Guidelines for the Use of All-Terrain Vehicles in the Cape Churchill Wildlife Management Area

by

Allan John Webb

A Practicum Submitted in Partial Fullfillment of the degree, Master of Natural Resources Management

Natural Resources Institute
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ABSTRACT

During the summer of 1983 field work was conducted in the Churchill region to determine the effects of off-road vehicle traffic on vegetation communities, thickness of the active layer of permafrost soils, and rut formation in the Cape Churchill Wildlife Management Area (W.M.A.).

During the winter of 1983-84, the literature on vehicle impacts and Manitoba legislation and regulations applicable to the Cape Churchill Wildlife Management Area were examined. To determine the recreational interests of Churchill residents, a questionnaire of local residents was applied to determine the amount of local recreational use of the W.M.A., including the use and ownership of motorized vehicles. Residents were also asked their opinion of vehicle impacts and various management options.

Low levels of vehicle use result in the removal of less hardy plant species, while continuous use results in almost total removal of all species. This denudation has little effect on rut formation, which depends largely on the soil moisture content and depth to aggregate or glacial till. Thickening of the soil active layer and limited thermokarst activity were detected at several sites with saturated deep organic soil which received regular, concentrated use.

Local recreational users reported about 2600 person-days of visits to the W.M.A., mostly for hunting or recreational vehicle driving. Two tour operators offer regular trips into the area during summer and fall, carrying about 2000-2700 people per year and generating 150-200,000 dollars in revenue.

Questionnaire respondents are concerned about damage caused by commercial vehicles. A majority oppose management options which would restrict recreational use; the adoption of designated routes and the improvement of trails to points of interest received support.

Management methods recommended to control damage caused by vehicles include a combination of designated routes and seasonal restrictions for commercial vehicles and for 4-wheel drive trucks used for recreational purposes; a freeze on new commercial activities requiring off-road vehicle travel until further research is completed; and the rescheduling of some off-road activity in support of academic and management research. No new restrictions on single-per-

son recreational vehicles such as All-Terrain Cycles or motorcycles are necessary, although the adoption of designated routes may be necessary in the future if their use continues to grow. The improvement of some segments of the coastal trail to accomodate these vehicles is recommended.

Educational and community liaison efforts should be increased to promote damage reduction and foster public cooperation in resource protection.

A set of suggested guidelines for future management of off-road vehicle use is provided.

ACKNOWLEDGEMENTS

The participation and cooperation of many people were invaluable in the course of this study.

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Maria Zbigniewicz, Jim Briskie and Dawn Bazely identified many of the plants encountered, while Ann Weiszmann drew the maps and illustrations used.

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Chapter I

INTRODUCTION

1.1 PREAMBLE

In the last 15 to 20 years all-terrain vehicles (ATVs) have become increasingly popular for commercial and recreational uses. Due to the potential for environmental damage to the sensitive areas where they are sometimes employed, serious concerns have been raised by their use for both recreational and commercial purposes.

Northern areas are among the most sensitive to damage caused by human activity due to their generally severe climatic conditions and low biological diversity and productivity. This is particularly true for regions which have permafrost-bearing soil.

1.2 STATEMENT OF PROBLEMS

Of particular concern in Manitoba is the use of all-terrain vehicles in the Cape Churchill Wildlife Management Area (W.M.A.) (Figure 1). The Cape Churchill W.M.A. was established in 1978 to preserve an area of important wildlife concentrations and distinctive landforms. These include several hundred woodland caribou (*Rangifer tarandus caribou*

Gmelin), a snow goose (*Chen caerulescens* L.) nesting colony and one of the largest polar bear (*Ursus maritimas maritimas* Phipps) denning areas in North America. These biological resources are contained in an extensive area of beach ridges, eskers and peat bogs which are quite accessible for both consumptive and non-consumptive uses compared to other areas in the north.

Because of its rich wildlife resources and easy access to areas of tundra and sea coast the Cape Churchill W.M.A. is frequently visited by both local residents for recreational purposes and by substantial numbers of tourists. A large number of these visitors tour parts of the W.M.A. in vehicles operated by two local outfitters. In the past, military activities and the recovery of rocket instrument packages have also been performed using various off-road vehicles.

As a consequence of commercial and recreational use of the W.M.A., changes to soil configuration and vegetative communities have occurred which are attributable to the use of vehicles of various types.

To provide for improved future management of the W.M.A., this study addressed the following problems:

1. The degree to which the area studied can sustain recreational and commercial uses.

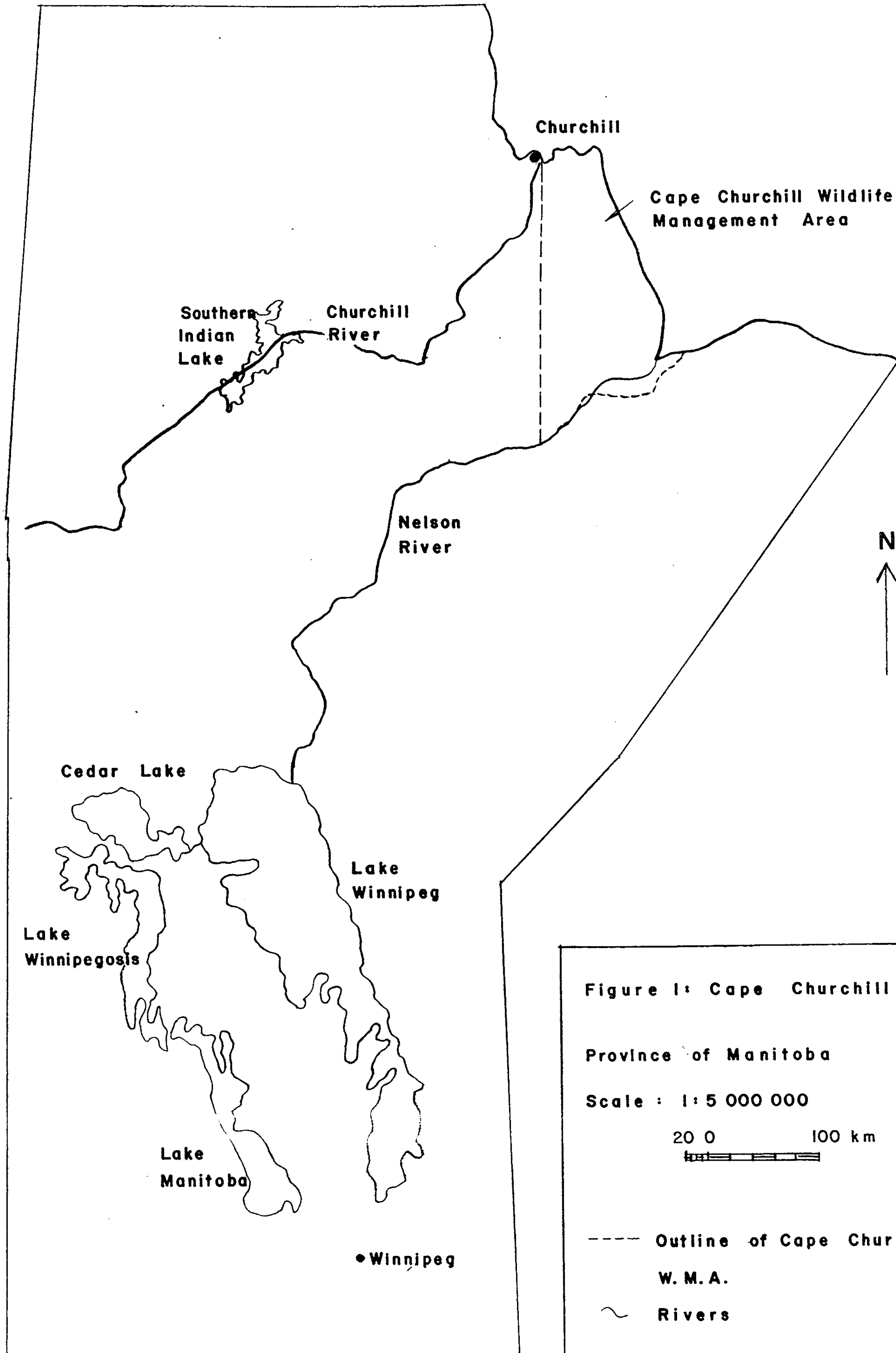

Figure I: Cape Churchill W.M.A.

Province of Manitoba

Scale : 1:5 000 000

20 0 100 km

---- Outline of Cape Churchill W. M. A.

~ Rivers

2. Whether significant damage is occurring to the soil structure and plant communities as a result of vehicular activity.

3. The definition and recommendation of management options available to remedy problems caused by vehicle use while protecting the interests of present and future users of the W.M.A.

1.3 OBJECTIVES

The objectives of the study were:

1. To determine the extent of off-road vehicle use in that portion of the Cape Churchill Wildlife Management Area adjacent to the town of Churchill.

2. To provide a profile of the types, numbers and users of off-road vehicles in the Churchill Area.

3. To estimate the economic value of commercial off-road vehicle use.

4. To compare plant cover and species composition in areas used by off-road vehicles with those unaffected by vehicle traffic.

5. To determine whether the active soil layer is increasing in depth as a result of vehicle usage.

6. To study provincial laws and regulations relating to off-road vehicle status in the W.M.A. and to suggest modifications which could make policies implemented under them more effective for environmental protection.

7. To recommend management options for the reduction of damage and assess whether they can be implemented in the existing economic, political and recreational climate of the area.

Chapter II

STUDY METHODOLOGY

2.1 SITE SELECTION

The selection of study sites was a partially subjective process which began before arriving in the field. Initial discussions with the practicum supervisory committee (Dr. T. Booth, Botany Department, Dr. I. Goulter, Civil Engineering Department, and Mr. D. Teillet, Manitoba Department of Natural Resources) produced a list of habitat types likely to be traversed by vehicle trails.

Aerial photomaps using 1:50,000 scale black and white images were then examined and compared with 1:50,000 scale NTS topographic maps to give some familiarity with major roads, trails and natural landforms such as lakes and beach ridges. This process yielded a number of localized areas which were then examined by ground reconnaissance in the first few days of field activity. Other areas outside the W.M.A. (the Goose Creek and Landing Lake areas) were also examined since it had been suggested that private recreational vehicle use would be heavy at those sites. Abandoned cutlines near Twin Lakes Hill were also visited.

The areas chosen from the aerial photos contained many local variations and anomalies in their soil types, microreliefs, soil moisture and plant cover. The selection of specific study sites then became an assessment of whether a set of tracks was typical of the average conditions for the general region within which it was located. Factors noted during reconnaissance which were used for site selection included soil type (organic vs inorganic) and depth as determined by probing with a steel rod, elevation, presence or absence of standing water, wetness of soil, slope, and surface cover. This process resulted in the selection of 14 sites, 12 of which lie within the W.M.A..

Traffic in the northern portion of the W.M.A. follows two general corridors of military origin, the coastal and inland trails. Most summer use follows the coastal trail, which contains several different types of vegetation and soil in the areas examined. Because of this diversity of conditions, most of the study sites were located along it. The inland trail, which offers less diversity of soil and vegetation conditions in the study area, was the location of two study sites.

Sites 1 and 2 represent rut conditions along much of the coastal trail, being slight depressions lying in surrounding level, reasonably well-drained terrain. Sites 3 and 4 are typical of ridges slightly elevated above the surrounding terrain with gravelly soil and a shallow organic soil layer overlying it. Site 5 is on the coastal trail where it cuts through a dense willow shrub population growing on a deep peaty soil base. Site 6 is a slightly elevated, lichen-covered dry plateau with a moderately thick organic layer soil underlain by stones. Site 7 is a lakeshore sedge community with a rich organic soil kept saturated by waves, by vehicle ruts which allow drainage from higher ground and by rainwater collection. Site 8, in a shallow depression at the foot of the Christmas Lake esker, has thick peat soil whose wetness is controlled by runoff from the esker and the surrounding higher lands. Site 9 is an area of shallow pools inhabited by sedges at the west foot of the Gordon Point beach ridge. Thermokarst development was beginning at the north edge of this site.

Sites 10 and 11 were on the inland trail east of the Christmas Lake esker. Site 10 included thermokarst slumps and areas where sedges had invaded, with deep organic soil. Site 11 was also an area of deep organic soil, but underlain by till. It is not subject to flooding and has no obvious signs of thermokarst development.

Site 12 was located on Gordon Point in dry, sandy soil which is typical of beaches and eskers in the study area.

Outside the W.M.A., sampling was also done in a muskeg area near the Churchill River which had received several passes with an ATC during the spring. This area was free from commercial and military use and allowed examination of ATC use alone in treed muskeg areas. Similarly, the author measured disturbance caused by his ATC in a sedge meadow at Dene' Village to estimate the immediate effects of light recreational use without the influence of past vehicle use.

These sites outside the W.M.A. were not intended as controls to be compared with the sites inside it, but rather were chosen to provide sites where the history of vehicle use was known and restricted to activity typical of recreation.

