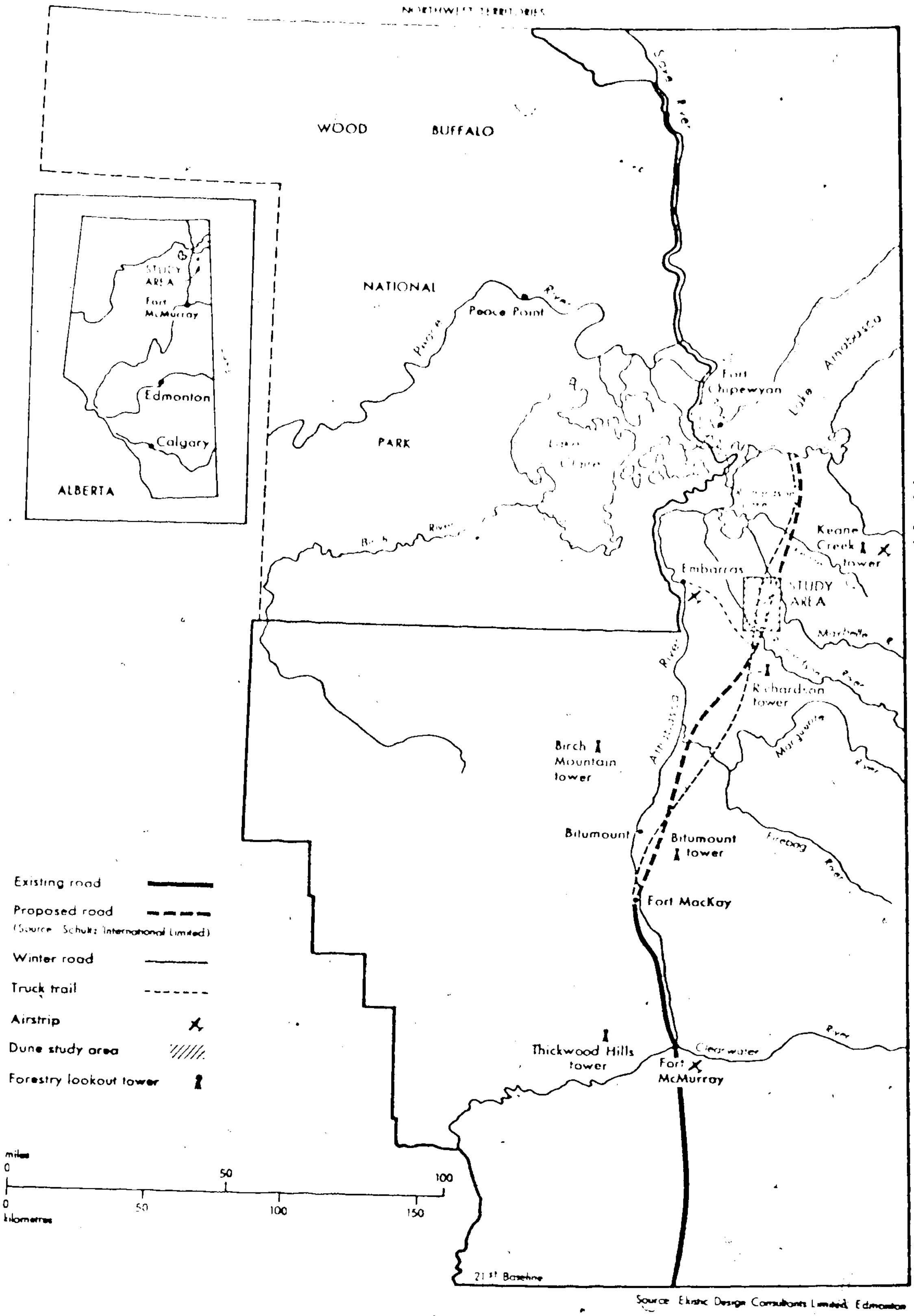
4.4.2.4 Other Interests in the Sand Dune Region

In June 1975, a permanent research station was established in the vicinity of Richardson Forest Tower (Figure 4.9) by the Botany Department of The University of Alberta. Studies are being conducted here to investigate ecological relationships in the sand dune environment. No results are yet available from these investigations.

4.4.3 Roads and Access

4.4.3.1 Existing Facilities

At present, motorized access is limited to light aircraft (approximately $300 return from Fort McMurray, 1976



Source: Ekistic Design Consultants Limited, Edmonton

Figure 4.9 Roads and access to the study area prices). A winter road (Plate 16), constructed in the early 1950's to connect Uranium City to Bitumount (with bridge at the Richardson River), connects with a truck trail from Embarras on the Athabasca River (Figure 4.9). Problems with ice ridges and drifting snow on the route across Lake Athabasca caused the road to be abandoned in the late 1[illegible]'s. Alberta Forest Service used it occasionally (4 wheel drive vehicles) until 1968 as far north as Embarras airfield. They continue to use the airfield as a supply cache but otherwise it is vacant. This route is walkable during the summer months but access to the active dune complex would be impeded by difficulties crossing the Richardson River.

4.4.3.2 Future Access

At least 1 road has been proposed that would significantly increase accessibility to the active dune complex. Schultz Consulting Ltd., Edmonton, has made preliminary studies of the economic feasibility of a road through the kame-kettle topography along the east side of the study area (Figure 4.9). Presumably, this road would be constructed if exploration companies discovered marketable quantities of uranium and an extraction industry developed (Kent 1975). Several other routes have been proposed to the west of the study area but would involve costly (monetary as well as environmental) construction through the Peace-Athabasca Delta.

The Provincial government is receiving pressure from northern communities (Fort Chipewyan, Fort Smith) to construct a road linking the north with southern centres.[1]

4.5 Summary

In this chapter I have inventoried the three main environmental components (physical, biological and human) of the study area. The inventory shows that previous use by man has been limited to winter road construction, trapping and scientific research. These activities have not had a significant effect on the system dynamics of that area. If man were to use the area as a wilderness recreation facility we need to further analyse the recreational aspects and environmental constraints inherent in the sand dune environment. These topics are the subject of the final 3 chapters.

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[1] A "Third Annual Publicity Journey" was staged by members of northern communities during March 1977. The 480 km trip from Fort Smith to Fort McMurray via Fort Chipewyan (locally known as The Muffaloose Trail) was staged to promote construction of an all-weather road to those communities. The route would serve as access to Wood Buffalo National Park, a communication route for northern residents to Edmonton and provide a loop route for vacationers into the Northwest Territories (News of the North 2 March 1977:22).

CHAPTER 5

ANALYSIS OF THE WILDERNESS RECREATION OPPORTUNITIES

5.1 Introduction

The sand dune area offers a variety of contrasts in topography and vegetation as one travels through mixedwood forests, along wetland margins, into jackpine-lichen woodlands and onto the unique active dune complex. These changing biophysical characteristics create a variety of experiences for the visitor. In this chapter the factors important to wilderness recreation in the study area are discussed. These attributes include landforms, vegetation, wildlife and location relative to human settlement. A schematic profile (Figure 5.1) provides a graphic summary of vegetation and landforms, their interrelationships and their contribution to the wilderness recreation potential. The main factors are summarized below.

5.1.1 The Active Dune Complex

Significant interest in the dunes has been expressed by Provincial agencies and previous visitors, which makes apparent the valuable contribution this feature (and surrounding lake and woodland environments) could make to the wilderness experiences of Albertans.

The impressiveness of this landform feature and the dynamic ecological relationships associated with it, in

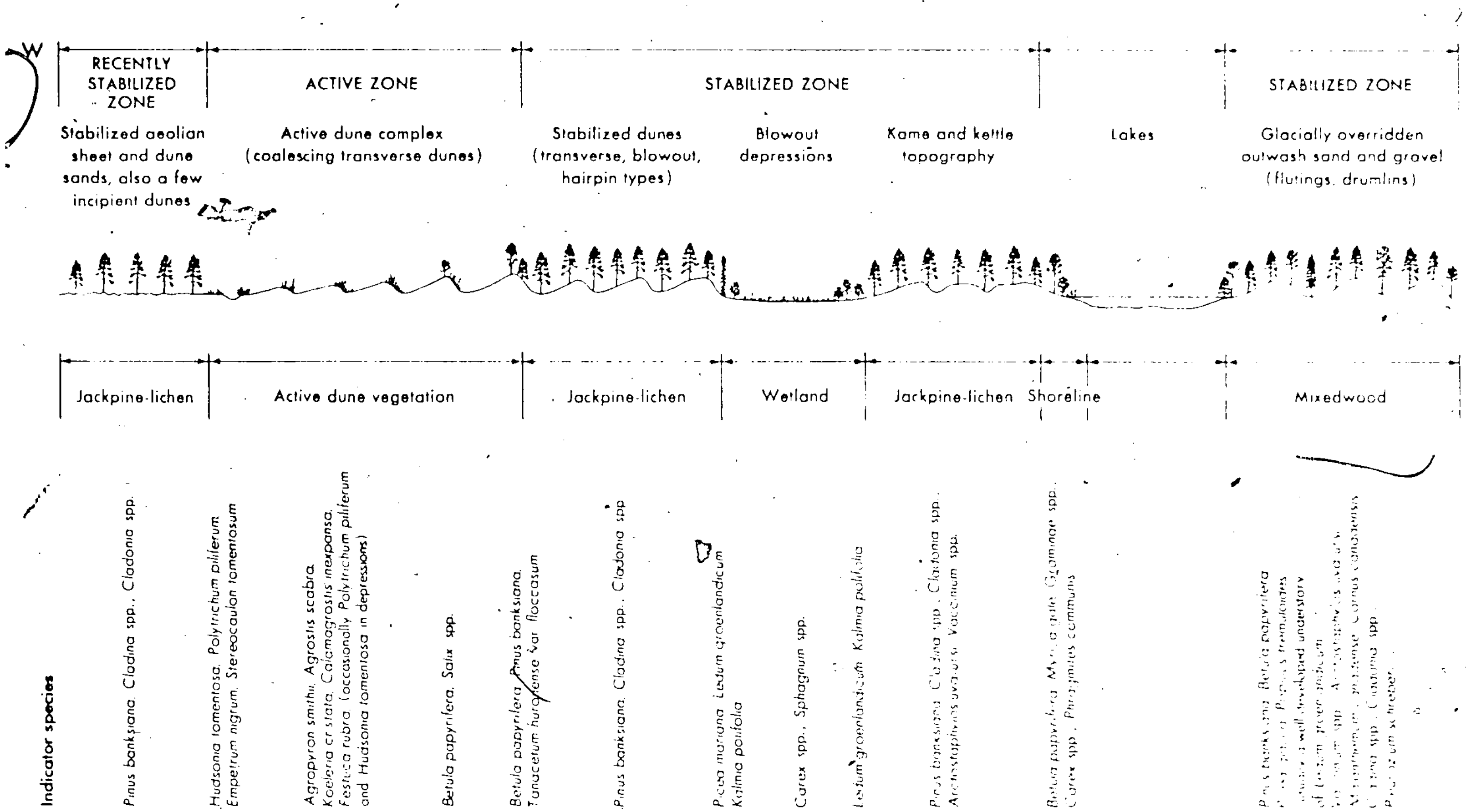

Figure 5.1 Schematic profile of major vegetation types and associated landforms in the study area

sharp contrast to the stabilized jackpine-lichen woodlands and small lakes into which it is advancing, should be of central concern to future recreation planners of the sand dune area. Visitors will certainly be attracted to the area where active sand spills over forests and into lakes, a zone where interpretive, scientific and aesthetic values are outstanding.

5.1.2 Blowout Depressions and Associated Dune Features

Four major dune types (parabolic, barchan, longitudinal and transverse), now stabilized by vegetation, are found in the study area. Because many dune ridges are adjacent to wetland depressions which are important habitats for a variety of wildlife species (Plate 17) they offer vantage points and thus have excellent trail potential. The interpretive value of these aeolian features could also be stressed in user education programs.