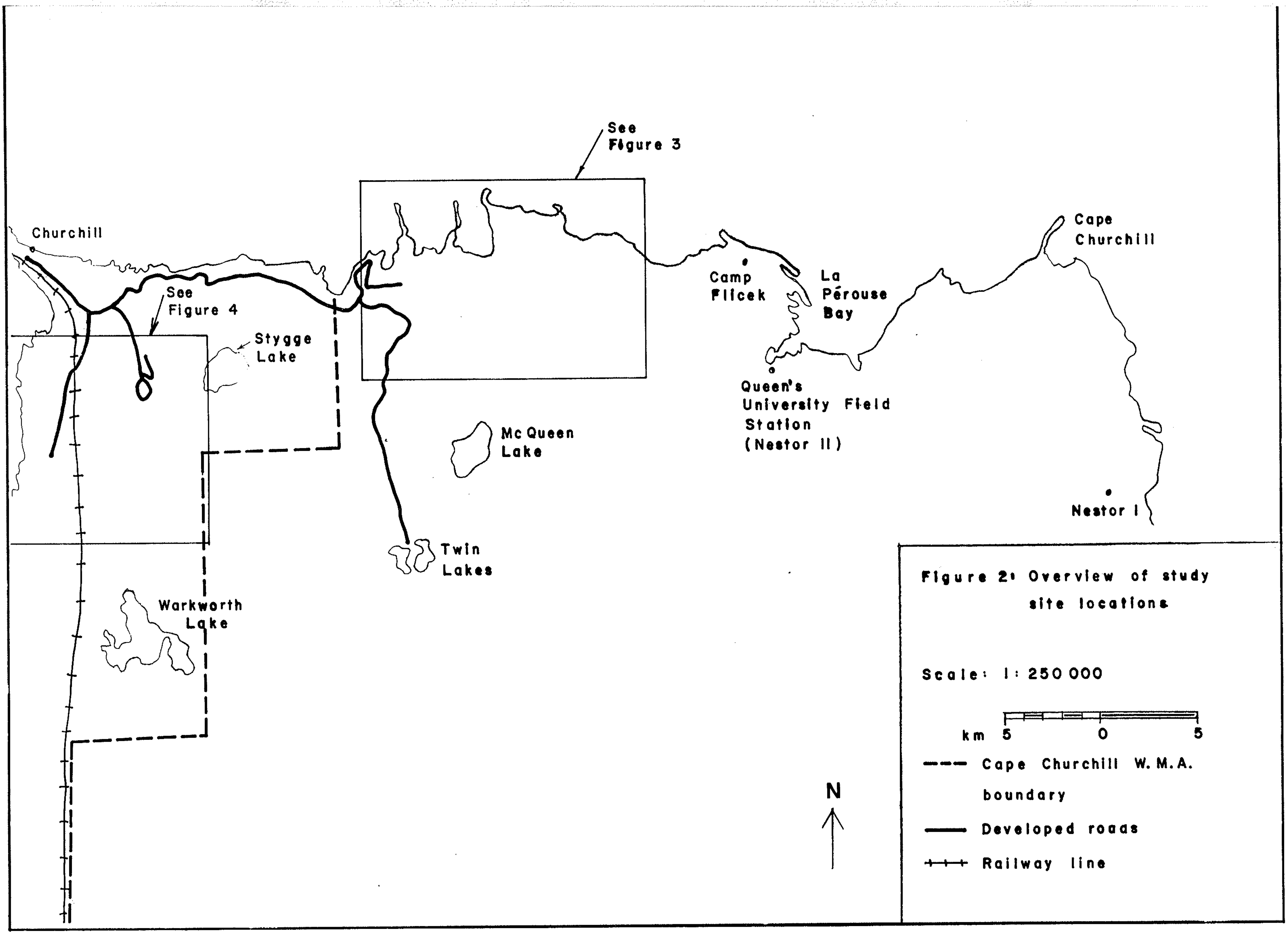

Figure 2: Overview of study site locations

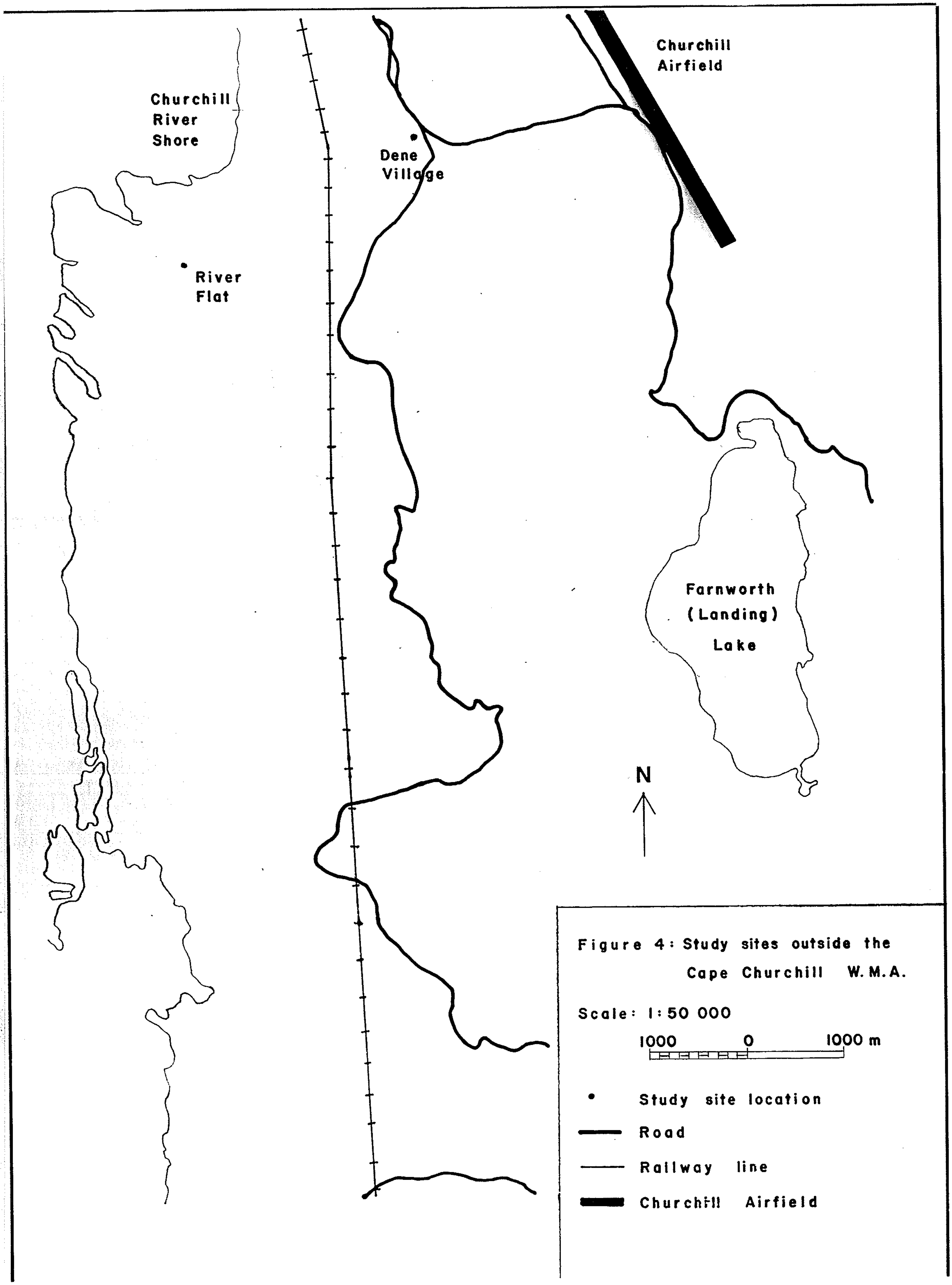

Figure 4: Study sites outside the Cape Churchill W.M.A.

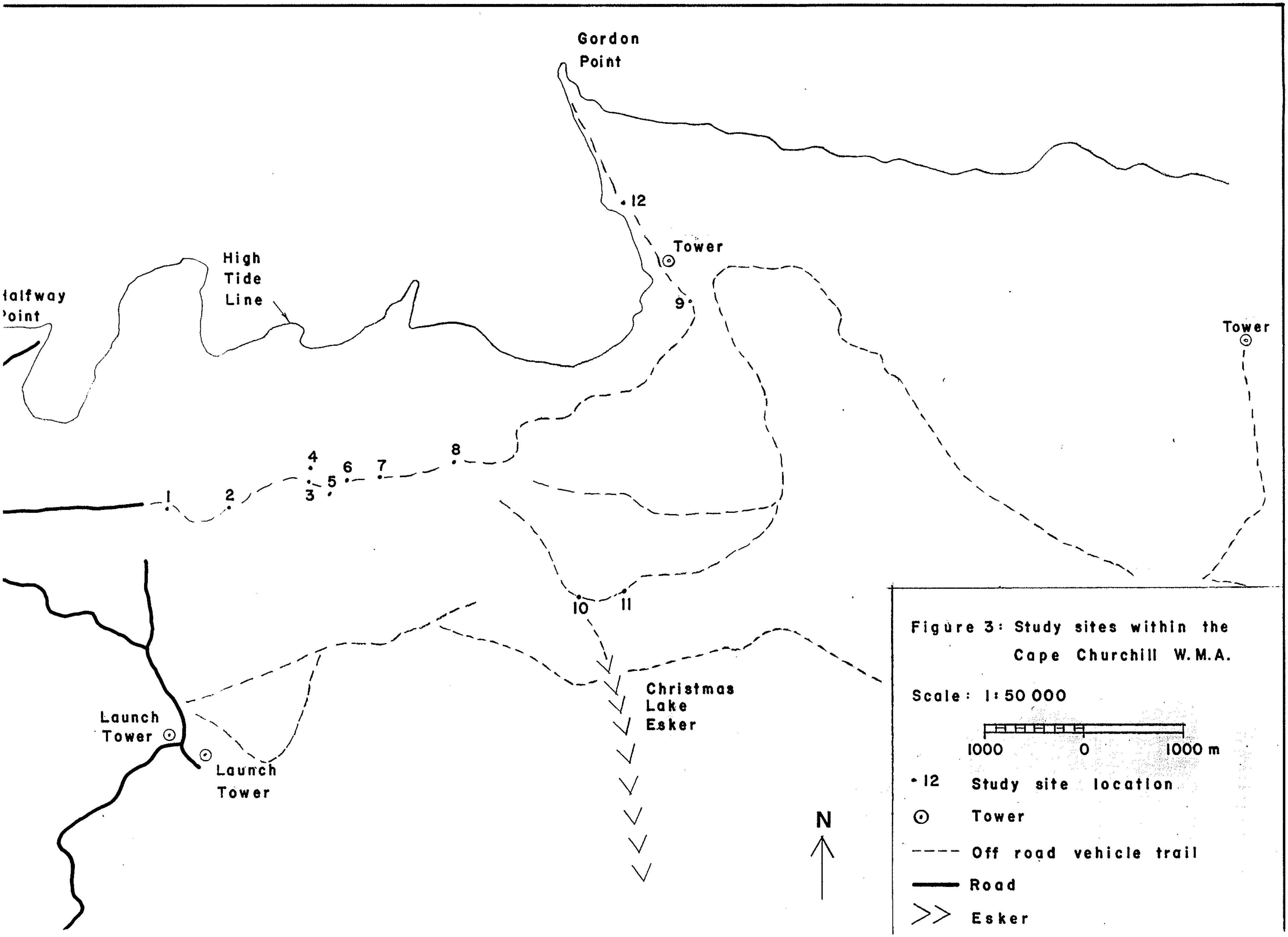

Figure 3: Study sites within the Cape Churchill W.M.A.

2.2 MEASUREMENT OF ACTIVE LAYER DEPTH

In order to determine the thickness of the active layer of the soil a simple rod test was used. A bluntly-pointed steel rod of 19 mm diameter was driven vertically into the soil until it was stopped by either frozen soil or rock and the distance of penetration below grade level was recorded in cm. This test was performed at 1 m intervals in at least 5 transects across the trails at each site.

This allows a comparison of the average depth of the active layer under the trails made by each type of machine vs that under the undamaged area adjacent to the trails.

This method of determining the depth of the active layer has been used in several studies of surface disturbance including Babb and Bliss (1974), Brown Beckel (1957) and Walmsley and Lavkulich (1975).

It should be noted that active layer thickness is defined by temperature, indicating that portion of the soil which is subject to annual freezing and thawing. The rod penetration test does not measure temperature but rather attempts to find frozen soil as indicated by soil resistance. Thus the 'active layer' indicated is not necessarily the same as would be indicated by temperature measurement.

In most cases, rod penetration was stopped by rocks or gravel rather than by frozen soil. This is easy to detect by the jarring which occurs when the rod is pounded on a rock, and by the sharp clanging sound compared to encountering frozen soil. For each probe note was taken whether the penetration was stopped by contact with stone or by frozen soil.

A t-test (Neter and Wasserman 1974) was used to compare the average rod penetration in the affected areas and in the apparently unaffected areas.

Knowing the means and standard deviations of rod penetration depths for each component of the trails allowed comparison of vehicle effects by means of a paired t-test which determines whether the data points were drawn from the same population using the formula

$$t = \frac{\bar{a} - \bar{b}}{\sqrt{(SEA)^2 + (SEA)^2}}$$

where $\bar{a}$ is the mean value of active layer depth for the undamaged area, $\bar{b}$ is the mean value of active layer depth for the affected area, and SEA and SEB are the standard errors associated with each. The calculated t-value was compared with a standardized t-table (Fisher and Yates 1973). A probability level of .05 was used.

Rod penetration testing at the River Flat site was done on July 24, 1983. The 12 sites in the W.M.A. were tested from July 25 to August 4, 1983.

Radforth (1973) used an index for assessing soil damage. This index of soil damage was applied at the first sites examined.

The MRI method assigns a rating to the impact of each class of vehicle at a given site. Since the limited time available for field work meant that only a few sites could be examined, this method would not supply enough data for statistical comparisons, whereas the transects using rod penetration allow the generation of several measurements for each type of vehicle impact present at a site.

2.3 VEGETATION SAMPLING

In order to quantitatively assess and compare plant communities it is necessary to choose measurement criteria which reflect the population and distribution characteristics of the communities studied. In this case, frequency, density and cover were determined for each of the species which contribute to those communities. Frequency represents the number of sampling units in which individuals of a given species occur. Density is the number of individuals of that species per sampling unit and cover is the vertical projection of the area of the sampling unit occupied by that species as a percentage of the total area of the sampling unit.

The sum of the relative percentages of these values for each species is the importance value of that species in the community (Barbour *et al*. 1980). Importance values are often used to describe the degree to which particular species dominate their communities.

For some types of ground cover such as lichens, bare ground or water, the cover may not consist of individual plants. For those species for which density could not be determined and for bare ground and water, frequency and cover were recorded. Since importance values cannot be calculated without knowing the relative densities of the species, all statistical comparisons of cover types were made using cover values.

Using average relative cover values, the five most dominant species for each source of vehicle impact were chosen and their average cover values analyzed to see whether the average cover values for the dominant species were significantly different at the impacted and undamaged portions of each site. This comparison was made using a paired t-test (Neter and Wasserman 1974) which compares the mean values of two populations based on the variances of the samples around the mean to determine whether the two populations are subsets of a larger population.

To generate data for this part of the study a belt transect method was chosen. This consisted of a series of contiguous square sampling quadrats laid along a line perpendicular to the long axis of the vehicle trails to form a linear cross-section of the site (Figure 5).

The belt transect method was chosen because the distribution of impacts is non-random and the various categories of impacts lie parallel to each other. A random method of placing sampling points would not necessarily include all categories of vehicle impact at a site and would not always produce a sufficient number of samples to analyze. Similarly, a series of samples oriented parallel to the axis of the trails would not necessarily encounter all types of impact present at the site. As well, this conformation is more subject to the effects of environmental gradients (e.g. the effects of a slope) while the perpendicular method used helps ensure that all quadrats of a given transect occur at the same point along the gradient.

The transect was begun in the centre of the set of tracks which appeared to be the widest, most current and most heavily used. The transect was then extended perpendicular to the sets of tracks crossing the site into the undamaged area adjacent to the trail(s). Each type of vehicle impact received at least 5 quadrats except where the impacted area was narrower than the distance spanned by 5 quadrats.

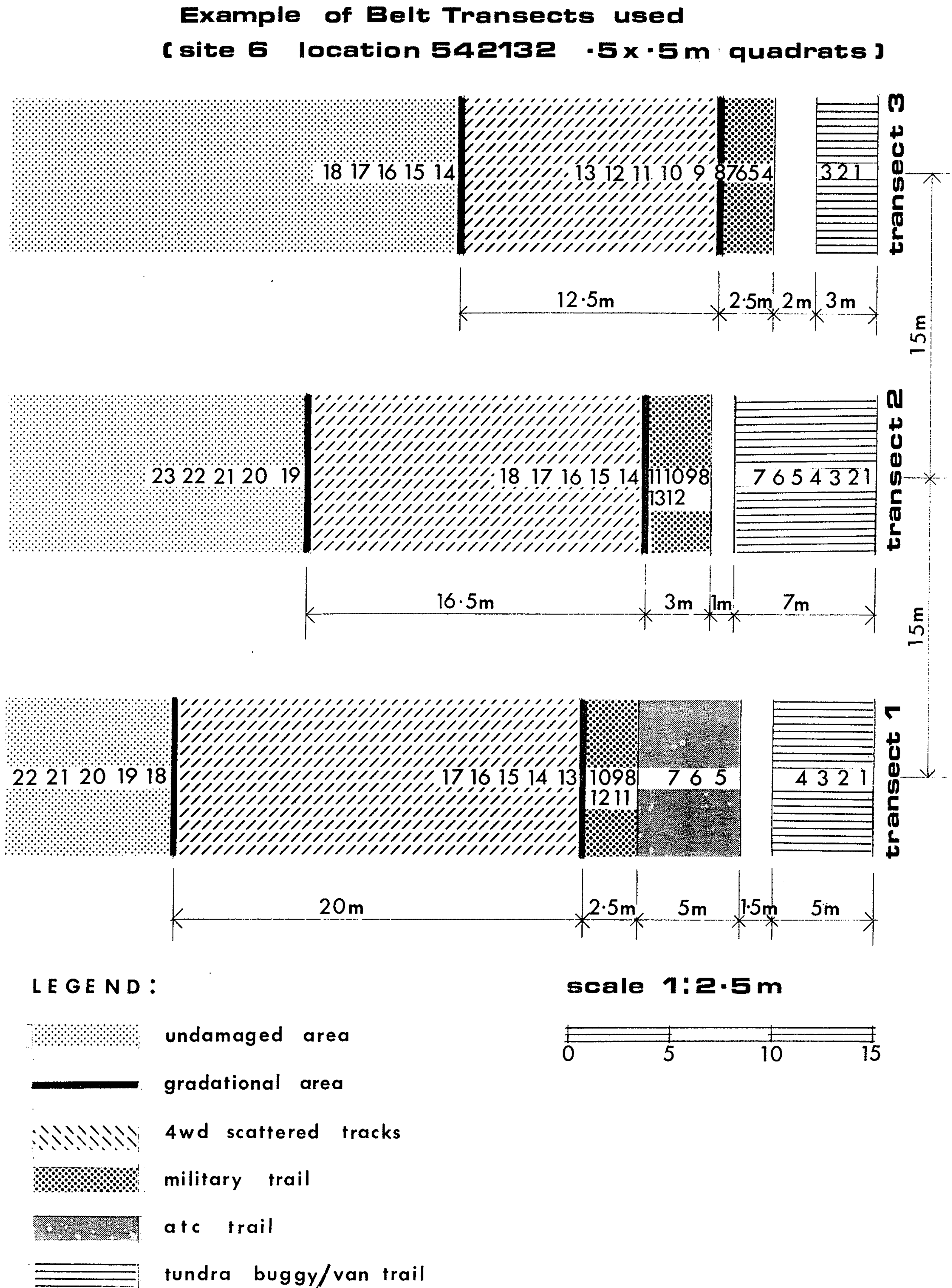

Figure 5: Vegetation belt transect method.

Quadrat size was chosen in the field by plotting a species-area curve formed using a 'nested quadrat' (Barbour *et al*. 1980). The nested quadrat was performed in apparently undamaged vegetation adjacent to each site in order to have a maximum diversity of species and so choose an adequately large quadrat size. This method is based on the assumption that undamaged vegetation has a greater number of species than the impacted areas adjacent to it and that vehicle traffic has resulted in the loss of the missing species or individuals. At most sites, a quadrat size of 50x50 cm was used; sites 5 and 12 used quadrats of 1.0 sq. m area.

The use of transect methods to gather vegetation data at sites impacted by vehicle, horse and foot traffic is discussed by Hernandez (in Bliss and Wein 1971a), Liddle (1975) and Weaver and Dale (1978).

Plants were identified according to the keys of Porsild and Cody (1980). In some cases it was not possible to identify species completely due to lack of seasonal floral identifying characteristics . All vascular plants are identified to at least the generic level, as are the three major genera of lichens present (*Cladonia*, *Cladina* and *Cetraria*).

Plant names and authorities used are those which appear in Scoggan (1959).

Vegetation sampling was done at the Dene Village and River Flat sites from July 22-25, 1983. Vegetation sampling at the 12 sites within the W.M.A. occurred between August 4 and August 18, 1983.

2.3.1 <u>Limitations of Cover Value Comparison Method</u>

A number of potential methods of studying vegetation characteristics are available. The results obtained will depend at least partially on how study sites are selected and how conditions at each site are then examined.

Objective methods of selecting points to examine (such as random placement of quadrats) were considered. The random placement of quadrats would however be expected to result in many quadrats not occupying an impacted area. To ensure that data was collected from tracks left by various types of vehicles with approximately the same sample size from each and from adjacent undamaged areas, a transect method was chosen to provide a cross section of each site. Replication was performed by having at least three such transects at least 10 m apart at each site.

The placement of transects was also partially subjective. Lambert (1972) was able to locate several transects in an area prior to use. Vehicles were then allowed to cross the area as they would. This permitted more objective placement of sample quadrats.

In the case of Churchill, the vehicle trails were already established, forcing the choice of subjective methods of site selection already described.

The data collected at each site depended on the nature of the cover present. For species which take the form of discreet individuals, the frequency and density can easily be determined by counting and the percent cover estimated or measured. For some cover types (e.g. standing water, bare ground, mats of lichen species) density cannot be determined because the cover does not consist of discreet individuals. Hence the calculation of a completely objective description could not be done.

Instead, the use of more subjective methods of description such as indices are required. The MRI index of Radforth (1971) was considered. One study of terrain disturbance (Willard and Marr 1970) used the Braun-Blaunquet index of species importance (Braun-Blanquet 1932). In the case of the Churchill study, the author lacked the familiarity with northern vegetation needed to obtain accurate results using these subjective methods.

As a consequence of these considerations, comparisons of estimated cover values were used to determine the changes in dominance and diversity caused by vehicle traffic. This method generated data which could be statistically analyzed. However, it is necessary to bear in mind the following limitations:

1. Cover values were estimated, not measured. The shape and growth habit of a species probably causes some

bias in the value estimated. While estimates were carefully made picturing the coverage of each species compared to a grid laid on the quadrat, this subjective method cannot be done as accurately as laboratory methods such as photometric sampling of vegetation clipped from the quadrat.

2. Due to differing rates of growth, presence or absence of flowers and presence or absence of leaves at given times of the year, the relative cover values of species vary over the year. This may affect the replication of the estimates depending on what part of the growing season is used for field work.

3. The estimate of the diversity of the community for each impact type at each site is based on the presence or absence of species (i.e. number of species) and not on their relative proportions of density and frequency as is done in indices of diversity such as those of Simpson or Shannon & Weaver (Barbour _et al._ 1980).

2.4 CHURCHILL RESIDENT RECREATIONAL QUESTIONNAIRE

One of the objectives of the study was to elicit a response from residents of Churchill to determine the amount of recreational activity of various types presently occurring within the boundaries of the W.M.A.; the demographics of the present and potential users of the W.M.A. to estimate future demand; and the perceptions of local residents about the extent of environmental impacts and proposed methods of reducing them.

Due to the number of potential respondents in Churchill it was decided to use a mail-out format for the recreational survey. Each household listed on the 1983 voters list for the Local Government District of Churchill (1983) received a questionnaire. To decide which individual in the household the questionnaire would be addressed to, the current telephone directory (Manitoba Telephone System 1983) was used. This created a bias towards male respondents.

The questionnaire was designed with an emphasis on rapid and easy response rather than asking for written comments or suggestions although a section for comments was provided if the respondent wished to make detailed suggestions. The format of the questionnaire also allowed computer analysis and cross- referencing of responses. A copy of the questionnaire is shown in Appendix B.

The data generated by the questionnaire were coded and analyzed using the BMDP P4F program. This program produces simple data description including the number of responses to each question, frequency of each possible choice within a question, and the mean and variance for responses to each question as well as providing crosstabulations of the responses to any or all pairs of questions. This allows determination of how the respondents' attitudes to one question relate to their attitudes regarding others. The P4F program allows the generation of various statistics based on these crosstabulations. For this study, the program was used to produce crosstabulations of observed, expected and excluded responses and to generate a Chi-square statistic (Thompson 1941) to assess the independence of the answers to each of the pairs of questions. A complete program description may be found in Dixon and Brown (1979).

Chapter III

CHARACTERISTICS OF THE STUDY AREA

3.1 PHYSICAL FEATURES

The coastal area to the east of Churchill where off-road vehicle use is concentrated is a plain of low relief with limestone till and marine alluvial deposits. Small lakes and ponds are common. The most common sources of relief are remnant beach ridges.

Elevation ranges from sea level to about 10m along beach ridges and eskers and about 45m at Twin Lakes hill.

The northern part of the study area, including all of the sites along the coastal trail, is shown in Figure 6.

The characteristics of the soil active layer in the Churchill area are discussed in Section 4.2.

This view looking north east shows the NRC Launch facilities at the lower right corner and Gordon Point at the top centre. The portion of the coastal trail examined lies between the centre of the picture and the tip of Gordon Point. Most of the inland trail lies to the left (south) out of the picture.

Figure 6: Aerial view of the northern portion of the study area showing general terrain features.

3.2 VEGETATION

The Churchill area lies in an area of complex climatic and biological interactions. The result is a diverse ground cover which is greatly effected by microenvironmental factors of slope, soil type and exposure to weather.

Scoggan (1959) identified 9 distinct types of plant habitats in the Churchill vicinity. The sites used in this study appear to correspond to Scoggan's "stable dunes above upper beach", "quartzite ridge above stable dune area", "marshy ground, wet peaty meadows, and margins of ponds", and "hummocky peat bog" areas.

In the study area, the ground cover consists of mixed lichen-heath plateaux dominated by *Vaccinium uliginosum* L. and *V. vitis-idae* L. var. *minus* Lodd., *Cladonia* sp., *Cetraria* sp., and *Cladina* sp. along with *Empetrum nigrum* L. These slightly elevated areas are separated by small, shallow ponds which support stands of sedges (mostly *Carex* spp.) and grasses (*Eriophorum* spp.) around their edges. Small gullies and depressions support sedge and moss populations in their lowest areas, with low willows (*Salix glauca* L. var. *acutifolia* (Hook.) Schneid. and *S. planifolia* Pursh) and birches (*Betula glandulosa* Michx. and *B. glandulosa* var. *glandulifera* (Regel) Gl.). along the fringes of the gullies. In some places better sheltered against the wind by ridges and eskers, low spruces (*Picea mariana* (Mill.) BSP.) are found. Beach ridges and eskers support avens (*Dryas integrifolia* M. Vahl). and dense mats of saxifrages (*Saxifraga tricuspidata* Rottb.).

3.3 CLIMATE

The Churchill region has a low average temperature, with the mean daily January temperature being -27.5 degrees Celsius and the July mean being +11.8. The annual mean temperature is -7.2 degrees (Environment Canada 1983a). The average frost-free season is 76 days, while the average dates for last spring frost and first fall frost are June 24 and September 9 respectively (Environment Canada 1983b). Precipitation is light, totalling 40.3 cm per year (Environment Canada Winnipeg Meteorology Office, pers. comm.)

The season of continuous snowcover (2.5 cm or more) averages 209 days in length, with the mean date of first snowfall being October 15 and the mean date of snow disappearance May 28 (Potter 1965).

A summary of climatic averages for the Churchill region is found in Appendix D.

Chapter IV

REVIEW OF LITERATURE

4.1 PERMAFROST

4.1.1 Definition and Characteristics

Permafrost is defined as soil which remains below 0 degrees Celsius for more than one year (Brown 1958). This definition may encompass organic soil, aggregate-based soil, and solid rock (Adam 1978). Churchill lies within the southern border of the zone of continuous permafrost shown by Brown and Pewe (1973).

Permafrost soil usually consists of a frozen zone which may be several meters to several hundred meters deep, topped by an 'active layer' which freezes and thaws annually due to surface heating. The depth of the active layer depends on several factors which govern the rate of heat exchange between the soil and the external environment. These include soil composition, climate and the vegetation cover at the site (Brown 1958).

In the context of vehicle impacts on permafrost soil, the most important factor governing the depth of the active layer is the degree of insulation against solar radiation and convective heat exchange with the soil. This insulation is provided in most permafrost areas by dead organic material such as peat and humus (Walmsley and Lavkulich 1975). Changes in the degree of insulation provided by this covering layer result in change of the active layer depth. The addition or removal of ice in the upper portions of permafrost soil may result in changes in the appearance of a site (thermokarst effects).

4.1.2 Thermokarst and Thermokarst Development

Thermokarst effects are those changes in soil structure or topography which result from the addition or removal of water in the permafrost component of the soil (French 1976). These changes normally result from the melting of ground ice. This effect is shown in Figure 7.

The mechanism of thermokarst development varies from site to site depending on the nature of the disturbance, soil ice content, and soil and vegetation composition. Characteristically, surface disturbances such as vehicle ruts compact and displace soil and remove vegetation cover. This results in increased downward heat flux by conduction, increased contact between the soil and warm air (convective heating) and increased absorption of radiant energy since soil albedo decreases as dark soil is exposed in place of light coloured lichens or other vegetation (Hegginbottom 1974).

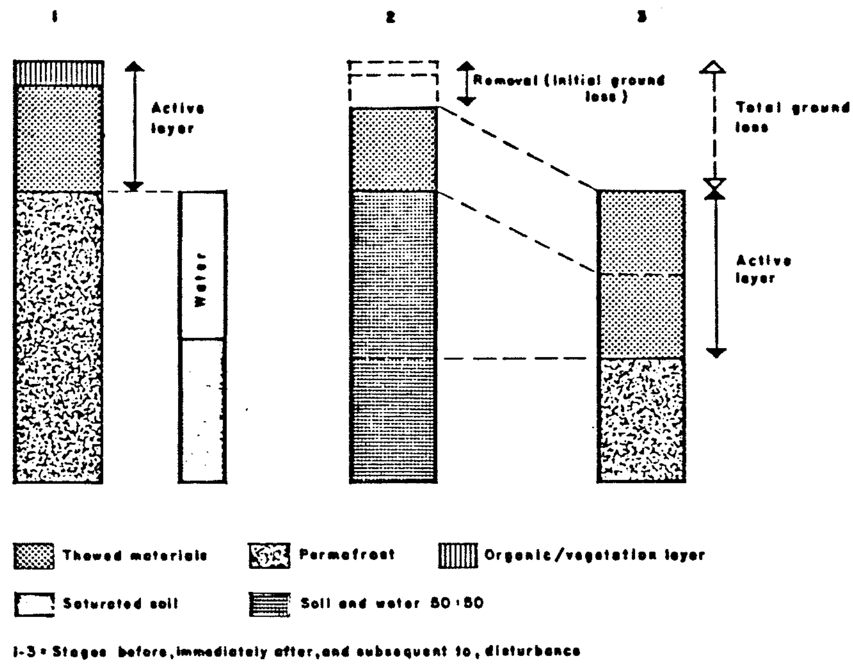

Figure 7: Thermokarst slumping (After French 1976).

As subsurface ice melts and water drains away, the total volume of the soil decreases, resulting in slumping and the possible formation of gullies and localized soft spots. The severity of these effects depends on the degree of surface disturbance involved, the insulating efficiency of the remaining active layer, and the ice content of the permafrost soil layer (Hegginbottom 1974).

Changes in topography and surface soil characteristics can continue for several years after the initial disturbance, since some of the changes involved can trigger other effects which promote further change. An example of this self-reinforcing change is the collection of water in ruts caused by minor slumping which may further increase heat transfer and so promote additional slumping which would not be present at a drier site (Radforth 1971).

In several quadrats examined, use of trails resulted in the subsurface till becoming closer to the surface. This is apparently the result of upheaving by frost action. The mechanism of upfreezing is not fully understood, but appears to be common in sediments which have coarser particles [small rocks] interspersed with much larger amounts of fine particles according to French (1976).

4.2 CHURCHILL AREA ACTIVE LAYER CHARACTERISTICS

Available information on the nature of the active layer in the Churchill area is limited. Brown Beckel (1957) measured soil temperatures and related them to ambient air temperature and snow cover in the 1950-53 period at several sites with varying soil characteristics. An effort was also made to determine the effects of removing ground cover on the temperature gradient in the active layer. None of Brown Beckel's sites were within the study area of this report. Most were located immediately to the west of Churchill airport and to the north of Landing (Farnsworth) Lake.

His summary of these tests states:

> 1. The thickness of the active layer varies from 2.4-3.6 m (8-12 ft.) in areas of sandy soil and 0.9-2.4 m (3-8 ft.) in clay, clay- sand or clay-

gravel soils topped by 15-30 cm (6-12 in.) of peat. In swampy areas, the depth of the active layer varies depending on the amount and depth of water present. Under water or in saturated soils, the active layer is 1.1-2.3 m (3.5-7.7 ft.) thick. Where tussocks, hummocks or mounds occur in wet areas, the active layer is 0.9-1.9 m (3-6 ft.) thick.

2. Deeper levels of perennially frozen ground are found in areas with a thin peat overburden than in those areas with a thicker overlying layer of peat.

3. Where plant cover has been removed, the frost level may recede as much as 1.3 m (50 in.) during a three year period.

4. Maximum depth of thaw occurs between August 15 and October 15, with the average being September 15.

5. Lower parts of the active layer freeze and thaw as much as 100 days later than the upper parts. Lowest temperatures reached by portions of the active layer occur during the period between mid-December and mid-May, with the average lowest temperature for the active layer as a whole occurring about March 1.

4.3 VEHICLE IMPACTS

Predicting the impact of a particular vehicle on an area of tundra is difficult due to the large number of variables involved, particularly when the use is ongoing rather than occasional. Much past research related to oil exploration, which typically involves heavy use of a trail for a short period of time followed by abandonment. By contrast, vehicle traffic in the Cape Churchill W.M.A. tends to use the same trails year after year but with less concentrated activity than oil exploration. These differences in the duration of use and interval between trips mean that studies of oil exploration impacts may not be directly applicable to the Churchill region.

4.3.1 Vehicle Characteristics Affecting Impacts

At present, both wheeled and tracked vehicles are used on tundra areas in North America. The environmental effects of each type vary with different soil and vegetation conditions.

Wheeled vehicles cause deeper ruts and more vegetation removal than do tracked vehicles in most cases although tracked vehicles affect a larger total area than do conventional wheeled vehicles. (Wooding and Sparrow in Ittner 1978). A different view is held by J.R. Radforth and Burwash (in N.W. Radforth and Brawner 1973). They report that tracks with grouser bars pick up and scatter peat more than do flat tracks carrying the same weight, and that vehicles using large, low pressure tires produce initial disturbance levels lower than either type of tracked vehicle of similar weight. They attribute the shearing effects of tracks to differential velocities between the track centres and edges.

Bellamy *et al.* (1971) report that a vehicle fitted with smooth, pliable rollers rather than tracks or wheels produced the least damage of any of five different vehicles of various weights and track and wheel configurations.

Vehicle weight (expressed as ground pressure) is also important since the ground pressure determines how deep the vehicle will sink into the soil. For a given site, the amount of damage sustained decreases with decreasing vehicle weight (Bellamy et al. 1971). The ground pressure also determines the amount of traction which can be exerted by the vehicle and consequently the amount of shear force between the vehicle and the soil. This influences the removal of soil and vegetation from the track (Ferris 1980).

Depending on the soil type encountered vehicle speed may be a major factor in rut formation. On dry soil, speed is of little consequence. In wet areas, large wheels on high speed vehicles may squeeze peat and soil material out of the track (Dyke and Teillet 1981) while tracked vehicles operating in standing water or very wet peat may also displace or wash out soil or peat (Radforth 1971).

Ferris (1980) recommends that if tracked vehicles must be operated in wet areas, they should be operated in low gears and at low speed to reduce slippage and prevent track washing.

Vehicle turning radius is also a factor in the severity of impacts created by tracked vehicles. Radforth (1971), Egginton and Ferris (1980) and Ferris (1980) noted that disturbance is much greater when tight turns are made with skid-steer vehicles due to the uprooting of vegetation and displacement of soil by track slippage. Radforth (1971) suggests that turns made by tracked vehicles should have a minimum radius of 60 feet (18m).

The research of Radforth (1973) showed a tendency for wheeled vehicles to cause less damage in dry uplands and while climbing hills with mesic vegetation than was caused by tracked vehicles. He recommended that tracked vehicles be subject to tighter control than vehicles with low-pressure, flexible tires in such areas and that wheeled and tracked vehicles not use the same trails.