5.1.3 Lakes and Lakeshores

The natural landscape of the study area presents strong contrasts between relatively flat, semi-arid dune plains and undulating kame and kettle topography containing many lakes. Waterbased recreation is a central theme in many recreational developments. It is also a high priority amongst wilderness recreationists (Hendee et al. 1971). The numerous lakes of the sand dune area are of moderate quality in terms of available sandy shorelines and usable backshore areas for campsites. Yet, water is clear and potable, and the gently sloping, sandy near-shore and off-shore areas provide family swimming opportunities. Swimming is excellent during mid-summer because water is clear, cool and uncontaminated, and lake bottoms are sandy with little organic buildup or aquatic vegetation. Sandy shorelines and lake bottoms (especially the arcuate north shore of Larocque Lake) add to the functional and aesthetic qualities of many of these water bodies. Many lakes exist to the east of the study area and could also be considered in any plans for future recreational development. Lakes adjacent to the active dune complex are extremely well suited to swimming at locations where the dunes are advancing into them (Figure 5.1; Plate 18).

5.1.4 Jackpine-lichen Woodland

The jackpine-lichen woodland of the study area has several important recreational qualities. Firstly, they are open and parklike without a stratum of shrub vegetation to restrict hiking. Well developed terrestrial and arboreal lichen strata add a striking aesthetic contrast to the dark tones of jackpine. Thirddy, jackpines have many interesting shapes, especially those affected by witches broom. Fourthly, this community type contrasts sharply with wetland vegetation and the active dune complex (Figure 5.1). Lastly, the jackpine-lichen woodland is composed of a diversity of stand ages, a mosaic induced by frequent lightning-caused fires. This diversity and openness offers a serene, unrestricting environment especially suited to walking, hiking, nature observation, snowshoeing and cross-country skiing.

5.1.5 Other Vegetation

The mixedwood community type is the most diverse upland vegetation in the study area. The diversity of tree species combined with 5 well developed strata provides excellent wildlife habitat for a variety of birds and mammals. Many of these communities occur along steep river banks and lake margins which in combination could provide excellent trail locations.

The diverse band of vegetation that occupies shorelines adds to the aesthetic qualities of potential water-based activities. Riparian species, especially the dense "hedge" and abundant roots of *Myrica gale*, create a durable turf along the shoreline. This important riparian fringe could be useful as a buffer to separate campsites and water-based recreation activities, while providing an interesting environment along which trails may be located.

Another important recreational aspect of the vegetation of the sand dune region is the absence of noxious weeds commonly associated with man-altered landscapes (Alberta Ecological Survey 1976). On the other hand, uncommon and rare species such as *Chimaphila umbellata*, *Cicuta bulbifera*, *Epilobium hornemannii*, *Juncus* *brevicaudatus* and *Saxifraga bronchialis* occur in the study area and add interest to the sand dune environment.

5.1.6 Wildlife

Wildlife of the study area represents a nearly pure wilderness population. Only in the wilderness areas of Alberta, those not receiving heavy recreational use, can visitors observe such wilderness species as Bald Eagles teaching their offspring the rules for survival, or observe Osprey and Sandhill Cranes, or view such increasingly rare species as the Pileated Woodpecker, and observe the interesting social behavior of a group of Common Loons or view large groups of Booming Nighthawks.

A few examples of my experience in the study area can serve to indicate the value of wildlife to a wilderness experience. On many occasions I observed Sandhill Cranes, common in the study area. They were extremely timid and thus difficult to observe at close range. One sighting at less than 35 m on 16 July 1976 (Figure 8 Site 71) of 2 juveniles with adults left me with a lasting impression of the wilderness quality of the sand dune region. Almost daily I observed Common Loons on the lakes of the study area. On one particular occasion, I sighted over 30, cooperatively preying on fish in Larocque Lake. On all occasions they appeared to be unconcerned with my presence. Their call, nocturnal flyovers and take off and landing antics were a near constant reminder of the wilderness quality of the sand dune area.

Many aspects of the wildlife in the study area are amenable to nature study. For example, the shoreline vegetation on many lakes is composed of a strip of sweet gale, grasses, sedges and forbs (Plate 19). This vegetation, in close proximity to a water body, provides suitable breeding habitat for a variety of insects and other arthropods which in turn provide the base of a broad food web. Insects are a food source for many birds, small mammals (such as the insectivorous masked shrew), toads and frogs that also use the riparian vegetation as habitat. Because of the abundance of small animal life, larger predators also frequent the riparian fringe. This interesting ecosystem thus provides an example of a complex food web, and is but one of the many resources that could be developed into a wilderness interpre[illegible]n program.

Wetland depressions, whic[illegible] frequented by an abundance of waterfowl and shorebirds, are also areas of biological diversity. These fascinating areas (for example the blowout depressions - Figure 5.1) should be considered in future recreational planning where educational and scientific values can be accentuated. Mammal populations are not large in the study area, but black bears, beavers, otters and red squirrels are frequently observed. The habitats used by these species add to the wilderness essence and the interpretive value of the dune region. Furthermore, their easily identified tracks, trails, and droppings also add to the wilderness experience. Dropped antlers and abandoned eyries indicate previous use by caribou, osprey and eagles, additional resources for nature interpretation programs.

In addition to the wildlife populations recorded for the study area it is worthwhile to discuss the absence of certain species in the framework of wilderness quality. Notable exceptions in the list of wildlife are House Sparrows (*Passer domesticus*), Common Starlings (*Sturnus vulgaris*) and Black-billed Magpies (*Pica pica*). The fact that these species are not present illustrates the lack of human impact on the ecology of the sand dunes and is an important asset to recreationists who seek a wilderness experience. Care should be taken to avoid creating conditions that would enable pest species to become established.

5.1.6.1 Fish

Although our field party had considerable success with sport fishing in Jade Lake, no data are available from which to estimate annual productivity. Detailed fisheries research must be conducted before the potential for recreational angling can be assessed and catch limits assigned, but populations would likely remain high under regulated fishing.

5.2 The Sand Dune Area in the Context of the Northeast Alberta Region

The sand dune region is wilderness by virtue of its size (approximately 3,000 km²), naturalness and distance from human settlement. The closest major population centre is Fort McMurray, 170 km to the south. As there is no road access, the area remains inaccessible to the majority of the population. Thus the distance from developed areas and the lack of human visitation has enabled the sand dune region to remain as a large, self-regulating ecological unit (Pimlott and Littlejohn 1971).

5.3 A Theme for Wilderness Recreation Activities

The theme for wilderness recreation in the study area could best be exemplified by accentuating ecology and the work of wind. Ecology is becoming a popular subject in all levels of formal education in Canada. Plant succession on sand dunes is a classic subject in ecology (Cowles 1899, Olson 1958, and others). The studies by Cowles (1899) of plant succession on Lake Michigan dunes helped to found the idea of dynamic ecology (Olson 1958:125). Thus, the scientific and educational aspects would greatly add to the recreational qualities of the study area if an interpretive program were designed around this theme. Wilderness recreation activities suitable to the aeolian landscape and the delicate vegetation are listed in Table 5.1.

5.4 Summary

In this chapter I have shown that the sand dunes region could contribute to an exceptional wilderness recreation experience. However, many of the features of this area are very delicate, and are easily disturbed by man's visitation. Therefore non-consumptive activities have been stressed (Table 5.1). These activities should be worked into any recreational development plan for the sand dune region. The constraints to recreational use are analysed in Chapter 6.

Table 5.1 Wilderness Recreation Activities Suitable to the Sand Dune Area of Northeast Alberta

Nonconsumptive Activities	Consumptive Activities
1. Backwoods	1. Backwoods
nature walks	berry gathering (in season)
walking for pleasure	
trail lunches	collecting lichen specimens
photography	
painting	
camping	
hiking	
backpacking	
orienteering	
2. Water Sports	2. Water Sports
swimming and wading	fishing in lakes and rivers
canoeing	
3. Winter Activities	3. Winter Activities
cross-country skiing	ice fishing
snowshoeing	
winter camping	
winter survival experience	

CHAPTER 6

ENVIRONMENTAL CONTRAINTS TO DEVELOPMENT OF THE SAND DUNE AREA AS A WILDERNESS RECREATION FACILITY

Dune systems and inland wetlands are two of the most fragile ecosystems for recreation use (Hookway and Davidson 1970:22).

6.1 Introduction

In this chapter, 4 environmental concerns are identified and analysed in the context of use of the sand dune area for wilderness recreation:

1) Fire

2) Surface erosion

3) Conflict with wildlife

4) Fragility of the plant cover.

6.2 Environmental Constraints for Recreation in Seral Jackpine-lichen Communities

In the early seral stages, forest fires lead to even-aged stands which are too dense to allow adequate lichen carpets to develop (Richardson 1975). Under natural conditions fires occur sporadically over time and space, resulting in a diverse mosaic of stand ages, densities and terrestrial lichen cover. This natural diversity s desirable in an interpretive and a recreational sense.

An increase of man-caused fires will lead to increased surface erosion and extensive areas of early seral communities. For a number of years these dense even-aged jackpine forests are difficult to walk through. They are also low in wildlife carrying capacity. Small areas of early-successional communities would have value as an interpretive resource but the appeal to recreationists would be limited because downed trees, burned snags, ash and charcoal make walking unpleasant.

Witches broom can create an aesthetic effect, offering physiognomic diversity within extensive stands of otherwise uniform, even-aged jackpine. Increases in man-caused fires would also alter this qual tative aspect of the natural vegetation.

6.2.1 Implications for Management

Several implications for management of the sand dune area for wilderness recreation are suggested from the fire research results.

1) The current government policy in Alberta is suppression of all forest fires. This policy should be reviewed in the context of a wilderness management plan for the sand dune area. Large scale fire is not desirable because extensive areas in initial phases of revegetation are low in recreation value and wildlife carrying capacity. But small fires could be allowed in order to maintain a landscape mosaic, diversity and edge effect, an environment that is interesting to recreationists while providing natural

habitat for wildlife. Exclusion of fire through increased suppression may result in disruption of the inherent natural processes of plant succession, surface erosion and stabilization. Mismanagement in so delicate an ecosystem could lead to widespread erosion problems and long term changes in vegetation communities.

2) On the other hand, at a number of fire locations, the cover-abundance of ericoid shrubs has increased. Rowe and Scotter (1973) found similar post-fire successional patterns in other areas of the boreal forest. Ericaceous ground cover is more resistant to the effects of human disturbance, thus prescribed burning could be a management tool to stimulate shrub production and increase the durability of ground cover at heavily used areas.

3) All portions of the study area have been subjected to repeated fires. More research is needed to enable the forecasting of dangerous fire periods. A more detailed study of the flammability of terrestrial lichen communities would improve knowledge of the potential areal extent and frequency of surface fires, a management concern if increased use by man occurs.

6.3 Surface Erosion

One of the most important factors impeding wind erosion of the fixed dunes is lichen ground cover. Lichens such as _Stereocaulon tomentosum_, _Cladonia cristatella_ and _C. gracilis_ colonize bare soil and bind the surface against wind erosion. But when dry, lichens are not only extremely flammable, they are also very fragile and easily dislodged from the sandy substrate.

Several natural factors are important in initiating wind erosion, including relief, fire and wildlife, both singly and in combination. Many examples of surface erosion were observed on the tops of stabilized dune ridges where blowout depressions up to 10 m in diameter and 1 m deep occur. The causes for increased erosion along the ridges are a combination of dryness of site, increased exposure to wind, repeated use by wildlife for trails and a greater incidence of fires caused by lightning strikes on the highest local points of land, all causing reduced ground cover and accelerated wind erosion.

Although these locations provide excellent vantage points for observing the surrounding natural features, concentrated use by recreationists could result in severe damage to the patchy lichen cover now binding the sand surface of these ridges. This in turn could lead to large-scale erosion of the dune ridges.

Another cause of surface erosion can be attributed to use of the area by caribou. Although the last large migration into the study area occurred during the winter of 1953, the winter feeding craters (Plate 8) are still readily visible, marked by altered composition of the lichen cover, bare sand and gravel areas and many small blowouts (averaging 2 m wide by 10 cm deep).

Surface erosion by wind is evidently a major environmental consideration for any future use of the dunes region by recreationists, especially if roads or trails are to be constructed. For example, the winter road (Section 4.4.3.1) has resulted in numerous blowouts, especially where the road has traversed the SW-facing slopes of stabilized dunes.

Special attention should be paid to factors that potentially could cause erosion of the fixed dunes. Careful planning to avoid the dune ridges and recently stabilized dune surfaces in the western portions of the study area should reduce wind erosion problems. Establishment of a rational management program may prevent erosion on a broad scale, but very specific field action is required to control erosion once land use begins. Surface erosion is therefore a serious constraint to use of the sand dune area by recreationists.