4.3.2 Other Factors Affecting Impacts

The presence of a thick layer of peat soil tends to prevent thermokarst development whether or not the living vegetation component is removed (Hegginbottom 1974, Wooding and Sparrow in Ittner 1978). Continued vehicle use causes this layer to decompose, lessening its insulating value. Haag (in Bliss 1973) considered peat thickness and soil characteristics to be the most important factor in maintaining the appearance of a site during use, and suggested that load limits or control of traffic intensity is the best way to accomplish the preservation of the peat layer. The presence of extensive root systems in the peat also helps soil resist rut formation by increasing the mechanical strength of the soil against shear forces.

The net effect of the vegetation-soil interface is to create a threshold of tolerance to vehicle impacts, particularly for tracked vehicles. As churning and decomposition occur following heavy use, the insulating ability and shear resistance of the soil decrease and rut formation and thermokarst development are promoted with increasing severity as use continues.

This threshold effect allows the management of traffic intensity depending on the type of soil and type of vehicle operation being considered. Babb (in Bliss and Wein 1971) found that up to 60 passes with a Ranger tracked vehicle having a ground pressure of 0.1 kg/sq. cm had little effect on either active layer depth or terrain appearance.

Radforth (1971) defined an acceptable level of damage in mesic terrain as level 4 on his MRI index (destruction of soil mound tops combined with the removal and scattering of up to 10% of original vegetation). He found that this impact occurred after 10-20 passes by a 4,900 kg rubber-tracked vehicle. Damage intensity increased rapidly after this level of use was reached.

Ferris (1980) found that the threshold of damage with a light tracked vehicle was 21 passes in peat before the insulating cover broke down; 31 passes in wet sedge terrain caused the formation of ruts to the frost table; and 20-25 passes in wet clay till was the maximum use before the vegetation mat was damaged and rut formation was accelerated.

If a threshold level of acceptable damage is adopted, the amount of traffic which causes that damage may be concentrated on a particular trail or dispersed over a larger area. Kerfoot (1972) pointed out that at low levels of use much of the impact on a site is the compression of the organic soil layer and vegetation, not their physical removal. If the number of vehicle passes is the most important factor governing impact, impact could be reduced in some cases by dispersing use rather than adopting a designated route.

This view was supported by Lambert (1972) who examined the impacts of oil exploration vehicles at low levels of intensity as compared to the same vehicles making the same total number of passes over the 10 m wide trails required by NWT land regulations.

This approach would work best at relatively low, temporary levels of use. In the case of the Cape Churchill W.M.A., areas of wildlife concentration are consistent and repeated use of the trails to them occurs each year; consequently even if traffic were dispersed by means of several routes each of those routes would still receive quite heavy use. As well, for wheeled vehicles few passes are necessary to create ruts in soft, wet soil. Thus dispersal of traffic would not necessarily result in levels of use below an acceptable threshold of damage.

These investigations of thresholds of damage were all done using vehicle passes concentrated in a short period of time. There were no conclusions made regarding how the temporal distribution of use would affect threshold values. It seems intuitively correct that a longer recovery period must be allowed between passes if the threshold number of passes is to be increased.

As well as vehicle characteristics and determinants of vehicle use such as the number of passes required over a given area, other physical and usage factors come into play. Topographic considerations such as slope and exposure to weather factors affect both the soil characteristics of an area and the protective vegetation which grows on it.

Trails climbing slopes are sensitive to damage due to the increased tractive effort needed to follow them, decreased soil stability (tendency to slumping and solifluction) and water erosion (Sparrow et al. 1978, Radforth 1971, Hegginbottom 1974, Weaver and Dale 1978).

Weather is also important, since frozen soil has much higher resistance to shearing and displacement, as well as undergoing less compression and hence resisting surface water collection. The seasonal distribution of activity thus has a strong effect on the formation of ruts or thermokarst. Several sources refer to the relative freedom from impact of frozen soils and winter-dormant vegetation (Hegginbottom

1974, Ferris 1980, Hernandez (in Bliss and Wein 1971), Radforth 1971, Wooding and Sparrow in Ittner *et al.* 1978, DIAND 1983, Stirling and Jonkel 1970). Precipitation is also a factor in exacerbating ruts after they have been formed since rainwater may collect in ruts, increasing thermal conductivity; large amounts of rainwater may also result in erosion on sloping terrain (Radforth 1971).

The moisture content of soil (and thus its vulnerability to traffic) may vary greatly over short periods depending on the amount of rainfall or runoff encountered. Figures 8 and 9 show the improvement in the appearance of the coastal trail at study site 5 following the drying up of spring runoff and a lack of rain. Figure 8 (looking northwest across site 5) was taken on July 14. Figure 9 (looking southeast from the spot where the observer is standing in the first picture) was taken August 9. The deep Tundra Buggy ruts in the peat cover have become much less noticeable as the peat dried and shrunk. Some dry peat was also removed by wind.

Note the till present in the bottom of the ruts in both pictures and the 4WD van tracks in the second picture.

Figure 8: Site 5 on July 14, 1983.

Figure 9: Site 5 on August 9, 1983.

French (1976) notes the ability of vehicle trails to channel rain or runoff, leading to thermal erosion and gully development; however, he points out that most tundra is quite flat, has low amounts of snowfall and rain, and that thermokarst development usually results in irregular terrain which is not conducive to the formation of extensive gullies. Thus "for the most part the problem of vehicle track disturbance is an aesthetic one" (French 1976).

Another consideration is the effect of vehicle traffic on water bodies. In some cases, vehicles in the Churchill area are already using ponds to bypass difficult areas; in others, ponds could be used as alternate routes. Federal government policy on access roads and trails in the north is to avoid using bodies of water (especially streams) if possible (Hardy Associates (1978) Ltd. 1984). However, fording of water bodies is considered permissible if fish and wildlife populations using the water body are low, traffic volumes on the trail are low, approaches and exits have gentle slopes, and banks consist of coarse-sized materials which are not subject to erosion and displacement (Hardy Associates (1978) Ltd. 1984).

4.4 REACTION OF VEGETATION TO VEHICLE IMPACTS

The effects of vehicle traffic on vegetation is a highly complex relationship between vehicle type, soil type, topography and vegetation. Different types of vegetation have varying capacities to resist the shearing, crushing, soil displacement and microhabitat changes which result from vehicle traffic. Several studies are available which examine aspects of these interactions.

The effect of tracked and wheeled vehicles has already been discussed in respect to soil changes; events such as the expulsion of soil from the path of a wheel or track have obvious consequences for the plants which were rooted in that soil.

While wheeled vehicles have little shearing action on vegetation and create damage by displacing soil, some crushing of vegetation may also occur (Sparrow _et al_. 1978). Tracked vehicles, however, may cut and pull up vegetation despite not sinking as deeply as wheeled vehicles at the same site. Radforth (1971) and Ferris (1980) noted the tendency of tracked vehicles to remove and redeposit chunks of peaty turf or patches of lichens when turning. The metal grouser bars connecting the track segments on rubber-tracked vehicles may also have a cutting action on vegetation, shearing it between the bar and firm soil. (See Figure 10).

The type of vegetation present before damage has a strong influence on the amount of traffic needed to produce ruts and on the possibility of revegetation. Vegetative communities, soil and moisture must be treated as parts of a unit when looking at this aspect of vehicle impacts.

Closeup view of vegetation shearing by a Trackmaster on firm soil.

Figure 10: Trackmaster track closeup.

Wetland genera such as <u>Carex</u> and <u>Eriophorum</u> are the most vulnerable to damage because they grow from highly organic, wet soil (Sparrow <u>et al</u>. 1978, Hernandez 1973) while those growing on better-drained, more upland sites are more resistant.

On drier, upland sites throughout the low Arctic, vegetation consists of various lichens and heath-type dwarf shrubs on a shallow organic soil (Zoltai and Johnson 1977). The reaction of this type of community to impact is variable depending on the intensity of use; low intensities cause little change, but sustained use results in the fragmentation of the lichen component and its removal by wind erosion (Zoltai and Johnson 1977). Sparrow <u>et al</u>. (1978) also noted that while the soils at dry sites are quite resistant to physical damage the plants growing on them are highly stressed by lack of water and nutrients and are thus unable to sustain high levels of traffic due to these pre-existing environmental limitations.

Another important aspect of site vegetation is the ability to use species composition to predict the reaction of the site to vehicle impacts. The species and growth habits of plants present at a site are a valuable clue to the underlying soil characteristics and hence can aid in the choice of trail locations (Brown (1974), Zoltai and Johnson (1977), Ferris (1980). Brown (1974) and Radforth (1971) discuss the use of aerial photography to assess permafrost presence and extent. Webber and Ives (1978) pointed out the correspondence between landform boundaries, soil types and vegetation types; this allows mapping of soil and vegetation communities from aerial photographs and provides a means of predicting response to disturbance at a given site. Thus land use decisions such as the location of trails are facilitated by the interaction of these physical and biological relationships.

The final vegetation-related consideration is the effect of travel during different seasons on native species. Travel during the portion of the year when the ground is frozen and plants are dormant is much less damaging than summer use. This is partly due to the greater strength of the soil and partly because the parts of a dormant plant exposed to damage during this season are less vulnerable. Leaves and young shoots are not present, so that exposed portions are either woody stems for the perennial species or dead stems for annual species. The roots of perennial species tend to be well-protected by frozen ground and snow cover.

Studies discussing the lessened impact of vehicle travel during winter (especially with deep snow cover) include Bliss and Wein (1971b), Hernandez (1974), Hegginbottom (1974) and DIAND (1983). These studies illustrate the desirability of keeping as much traffic as possible to seasons when soil is frozen and plants are dormant.

4.5 REVEGETATION OF DISTURBED AREAS

Revegetation of affected areas may be considered with two objectives in mind. The first is to restore abandoned trails to a state as close as possible to the adjacent undamaged areas. The second is to make trails which will continue in use as stable and attractive as possible by promoting as hardy and complete a ground cover as can be maintained at the desired intensity of traffic. Both objectives may be applied to the Churchill area.

Several revegetation studies have dealt with the stabilization and recolonization of abandoned trails, either by natural processes or as accelerated by the seeding of new species, soil treatments or fertilization. Typical examples are Babb and Bliss (1974), Hernandez (in Bliss and Wein 1971a), Bliss and Wein (1971b), and Hernandez (1973).

Repropagation of native species has also been performed in some areas. Shaver et al. in Miller (1983) discussed the effects of revegetation programs for soil erosion prevention and their effects on native plant species. They concluded that native species rather than introduced ones should be used and that the most important factor for successful revegetation was the preservation or restoration of the organic soil layer. The use of fertilizer and the broadcasting of seeds were of less importance and were needed only under special circumstances such as the loss of the original organic soil mass.

Since conditions in these locations were not the same as those of the Churchill region the chief relevance of these studies is to illustrate the succession of species at different types of sites, allowing the observer to estimate the time since the trail was last used and the time needed for complete vegetation coverage.

The pattern of revegetation varies according to the degree of damage to the soil (Babb and Bliss 1974), wetness (Lambert 1972), the presence of plants in adjacent areas to provide recolonizing stock, and the method of reproduction used by residual and adjacent plants (Hernandez 1973).

Revegetation of an area is not necessarily by the species which were present before damage occurred. This is because the vehicle impacts often include changes to the soil characteristics and increased water content, both as soil moisture and as standing water.

Wein and MacLean (1973) examined the recolonizing requirements of various species in the Mackenzie Delta area and found that Calamagrostis canadensis was a typical recolonizer of areas with little disturbance while in wetter areas with peat substrates Arctagrostis latifolia and Senecio congestus were the most successful pioneers. Major disturbances resulting in dry, exposed mineral soil favoured Epilobium angustifolium and Calamagrostis canadensis as early recolonizers.

Babb and Bliss (1974) studied disturbed areas in the high arctic and reported that where vegetation destruction was complete, revegetation was "mainly a simple, simultaneous re-invasion by most of the native species present", with the most rapid recolonizers being the most efficient seed or bulbil producers. Woody perennials were slower to return, while lichens showed no sign of re-invasion even ten years after disturbance.

Where revegetation is by original species, these species may be those which have substantial roots (such as Betula spp.) which resist vehicle damage and are thus survivors rather than recolonizers or those which spread rhizomatously such as Carex. Babb and Bliss (1974) noted that "Where the destruction of plant cover is less than complete, mechanically protected or resistant individuals are favoured." Bellamy *et al.* (1971) examined recolonization by species formerly present and reported that only three of twenty species present reproduced by seeds, the others having developed from vegetative propagules which had survived damage.

Hernandez (in Bliss and Wein 1971a) examined regrowth and recolonization on winter roads and summer seismic trails in the Mackenzie Delta area. He found that pioneering species in wet areas (trails through sedge meadows) were *Arctophila fulva* (Trin.) Rupr. and *Carex aquatilis* Wahlenb.). In drier but still moist areas *Senecio congestus* (R. Br.) DC., *Epilobium angustifolium* Honck. and *Luzula confusa* Lindeberg were common while on winter roads the fastest recovering original species was *Rubus chamaemorus* L. Summer seismic lines through upland areas which formerly had heath species such as *Empetrum* spp., *Vaccinnium* spp. and *Arctostaphyllos* spp. were recolonized by grasses such as *Poa* spp., *Arctagrostis* spp. and *Calamagrostis* spp.

A later study by Hernandez (1973) in a series of habitats ranging from wet tundra to forest communities detailed the effect of traffic on the original species and the success of recolonizing species. The proportion of residual woody species increased and grasses and sedges were the most successful recolonizers.

Bliss and Wein (1971b) reported that native species gradually invaded seismic lines, but that grasses were the fastest recolonizers. Where substantial amounts of rhizomes and roots remained in the disturbed soil, they estimated that 30-50 per cent of the original cover would be regained after 3-5 years; where soil subsidence of more than 0.5m had occurred revegetation was possible but would not likely prevent further subsidence. Wet sites such as sedge meadows were recolonized by the same species which were originally present.

Although recovery of vegetation in northern areas is commonly thought to be very slow, Webber and Ives (1978) assert that 'Tundra succession, particularly in the low-arctic, is more rapid than it is generally thought to be. Secondary succession or recovery from non- disruptive damage is frequently quite complete after 5 to 10 years... This is a very short time by the standards of any biome.'

The speed of revegetation and the species composition of the resulting community depend on several factors including the amount of soil damage done and alterations in the microhabitat which resulted from use. These factors are in turn controlled by variables such as vehicle weight, intensity of use, and the season of use. Consequently, even different parts of the same site which are in close proximity to each other may display widely differing rates of recovery. For example, Hernandez (in Bliss and Wein 1971a) found 10-15 year old tracked vehicle trails which had ruts with bare soil exposed at the bottom, but which supported extensive growths of *Arctagrostis* at the sides of these ruts. Kerfoot (1972) noted trails made by summer seismic activity in the Mackenzie Delta were largely revegetated after 8-9 years but that the degree of revegetation varied widely from site to site, with some trails showing exposed mineral soil in the track paths and varying degrees of cover in the trail centres.

Bellamy *et al.* (1971) stated that "The study of old tracks in the Mackenzie Delta and also around Churchill in northern Manitoba revealed, without doubt, that long term regeneration is more efficient in the most poorly drained vegetation types...In most cases, ruts more than 5 yr old had disappeared in the FI vegetation of watertracks and around standing water. In contrast, ruts in EH vegetation of high centre polygons and palsas...were still obvious from both the air and on the ground although they were more than 20 yr old." (See Appendix A for description of coded vegetation types).

Similar effects were noted in the old military trails in the Cape Churchill W.M.A.: different parts of the same set of ruts may vary greatly in the density of plants supported because of differences in drainage, water collection, amount of mineral soil exposed, etc.

In summary, it is the consensus of the literature examined that less-damaged parts of trails in mesic habitats, or trails through very wet sedge (Carex spp.) communities, may be revegetated with a substantial amount of ground cover within about 5-10 years in mesic locations and within as little as 2-3 years in sedge meadow. However, with the exception of the sedge meadow habitats, the composition of the recolonizing plants is unlikely to be similar to the original community, with many lichen and heath species completely replaced by grasses and sedges which have higher tolerance for moisture and which develop root systems much faster. Some woody plants with extensive root systems may survive the removal of their above-ground structures and regrow from the remaining roots, thus dominating the plant cover present within a few years of disturbance. Succession may be biased toward species with increased moisture tolerance compared with those present before disturbance. Sedges and grasses, which are among the most sensitive species to disturbance during the summer months, are among the best recolonizers of all habitats due to their moisture tolerance and ability to spread vegetatively.

4.6 PAST ACTIVITY IN THE W.M.A.

4.6.1 Off-Road Military Activity in the Churchill Area

The military base at Fort Churchill was a major research centre for off-road vehicles from 1945 to 1964. Churchill was designated an area for arctic tactical training and cold weather equipment testing due to climate and the availability of the railroad to move vehicles and equipment (Carroll in Beales 1968).

Spring of 1945 saw the first operational tests of the Weasel and Penguin Mark I utility vehicles for the American and Canadian Armies respectively (Carroll in Beales 1968). These were small metal-tracked utility vehicles with a ground pressure of approximately 0.14 kg/sq. cm (Black 1957).

Following two successful overland expeditions in the springs of 1945 and 1946 the Canadian Defence Department established the Joint Services Experimental Station to coordinate winter exercises and develop techniques for winter military activity (Carroll in Beales 1968).

Another organization, the Defence Research Board Northern Laboratory (DNRL) (sic) was established in 1947 to refine existing military equipment for northern conditions, to develop specialized equipment, and to study human response to arctic conditions such as winter clothing requirements and reactions to summer heat and insects. The DNRL (sic) also conducted engineering and soil studies to determine soil conditions for construction in northern areas. This research was largely completed by 1956 (Carroll in Beales 1968).

A smaller program was the annual exercises of the Royal Canadian Corps of Signals which conducted trials and manoevers each year from 1946 to 1956.

The major off-road use in the area which later became the W.M.A. was by the Royal Canadian Army Service Corps (RCASC) which conducted tank testing, cold weather tactics and survival training. It also maintained the gunnery range east of Fort Churchill (A. Chartier, personal communication).

The RCASC support of the training operations was provided by a group of 32 Nodwell tracked vehicles plus a number of smaller tracked vehicles of various types depending on the nature of the test or exercise. Activity was heaviest in September and October each year although survival and winter training on a smaller scale could occur at any time between November and April (A. Chartier, personal communication).

The Service Corps establishment in Churchill included both tracked and wheeled vehicle sections but only the tracked section operated off-road (A. Chartier, personal communication). The largest of these exercises occurred in 1957 when about 1,000 troops received winter training; the training and support staff for these operations totalled 443 military and 338 civilian personnel when the program terminated in October of 1963 (Carroll in Beales 1968).

By the mid-1960's interest in Churchill as a military training area and proving ground was beginning to fade. The Joint Services Experimental Station closed in March of 1964. The Defence Research Board Northern Laboratory had largely completed its programs by the fall of 1956 and was gradually phased out and replaced with rocket research and atmospheric testing of military application during the late 1950's (Carroll in Beales 1968).

The army exercises were also reduced, with the base being formally closed as a year-round establishment in late 1963 (Carroll in Beales 1968). The last off-road tracked vehicle operations took place in 1965 (A. Chartier, personal communication).

4.6.2 The Churchill Research Range

A second major governmental user of the area east and south of Churchill is the National Research Council (NRC) rocket launch facilities. While this installation is officially called the Churchill Research Range (CRR) it is frequently referred to by local people as "Launch" or "NRC".

Construction of the range facilities started in 1953 and was completed in 1957. The initial atmospheric research was carried out jointly by the Canadian and United States air forces supported by a large number of civilians (Carroll in Beales 1968).

Following the end of IGY, emphasis shifted to military research for the US Air Force on auroral disturbance of radio propagation. This work was carried out by the Defence Research Telecommunication Establishment supported by the Canadian Armament Research and Development Establishment which developed and supplied the rockets used (Carroll in Beales 1968).

The USAF handed over operation of the range facilities to the National Research Council of Canada in 1966. Since that time the annual number of rocket launches has decreased greatly.

During the course of the earlier programs, recovery of instrument packages was done by overland travel with tracked or wheeled vehicles. Most of the recovery of instrument packages appears to have been in the area south of the launch site and therefore out of the study area for this report. As well, since much of the activity was in winter it is likely that comparatively little damage was done by this dispersed traffic.

The National Research Council leases a large portion of the W.M.A. from the province of Manitoba for use as a rocket impact zone (Figure 11). This lease runs until the end of

1992 (D. Teillet, personal communication). Much information can now be obtained by telemetry rather than by overland travel. Recovery is now usually done by helicopter if the payload must be retrieved (E. Zipf, CBW radio interview-- see personal communications).

The closure of the launch facility was announced in December 1984, to become effective April 1, 1985. Thus it appears likely that little or no future terrestrial impact will occur.

4.6.3 Oil Exploration

In the late 1960s, oil exploration was carried out at several points in and around Hudson Bay by Merlin Exploration Company Ltd. and Aquitaine Company of Canada Ltd. (Stirling and Jonkel 1970). The most lasting effect of these ventures is the presence of buildings at two sites along the coast south of Cape Churchill which are occasionally used by researchers and hunters (A. Silis, personal communication). The use of vehicles associated with oil exploration resulted in trails along several parts of the Manitoba coast and at least one major trail following the move of a drilling rig from Broad River to Churchill (Stirling and Jonkel 1970).

4.7 LEGISLATION CONCERNING THE CAPE CHURCHILL W.M.A.

The Cape Churchill Wildlife Management Area is the largest and most northerly bloc of crown land in Manitoba designated for wildlife management. Consisting of about 18,800 sq. km, the W.M.A. occupies the central third of Manitoba's coastline and stretches inland to the Hudson Bay Rail Line.

The W.M.A. is an important area for recreational and commercial tourist activity as well as for the preservation and management of wildlife. The continued presence of all-terrain vehicles represents a conflict between the two most important purposes of the W.M.A.: the conservation of wildlife and the provision of recreation to the people of Manitoba. An understanding of the objectives and present nature of the W.M.A. program is necessary to help resolve these conflicts.

4.7.1 The Wildlife Management Area Concept

W.M.A.s are areas of crown land designated under the authority of the Manitoba Wildlife Act (1980).

These areas are specified by section 5 as Public Shooting Grounds, Registered Trapline Districts, Special Trapping Areas, Wildlife Management Areas, or such other types of areas as the Lieutenant Governor in Council may specify in the regulation designating the area.

According to the _Five Year Report to the Legislature_ on wildlife (Manitoba Wildlife Branch 1982), the specific objectives of the W.M.A. program are:

> To enhance quality of life for all Manitobans by providing a diversity of wildlife-related recreational opportunity,
>
> To maintain present ecological diversity and promote restoration and
>
> To provide economic benefits to Manitobans through the use of wildlife in W.M.A.s.

Given these objectives, the _Five Year Report to the Legislature_ stated:

> Public use of W.M.A.s is governed by legislation under the Wildlife Act based on past practice, location, ecological sensitivity of the area and status of local wildlife populations. Regulations reflect concern for wildlife productivity and for the original purpose for which the area was set aside. Common public uses include hunting, trapping, nature interpretation, environmental education, scientific research, photography, cross-country skiing and hiking.
>
> Commercial uses such as haying, grazing, beekeeping, mineral extraction and trapping are allowed provided they complement habitat management and public use.

4.7.2 _Purpose of the Cape Churchill W.M.A._

The specific purposes of the Cape Churchill W.M.A. as listed by Teillet (1983) are:

> *to ensure that the Wildlife Management Area is managed within the framework of the provincial wildlife strategy.
>
> *to ensure that appropriate use is made of wildlife.

*to ensure that the wildlife resource is passed on to future generations in at least as vigorous a state as it was received by our generation.

*to maintain or enhance the variety of forms and amounts of wildlife use opportunities for the recreational benefit and enjoyment of Manitobans.

*to provide for subsistence and commercial use of the resource within the constraints of a defined allocation process and the capacity of the resource to withstand such exploitation.

*to promote the use of wildlife for scientific and educational purposes, and

*to alleviate wildlife damage to people and property.

For the Cape Churchill W.M.A. high priority is placed on the management and research of key species found in the coastal area of the province: caribou, polar bears and snow geese and on the viewing and consumption of wildlife and the appreciation of wildlife habitat by local residents and tourists.

The protection of the polar bear denning area and the Cape caribou herd are major reasons for the designation of the area for special status.

In addition to this conservation-oriented objective, there is also a desire for crown land to be accessible to users of all types. In this respect the Cape Churchill W.M.A. is the second most visited W.M.A. in the province following the Oak Hammock Area. An estimated 2000-2700 people per year tour the northern parts of the W.M.A. with the two commercial tour companies currently operating. An estimated 5000-7500 visitor-days per year are spent by Churchill residents for purposes as diverse as hunting and berry-picking. D. Teillet (personal communication) estimates an additional 10-20,000 visitors drive into the northwestern corner of the W.M.A. along the NRC road annually without leaving the road area.

4.7.3 Jurisdiction and Land Tenure in the Cape Churchill W.M.A.

The Cape Churchill W.M.A. was established by Manitoba Regulation 17/78 (1978).

There are no parcels of privately owned land in the W.M.A. Permanent structures within the northern portion of the W.M.A. include the rocket launch site, three buildings at Twin Lakes owned by the National Research Council, the Queen's University Research Station at La Perouse Bay and abandoned buildings at Camp Flicek. There are two abandoned buildings on the Christmas Lake esker and two shacks formerly used for oil exploration south of Cape Churchill, along with the Nestor I field station used by the provincial and federal governments for wildlife research. There are also several small observation towers built over the years for military and civilian purposes. All of these permanent structures are the focus of vehicle traffic at varying times of the year. The location of these structures is shown in Figure 2. South of Churchill, an abandoned military building at Marantz Lake is sometimes used by climatic researchers.

The southeastern corner of the W.M.A. contains the abandoned structures of Port Nelson.

There are several encumberances on land use which prevent the full control of the W.M.A. by the Wildlife Branch. As described by Teillet (1983) these include control over development and taxation by the Local Government District (LGD) of Gillam over 1400 sq. km situated in the southwestern part of the W.M.A. Other areas include two Manitoba Hydro water reserves totalling 4,555 sq. km and the National Research Council lease of 790 sq. km for rocket launching, monitoring, control and administration. This lease gives total control of land use to the NRC including access and development. As well, a large part of the remainder of the W.M.A. has been used for rocket impact and recovery and was subject to restrictions on air traffic when tests were in progress. A more complete description of these interests in land use may be found in Appendix E. The locations of these portions of the W.M.A. are shown in Figure 11.

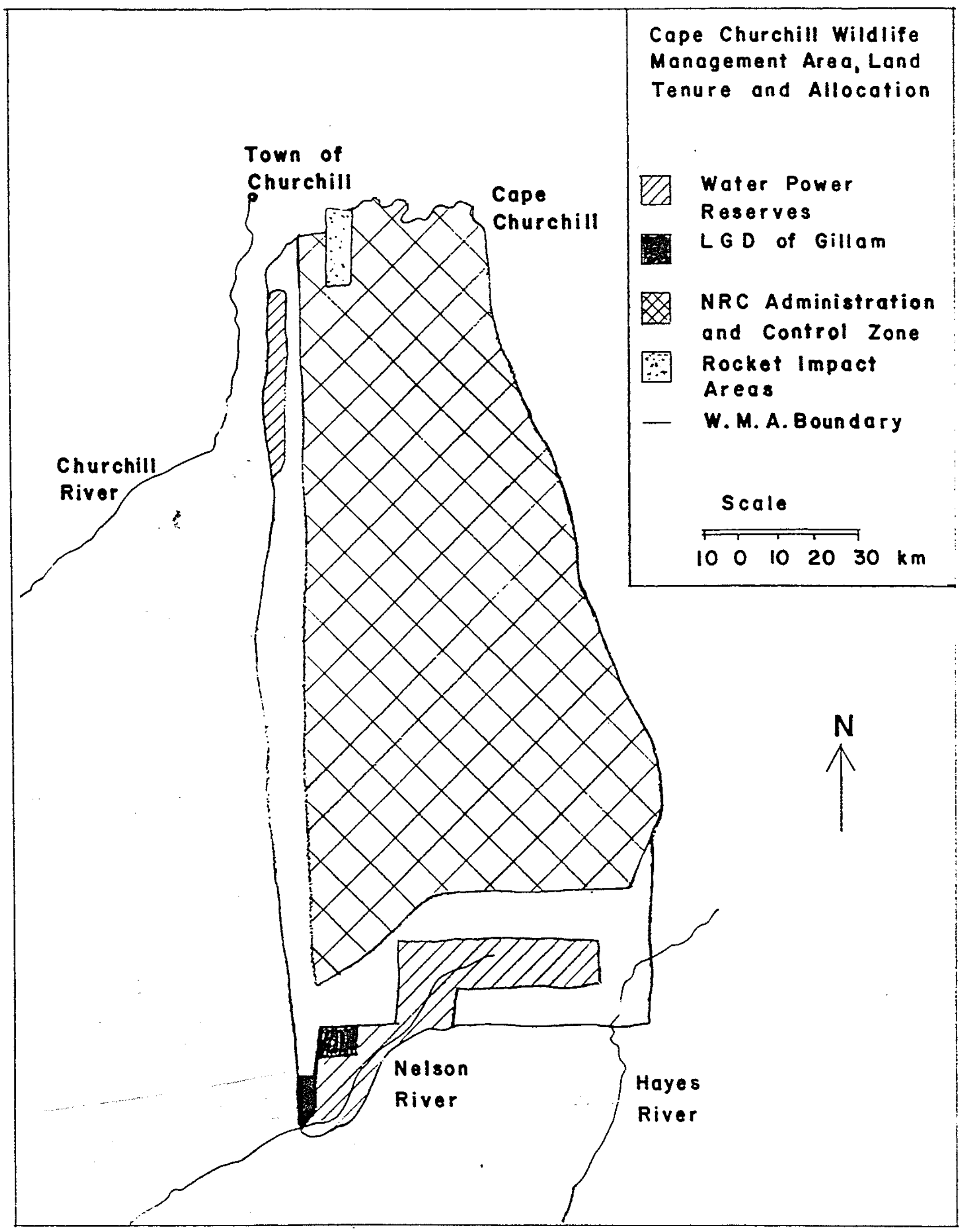

Figure 11: Non-wildlife land allocation (Teillet 1983).

4.8 LEGISLATION CONCERNING VEHICLES ON CROWN LAND

Several types of crown lands have been set aside for resource management in Manitoba under two major pieces of provincial legislation which specifically allow for regulation of vehicle use. These are the Park Lands Act (1972) and the Wildlife Act (1980). The Snowmobile Act (1970) is also important in the context of private recreational vehicles since it governs the licensing of snowmobiles and all-terrain cycles.

4.8.1 The Wildlife Act

Sections 2 to 6 of the Act spell out the powers and mandate of the provincial government to acquire and manage land for the conservation and use of wildlife. Section 3 states:

> A regulation made under section 2 may, for the purpose of managing and enforcing the use or uses prescribed for each designated area, prescribe activities and things that are permitted or prohibited, as the case may be, within the area, and may prescribe restrictions, terms and conditions and other requirements that shall be observed by any person within the area.

These general powers suggest the ability to bar or limit vehicle access, set seasons of use and restrict or prohibit certain recreational or commercial activities.

In practice, W.M.A.s are considered to be multiple use lands, with the Cape Churchill W.M.A. providing an example: subsistence uses such as native hunting and commercial uses such as trapping and organized tourism are allowed provided that activities can be monitored and allocated in a structured manner.

The acceptance of the notion of lands being set aside for multiple uses creates the problem of allocating resources among those uses. At present there is a lack of formal guidelines for judging the merits of these competing resource uses.

The portion of the Wildlife Act which deals with damage to wildlife habitat is subsection 50(1) which states that

> No person shall destroy or damage habitat on Crown lands, except pursuant to a licence, permit or other authorization issued or given under this or any other Act of the Legislature.

Subsection 50(2) reinforces this statement by allowing the Crown to recover damages for the restoration of lands so affected:

> The Crown has a right of action against any person who wilfully or negligently destroys or damages habitat on Crown land, and may recover damages from him for any costs that may be required to be expended for the rehabilitation of the habitat to a state approved by the minister.

The broad range of purposes assigned to W.M.A.s have resulted in little use of this section. It is not specific to designated crown lands; what might be deemed 'damaging' to habitat on designated lands might not be so considered on adjacent undesignated lands.

Section 50(1) could be made more useful in protecting habitat on designated Crown lands if it made reference to 'wilful or negligent' damage as does subsection 50(2), thereby clearly defining its target. This might overcome the problems associated with the present wording which could be interpreted to prohibit normal use of vehicles as well as their negligent or malicious use since even normal use will result in some damage to soil or vegetation in the area.