6.4 Conflict With Wildlife

Two constraints to the use of the study area for wilderness recreation may be imposed by local wildlife populations. These factors are the presence of large numbers of black bears and the use of the area for breeding habitat by species of rare avifauna.

6.4.1 Black Bear

Black bears are numerous in the dunes region. Although this animal is not normally aggressive to humans, increased visitation would inevitably result in management problems, especially those associated with garbage disposal and the plundering of visitor food supplies (Marsh 1972). For example, a garbage pit dug during the 1975 field season was uprooted only hours after trash was buried. Every attempt was made during the 1976 field season to incinerate burnable trash and remove non-burnable trash at the end of the field season. Bears were nevertheless seen in the vicinity of the basecamp on an average of 3-4 times per week during 1976. No damage was done to the campsite.

Problems arising from increased visitation to the area could be minimized if education programs were developed (Moment 1968). Such an education program should deal not only with black bears and their life history, but also with other topics of natural resource utilization relevant to wilderness recreation activities (for example, guidelines for camping, cooking with wood fires, maintaining the quality of faunal and floral communities). In other words, the visitor should be educated to a standard of conduct which would maintain the quality of the backcountry environment and still provide a satisfactory wilderness recreational experience (Walker 1976).

6.4.2 Rare Wildlife Species

In Section 4.3.2, I noted that many uncommon bird species were resident in the study area. Also noted was the 'naturalness' of the wildlife population (Section 5.2.2.3). It is not known if our presence in the study area was detrimental to the avifauna. But special concern should be taken to avoid development in the vicinity of nesting sites of such species as Bald Eagles, Ospreys, Sandhill Cranes and Common Terns. Education programs and management of visitation to avoid these areas during nesting periods should reduce impacts. In should be noted, however, that if human visitation increases such wildlife usually decreases.

6.5 Vegetation Impact Studies

In terms of wilderness recreation two major impacts can be expected, camping and hiking. Both activities will result in negative effects upon the natural vegetation. For example trail heads, campsites and unique attractions receive the most use and the greatest environmental impact. In this research it has been noted repeatedly that the natural ground cover will be a severe constraint to recreational use. Therefore, potential campsite locations were assessed for their ability to sustain recreational use and their ability to recover after use. For the same reasons, the effects of trampling (by wildlife and humans) were evaluated.

6.5.1 Campsite Capability Studies

The capability ratings for campsite use at 9 lakeside locations are shown in Table 6.1. These data indicate that the capacity for such campsites to withstand recreational use range between 15.0 and 21.0 which is classed by Lesko (1973) as low to very low.[1] It must be emphasized that these are relative values and that choice of rating factors is subjective (Lesko 1973:9).

In response to Lesko's (1973) plea for additional factors for assessing site capability, I propose that several qualitative site factors be added to this site resistance rating system for planning and management of campsites in the sand dune area. In general, scenery and proximity to water complemented the aesthetic component of campsite locations. Shoreline vegetation, highly variable cloud patterns, reflections on the water surface and the open, parklike jackpine-lichen woodland add greatly to the appeal of these locations. In addition, shoreline conditions are very suitable for swimming, wading, boating and float plane access at those locations. Firewood was plentiful at all but site 1. These scenic and funtional

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[1] Lesko developed a 5 level rating system for campsites in Alberta. The scale includes the following capability value (CV) divisions: CV=0-6 not recommended for campsite use; CV=7-20 very low; CV=21-30 low; CV=31-40 medium; CV=41-56 high.

Table 6.1

Physical Site Capability Ratings for Campsites at 9 Lakeside Locations in the Study Area

	FACTOR (F)	CAMPSITES								
		Jade Lake								Larocque Lake
		1	2	3	4	5	6	7	8	9
F_1	Degree days above 5.6°C[1]	180-/1 210/	180-/1 210/	180-/1 210/	180-/1 210/	180-/1 210/	180-/1 210/	180-/1 210/	180-/1 210/	180-/1 210/
F_2	Mean annual water deficit (cm)	5.1-/6 10.2/	5.1-/6 10.2/	5.1-/6 10.2/	5.1-/6 10.2/	5.1-/6 10.2/	5.1-/6 10.2/	5.1-/6 10.2/	5.1-/6 10.2/	5.1-/6 10.2/
F_3	Shrub cover (%)	30/4	15/2	15/2	55/6	50/4	30/4	15/2	40/4	55/6
F_4	Grass cover (%)	1/1	0/1	1/1	1/1	0/1	0/1	0/1	0/1	0/1
F_5	Slope (°) and total ground cover (%)	1,100/8	1,100/8	4,85 /8	0,100/8	4,100/8	8,100/6	7,100/6	1,95 /8	1,90 /8
F_6	Depth of rooting (cm)	14/2	28/4	26/4	30/4	30/4	40/2	25/4	45/8	40/8
F_7	Thickness of the Ah soil horizon (cm)	1.0/2	3.0/6	1.3/2	1.3/2	1.5/4	3.0/6	1.5/4	1.0/2	2.0/4
F_8	Thickness of the forest floor (LFH) (cm)	3.0/2	3.0/2	1.3/1	3.0/2	3.0/2	3.0/2	1.5/1	1.0/1	1.0/1
F_9	Soil texture and drainage (see Lesko 1973:8)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Capability value (CV)[2] after Lesko (1973)	15.6	18.0	15.0	18.0	18.0	16.8	15.0	18.6	21.0

[1] NOTATION includes the measurement in upper left and Lesko (1973) numerical scale equivalent in bottom right. Source F_1, F_2: Atlas of Alberta (1969).

[2] $CV = (F_1 + \ldots + F_8)(F_9 \times F_n)$ where F_n is the factor with 0 rating. The higher the CV, the better is the capability of the site to withstand recreational use. CV has a range of 0 to 56.

attributes should be considered in the rating of a wilderness campsite. When coupling the qualitative information (scenery, location, presence of wildlife) with an analysis of selected ecological factors, the low rating determined by the Lesko system could be modified to suit a management framework for the sand dune area.

The initial results of lakeside campsite analysis indicate that:

1) Physical site conditions would change to the point where the lichen ground cover would be destroyed leaving bare soil (sand is durable and not an undesirable tent pad). Little potential for wind erosion is expected at these locations due to their low elevation, protection by trees and comparatively moist soil

2) With adequate site preparation and management these locations could provide excellent wilderness campsites.

6.5.1.1 Campsite Disturbance Studies

In order to assess these results, 3 previously used sites with similar environmental conditions were analysed. Pre-use site conditions, use levels and timing and duration of use were the dependent variables. This analysis was designed to determine the degree of disturbance to ground cover and surrounding vegetation from different types of camping and seasons of use. A summary of impact data for the 3 campsites is included in Table 6.2.

A comparison of the data from these 3 sites points

Table 6.2

Impact Summary for 3 Campsites in the Study Area

Factors Analysed	Winter Basecamp[1]	1973 Basecamp	1975-1976 Basecamp
Time and duration of use	25-27 February 1975 (3 days)	July-August 1973 (40 days)	3-21 August 1975; 25 June - 1 August 1976 (54 days)
Number of man-days (No. of people x length of stay)	6	80	126
Vegetation type	Jackpine-lichen woodland	Jackpine-lichen woodland	Jackpine-lichen woodland
Soil group	Orthic Eutric Regosol	Orthic Regosol	Orthic Eutric Regosol
Site capability value (after Lesko 1973)	16.8 (very low)	15.0 (very low)	15.0 (very low)
Description of activities	Basecamp for winter reconnaissance work, erected 2 man tent, campfire	Basecamp for research on active dune complex (M. & A. Landals), tent, tables, trails to lake, privy, 2 garbage pits	Basecamp for 2 summer field seasons, tent, tables, benches, storage area, cook table, fire pit, trails
Area of disturbance	80 m^2 5 m^2 total ground cover destroyed 75 m^2 partial disturbance	90 m^2 10 m^2 total ground cover destroyed 80 m^2 partial disturbance	286 m^2 104 m^2 total ground cover destroyed 182 m^2 partial disturbance
Description of disturbance	Total ground cover destroyed under fire pit, areas trampled around fire and at tent entrance, jackpine branches broken, stump from tree cut for firewood.	Lichen cover destroyed in area of tent, table, trails, privy. Wind erosion had been initiated along the trail to Jade Lake where lichen cover had been destroyed and shore was steep (slope = 22°)	Total ground cover destroyed under tent, tables, fire pit area and paths to these locations. Dark Ah layer removed on most heavily used areas. Jackpine roots exposed at 3 locations on path from tables to tent.
Visitor Impact Rating (after Willard and Marr 1970)	2	3	4
Recovery of Vegetation	None by 30 June 1976	Partial regrowth of *Polytrichum piliferum* and forbs, especially *Maianthemum canadense* by 30 June 1976	None by 31 July 1976

[1]Locations plotted on Figure 4.4

out several important environmental and aesthetic concerns. 1) Even winter camping of short duration (6 man-days) resulted in significant disturbances to the lichen cover and nearby jackpines. Although 35 cm of snow covered the site when we arrived, 5 m² of lichen cover was completely destroyed (fire pit and area trampled around pit). This type of disturbance is very similar to that of winter cratering by caribou where revegetation has been extremely slow. Therefore, the impact of the 1975 winter camp will [illegible]y be visible for 40-60 years.

2) Disturbances at the other two sites were similar in type but more severe. Impact ratings (Willard and Marr 1970) increased from 2 at the winter site to 4 at the 1976 basecamp (Table 6.2). The increase was due to disturbance to the lichen cover (57% of the disturbed area had total removal of ground cover), removal of the Ah layer under the areas most trampled, broken branches on many nearby jackpine, several trails radiating from the camping area and a number of exposed jackpine roots in the most heavily trampled areas. (Jackpine of the study area develop a tap root 3 m or more long but also a horizontal root structure just under the soil surface in response to soil moisture which is normally highest in the shallow layer immediately under the lichen cover.) It is not known how much this will reduce the moisture balance of the affected jackpines, but it could reduce their vigour and eventually result in blowdown.

It is apparent from this brief analysis of existing campsite use that the easily removed ground cover leads to rapid deterioration in site quality and is thus a most important constraint on recreational use of the study area. If wilderness recreation is planned for the sand dune region, intensive site management could reduce this problem. The accumulative site damage from repeated use may require site designation and hardening of the most heavily used areas (tent pads, fire pits, privies, firewood supply areas). This practice would localize disturbance to predetermined sites and reduce the spread of damage to other areas. If costs are too great (either in a management sense or in terms of socially acceptable environmental change in a wilderness area), then the rapid potential deterioration of site quality is another severe constraint to use of the sand dune area for wilderness recreation.

6.5.2 Trail Trampling Studies

Two types of trail disturbances, game and human, were analysed.

6.5.2.1 Game Trails

The jackpine-lichen vegetation type has extremely low tolerance to trampling. Even at the lowest levels of trampling (red squirrel trail) all lichen species are destroyed creating a visible trail averaging 10 cm wide (Plate 20). The response of vegetation to this disturbance

(Table 6.3) is usually a slight increase in the cover value for two mosses *Polytrichum piliferum* and *Dicranum fuscescens*. No adverse effects from soil erosion were recorded. Soil on the trail surface was covered by a greyish crust made up of mineral soil and organic debris. Also, some 50% of the surface was covered with an average of 1.5 cm of organic litter (needles, cone bracts, twigs, bark chips).

In comparison, the bear trail sampled was under a more dense jackpine canopy in a moist lakeside location. The undisturbed vegetation was more diverse, including a number of forbs. Vegetation on this 25 cm wide trail differed noticably. The lichen cover was replaced by the same mosses as on the squirrel trail (*Polytrichum piliferum* and *Dicranum fuscescens*), along with several species of grasses and sedges. The LFH layer was composed of organic material similar to the red squirrel trail plus numerous bear scats. No bare soil was exposed (an organic-mineral soil admixture formed a crust on the trail surface), but less than 10% of the surface was covered by organic debris and living plants.