The need to formalize the relationship between commercial and scientific users of W.M.A.s and the provincial government was recognized by Manitoba Regulation 251/83 which came into effect in December 1983. This regulation narrowed the range of activities permitted in W.M.A.s and the circumstances under which they can be performed so that a permit is now required for many activities which were not formally controlled in the past. The regulation states:

> 2. Subject to sections 3 and 9, no person shall participate in or undertake any activities such as grading, clearing of roads or trails, gravelling, clearing, bulldozing, draining, diking, blocking of man made or natural waterways, bridging, haying, grazing, cultivation,burning, fencing,logging, mineral exploration or extraction, applying insecticides or herbicides, or occupying, using, constructing, erecting or placing of buildings, structures or tents, or any other similar activity, across, within, or into any Wildlife Management Area.
>
> 3. Subject to section 4 and to subsection 5(e), section 2 does not apply to a person occupying or using a portable structure or tent that is designed primarily for temporary living accommodations provided that person is engaged in lawful recreational activities or in the lawful hunting

> of wildlife, and that such structure or tent is removed when the person using the structure or tent leaves the Wildlife Management Area.
>
> 4. No person or employee, or agent of a person, shall, within the Cape Churchill Wildlife Management Area or the Cape Tatnam Wildlife Management Area, while engaged in the supplying of accommodation or touring facilities or while engaged in scientific or research studies,
>
> a) use a vehicle; or
>
> b) occupy, use, construct, erect or place any building, structure or tent.
>
> 9. Notwithstanding anything contained in this regulation, the minister may grant, subject to such terms and conditions as he may prescribe, a permit to undertake certain activities across, within, or into any Wildlife Management Area.

The effect of this regulation is to require the licensing of commercial tour operations and research activities in the W.M.A. and to provide explicit legal basis for the imposition of terms of use.

This regulation could perhaps be interpreted to prevent the making of new trails in hitherto undisturbed areas by commercial or recreational users under the general provisions of section 2.

As of July 1984, there have been no formal permits issued. Instead, the Department of Natural Resources has issued letters of permission valid for one year to existing users (D. Teillet, personal communication).

Some precedents already exist for such a method. Provincial hunting regulations include designated routes for the use of snowmobiles and ATVs for big game hunting in some areas including W.M.A.s. In other W.M.A.s, the use of any vehicles off provincial and municipal roads is prohibited to prevent the destruction of fragile or unique habitats (e.g. Manitoba Regulation 164/83).

4.8.2 The Park Lands Act

Several parts of the province have been designated for use as provincial parks under the authority of the Park Lands Act (1972). Aspects of their management could provide a useful pattern for future changes in the management of other designated lands including W.M.A.s.

The use of master planning processes is becoming increasingly popular in the management of designated Crown lands. The first example of this in a Manitoba provincial park is the Whiteshell Master Plan (Manitoba Parks Branch 1983) which includes road access zones, two intensity levels of recreational areas and a wilderness zone where no motorized vehicle activity is permitted.

By contrast, the Cape Churchill W.M.A. is divided into five zones (Figure 12) for the promotion of different resource development and conservation strategies. These zones have no formal legal status and are not used to control or promote any particular recreational or commercial activity. Instead they serve as a guideline or suggestion for appropriate uses of the areas so zoned. Appendix F describes these zones and their objectives.

The tone of the Park Lands Act grants greater powers to lower levels of government than does the Wildlife Act, allowing more flexibility to respond to local conditions. While the Wildlife Act requires Orders-in-Council to implement many of its provisions, the Park Lands Act gives broad powers to the Minister (or in some cases the Director of Parks) to make regulations so long as they are not inconsistent with the intent of the Act or any regulations made by order in council (Section 12(2)).

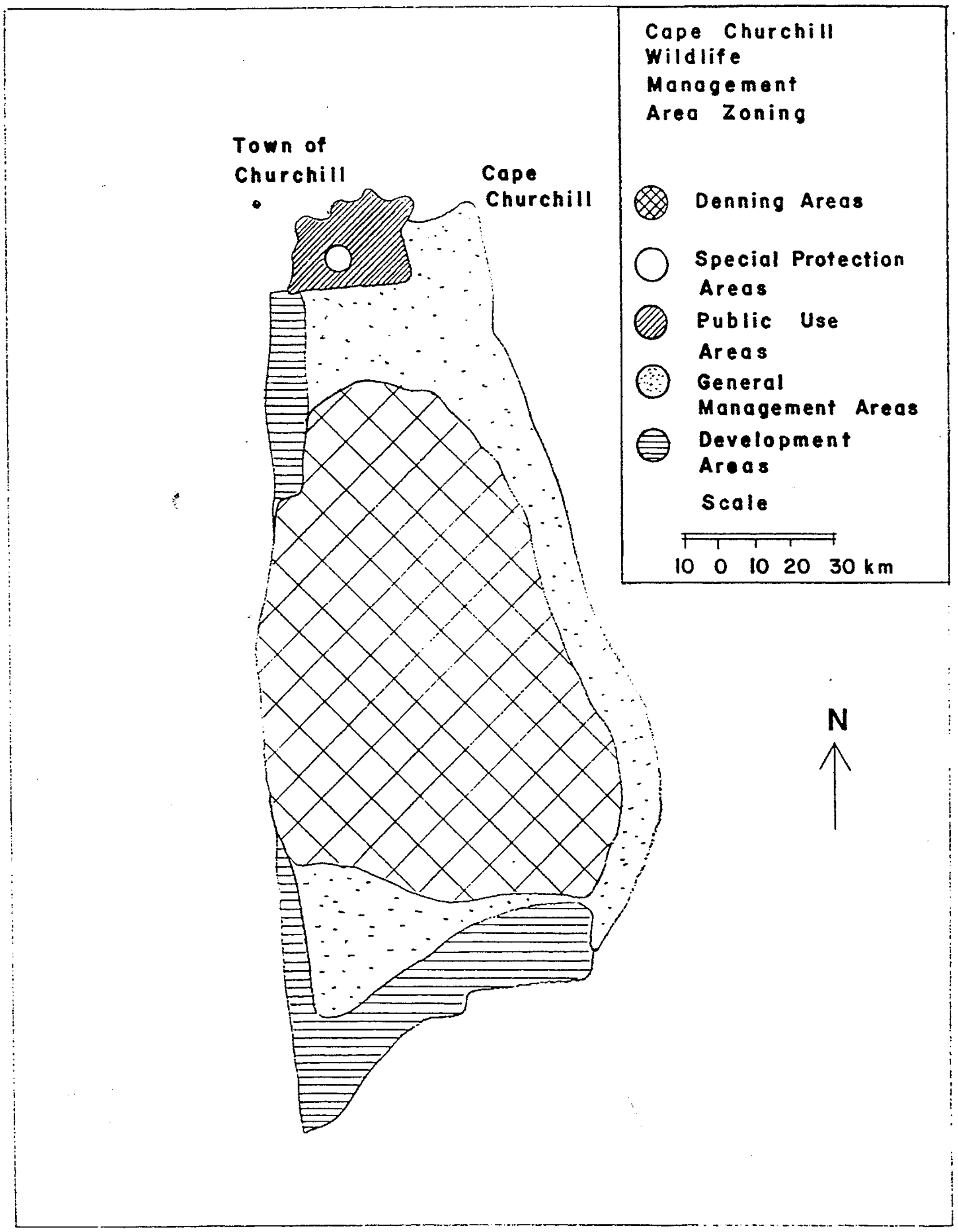

Figure 12: Management zones in the Cape Churchill W.M.A. (Teillet 1983).

A considerable part of the powers of the Park Lands Act derive from the fact that it places a reverse onus on many potential uses: many activities, including recreational vehicles used off existing maintained roads, are prohibited except where expressly permitted. This is in direct contrast to the Wildlife Act which generally permits anything which is not expressly prohibited. Thus the experience with zoning and designated routes in parks could be examined for use as model in planning these aspects of use in Wildlife Management Areas.

4.8.3 The Snowmobile Act

The first Manitoba legislation to deal specifically with all-terrain vehicles was the Snowmobile Act (Manitoba Snowmobile Act 1970).

The regulation of environmental damage is not a major objective of the Snowmobile Act. However, it grants powers to municipal or provincial governments to issue regulations concerning ATVs under some circumstances. This act was originally concerned only with over-the-snow vehicles. It was subsequently amended to include all off-road vehicles used primarily on snow or ice which are not acceptable for registration under the Highway Traffic Act. Section 1(1)(j) of the Snowmobile Act specifically includes three-wheeled ATC-type vehicles.

Most of the Act is concerned with licensing, insurance and safe operation of snowmobiles and related vehicles. These provisions deal with the restriction of their use on maintained roads and rail beds, and accident reporting, not with environmental concerns.

However, provision for the management of damage or noise created by snowmobiles is available under Section 34 which allows for the making of regulations concerning snowmobiles by local governments in organized districts or by the provincial government on unorganized lands. This provision overlaps the more explicit management powers already available in W.M.A.s through application of the Wildlife Act.

4.9 MINIMIZING RECREATIONAL IMPACTS

Reducing the impact of recreational use in wilderness areas is a task which confronts resource managers in many different types of habitat.

The wide-spread use of off-road recreational vehicles is a comparatively recent (since the late 1950s) and quickly growing phenomenon (Shay in Ittner *et al.* 1978).

As sales of various types of off-road vehicles have risen, so have the concerns about their environmental impact. Folster (1984) examined some of the public concerns expressed over recreational off-road vehicle impacts in eastern and northern Canada.

Several means are available to deal with the problems of damaging use of resources in areas of designated land. In many cases, a combination of these methods is useful or necessary.

4.9.1 Designated Recreational Vehicle Use Areas

The first is the provision of alternate sites designed to meet recreational demand using land which is less prone to damage. Spolar in Ittner *et al.* 1978) notes that many vehicle trails in recreation areas are based on routes originated or built for low volume foot and animal traffic and are not properly designed for vehicle use. Nicholes in Ittner *et al.* (1978) suggests that the provision of areas designed and publicized for use by recreational vehicles would greatly reduce the impacts of unstructured use at other sites.

While this approach can reduce the effects of off-road vehicles on areas which were primarily designated for other uses, it also may have serious drawbacks. First, an area of land must be available for this use. This land may not be available in areas such as Churchill due to competing land uses and geographic constraints.

As well, Shay (in Ittner *et al.* 1978) points out that the land set aside must have suitable carrying capacity to satisfy the recreational demands of the vehicle users. If it does not, they will continue to use other lands outside the designated ORV area. Shay also examined the costs of a proposed motorized recreation area in California and found that the costs of developing and maintaining the site so that it would continue to be attractive to vehicle users totalled about $10 per user per day.

4.9.2 Modification of Existing Trails

Two approaches may be taken to the modification of existing trails. One is to attempt to restore the trails to pre-use conditions of vegetation and soil stability. This may be done by soil modification such as fertilizing (Babb and Bliss 1974) or reseeding with hardy, fast-growing species (Bliss and Wein 1971b). The other is to modify the physical resistance to damage of the site by modifying drainage or soil conditions.

Wernex (in Ittner et al. 1978) states that if careful planning is applied, a trail can be designed which will protect the threatened resource, satisfy user needs, and be cost effective. His steps include the routing of trails to avoid sensitive areas [e.g. wet areas and steep slopes], provision of special features such as drainage, gravel, wire mesh or corduroy material to strengthen trails where sensitive features cannot be avoided, and adequate publicity and user education so that potential users are aware of the protected trail and why they should use it.

While Wernex dealt with the choice and construction of new trails, some of these methods could be applied to existing trails if user demand, damage levels, and cost warranted.

Although it does deals with the design of trails for pedestrian, horse and bicycle use rather than vehicle traffic, the Parks Canada Trail Manual (Parks Canada 1978) is a valuable source of information regarding the planning and design of trails. The manual stresses the avoidance of wet or steeply sloped areas wherever possible, and the provision of drainage dips, water bars, or tread armour on trails where necessary as well as providing illustrations of their use. Many of the suggested methods could be used to improve existing trails.

4.9.3 Regulations Governing Vehicle Use

Another approach to controlling vehicle impacts is to issue legislation or regulations specifying what types of vehicle use or locations are unacceptable. Since existing Manitoba legislation and regulations have already been mentioned, this section will examine compliance with regulations in general. The concept of designated routes in a managed area is included in this management option.

The purpose of regulations for use of designated land is summarized by Lucas (1973) who stated that "Change in Wilderness is too rapid to allow visitation to grow unmanaged and to let interference with natural ecological forces continue." This approach seeks to limit damage without unnatural techniques such as the alteration of drainage patterns or modification of trail surfaces already mentioned. Instead, it assumes that by limiting damaging activities, natural forces and processes will maintain or improve the affected areas.

The degree of control provided varies. Hendee and Lucas (1973) examined the use of self-registration camping permits in western American national parks. While these permits can provide valuable information on user demand and resource preferences, they are of little value in restricting damaging activity.

A more restrictive control is a mandatory use permit which specifies where certain activities can occur and prohibits others. Several American national parks allocate backcountry camping and hiking areas by requiring users to register in advance for a particular management unit and time period (Hendee and Lucas 1973). In general, public support of these programs is strong. Fazio and Gilbert (1974) reported that between 67 and 80% of various groups of users of these parks felt that resource allocation by permit was necessary. Plager and Womble (1981) examined compliance with permits in an Alaskan national park and found that 93% of hikers had obtained permits. About 50% of those who had permits deviated from the conditions under which they were granted. Of those who violated conditions of their permits, 58% did so deliberately (e.g. camping in non-assigned areas) while the remainder were affected by inclement weather, bad planning, injury, or left the park before their allotted time had expired.

These high levels of compliance were obtained by a combination of effective law enforcement and public education and interest. Hendee and Lucas (1973) summarized the benefits and costs of a mandatory permit system for controlling back-country activity. Among these were:

<u>Benefits</u>

1. User safety is increased because the departure time, destination and expected time of arrival of the user are known in case of emergency.

2. Information and interpretation are available to the user--when obtaining their permits users come in contact with managers who can provide accurate information on conditions of use, maps, safety hazards, etc.

3. Managers obtain information on what areas or types of recreation have been or are in demand, allowing improved planning and maintenance. As well, contact between managers and users is increased.

4. Enforcement of regulations is improved because violators are more easily identified and are bound by the conditions of the permits they have accepted.

<u>Costs</u>

1. Visitors may experience inconvenience or extra travel costs in seeking their permits.

2. Some areas may be previously assigned and so are unavailable to later users (i.e. the number of users at a site is rationed).

3. Increased labour costs are likely since there must be adequate staff to issue and enforce permits without detracting from other activities. As well, the increased educational and interpretive contact with users is likely to require additional labour.

4. The introduction and enforcement of a permit system must be seen to be efficient and fair; otherwise, users of the resource will lose respect for management efforts and will withhold their cooperation.

Bradley (in Ittner et al. 1978) points out several weaknesses in the imposition of regulations to reduce the impact of recreational use in the outdoors due to several factors:

1. Difficulty in enforcing regulations, including problems in observing infractions and successfully prosecuting before courts which are busy with more important cases; increasing ineffectiveness as word spreads that nothing happens to violators.

2. The fact that most impacts result from insensitivity to environmental consequences, not malice. Since there is usually no intent to be destructive, the main objective of management should be to change the habits of users by education.

3. Issuing regulations tends to antagonize users, reducing their willingness to cooperate in lessening impacts and promoting careless use of the resource.

The importance of good public relations with affected users should not be underestimated if this approach is to be effective. Behan (1974) characterized the opinions of Hendee and Lucas (1973) as "paternalism" and their language and ideas as "authoritarian, serious and cold" while attacking regulatory permits as a sign of "heavy-handed government" creating a "police state wilderness".

4.9.4 User Education Programs

The final approach is that of educating the users of an area about the nature of their impacts and explaining the methods which are being employed to counter the damage.

In many cases, operators of off-road vehicles do not understand the potential for damage possessed by their machines (Diamond in Folster 1984). In this situation, a public education campaign can alter user behavior by indicating the problem and providing alternatives.

User education programs may have more than one purpose. An obvious goal is to provide users with accurate information on resource management policies and regulations (Hendee and Lucas 1973). A second objective is to influence patterns of use. In describing methods of distributing recreational activity, Lucas (1973) stated "Do not use controls if [user] decisions can be influenced by information, education and persuasion. High educational levels typical of Wilderness visitors and our knowledge of their motivations and attitudes make this a potentially useful, inoffensive approach."

Schoenfeld (1957) noted that resource managers "must have public support, or at least sufferance, if resource management is to be practiced" and that "a favourable climate of public opinion must precede management."

4.10 PUBLIC INVOLVEMENT AND INFORMATION PROGRAMS

The creation of a public relations and public involvement program can greatly aid in the delivery of a management program. Conversely, the management of publically-owned resources is hampered if management programs are not understood by or are not known to the public which uses the resources. Gabrielson (in Schoenfeld 1957) stated that "The most uncertain factor (in wildlife management) is not management (of game) itself but public support for a suitable and effective program."

Public understanding and support for a program is most easily obtained with the aid of a planned public relations program. Schoenfeld (1957) noted that "In public relations, as in the physical universe, nature abhors a vacuum. When the reticence of wildlife scientists creates a news vacuum, the vacuum never stays empty....You may have good public relations or bad public relations, but you will always have public relations." His solution to this problem was for wildlife managers to supply "continuous, clear, and candid summaries of their activities".

Cutlip and Center (in Fazio and Gilbert 1981) defined such an effort: "Public relations is the planned effort to influence public opinion through good character and responsible performance, based upon mutually satisfactory two-way communication."