Analysis of these natural trail disturbances revealed that:

1) The lichen surface is extremely fragile and easily removed

2) Soil erosion is not necessarily initiated by simply removing the lichen cover

Table 6.3

Species Composition, % Ground Cover Adjacent to Trail Trampling Plots and on 6 Trails of the Study Area

	Presence and Cover Abundance Values (Table 2.1)											
	Trails Sampled											
	ANIMAL TRAILS				HUMAN TRAILS							
					Random				Simulated			
	Red Squirrel		Black Bear		Trail 1		Trail 2		Trail 3 (Dry)		Trail 4 (Wet)	
Location of sample	On	Off	On	Off	On	Off	On	Off	On	Off	On	Off
Number of tramples	--	---	--	---	100		+1000		50		50	
Total ground cover (%)[1]	50	85	<10	85	40	100	0	100	<1	100	70	100
Trail width (cm)	10		25		40		60		25		30-35	
Pinus banksiana		5		6		5		6		5		5
Arctostaphylos uva-ursi								1				
Vaccinium myrtilloides		2						2				
Vaccinium vitis-idaea			2	2				2				
Carex spp.			1									
Gramineae			1									
Maianthemum canadense								1				
Pyrola virens								1				
Solidago decumbens			2	1								
Polytrichum piliferum	4	3	3	1				2	1	2	2	2
Polytrichum juniperinum					5							
Pleurozium schreberi					3			3				
Dicranum fuscescens	3	2	2	1				1				
Ptilidium ciliare								3				
Cladina mitis		7		6		7		8		7		7
Cladina stellaris		1				2		1		2		2
Cladonia uncialis		4		3		3		2		3		3
Cladonia gracilis		3		2						3		3
Cladonia cornuta		3		2		2		1		3		3
Cetraria nivalis		1				1		1				
Cladonia amaurocraea		2						1				
Cladonia deformis				1		2		1		2		2
Peltigera malacea										1		1
Cladonia islandica		2				1				1		1
Cladonia pleurota	1			1				2				
Cladonia [illegible]		1										

[1] ground cover includes living plants, needle litter, crushed organic material, bark chips, cone bracts, twigs, etc.

3) Under conditions of shade and increased moisture, resistant grasses, sedges and mosses partially replace the fagile lichen mat

4) Black bear trails are already established in locations that have recreational potential

5) Interpretive and scientific values (nature study and revegetation experiments) could be important functions of game trails.

6.5.2.2 Human Trampling Experiments

It was not possible to assess how much trampling pressure had created the game trails. Analysis of 2 types of human trails provided quantitative evidence that the lichen cover withstands very little use.

6.5.2.2.1 Random Trail Use

The 2 trails from basecamp to the garbage dump and to Jade Lake (trails 1 and 2 respectively; Table 6.3) resulted in different degrees of disturbance dependent mainly upon amounts of use (Plates 21, 22). Trail response to increased use included:

1) Trail width increased from 40 cm (trail 1) to 60 cm (trail 2)

2) Ground cover was reduced by 60% after approximately 100 tramples over a 10 week period (trail 1). A 100% destruction of living vegetation occurred on trail 2. This trail recieved >1000 tramples over the same period but user

activities were more severe than on trail 1 (carrying camping gear and supplies to basecamp, hauling water, etc.)

3) Once again, the mosses *Polytrichum piliferum* and *Dicranum fuscescens* were the most durable plants.

4) 10% of trail 2 was exposed sand. Potholes were developing at 2 locations

5) There was no apparent damage to the ericoids *Vaccinium myrtilloides* and *V. vitis-idaea* along trail 2, but many roots were exposed on the trail surface. Over a longer period, disturbance of the roots would negatively affect the plants (Marsh 1976).

6.5.2.2.2 Simulated Trail Use

In an experiment to compare durability of the ground vegetation when dry (relative humidity 43%) and when wet (relative humidity 85%), I found that moist lichens were more resistant to disturbance. The responses to trampling under simulated trail conditions included:

1) Disturbance after 5 tramples on the dry lichen mat was equal to the disturbance of 50 tramples on wet lichen, with 30% of the cover dislodged

2) The type of disturbance varied. When dry, the lichens were crushed, often to a fine powder. When wet, they were torn loose from the soil surface and kicked along by the foot

3) Trail widths varied (dry=25 cm, wet=30-35 cm)

4) Mosses on the wet trail did not appear to have been

affected by 50 tramples

5) After 20 tramples, only 1 cm of the LFH layer and living vegetation remained on the dry trail (unaffected ground cover was 5-7 cm deep). After 50 tramples, many bare spots were visable (LFH=0) and the only living vegetation was *Pol chum piliferium* (cover 1%).

Analysis of these simulated trail experiments rev that:

1) When wet, lichens are more resistant to crushing, but are easily dislodged

2) Visible trails are created in the lichen cover with 15 or less tramples (5 when dry, 15 when wet)

3) Mosses, although more resistant than lichens, cannot resist much trampling pressure

4) The lichen ground cover is a major constraint to use of the jackpine-lichen woodland if a wilderness environment is to be maintained. With the openness of the jackpine-lichen woodland, the natural tendency is to walk in a random pattern from a fixed site (Cordes *et al*. 1975). This combination of unrestricted travel over an extremely fragile ground cover will result in rapid change in the visual and ecological conditions in and around heavily used sites.

6.6 Summary

Flammability of vegetation, surface erosion by wind, conflicts with wildlife and the delicate ground vegetation are major envrionmental constraints to man's use of the study area for wilderness recreation. Even short term use of camping and hiking facilities results in long lasting impacts on the flora. If the dune area is to be used for wilderness recreation, these conditions will require an intensive management program specially designed to preserve the fragile ecological and aesthetic resources. Alternatives for utilization of this environment are presented in the concluding chapter.

CHAPTER 7

CONCLUSION

7.1 Available Resources

The perception of an area depends on the use to which it is to be put. The same area will be seen differently by a mining geologist, a forester, or a recreationist. In this study I have analysed the wilderness recreation potential of the sand dune region based on the assumption that wilderness requires a large area of natural environment relatively undisturbed by man. Central to this assumption was the idea that, if the area was wilderness and contained features that could be valuable to a wilderness recreation experience, how then should the area be managed to preserve these qualities?

The sand dune area of northeast Alberta is wilderness; totally undeveloped, remote from human settlement, and not easily accessible. It is also major ecological resource in Alberta. Here dynamic processes of wind erosion and deposition, vegetation succession, fire and plant regeneration, have continued for some 10,000 years relatively undisturbed by man. This large area (3000 km^2), only a small portion of the vast, undisturbed region of northeast Alberta, offers a diversity of landscape and recreational possibilities, an interpretive and educational resource, conducive to providing a highly satisfactory wilderness recreation experience. The value for wilderness recreation may be attibuted to:

1) The natural history of the aeolian landscape and the associated biological features

2) The interpretive and educational potential of a dynamic aeolian landscape and associated ecological processes

3) The potential as a scientific research area (Section 7.4)

4) The unique aesthetic qualities of the active dune complex and contrasting jackpine-lichen woodland.

In a concluding statement about the active dune complex and adjacent jackpine-lichen woodland, members of the Alberta Ecological Society (1975:5) stated "we feel it represents the closest thing to true wilderness that any of us has ever had the opportunity to see".

Several features of this environment, however, are extremely sensitive to impacts and are therefore constraints on the use of the area for wilderness recreation.

Increasing development in northeast Alberta can be predicted at this time because growing industrial activity will result in rising human populations and therefore the demand for a variety of recreation opportunities will increase. Maximizing visitor satisfaction, a major concern of recreation planners, can be accomplished for a region only if provision is made for a spectrum of opportunities. These opportunities should be designed to satisfy the diverse and often conflicting tastes of the recreating public (Lime and Stankey 1971). Therefore, it is necessary to discuss some development alternatives for management of the sand dune area.

7.2 Possible Management Alternatives

We are in a fortunate position at this time in northeast Alberta because:

1) There are a number of physically and biologically different areas offering a variety of recreational opportunities. These areas include the Peace-Athabasca Delta, the many lakes and forested areas of the Canadian Shield, the expanses of Wood Buffalo National Park and the chain lakes and forests of the Birch Mountains Upland. Large portions of these areas are undeveloped.

2) These various areas have different carrying capacities for recreation. Management to match the capabilities of the resource with appropriate uses is much more sound than trying to correct damage from misuse.

Therefore, in the context of a systems plan for recreation development in northeast Alberta, the sand dune region has several management possibilities. Central to each alternative is the need to preserve the unique active dune complex. These are listed according to the need for an increasing level of management input (money, facilities, use restrictions, policing, etc.).

1) Special Ecological Reserve. The sand dune area contains special features of high cultural and natural values

requiring protection or preservation. The active dune complex is the largest in Alberta and could provide the laboratory for many students of natural science. With limited use, perhaps through a permit system, special research teams could study the area, then incorporate the study findings into long term baseline monitoring of ecological changes in the rapidly industrializing northeast Alberta region. The areal extent of the reserve need not be large but should include the active dunes and a sizable buffer zone around the feature.

The Alberta Historical Resources Act (1977) could be used to establish this area as a historical site (Mussieux 1978) until legislation is passed in Alberta specifically designed for creating ecological reserves. New legislation is being proposed (Bill 202) for establishing ecological reserves. It has received second reading in the House and is scheduled for third reading in the 1978 fall session (Davis 1978).

2) Ecological Reserve Area. This would be used primarily for scientific research, including baseline monitoring, conservation of genetic resources, and study of the functioning of natural systems. The area should be in excess of 2000 ha and include all components of the functioning ecosystem including the active dune complex (Achuff 1975). The natural revegetation process on the sand dunes may be of value to scientists responsible for

developing revegetation techniques in the oil sands tailings and spoil areas. Ultimately, the maximum value of this area to society could come from its scientific value. These are specific objectives on which management plans can be designed. Although no legislation exists in the Province with which this designation could be made, The Alberta Wilderness Act (1971) could be used to reserve the area until such legislation is available (see alternative 1).

3) Wilderness Area. Under the Alberta Wilderness Act (1971), the sand dune area could be designated as a wilderness area (as have been the White Goat, Siffleur and Ghost River Wilderness Areas). But this should only be a temporary alternative designed to restrict:

1) Forestry, mining or other industrial uses
2) Construction of roads, railw , aircraft landing strips
3) Travel except on foot
4) Hunting or trapping
5) Fishing
6) Landing of aircraft
7) Depositing litter except in places designated for that purpose
8) Removing of plant or animal life or conducting scientific research unless authorized by the Lieutenant Governor in Council
9) Use of a horse or pack animal or any motorized vehicle.

(Alberta Wilderness Act 1971:549-550.)

This 'set it aside and leave it alone' policy has resulted in progressively increasing environmental deterioration in the mountain wilderness parks, a result of uncontrolled use and a lack of management planning. Increased and unmanaged use has resulted in ad hoc trail and campsite use, litter and sanitation problems leading to a severe decline in the quality of these mountain environments.

Therefore, an operational framework for wilderness recreation in the sand dune area should include clearly stated objectives for designating the area (i.e. to preserve an example of a unique geological feature for scientific, educational, cultural heritage and baseline monitoring), upon which a management plan can be designed and implemented.

4) Family Wilderness Area. To my knowledge, none of the wilderness areas of western North America have been developed around the concept of a family wilderness. Ghost River, White Goat and Siffleur Wilderness Areas are mountain parks and require physical capabilities beyond those of young children and older folks. The landscape of the sand dune area - the open, parklike jackpine-lichen woodland, the sandy, gradually sloping beaches along many of the lakes, the sand waves of the active dune complex - lends itself to this type of development. Due to the ecological constraints in the sand dune environment (Chapter 6), and possible development pressures from an expanding industrial complex in the Athabasca Oil Sands, there is a real need to

manage the [illegible] to zone highly sensitive unique features for preservation, to modify (harden) heavy use areas and provide facility development as intensive use zones, and to establish access and circulation corridors as transition and buffer zones.

Perhaps the most relevant legislation for preserving the active sand dune complex is the Provincial Parks Act (1974). This act gives Recreation, Parks and Wildlife the mandate to establish provincial parks, design recreation facilities and implement management to preserve the natural conditions of that area. The trend in Alberta in the last 2 years has been to obtain large areas for parks and provide a spectrum of recreation opportunities within that facility. For example, Kakwa Provincial Park in northwestern Alberta was created to protect the spectacular Kakwa Falls and pristine wilderness areas to the west from the uncontrolled, rapidly increasing recreational use it was receiving. The possibility also existed that the falls would be dammed for hydroelectric power. The area around the falls is now zoned for intensive recreational use while large portions of the backcountry, important areas for wildlife habitat, are managed to preserve pristine wilderness conditions.

This philosophy of zoning large parks for a variety of users has recently resulted in Kananaskis Country, a multi-purpose recreation area in southwest Alberta. Industrial development in northeast Alberta and the increasing accessibility of the sand dune area point to the urgency of designing similar management plans for the sand dune area. In this light, perhaps the Provincial Parks Act is the most suitable alternative for a realistic management plan.

7.3 Limitations of the Present Study

So many factors in a wilderness recreation experience are a personal complex of mental and environmental factors. This has created a particular challenge throughout this rese h, to identify objectively, and in a systematic , the envi onmental qualities that would contribute or etract from a satisfactory wilderness recreation experience. In Section 5.1.6 I recalled exceptional experiences that contributed to my impressions of the dunes area. I also suggested qualitative aspects of specific features that to me, represent the special wilderness attributes of that area. These remain my best judgements, but they are very personal judgements. As with all scientific work that requires qualitative assumptions, this inserts into the study a number of biases and limitations.

I made a number of assumptions concerning wilderness recreational use of the sand dunes, including the need for campsites and trails, and then conduc ct assessments to predict environmental problems tha e expected if this use occurred. These assump were personal but they were formulated as objectively as possible after a literature review, reconnaissance field work and general observations of impacts on other wilderness environments.

In summary, I found that there are no accepted guidelines for assessing wilderness potential and planning wilderness recreation. Nevertheless, I believe this research provid a framework within which to plan a wilderness recreation facility in the sand dune region if and when a decision is taken for its development. The analysis presented here will become more complete as the environmental baseline information on the dune region is widened, as our knowledge of the elusive human factors involved in wilderness recreation improves, and as policies for the management of wilderness are designed and tested.

This thesis is therefore a working model. The basic physical, biological and human components have been presented and analysed, the qualitative aspects discussed and constraints on use analysed. It remains to take this information, couple it with an analysis of the ser component, and formulate a management policy consisten with the environmental conditions of the sand dune area. In the broader context, the policy should be integrated into a systems plan for recreation development in northeast Alberta.

7.4 Future Research

Several aspects of recreat potential and the natural environment of the sand area need to be investigated further.

1) User or demand studies. Through a mail-back questionnaire, researchers could acquire quantitative data on demand for recreation in a sand dune environment as input into a backcountry management plan. Data would be required on social carrying capacity, user conflicts, willingness to pay to travel to such a distant facility, visitor expectations and attitudes toward facility development and management. Social carrying capacity research has not been attempted by the present study yet should be completed before any management plans are made. Managers will be charged with the task of balancing demand for a site with what that site can supply.

2) Before designation of park boundaries can be ecologically sound, more detailed alysis of the functional aspects of the sand dune ecosystem (climate, fire, revegetation process, etc.) may be required.

3) On 2-3 May 1976, I made a reconnaissance survey of Moose Lake Provincial Park to compare environmental impact at that facility with those noted for the study area. Situated in an area of stabilized sand dunes and jackpine-lichen

woodland along the north shore of Moose Lake, Alberta, this park had many similarities to the study area. Impact on the campsites can be described as total destruction of all ground cover, broken branches on all jackpine in the campsite areas, random trail patterns and no natural screening between campsites. Examination should be made of this and similar areas (for example, Lesser Slave Lake Provincial Park) to compare disturbances at campsites and along trails with those noted for the study area. This could add important detail to the planning and management of wilderness recreation in the dune region. Fish populations in the lakes of the area appear to be large, but fisheries research is needed before a carrying capacity for recreational fishing can be established and catch limits assigned.

4) This study has assessed environmental conditions and reported on the wilderness qualities of the sand dune area. The next step should be the incorporation of this information into a broad regional plan for development in northeast Alberta so that the extensive resources of this part of the Province will be developed rationally.

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Appendix 8.1

Systematic Tabulation of Plant Species

Scientific Name	Common Name
Vasculars[1]	
Equisetaceae	Horsetail family
Equisetum fluviatile L.	horsetail
Equisetum sylvaticum L.	woodland horsetail
Lycopodiaceae	Club-moss Family
Lycopodium annotinum L.	stiff club-moss
Lycopodium clavatum L.	common or running club-moss
Lycopodium complanatum .	ground cedar
Pinaceae	Pine Family
Larix laricina (Du Roi, K. Koch	tamarack
Picea glauca (Moench) Vo.	white spruce
Picea mariana (Mill) BSP.	black spruce
Pinus banksiana Lamb.	jackpine
Typhaceae	Cattail Family
Typha latifolia L.	common cattail
Najadaceae	Pondweed Family
Potamogeton alpinus var. *subellipticus* (Fern) Ogden*	pondweed
Potamogeton natans L.*	pondweed
Potamogeton obtusifolius Mert. and Koch*	pondweed
Juncaginaceae	Arrow-grass Family
Scheuchzeria palustris L. var. *americana* Fern.	slender arrow-grass
Gramineae	Grass Family
Agropyron smithii Rydb.	western wheat grass
Agrostis scabra Willd.	hair or tickle grass
Bromus marginatus Nees	brome grass
Bromus pumpellianus Scribn.*	northern awnless brome
Calamagrostis inexpansa A. Gray	northern reed grass
Festuca rubra L.	red fescue
Koeleria cristata (L.) Pers.	June grass
Oryzopsis pungens (Torr.) Hitchc.*	rice grass
Phleum pratense L.	timothy
Phragmites communis Trin.	reed

Scientific Name	Common Name
Vasculars (contd.)	
Cyperaceae	Sedge Family
Carex aquatilis Wahlenb.	sedge
Carex praticola Rydb.*	sedge
Carex rostrata Stokes	sedge
Eriophorum brachyantherum Trautv.	cotton grass
Scirpus atrocinctus Fern.	wool grass
Juncaceae	Rush Family
Juncus balticus Willd.	wire rush
Juncus brevicaudatus (Engelm.) Fern.	rush
Liliaceae	Lily Family
Maianthemum canadense Desf. var. *interius* Fern.	wild lily-of-the-valley
Smilacina trifolia (L.) Desf.	three-leaved Solomon's seal
Orchidaceae	Orchid Family
Cypripedium acaule Ait.	stemless lady's-slipper
Goodyera repens (L.) R.Br.	rattlesnake plantain
Salicaceae	Willow Family
Populus tremuloides Michx.	aspen
Salix arbusculoides Anderss.	willow
Salix bebbiana Sarg.	beaked willow
Salix mackenzieana (Hook.) Barratt	willow
Salix planifolia Pursh	willow
Salix scouleriana Barratt	willow
Myricaceae	
Myrica gale L.	sweet gale
Betulaceae	Birch Family
Alnus crispa (Ait.) Pursh	green alder
Betula papyrifera Marsh.	paper birch
Betula pumila L. var. *glandulifera* Regel*	swamp birch
Santalaceae	Sandalwood Family
Geocaulon lividum (Richards.) Fern.	bastard toad-flax
Loranthaceae	Mistletoe Family
Arceuthobium americanum Nutt.	Dwarf mistletoe
Polygonaceae	Buckwheat Family
Polygonum scabrum Moench*	knotweed
Nymphaeaceae	Water-lily Family
Nuphar variegatum Engelm.	yellow pond-lily
Fumariaceae	Fumitory Family
Corydalis sempervirens (L.) Pers.	pink corydalis

Scientific Name	Common Name
Vasculars (contd.)	
Cruciferae	Mustard Family
Arabis lyrata L.	rock cress
Sarraceniaceae	Pitcher-plant Family
Sarracenia purpurea L.	pitcher-plant
Droseraceae	Sundew Family
Drosera rotundifolia L.	sundew
Saxifragaceae	Saxifrage Family
Saxifraga bronchialis L.*	saxifrage
Rosaceae	Rose Family
Potentilla palustris (L.) Scop.	marsh cinquefoil
Potentilla tridentata Ait.	three-toothed cinquefoil
Prunus pensylvanica L.f.	pin cherry
Rosa acicularis Lindl.	prickly rose
Rubus chamaemorus L.	cloudberry
Empetraceae	Crowberry Family
Empetrum nigrum L.	crowberry
Cistaceae	Rockrose Family
Hudsonia tomentosa Nutt.	sand heather
Onagraceae	Evening Primrose Family
Epilobium angustifolium L.	fireweed
Epilobium hornemannii Reichenb.*	willow-herb
Araliaceae	Ginseng Family
Aralia nudicaulis L.	wild sarsaparilla
Umbelliferae	Carrot Family
Cicuta bulbifera L.	water hemlock
Cornaceae	Dogwood Family
Cornus canadensis L.	bunchberry
Pyrolaceae	Wintergreen Family
Chimaphila umbellata (L.) Bart. var. *occidentalis* (Rydb.) Blake	prince's pine
Pyrola virens Schweigg.	greenish-flowered wintergreen
Ericaceae	Heath Family
Arctostaphylos uva-ursi (L.) Spreng.	common bearberry, kinnikinnick
Chamaedaphne calyculata (L.) Moench	leather-leaf
Kalmia polifolia Wang. var. *mycrophylla* (Hook.) Rehd.	mountain laurel

Vasculars (contd.)

Scientific Name	Common Name
Ericaceae (contd.)	Heath Family (contd.)
Ledum groenlandicum Oeder	common Labrador tea
Ledum palustre L. var. *decumbens* Ait.	northern Labrador tea
Vaccinium myrtilloides Michx.	blueberry
Vaccinium vitis-idaea L. var. *minus* Lodd.	bog cranberry, cow-berry
Primulaceae	Primrose Family
Trientalis borealis Raf.	star-flower
Gentianaceae	Gentian Family
Menyanthes trifoliata L.	buck-bean
Apocynaceae	Dogbane Family
Apocynum androsaemifolium L.	spreading dogbane
Boraginaceae	Borage Family
Lappula echinata Gilib.	blue-bur
Scrophulariaceae	Figwort Family
Melampyrum lineare Desr.	cow-wheat
Lentibuliaceae	Bladderwort Family
Utricularia sp.	bladderwort
Caprifoliaceae	Honeysuckle Family
Linnaea borealis L. var. *americana* (Forbes) Rehd.	twin-flower
Campanulaceae	Bluebell Family
Campanula rotundifolia L.	bluebell, harebell
Compositae	Composite Family
Achillea millefolium L.	common yarrow
Artemisia campestris L.	aster
Aster puniceus L.	purple-stemmed aster
Hieracium umbellatum L.	narrow-leaved hawkweed
Senecio pauperculus Michx.	ragwort
Solidago decumbens Greene	goldenrod
Solidago gigantea Ait.	goldenrod
Solidago graminifolia (L.) Salisb.	goldenrod
Solidago lepida DC.	goldenrod
Solidago nemoralis Ait. var. *decemflora* (DC.) Fern.	goldenrod
Tanacetum huronense var. *floccosum* Nutt.	tansy

Scientific Name	Common Name
Mosses[1]	
Sphagnopsida	
Sphagnum spp. L.	peat moss
Bryopsida	
Ditrichaceae	
Ceratodon purpureus (Hedw.) Brid.*	moss
Dicranaceae	
Dicranum fuscescens Turn.	moss
Dicranum polysetum Sw.	moss
Dicranum undulatum Brid. (D. *bergeri* Bland.)*	moss
Bryaceae	
Pohlia nutans (Hedw.) Lindb.*	moss
Brachytheciaceae	
Pleurozium schreberi (Brid.) Mitt.	moss
Hypnaceae	
Hypnum cupressiforme Hedw.*	sheet moss
Ptilidium ciliare Hedw.	moss
Hylocomiaceae	
Hylocomium splendens (Hedw.)*	stair-step moss
Polytrichaceae	
Polytrichum piliferum (Hedw.)	moss
Polytrichum juniperinum (Hedw.)	juniper moss
Lichens[1]	
Peltigeraceae	
Peltigera aphthosa (L.) Willd.	lichen
Peltigera canina (L.) Willd.	dog lichen
Peltigera malacea (Ach.) Funck	lichen
Hypogymniaceae	
Hypogymnia physodes (L.) Nyl.	lichen
Parmeliaceae	
Cetraria pinastri (Scop.) S. Gray	lichen
Parmeliopsis ambigua (Wulf.) Nyl.	lichen
Parmeliopsis hyperopta (Ach.) Arn.	lichen
Parmelia sulcata Tayl.	lichen
Cetraria halei Culb.	lichen
Cetraria nivalis (L.) Ach.	lichen
Cetraria islandica (L.) Ach.	island moss
Cetraria ericetorum Opiz.	lichen