Meeting this goal requires the performance of several steps according to Fazio and Gilbert (1981):

1. Having a sound and defensible management plan to put before the public.

2. Identifying the segment(s) of the public to which information will be directed.

3. Designing a media or meeting program which transmits the desired information (e.g. pamphlets, advertising, public meetings).

4. Establishment of a mechanism to determine public response and incorporate public opinion into both the management objectives and the public relations program.

5. Periodic updating of both the management plan and public relations efforts to keep target portions of the public informed about changing conditions and new developments relating to the resource.

Chapter V

USERS OF THE CAPE CHURCHILL W.M.A.

5.1 FORMER MILITARY USE

Several overall conclusions may be drawn from the brief review of military usage of the area already given and from observation of the trails of military origin which remain. First, activity was concentrated in the fall and winter periods when the vulnerability of the soil to damage is highly variable. Much of the use of heavy vehicles occurred following freezeup when the susceptibility of the soil to physical displacement is minimal and when there is sufficient snow cover to help protect vegetation of low stature.

However, some of the use in September and October undoubtedly occurred on unfrozen ground. Black (1957) stated that small tracked utility vehicles tested on coastal tundra in Alaska could make many passes over a trail without breaking through the turf, but that larger utility vehicles, tanks and bulldozers broke through the cover and rode on the frozen component of the soil. Freezeup and breakup were the most critical times for rut formation on tundra, and marshes and soils with ice wedges represented the most critical areas for travel difficulties. If these conditions also applied to the Fort Churchill area, the short period of fall use during freezeup was probably the time when the majority of military damage occurred. This season corresponds to the early part of the current bear viewing period when both tracked and wheeled vehicles are in use on unfrozen or partly frozen ground.

Secondly, the use of military tracked vehicles such as armoured personnel carriers and utility vehicles such as Nodwells tended to be confined to areas of trail as flat, smooth, and stone-free as possible. The problems of steel-tracked vehicles encountering steep grades and hidden rocks were apparent as early as the Lemming and Muskox exercises in the mid-1940's, resulting in mechanical breakdowns and machines getting stuck or stranded on obstacles (Carroll in Beales 1968). In the area which later became the Cape Churchill W.M.A., the best travel routes to the east were along the inland trail, which tends to be relatively low-lying and marshy, and along eskers and beach ridges which are usually flat-topped and free of large rocks.

On the coastal trail, rocks are a serious obstacle to tracked vehicles owing to the danger of losing a track and damaging stresses to the chassis of the vehicle (A. Chartier, personal communication). For this reason, the military users of the coastal route tended to avoid rocky areas and instead used pond edges or gullies and picked peaty areas in preference to the higher and more stony ridges and till areas.

Consequently, the inland trail and numerous segments of the coastal trail traverse areas which are permanently or seasonally wet, have highly organic soil and few rocks, and are thus quite susceptible to both the physical disruption of vehicle traffic and the absorption of heat by their dark soils when vegetation has been removed.

The location of the military trails has been the dominant factor in determining where the current commercial and recreational use is located since the military routes run to areas of interest such as La Perouse Bay and Gordon Point and have been closely followed by both the tourist operators and individual recreational users.

5.2 CHURCHILL WILDERNESS ENCOUNTER

Churchill Wilderness Encounter (CWE) is a touring and outfitting company owned by Al and Bonnie Chartier which offers a wide variety of nature-oriented activities, most notably bird watching and polar bear photography within the W.M.A. The company will also carry people or supplies to outlying areas for hunting or in support of academic and government research activities.

The off-road portion of Churchill Wilderness Encounter's activity grew out of Mr. Chartier's experience with military use of the Churchill area in the 1960's. The Chartiers' first use of off-road vehicles in the area now within the

W.M.A. was for their own recreation in the late 1960's. Churchill Wilderness Encounter began carrying paying tourists in 1974 (A. Chartier, personal communication).

During the 3-5 years prior to 1983, about 700 tourists were served annually in the period from early July to early September, with another 500 arriving during the height of the bear viewing season from October 10 to November 10. The demand for nature tours appears to be growing rapidly: during the 1983 season, CWE had about 1,800 customers (Lowery 1984). Many of the customers travel off-road to view birds and bears in tours offered using a variety of vehicles.

Off-road equipment consists of:

1. One 9-passenger 4-wheel drive van used on and off-road.
2. Two 7-passenger Thiokol Trackmaster tracked vehicles (See Figure 13).
3. One 8-passenger hovercraft.
4. One small 2-passenger tracked utility vehicle.

CWE has a year-round staff of 3 with an additional 4 guides during the fall season (A. Chartier, personal communication).

Specifications for the Trackmaster used in July 1983 and ground pressure calculations for the van are found in Appendix G.

Offroad activity is highly seasonal, with the type of vehicle used depending on soil firmness, snow cover and the object of the particular trip being offered that day. Winter and early spring activity is infrequent and done on a charter basis only.

During the period from late April to mid-June approximately one trip per week is made with a Trackmaster to resupply the scientific researchers using the areas south and east of Churchill; tourist use of the vehicles usually begins in late June or early July with about one trip per week into the W.M.A. using a Trackmaster. These tours continue until the beginning of September depending on the onset of summer and the movement of animal life for a total of about 8 trips; another 2-3 trips may be made in September. The heaviest Trackmaster use occurs during the bear-watching season when both Trackmasters are in use almost every day from about October 10 to November 10 for a total of about 50-60 trips.

Overall the Trackmasters are used for about 80 trips per year in the W.M.A., with about 75% of activity being after the first frost. Summer trips with the Trackmasters are usually restricted to the inland trail between the NRC Launch and the research station at La Perouse Bay. The coastal trail has been used only a few times by CWE because of its rocky terrain, although the part to the west of the Christmas Lake esker is sometimes used because is relatively

Figure 13: Thiokol Trackmaster (foreground) and Tundra Buggy.

dry and flat compared to the corresponding part of the inland trail. Vehicles may then travel south along the Christmas Lake esker about 3 km and rejoin the inland trail, having bypassed the rocky area near the NRC Launch.

The GMC 30 4WD van was first used extensively in the summer of 1983. This 9-passenger vehicle normally carries 5-7 customers for summer day trips of several hours duration. During the July to September period, about 3 trips per week were made for an annual total of approximately 30. The van is used less frequently during the bear season because of the relative lack of protection it affords for photographers.

The van has less ability to traverse soft ground than the Trackmasters. Consequently, its normal route follows the northernmost parts of the coastal trail between the end of the Launch road and the Christmas Lake esker. From there, it is possible to continue eastward for a short distance, but the normal route is south along the Christmas Lake esker for several kilometers depending on the presence of birds, which are the major attraction for passengers during the summer season.

Several advantages are enjoyed by the van over the Trackmasters; first, maintainance is much less frequent and difficult; a trailer is unnecessary to move the vehicle to and from town; and no separate vehicle is required to bring the passengers from Churchill to the start of the trail.

There are also several disadvantages. Use of the van is restricted by soft ground during the summer and by its vulnerability to bears in the fall. Many areas in the W.M.A. cannot be visited during the tourist season for these reasons. Equally important is that customers prefer the more exotic tracked vehicles to the relatively conventional van. As a result of these considerations, use of the van off-road in the W.M.A. is unlikely to expand and will probably decrease.

It might be possible to overcome the problem of limited areas available to use the van by installing larger, lower-pressure tires. This option has been considered by CWE (M. Reimer, personal communication).

At present, neither the van nor the Trackmasters present a major problem of creating new areas of damage since all the CWE operations during the unfrozen season are on existing trails and the vehicles are driven carefully to prevent wheel spinning or skidding. Continued emphasis on use of the van during the summer months would be desirable because this vehicle operates on trails which are quite resistant to damage.

Most of the use of the Trackmasters occurs when the ground is frozen. This situation is also desirable, since the inland trail appears to be capable of sustaining only low levels of use when in an unfrozen state. The present level of use during the unfrozen season is close to the thresholds of permanent damage estimated in the literature by Radforth (1971) and Ferris (1980), suggesting that increased use of the inland trail should not occur during the unfrozen season without careful monitoring.

The success of his venture depends on the presence of birds and bears during a short season of the year. Consequently it is not economically feasible to adjust the timing of tourist-related operations.

The outfitting and guiding of hunters is also a service provided by CWE, although its economic importance ranks after birdwatching, bears and river trips for whales. Due to the timing of the hunting season, most of this activity occurs after freezing is under way.

5.3 TUNDRA BUGGY TOURS LTD.

The Tundra Buggy (Figure 13) was constructed by Len Smith of Churchill in 1980-81 and is operated by Mr. Smith and Roy Bukowsky. This large wheeled vehicle currently carries about 50% of summer off-road tourists and has been used for wildlife research by several government programs as well as for bear photography by film crews.

A second vehicle was constructed during the winter of 1983-84 which is similar to the older one (Lowery 1984). During part of the 1984 summer season, the original Tundra Buggy was out of service while the newer vehicle was used for 3 trips per week beginning in mid-June. Specifications for the first Tundra Buggy are shown in Appendix G.

A total of 40 half-day tours (275 person-days) were made between June 12 and October 18 involving 550 passengers. In the October 16-November 8 period, both vehicles were in use for a total of 38 days with 17 passengers per trip (646 person- days).

1984 bookings totalled 782 passengers for 850 person-days (R. Bukowsky, personal communication).

Owing to mechanical problems with the first Tundra Buggy during the summer of 1984, a large tracked bus formerly used for glacier tours was purchased for use as a backup vehicle. This 28-passenger machine may be sold or may be converted to operate on wheels similar to those of the Tundra Buggies and used as a mobile classroom for nature tours and interpretive programs.

Many of the passengers carried by the Tundra Buggy during the summer portion of the tourist season arrive on VIA Rail Explorer tours. This tie-in assures that most of the 28 seats are filled for each trip.

Activity varies from year to year with demand, weather, and the availability of wildlife. Typical use patterns were supplied by Mr. Bukowsky (personal communication). From mid-June through the end of September, about two trips per week are made along the coastal trail between the end of the road near the National Research Council Launch site and the tip of Gordon Point. Assuming 20 passengers for 24 trips, this accounts for 480 passengers during the summer season. During the bear season, which begins approximately October 1, 5-7 trips per week are made until mid-November. Assuming 20 passengers per trip for 30 trips, another 600 people visit the W.M.A.. The trips after freezeup range as far east as the vicinity of Knights Hill, with a few in the last part of the season going to Cape Churchill. The duration of these fall trips is one day while the summer trips are halfdays. Thus an annual total of about 840 passenger-days is recorded. Most of this October and November activity is along the coastal trail. Very few trips have been made along the inland trail because of its wetness in summer and the lower number of bears along it compared with the coast area during the later part of the tourist season. Many of the later trips for bears involve travel on beaches or on the sea ice wherever possible because of the much smoother ride and increased speed which are possible. However, the sea ice and that of the larger lakes is not strong enough to hold the Tundra Buggy until about November 15.

Another category of Tundra Buggy use is as a vehicle chartered by researchers and film crews. The large size of the machine makes it safe for close encounters with bears. Furthermore, it can pull a tracked trailer for additional space when staying in the field for several days. These charter trips are of variable length and location and like the late fall bear tours they do not necessarily stay on existing trails.

5.4 SCIENTIFIC AND RESOURCE MANAGEMENT USERS OF THE W.M.A.

5.4.1 Biological and Climatological Research

Due to the large concentration of wildlife and diverse habitats which come together in the Churchill area, a considerable amount of biological research is done in the W.M.A..

The largest number of projects are located at the Queen's University Field Station at La Perouse Bay. A variety of programs are ongoing. The equipment used includes a tracked Argo vehicle (see Figure 14) and two ATCs. The major use of these machines is to carry materials between the landing strip near Knights Hill and the station. The vehicles are driven to and from Churchill at the beginning and end of the research season.

Figure 14: Tracked Argo and ATC along the inland trail at Site 11.

A total of 6 ATC passes by botanists based in Churchill were observed during the field period of this study (July 16-August 20 1983).

Another program using a vehicle is an ongoing climatology study which includes field work based at an abandoned military building on Marantz Lake, south of Churchill. A wheeled Argo is used to transport equipment along an abandoned rail spur and through an area of abandoned borrow pits and ridges. Much of the traffic is during the spring when considerable snow cover remains. While some of the route is over resistant terrain, areas of deep peat have been encountered which make the wheeled Argo difficult to use (A. Silis, personal communication). Other sites for the program are visited by air.

The second major user of vehicles in the area is the provincial Department of Natural Resources. Three ATCs, several snowmobiles and a Bombardier (See Figure 15) are available, although only the ATCs are operated during the unfrozen part of the year. Polar bear research resulted in several trips through the study area to the Nestor I field station. Several trips per year may be made for law enforcement purposes by Conservation Officers.

The author's use of an ATC during field work for this study was probably the most intensive use of any small vehicle in the study area in 1983. Portions of the coastal trail received up to approximately 120 passes with a Honda 200E in the course of the fieldwork, while the portion of the inland trail where study sites were located received

Figure 15: Natural Resources Department Bombardier.

about 20 passes. This use was almost certainly responsible for the deterioration of the extreme west end of the coastal trail which was used when travelling to all of the 12 study sites in the area and for several days of reconnaissance before selecting the sites.

As previously noted, researchers sometimes charter one of the larger vehicles either for resupply purposes or for accommodation and transportation in the field. These charters represent a greater potential for damage than does the use of small, low- capacity machines like ATCs and Argos, since such traffic with small vehicles is infrequent and is not usually concentrated.

5.4.2 National Research Council Rocket Program

The major influence of the NRC activity on the Wildlife Management Area today is the paved road which runs from the town to the launch facilities 14 km southeast of the airport. This road allows all-weather access to the northwestern boundary of the W.M.A., from whence gravel roads lead 2-3 km into the northwest corner of the W.M.A..

Access past the gates of the CRR is normally controlled, but visitors are sometimes permitted to use the 15 km gravel road between the launch site and Twin Lakes hill which lies to the south of the launch site (I. Thorleifson, personal communication). There are three permanent structures at Twin Lakes associated with instrument monitoring. This area is sometimes visited by Churchill residents for moose and caribou hunting (I. Thorleifson, personal communication). Such use, including the driving of ATCs, usually occurs close to the access road because of the rough and wet terrain in the Twin Lakes vicinity. Twin Lakes hill is also accessible overland by ATC from the Christmas Lake esker, which terminates about 4 km to the east.

The Twin Lakes area also has several bulldozed cutlines which allowed access to instrument monitoring sites.

Only one major use of ground vehicles by the National Research Council has occurred recently. This was a tractor train which travelled down the extreme western edge of the

W.M.A. on the east side of the CN right-of-way to the Herchmer area during the winter of 1982-83 transporting equipment and materials for a satellite monitoring station (D. Teillet, personal communication).

5.5 RECREATIONAL USE AND USERS

The Churchill area offers a large number of potential activities for recreation; however, the area available for some of them is restricted by topographic considerations. This is particularly the case for motorized recreational activities such as the use of ATCs or 4WD trucks. The Cape Churchill W.M.A. is the largest block of land easily accessible to local people for these activities. Churchill is bounded on the west by the Churchill River, on the north by Hudson Bay and on the south by nearby treed areas. Thus the W.M.A. and the intervening undesignated crown lands to the east of the town receive a great deal of use for various types of outdoor recreation.

The magnitude and distribution of motorized recreational activity was estimated using a mail-out questionnaire.

5.5.1 Questionnaire Design

A mail-out format was chosen because of its convenience and the large number of potential respondents. Initial design was done according to the suggestions of Filion (in

Schemnitz 1980) which stresses conciseness, a flow of interrelated questions from general to specific, maximum use of closed, fixed- alternative questions and use of simple vocabulary with neutral wording.

A preliminary version of this questionnaire was examined by Dr. G. Mason of the University of Manitoba Institute for Social and Economic Research. The revised version was then examined by four Churchill residents for clarity of purpose and language.

5.5.2 Sample Size and Response Rate

The questionnaire of Churchill residents contained in Appendix B was mailed to 434 households. Unopened returned copies owing to refused mail or addressees departing without a forwarding address totalled 26. Of the remaining 408 households, returns were obtained from 141 (34.6% of the potential sample size). A summary of questionnaire results is found in Appendix C.

5.5.3 Demography of Recreational Users

The age and sex distribution of the present population is important in predicting future recreational use of the Cape Churchill W.M.A. since 82.1% of respondents consider themselves permanent residents. Survey respondents were 82.5% male and 17.5% female. The age distribution of respondents (Table 1) was:

TABLE 1

Age distribution of respondents.

Age (Years)	Percentage of Respondents
14 or less	02.0
15-24	12.4
25-34	44.5
35-44	19.4
45-54	12.4
55-64	05.0
65 or more	04.0

Respondents were also asked to give the age and sex categories of other members of their families to allow an estimate of the characteristics of the population as a whole. The distribution of the Churchill population (including respondents) reported by respondents is shown in Table 2 compared with that of the Manitoba rural non-farm population reported in the 1981 census (Statistics Canada 1982).