Scientific Name	Common Name
Lichens (contd.)	
Usneaceae	
Evernia mesomorpha Nyl.	lichen
Usnea subfusca Stirt.	lichen
Usnea hirta (L.) Wigg.	old man's beard
Alectoria fremontii Tuck.	lichen
Stereocaulaceae	
Stereocaulon tomentosum Fr.	lichen
Cladoniaceae	
Cladina stellaris (Opiz) Pouz. and Vezda	lichen
Cladina mitis Sandst.	reindeer moss
Cladina rangiferina (L.) Wigg.	reindeer moss
Cladina arbuscula Wallr. Rabenh.	lichen
Cladonia amaurocraea (Flk.) Schaer.	lichen
Cladonia uncialis (L.) Wigg.	lichen
Cladonia coccifera (L.) Willd.	lichen
Cladonia deformis (L.) Hoffm.	lichen
Cladonia fimbriata (L.) Fr.	lichen
Cladonia pleurota (Flk.) Schaer.	lichen
Cladonia chlorophaea (Flk.) Spreng.	lichen
Cladonia verticillata (Hoffm.) Schaer.	lichen
Cladonia gracilis (L.) Willd.	lichen
Cladonia phyllophora (Ehrh.) Hoffm.	lichen
Cladonia squamosa (Scop.) Hoffm.	lichen
Cladonia crispata (Ach.) Flot.	lichen
Cladonia cristatella Tuck.	British soldier lichen
Cladonia cornuta (L.) Hoffm.	lichen
Cladonia botrytes (Hag.) Willd.	lichen
Physciacea	
Physcia stellaris (L.) Nyl.	lichen

1 Preliminary plant identifications were made in the field and subsequently verified by the following members of the Department of Botany, The University of Alberta: vascular plants, Mme. Dumais; mosses, Tom Lee and Mike Ostafichuck; lichens, Dennis Lindsay.

* Species collected and identified by members of the Alberta Ecological Survey during fieldwork in the study area 24 - 28 July 1976.

Vasculars after Moss (1959) and Hultén (1968).

Bryophytes after Crum *et al.* (1973).

Lichens after Hale (1969) and Poelt (1973).

Appendix 8.2

Systematic Tabulation of Wildlife Species

Scientific Name	Common Name
Aquatic Vertebrates	
Fishes[1]	
Esocidae	Pike Family
Esox lucius L.	northern pike
Cyprinidae	Minnow Family
Notropis hudsonius Clinton	spottail shiner
Percopsidae	Trout-Perch Family
Percopsis omiscomaycus Walbaum	trout-perch
Gadidae	Cod Family
Lota lota L.	burbot
Gasterosteidae	Stickleback Family
Culaea inconstans Kirtland	brook stickleback
Pungitius pungitius L.	ninespine stickleback
Percidae	Perch Family
Perca fluviatilis Mitchell	American yellow perch
Stizostedion vitreum Mitchell	yellow walleye
Amphibians[1]	
Bufonidae	Toad Family
Bufo boreas Baird and Girard	boreal toad
Bufo hemiophrys Cope	Canadian or Dakota toad
Ranidae	Frog Family
Rana sylvatica Le Conte	wood frog
Birds[2]	
Gaviidae	Loon Family
Gavia immer Brunnich	common loon
Colymbidae	Grebe Family
Podiceps grisegena Reinhart	red-necked grebe
Pelecanidae	Pelican Family
*Pelecanus erythrorhynchos** Gmelin	white pelican

Scientific Name	Common Name
Birds (Contd.)	
Anatidea	Swan, Goose and Duck Family
Branta canadensis Cassin.	Athabasca Canada goose
Anas platyrhynchos L.	common mallard
*Anas strepera** L.	gadwall
Anas sp.	teal
Spatula clypeata L.	shoveler
Aythya affinis Eyton	lesser scaup
*Bucephala clangula** Bonaparte	American goldeneye
Bucephala albeola L.	bufflehead
Melanitta perspicillata L.	surf scoter
Mergus serrator L.	red-breasted merganser
Accipitridae	Kite, Hawk, Eagle, Harrier Family
*Accipiter gentilis** Wilson	eastern goshawk
Buteo jamaicensis Gmelin	red-tailed hawk
Buteo swainsoni Bonaparte	Swainson's hawk
*Aquila chrysaetos*** L.	golden eagle
Haliaeetus leucocephalus Townsend	northern bald eagle
Circus cyaneus L.	marsh hawk
Pandionidae	Osprey Family
Pandion haliaetus Gmelin	osprey
Falconidae	Caracara and Falcon Family
Falco columbarius Ridgway	Richardson's pigeon hawk
Falco sparverius L.	eastern sparrow hawk
Tetraonidae	Grouse and Ptarmigan Family
Canachites canadensis L.	spruce grouse
Bonasa umbellus Douglas	ruffed grouse
Lagopus lagopus Gmelin	willow ptarmigan
Gruidae	Crane Family
Grus canadensis Peters	sandhill crane
Charadriidae	Plover and Surfbird Family
Charadrius vociferus L.	killdeer
Scolopacidae	Snipe and Sandpiper Family
Actitis macularia L.	spotted sandpiper
Tringa solitaria Wilson	eastern solitary sandpiper
Totanus flavipes Gmelin	lesser yellowlegs
Erolia minutilla Vieillot	least sandpiper
Ereunetes mauri Cabanis	western sandpiper

Birds (Contd.)

Scientific Name	Common Name
Phalaropidae	Phalarope Family
Steganopus tricolor Vieillot	Wilson's phalarope
Lobipes lobatus L.	northern phalarope
Laridae	Gull and Tern Family
Larus argentatus Coues.	herring gull
Larus californicus Lawrence	California gull
Larus pipixcan Wagler	Franklin's gull
Sterna hirundo L.	common tern
Strigidae	Owl Family
Bubo virginianus Gmelin	great horned owl
Caprimulgidae	Goatsucker and Nighthawk Family
Chordeiles minor Forster	common nighthawk
Alcidinidae	Kingfisher Family
Megaceryle alcyon L.	eastern belted kingfisher
Picidae	Woodpecker Family
Colaptes auratus Bangs	yellow shafted flicker
Dryocopus pileatus Bangs	northern pileated woodpecker
Picoides arcticus Swainson	Arctic three-toed woodpecker
Tyrannidae	Kingbird, Phoebe and Flycatcher Family
Tyrannus tyrannus L.	eastern kingbird
Nuttallornis borealis Swainson	olive-sided flycatcher
Hirundinidae	Swallow Family
Iridoprocne bicolor Vieillot	tree swallow
Corvidae	Jay, Magpie, Crow and Raven Family
Perisoreus canadensis Peters	gray jay
Corvus corvax Ridgway	common raven
Corvus brachyrhynchos Brehm	common crow
Paridae	Titmouse and Chickadee Family
Parus atricapillus Harris	black-capped chickadee
Parus hudsonicus Godfrey	boreal chickadee
Sittidae	Nuthatch Family
Sitta canadensis L.	red-breasted nuthatch
Turdidae	Thrush, Solitaire and Bluebird Family
Turdus migratorius L.	eastern robin

Scientific Name	Common Name

Birds (Contd.)

Scientific Name	Common Name
Sylviidae	Kinglet, Gnatcatcher and Old World Warbler Family
Regulus calendula L.	ruby-crowned kinglet
Bombycillidae	Waxwing Family
Bombycilla garrula Reichenow	Bohemian waxwing
*Bombycilla cedorum** Vieillot	cedar waxwing
Vireonidae	Vireo Family
Vireo solitarius Wilson	solitary vireo
*Vireo olivaceus** L.	red-eyed vireo
Vireo gilvus Vieillot	warbling vireo
Parulidae	Wood Warbler Family
Vermivora peregrina Wilson	Tennessee warbler
Dendroica petechia Gmelin	yellow warbler
Icteridae	Meadowlark, Blackbird, Oriole Family
Agelaius phoeniceus Oberholser	redwinged blackbird
Euphagus carolinus Muller	rusty blackbird
*Quiscalus quiscula** Vieillot	common grackle
Fringillidae	Grosbeak, Finch, Sparrow, Bunting, Longspur Family
*Spinus pinus** Wilson	pine siskin
Loxia curvirostra Grinnell	red crossbill
Passerculus sandwichensis Bonapart	savanah sparrow
Junco hyemalis L.	slate-colored junco
Junco oreganus Ridgway	Oregon junco
Spizella passerina Oberholser	chipping sparrow
Spizella breweri Cassin	Brewer's sparrow
*Zonotrichia** Nuttall	Harris' sparrow
Melospiza georgiana Oberholser	swamp sparrow
Melospiza melodia Bishop	song sparrow

Mammals[3]

Scientific Name	Common Name
Soricidae	Shrew Family
Sorex cinereus Kerr	masked shrew
Vespertilionidae	Smooth-Faced Bat Family
Myotis lucifugus Le Conte	little brown bat
Leporidae	Rabbit and Hare Family
Lepus americanus Erxleben	snowshoe hare

Scientific Name	Common Name
Mammals (Contd.)	
Sciuridae	Squirrel Family
Eutamias minimus Bachman	least chipmunk
Tamiasciurus hudsonicus Erxleben	American red squirrel
Castoridae	Beaver Family
Castor canadensis Kuhl	American beaver
Muridae	Rat, Mouse and Vole Family
Peromyscus maniculatus Wagner	deer mouse
Clethrionomys gapperi	Gappers red-back vole
Ondatra zibethicus L.	muskrat
Canidae	Dog Family
Canis latrans Say	coyote
Canis lupus L.	wolf
Ursidae	Bear Family
Ursus americanus Pallas	American black bear
Mustelidae	Weasel Family
Lontra canadensis Schreber	river otter
Cervidae	Deer Family
Rangifer tarandus L.	caribou
Alces alces L.	moose

1 Identified by W.E. Roberts, Curator, Museum of Zoology, The University of Alberta, November, 1976.

2 Identified in the field by John Walker, Department of Geography, The University of Alberta.

* Species identified by members of Alberta Ecological Society during fieldwork in the study area 24 - 28 July 1976.

3 Mammals identified from field signs (scats, tracks, craters, dens, dropped antlers, etc.).

Fishes after McPhail and Lindsey (1970).
Amphibians after Hodge (1976).
Birds after Godfrey (1966) and Salt and Wilk (1958).
Mammals after Banfield (1974).

Appendix 8.3

Description of the two Principal Soil Types of the Study Area

Example A

Classification

Sub-group: *Orthic Regosol*

Location: sample site (Figure 4.1).

Parent material: aeolian sand overlying glacial outwash sands and gravels.

Topography: flat to gently rolling, recently stabilized (Stage 3) dune plain (Complex aspect).

Drainage: free to excessive.

Soil moisture: subxeric (1).

Vegetation and Cover Estimates: tree canopy: (*Pinus banksiana*) 10-20%
shrubs: (*Arctostaphylos uva-ursi*) <1%,
(*Empetrum nigrum*) <1%
herbs and grasses: ([illegible]) <5%
mosses and lichens: 75 ground cover of pioneer mosses (35-50%) and lichens (25-40%).

Orthic Regosol (Plate 23)

Horizon	Depth (cm)	Description
L	5-1	patchy, lichen cover, needle litter
F-H	1-0	mull (1 cm) partially decomposed needle litter and woody fragments, charcoal
C	0-	brown to rusty brown sand, very few roots, infrequent charcoal fragments, pH 5.5

Example B

Classification

Sub-group: *Orthic Eutric Regosol*

Location: sample site 1 (Figure 4.1).

Parent material: aeolian fine sand overlying glacial outwash deposits.

Topography: rolling, poorly developed, stabilized dunes, north aspect.

Drainage: free to slightly impeded.

Soil moisture: mesic (3).

Vegetation and Cover Estimates: tree canopy: *(Pinus banksiana)* 30-35%
shrubs: *(Arctostaphylos uva-ursi)* <1%,
(Vaccinium myrtilloides) 5-10%,
(Prunus pensylvanica) <1%
herbs and grasses: *(Maianthemum canadense)* 5-10%,
(Solidago decumbens) <1%
mosses and lichens: 100% ground cover of mosses (15%) and lichens (85%).

Orthic Eutric Regosol overlying *Paleosol* (Plate 4)

Horizon	Depth (cm)	Description
L	7-3	moss and lichen layer, with admixture of needle litter
F-H	3-0	mor (1-2 cm), decaying moss and lichen litter, mull (1 cm) fragments of pine wood and needles, sand, abundant charcoal particles
Ahj	0-14	dark greyish brown to black sand, charcoal particles, abundant rooting, pH 5.5, distinct color change at Bm boundary
Bm	14-30	yellow-brown sand, very little organic material, pH 5.5
C	30-65	light brown sand, no organic material, pH 5.5
IIB	65-68	small (1-7 cm diameter) rounded pebbles, light and dark brown sands, charcoal and organic litter - previous soil surface
IIC	68 -	white "beach" sand, highly quarzitic, no organic material, no pebbles

APPENDIX 8.4

Quartz Mineral Leases of the Sand Dune Region of Northeast Alberta

Permit No.	Lease Holder	Date of Issue	Current Lease Status
82	National Nickle Ltd., Calgary	16.12.1968	cancelled
83	National Nickle Ltd., Calgary	16.12.1969	cancelled
84	National Nickle Ltd., Calgary	16.12.1969	cancelled
87	McIntyre Porcupine Mines Ltd. Toronto	17.12.1968	cancelled
88	McIntyre Porcupine Mines Ltd. Toronto	17.12.1968	cancelled
89	Canadian Southern Petroleum Ltd., Calgary	17.12.1968	cancelled
91	Abidorne Oils Ltd., Calgary	18.12.1963	cancelled
92	Abidorne Oils Ltd., Calgary	18.12.1963	cancelled
93	Anco Exploration Ltd., Calgary	19.12.1968	cancelled
94	Anco Exploration Ltd., Calgary	19.12.1968	cancelled
95	Anco Exploration Ltd., Calgary	19.12.1968	cancelled
96	Anco Exploration Ltd., Calgary	19.12.1968	cancelled
97	Anco Exploration Ltd., Calgary	19.12.1968	cancelled
98	Anco Exploration Ltd., Calgary	19.12.1968	cancelled
99	Anco Exploration Ltd., Calgary	19.12.1968	cancelled
100	Anco Exploration Ltd., Calgary	19.12.1968	cancelled
101	Anco Exploration Ltd., Calgary	19.12.1968	cancelled
102	Anco Exploration Ltd., Calgary	19.12.1968	cancelled
109	Ledo Mines Ltd., Edmonton	20.12.1968	cancelled
110	Ledo Mines Ltd., Edmonton	20.12.1968	cancelled
117	Trigg, Woollett & Associates Ltd., Edmonton	22.01.1969	cancelled
118	Trigg, Woollett & Associates Ltd., Edmonton	22.01.1969	cancelled
179	Inexco Mining Company, Calgary	20.03.1974	cancelled
180	Inexco Mining Company, Calgary	20.03.1974	cancelled
181	Inexco Mining Company, Clagary	20.03.1974	cancelled
185	Eldorado Nuclear Ltd., Edmonton	23.08.1974	active
186	Eldorado Nuclear Ltd., Edmonton	23.08.1974	active
187	Eldorado Nuclear Ltd., Edmonton	23.08.1974	active

Permit No.	Lease Holder	Date of Issue	Current Lease Status
208	Great Plains Development Company of Canada, Ltd., Calgary	28.01.1976	active
209	Great Plains Development Company of Canada, Ltd., Calgary	28.01.1976	active
210	Great Plains Development Company of Canada, Ltd., Calgary	28.01.1976	active
211	Great Plains Development Company of Canada, Ltd., Calgary	28.01.1976	active
212	Great Plains Development Company of Canada, Ltd., Calgary	28.01.1976	active
214	Eldorado Nuclear Ltd., Edmonton	2.02.1976	active
215	Eldorado Nuclear Ltd., Edmonton	2.02.1976	active
216	Eldorado Nuclear Ltd., Edmonton	2.02.1976	active
217	Eldorado Nuclear Ltd., Edmonton	2.02.1976	active
218	Eldorado Nuclear Ltd., Edmonton	2.02.1976	active
229	BP Minerals Ltd., Calgary	28.01.1976	active
230	BP Minerals Ltd., Calgary	28.01.1976	active

APPENDIX 8.5

Air and Water Temperatures at Jade Lake Basecamp
3 - 23 August 1975

Date	Air Temperature (°C)		Water Temperature (°C)		Wind	Weather Conditions	
(August 1975)	0900	2100	0900	2100	Direction	AM	PM
3	14.9	15.0	19.5	19.8	S	clear	clear
4	14.9	20.0	19.8	21.3	S&SW	cloudy, fog	cloudy
5	20.5	19.0	20.9	20.5	S	cloudy, windy	calm, lightning
6	18.0	17.0	19.9	19.0	S	sunny, windy	scattered showers
7	17.8	16.0	19.3	20.0	W	sunny, windy	calm, cloudy
8	19.0	15.5	20.9	19.5	W	calm	clear
9	18.0	16.5	19.5	19.9	SW	clear	clear
10	17.5	17.8	21.0	20.0	NW	clear	rain all night
11	14.3	13.8	19.8	19.9	NW	rain	rain
12	11.9	8.0	19.1	18.7	NW	cool, overcast	rain
13	10.0	9.9	18.7	18.6	NW	rain	clear, cool
14	11.9	7.0	18.2	17.0	NW	cloudy, windy	cold, cloudy
15	10.0	12.0	17.8	17.5	NW	cool, sunny intervals	clear
16	13.0	10.9	17.9	17.9	WNW	clear	clear
17	17.1	11.0	18.0	18.8	W&SW	clear	clear
18	17.0	14.7	18.0	18.0	SSE	clear	cloudy
19	17.0	10.2	18.0	18.0	[illegible]	cloudy, cool	intermittent showers
20	17.1	16.0	18.0	18.0		cloudy, windy	clear
21	14.9	15.4	17.9	18.3		rain	clear
22	17.2	16.9	17.9	18.8	SE	rain, warm	rain
23	13.1	16.0	18.0	19.9	SE	rain all day	

APPENDIX 8.6

PLATES

Plate 1. Oblique aerial view to the south showing Alberta's largest active dune complex during winter. A system of coalescing transverse dunes is migrating ESE (right to left) across a forested landscape. Wind keeps the tops of the dunes free of snow (darker areas). 25 February 1975.

Plate 2. An ERTS regional view of northeast Alberta. The active sand dune complex (arrow) is just 1 of the many natural environments that in combination have potential for a variety of recreation opportunities. These include the lake district east of the study area, the Peace Athabasca Delta (centre), the lakes of the Canadian Shield (top centre) and the Birch Mountains Upland (under cloud, bottom left). 24 May 1974.

Plate 3. Oblique aerial view to the southwest of the eastern half of the study area, indicating the active dune complex (1), jackpine-lichen woodland (30-69% cover) (2), less dense jackpine-lichen woodland (<30% cover) occupying recently stabilized dune surfaces (3), and drier sites such as the stabilized blowout dunes (4), blowout depressions (5), and black spruce-sphagnum wetlands (6). 27 February 1975.

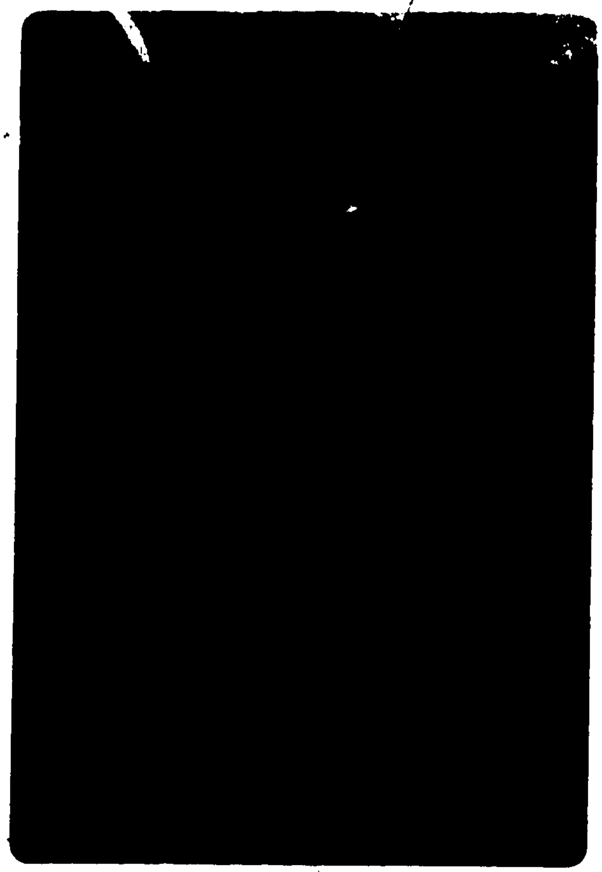

Plate 4. Orthic Eutric Regosol. This soil pit is described in Appendix 8.3. A 3 cm thick layer of rounded pebbles (65-68 cm from surface) indicates a previous soil surface, now overlain by aeolian sand. 8 August 1975.

Plate 5. Oblique aerial view to the northeast of the 2 largest lakes of the study area, Barber Lake (foreground) and Larocque Lake (centre) could provide future staging areas while offering a variety of water-based recreation opportunities. 19 August 1975.

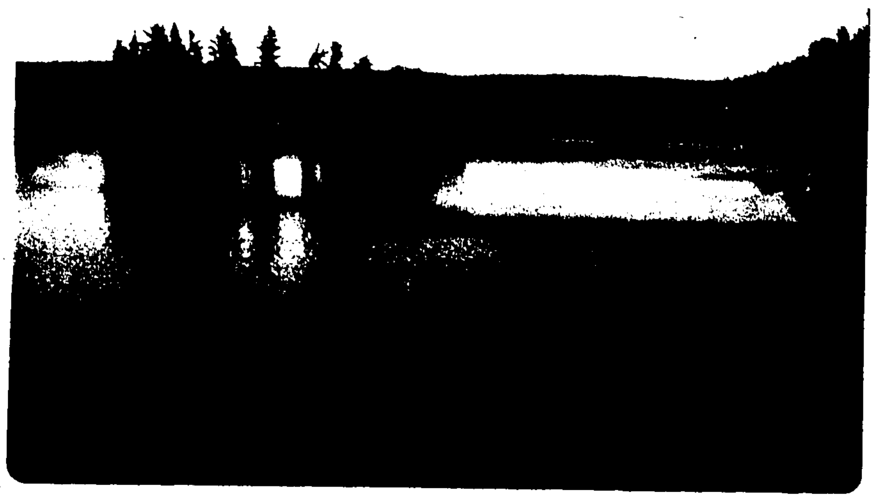

Plate 6. View to the north of Jade Lake. Shallow (<10 m), clear and potable water together with a variety of birds, aquatic mammals, good fishing and interesting shoreline vegetation, creates high wilderness recreation potential. 16 August 1975.

Plate 7. Jackpine-lichen woodland with nearly complete ground cover of Cladonia spp. and Cladina spp. Arctostaphylos uva-ursi in right foreground is also common. The openness of this vegetation type invites easy hiking but the lichen cover is easily crushed when dry and readily dislodged when moist. 6 August 1975.

Plate 8. Recently stabilized dune plain 100 m west of the active dune complex. The lichen cover is patchy (<70% cover) and in many areas shows the impact of caribou winter cratering (dark areas). Note jackpine affected by witches broom (Arceuthobium americanum) left and right centre. 20 June 1976.

Plate 9. This 157 year old jackpine stand was protected from crown fires by a large wetland. Fire scars on these jackpine were used to determine the frequency of surface fires on this site and to date the present lichen cover at 76 years old. Fire scars are on the south side of these trees indicating that fires advanced from the north around the wetland. 25 July 1976.

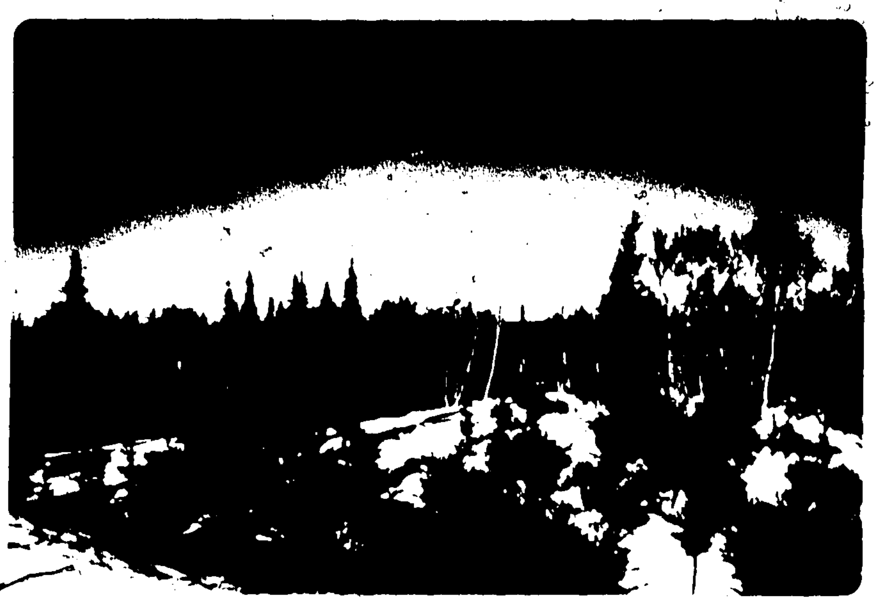

Plate 10. Jackpine, birch and white spruce dominate the mixedwood vegetation type near the advancing edge of the active dune complex (left foreground). 26 February 1975.

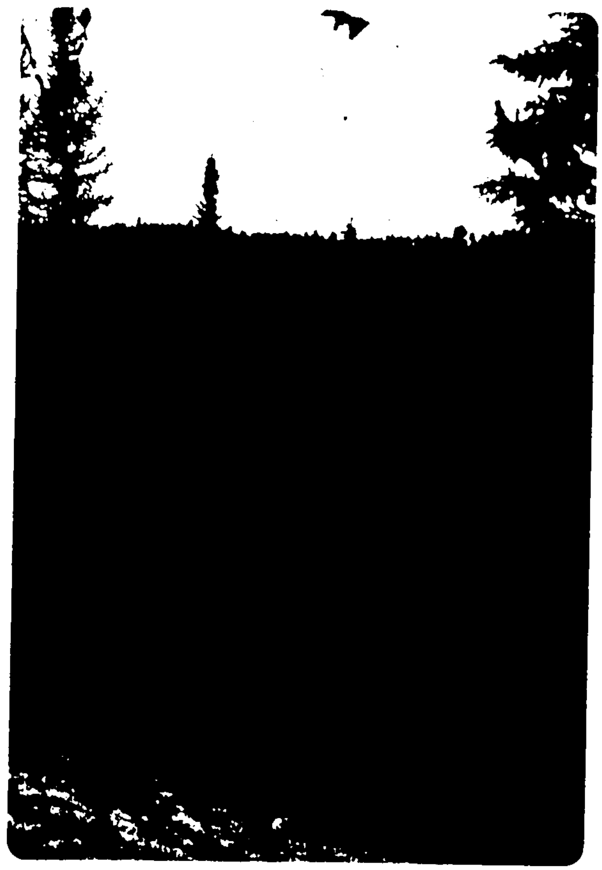

Plate 11. Wetland vegetation occupies many interdune depressions and lowland areas. Lichens dominate the dry slope (left foreground) while black spruce, labrador tea and sphagnum dominate the wet lowland area. 1 July 1976.

Plate 12. Hudsonia tomentosa and Polytrichum piliferum are the major pioneer species along the revegetating western edge of the active dune complex. Small dune ripples can be seen between Hudsonia tufts, evidence of the unstable, sandy substrate. 10 August 1975.

Plate 13. The lee slope of a transverse dune on the active dune complex (direction of effective winds left to right). Grasses are able to establish and migrate upslope under sand accretion. This vegetation influences dune shape and height by binding the sand and retarding erosion. Blowing snow in winter (Plate 1) abrades the grasses growing near the top of the dune ridges retarding the stabilization of the dunes. 12 August 1975.

Plate 14. White birch places adventitious roots enabling it to withstand sand accretion and erosion, thereby influencing dune shape and wave amplitude. Dark root masses on birches in foreground indicate a previous sand surface level some 1.5 m higher than present. The sand slope in foreground is the eroding windward side (direction of effective wind is away from viewer), and the horizon is the crest of the precipitation ridge. Note sand binding by birch in left background. 9 August 1975.

Plate 15. Thirty-five m high lee slope of precipitation ridge which is migrating into Owl Creek. Note undercutting of the dune at water-level. Because sand particles are unable to be transported by the slow moving water, the creek is slowly being infilled. 5 August 1975.

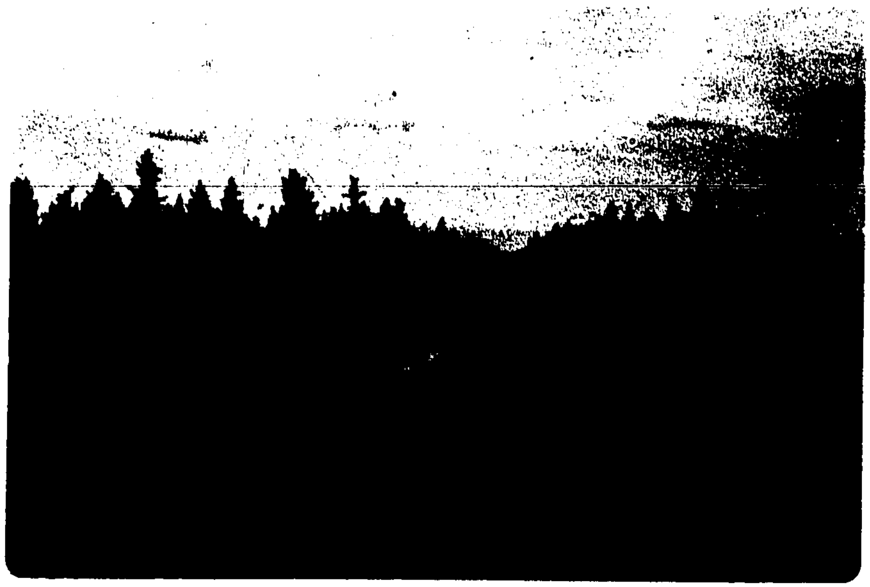

Plate 16. Winter road west of the active dune complex. The road was constructed in the early 1950's and used previous to 1960 to service Uranium City from Bitumont. Tracked vehicles that compacted the snow and lichens, plus lowered temperatures at the snow-lichen interface, are responsible for killing lichens along the route. Regeneration of lichen cover has not yet taken place, although there is some regrowth of jackpine. This road may provide access for all-terrain vehicles if a new townsite is established in the Fort Hills area to serve an expanding oil sands extraction industry. 10 August 1975.

Plate 17. This blowout depression is flanked by a stabilized dune and offers an interesting mixture of landform, vegetation and wildlife habitat. Dune ridge (horizon) could provide excellent observation points. 20 June 1976.

Plate 18. An excellent swimming facility occurs where the active dune complex spills into Swimming Hole Lake. 21 July 1976.

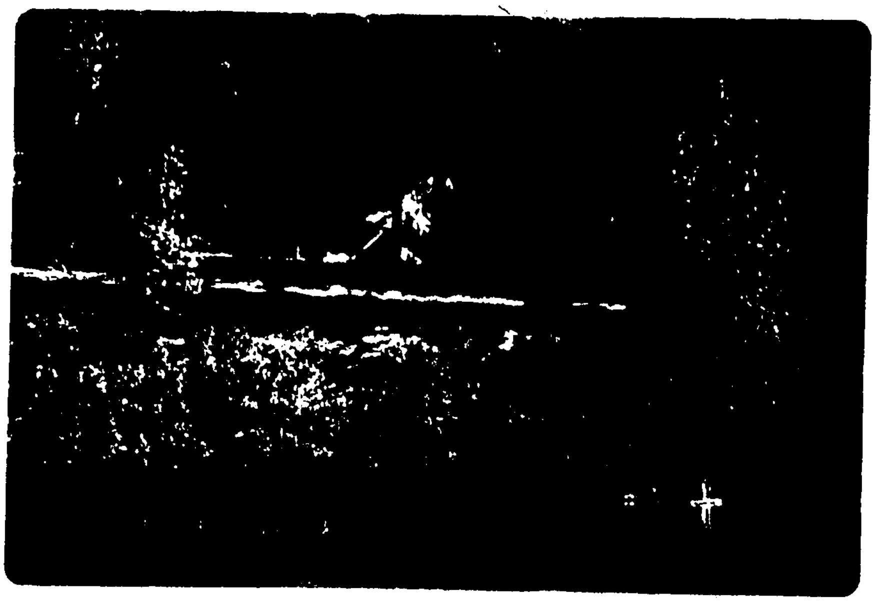

Plate 19. Littoral vegetation, north end of Jade Lake. The hardy shrub Myrica gale and an occasional white birch form a narrow band along the water's edge. 5 July 1976.

Plate 20. A 10 cm wide red squirrel trail in the jackpine-lichen woodland. Needle and other organic litter and 2 mosses Polytrichum piliferum and Dicranum fuscescens combine to bind the trail surface. 10 July 1976.

Plate 21. Trail 1 in centre is 40 cm wide, a result of 100 test trips during the 2 summer field seasons. Lichens dislodge easily when wet and crush readily when dry. Care should therefore be taken to locate use-areas close to lakes where the soil is more moist and vegetation is generally more durable. Arboreal lichens (on trees), common throughout the study area are most abundant in the eastern portions. 30 July 1976.

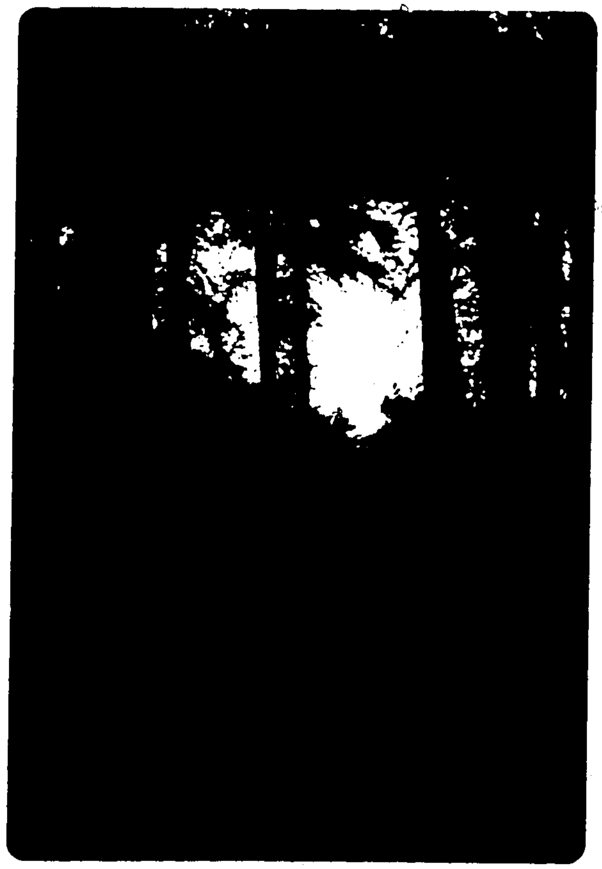

Plate 22. Trail 2 from basecamp to Jade Lake received more than 1000 tramples resulting in a 60 cm wide path which destroyed 100% of the vegetation. 30 July 1976.

Plate 23. The Orthic Regosol soil type (Appendix 8.3) is common under the recently stabilized dune landscape. Jackpine-lichen woodland that has stabilized these nutrient-poor sites are easily disturbed. Surface scar (at shovel) has been created by brushing action of a jackpine branch (lower left) during windy days. 6 August 1975.