From this comparison it may be seen that Churchill residents reported a population with slightly fewer members in the under 15 years group than the corresponding Manitoba population. There are substantially more members in the 15-44 age groups than in the Manitoba rural non-farm control population, fewer members in the 45-64 age group, and very few members of the 65 or older age group.

TABLE 2

Age and sex distribution of Churchill residents.

	Churchill				1981 Manitoba Rural Non-farm	
AGE GROUP	M		F		M	F
14 or less	62	(12.5%)	51	(10.3%)	(14.5%)	(13.9%)
15-24	53	(10.7)	81	(16.4)	(08.8)	(08.2)
25-34	54	(10.9)	92	(18.6)	(07.4)	(07.2)
35-44	43	(08.7)	19	(03.8)	(05.4)	(04.8)
45-54	10	(02.0)	14	(02.8)	(04.1)	(04.0)
55-64	5	(01.0)	6	(01.2)	(04.2)	(04.6)
65 or more	2	(00.4)	3	(00.6)	(06.5)	(06.5)
	229	(46.3%)	266	(53.7%)	(51.0%)	(49.0%)

Permanent residents are more likely than non-permanent residents to own recreational vehicles; 82.1% of respondents consider themselves to be permanent residents.

Crosstabulation of opinions on vehicle management vs. differing levels of education and occupations showed no significant effects of these factors using a [Pearson] X^2 test at the 0.05 level. A description of these comparisons is found in Appendix C.

Many residents belong to conservation organizations. Of the 141 responses received, 48 listed membership in one or more conservation or sporting organizations. The number of memberships by organization is shown in Table 3:

TABLE 3

Membership in Conservation- and Naturalist-Oriented Organizations.

Organization	Number of Memberships Reported
Manitoba Wildlife Federation	32
Canadian Wildlife Federation	22
Manitoba Naturalists Society	4
Ducks Unlimited	3
Canadian Arctic Resources Committee	3
Audubon Society	1
Saskatchewan Wildlife Federation	1
Canadian Nature Federation	1
	67

Interest in conservation and recreation is high, with past or present participation in organizations running at a rate of 47.5 memberships per 100 respondents (67 of 141) and 34.1% of all respondents (48 of 141) belonging to at least one organization.

5.5.4 Recreational Vehicle Ownership and Use

Respondents were also asked to indicate the number of off-road vehicles of each type they owned. Based on these results, the minimum number of recreational vehicles available to the families of respondents are shown in Table 4:

TABLE 4

Off-road vehicle ownership in Churchill.

Vehicle Type	Reported Number	Estimated Churchill Total*
4WD Trucks	34	70-100
Snowmobiles	127	250-375
Trail or Minibikes	42	80-120
ATCs	58	100-150
Other Vehicles**	23	?

* Estimate based on the total population of Churchill. The survey drew response from about 34% of potential households and accounted for 495 residents. Since the official population figure is 1304 (Manitoba Department of Municipal Affairs 1982) and unofficial estimates are about 1,000 year-round residents, the questionnaire appears to account for 1/3 to 1/2 of total residents. Thus survey results should be multiplied by 2-3 to give a total ownership estimate.

**Respondents listed 2 aircraft, 3 dune buggies, 1 Bombardier and 1 Weasel; several did not indicate what type of vehicle was owned. Consequently the accuracy of this number is uncertain.

Of the 113 respondents who described their use of the W.M.A., 57 (50.4%) use off-road vehicles while 56 (49.6%) never do. Vehicle users reported the frequencies of vehicle-related activities shown in Table 5.

If the use of snowmobiles is included, about 59% of motorized recreational activity reported occurs while the ground is frozen. If only wheeled vehicles are included, 68.8% of activity occurs during the unfrozen season.

TABLE 5

Recreational vehicle use in the Cape Churchill W.M.A.

Activity*	Average Number of Days per Year	Number of Respondents	User-Days of Activity per Year**
4WD Use(F)	1.7	61	104
4WD Use(UF)	1.5	61	92
Snowmobiling	8.7	50	435
Trail or Minibike(F)	0.3	59	18
Trail or Minibike(UF)	2.7	58	157
ATC(F)	1.3	60	78
ATC(UF)	3.1	60	186
		Total (F)	635
		(incl. snowmobiles)	
		Total (UF)	435
			1070

*(F) indicates activity when the ground is frozen; (UF) indicates activity when the ground is not frozen.
**Product of #users x average number of days per user.

Much of the use of vehicles in the W.M.A. is in support of other forms of recreation. Respondents were asked to estimate the number of visits they made to the W.M.A. for various purposes in order to establish the recreational priorities of the local people and estimate the demand on the W.M.A. The results are shown in Table 6.

TABLE 6

Recreational activities in the Cape Churchill W.M.A.

Activity	Average Number of Visits/Year	Number of Respondents	User-Days per Year**
Tourism/ Sightseeing	4.9	123	603
Wildlife Viewing	5.1	121	617
Hunting	4.1	121	496
Fishing	1.5	120	180
Trapping	1.2	120	144
X-C Skiing	0.2	119	24
Off-Road Vehicle Driving	4.2	118	496
			2560

*Average number of visits per year x number of respondents to that activity.

Thus recreational vehicle driving accounts for about 19.4% (496 of 2560 user-days) of all visits by respondents to the W.M.A.. Most use of vehicles is in support of sight-seeing, wildlife viewing and photography, and hunting. These figures may be doubled or tripled to estimate actual usage for for recreational purposes based on the response rate obtained.

Several patterns of recreational use emerge. Much of the summer vehicle use is aimed at enjoyment of the vehicles themselves, not in support of other recreational activities such as hunting or photography. Vehicle use after the ground is frozen is often a part of other forms of recreation such as viewing wildlife or hunting. For example, about 53% of the off-road use of 4WD trucks in the W.M.A. occurs when the ground is frozen (104 of 196 user-days) while 97% of trail and minibike use and 70% of ATC use occurs on unfrozen ground while most of the trail and minibike use is for recreational use during more favourable weather. These patterns suggest that much of the 4WD and ATC use during the frozen season is in support of hunting.

5.5.5 Attitudes of W.M.A. Users to Management Options

In order to determine the attitudes of users of the W.M.A. to potential management methods, respondents who used off-road vehicles in the W.M.A. were asked to indicate their perceptions of the vehicle impacts occurring, what levels of impact were caused by each type of vehicle, and their response to suggested management options. These opinions were expressed using a scale of 1 to 5, allowing the calculation of an average response value as well as a range of categories.

Perceptions of vulnerability of frozen and unfrozen soil

TABLE 7

Perceptions of damage levels by W.M.A. users.

Vulnerability of Frozen Soil (Question 10.1)					
	Most Vulnerable 1	2	3	Least Vulnerable 4	5
Number of respondents	3	2	3	14	34
Weighted Average=4.2					

Vulnerability of Unfrozen Soil (Question 10.2)					
	Most Vulnerable 1	2	3	Least Vulnerable 4	5
Number of respondents	23	14	10	16	37
Weighted Average=2.3					

to damage are shown in Table 7.

Question 11 dealt with the impacts to soil and vegetation attributed to various vehicle types. In this case, a rating of '1' indicated severe impact, while '5' indicated minimal impact. The results are shown in Table 8.

TABLE 8

Perception of damage intensity caused by various vehicles (by number of respondents).

Vehicle Type	Maximal 1	2	3	4	Minimal 5	Weighted Average
Large tracked or wheeled vehicles	34	6	7	4	6	2.0
All-Terrain Cycles	6	5	12	10	23	3.7
Snowmobiles	3	2	5	10	36	4.3
4WD Trucks	13	12	14	10	5	2.7
Trailbikes	7	7	12	11	15	3.4
Other Vehicles*	2	0	3	3	7	3.9

*Of the 15 respondents who assessed a level of damage caused by other vehicles, only one specified which type of vehicle was being referred to (bulldozers). Due to this imprecision, the information concerning these other vehicles is of little value.

Question 12 asked respondents to give their opinion on a variety of potential measures to reduce the impact of vehicles on the W.M.A.. Their responses are shown in Table 9.

Other measures were suggested by 14 respondents. These included an educational campaign to help users reduce impacts, the banning of commercial users and permanent structures from the W.M.A.; repair of trail areas by the former military users and several unspecified measures.

These results reflect strong local disapproval of excluding motorize vehicles from the W.M.A. Local users are also

TABLE 9

Reaction to possible management measures.

Method	Approval 1	2	3	4	Disapproval 5	Weighted Average
Limiting season of travel	11	9	11	5	17	3.2
Closure of W.M.A. to some vehicles	12	9	8	5	20	3.2
Closure of W.M.A. to all vehicles	4	3	4	3	41	4.3
Establishment of designated routes	20	8	10	0	16	2.7
Improvement of trails	21	6	9	1	10	2.4
Other	7	3	2	0	2	2.1

strongly in favour of increased consultation between local recreational users, commercial users, and government officials.

Of the 53 users who responded to the question of whether they would support the establishment of a multilateral committee to advise on aspects of management in the W.M.A., 42 (79.2%) were in favour. Some of those opposed cited a perceived lack of effectiveness of the former W.M.A. advisory committee as their reason for not supporting this option; several others expressed fears that such a committee would be dominated by commercial users or that its recommendations would be ignored by the provincial government.

A section of the questionnaire was reserved for comments and suggestions. It is difficult to adequately summarize the responses received. Many people expressed their concern that wildlife habitat and populations were being disturbed by the noise and other impacts of vehicles and hoped that the existing level of "wildness" could be preserved. Others felt that the W.M.A. is not sufficiently accessible for recreation and public enjoyment of wildlife.

One of the most important trends to emerge is that a substantial portion of the users of natural resources in the Churchill area feel isolated from decision making and may allow their perception of other activities of the provincial government to colour their response to vehicle impacts and vehicle management. Dissatisfaction with the diversion of the Churchill River and response to polar bear incidents in the community have created suspicion that many resource managers are unconcerned with Churchill and the opinions of its residents. These perceptions may lessen the effectiveness of any methods which are adopted to limit vehicle impacts in the W.M.A.

Chapter VI

CONCLUSIONS

6.1 IMPACTS ON SOIL STRUCTURE AND DRAINAGE

Comparison of active layer depth data reveals that significant differences between trail and undamaged active layers are rare at the 0.05 level. A summary of rod penetration tests is shown in Appendix I.

On trails whose origin could be attributed to the Tundra Buggy, significant thickening of the active layer occurred only in the wet, finely-divided organic soil found along the pond edge at site 7 and in the wet peat at site 8. Trails whose origin were attributed to the Trackmasters showed no sign of significant thickening of the active layer, even at the wet sites 10 and 11 along the inland trail. These trails are comparatively recent (i.e. since about 1970-75) and may show significant differences in the future, particularly since minor wet spots and depression of the trail below grade are beginning to occur. Figure 16 shows the old and new segments of the inland trail immediately to the west of site 11.

Note the large pool of water caused by slumping on the abandoned military trail (right) and the small wet spot beginning to form on the newer trail (centre). ATC and tracked Argo tracks are visible in the foreground. In the upper left, recent Trackmaster activity is visible.

Figure 16: The inland trail near Site 11.

Recent 4WD tracks showed no statistically significant differences in active layer depth at the 0.05 level, although old 4WD tracks at site 9 on the coastal trail and sites 10 and 11 along the inland trail show significant thickening of the active layer, probably as a result of the invasion of standing water.

Old and new 4WD tracks are shown in Figure 17 and Figure 18. The older tracks were along the coastal trail near site 6; the younger tracks (top) were photographed near Landing Lake.

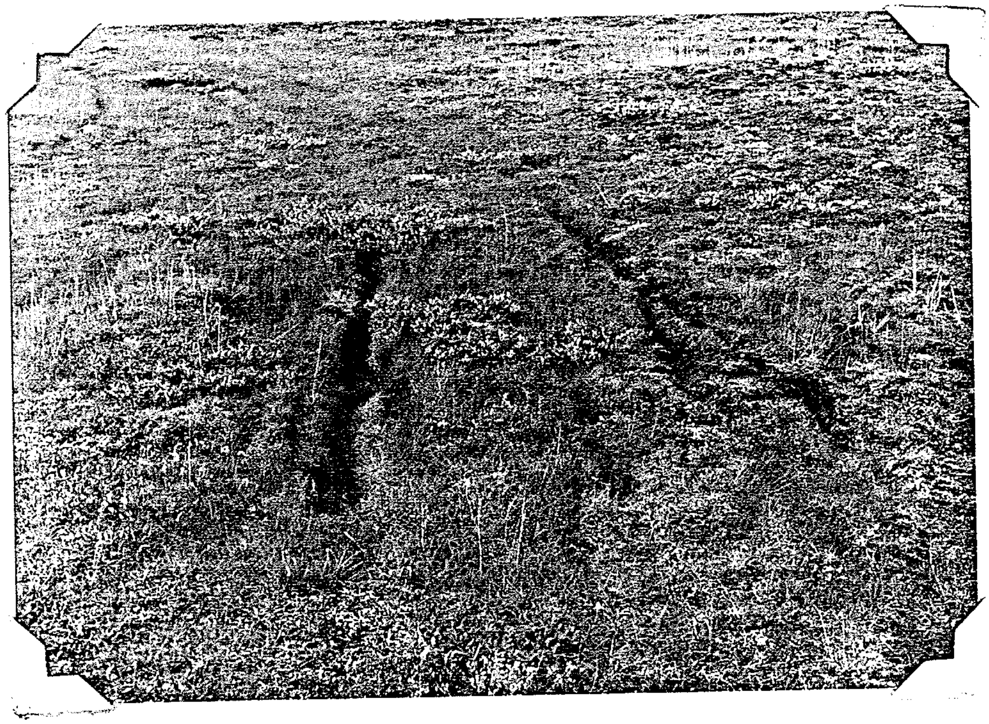

Figure 17: Old 4-wheel drive tracks.

Figure 18: New 4-wheel drive tracks.

Thickening of the active layer and the beginning of ponding was caused by ATC use at one site along the coastal trail (Figure 19).

It should be noted, however, that no statistical difference was established at the 0.05 level despite the obvious qualitative differences in the active layer observed at this portion of the site. At other locations ATC use results in the formation of a soil slurry but no thermokarst activity due to the presence of subsurface till. Figure 20 shows a collection of ATC tracks of varying levels of use near the extreme west end of the coastal trail.

Figure 19: ATC-caused soil damage at Site 9.

A number of different intensities of ATC use at the west end of the coastal trail. The ATC tracks at the top centre of the picture (crossing the small water-filled depression) have received several hundred passes. Faint marks from two Trackmaster passes are visible parallel to these tracks, closely adjoining the shore of the large pond in the upper right corner of the photo. More lightly-used ATC tracks are visible leading from the upper left corner to the centre of the picture where they join the main trail. At the mid centre of the photo the point where the Tundra Buggy leaves the large pond at upper right to rejoin the main trail is visible. Note the older Tundra Buggy tracks parallel to the pond shore and the numerous ATC tracks parallel to the main trail after it leaves the pond area.

Figure 20: ATC tracks in wet soil with shallow subsurface till.

Intensive summer use of the inland trail or the wettest portions of the coastal trail (pond shores and areas of deep saturated peat) by ATCs probably has the potential to trigger thermokarst development. However, these areas are not currently receiving high levels of use during the most critical season.

Age of the trail is an important factor in those areas where significant changes have been observed. Of the nine combinations of site type and vehicle type which produced significant changes in active layer depth, four included past use of military tracked vehicles on those segments of the trails and two involved 4WD tracks which appeared to be of military origin. Since military off-road activity ceased prior to 1965, these tracks must be at least 20 years old. More recent tracks (i.e. those made by the two Trackmasters, which have operated for about 15 years following the cessation of military activity) through these areas have not yet produced significant changes at the 0.05 level. The bulk of these tracks presumably date from after 1974 when Churchill Wilderness Encounter began to offer tours on a regular basis.

Soil depth and composition control the depth to which ruts may deepen. Most parts of the coastal trail in the study area are underlain by glacial till which prevent ruts from deepening below 30-50 cm. This effect was noted on both old and newer trails. Consequently, most of the ruts observed along the coastal trail within the study area were the result of the physical displacement of soil, not the removal of subsurface ice. This conclusion is reinforced by the presence of ridges of soil displaced by traffic which occur along the edges of the ruts at many of the locations where damage occurred. Most of the problem areas along the coastal area are of the displacement type, often lying at the foot of a small slope (See Figure 21).

Figure 21: Site 1 along the coastal trail.

On some portions of the inland trail examined, frozen organic soil is encountered before bedrock or an extensive layer of till. The trail surfaces are churned, fine-grained soil up to 20 cm thick. Some thermokarst development has occurred, with some portions of military origin slumping and forming small ponds 50-70 cm deep. The effect of age can be seen in Figure 22 along the inland trail. The extensive ponding along the portion of military origin (right) compared with the small wet spots found along the younger segment currently in use (left) should be noted.

Figure 22: Old and new portions of the inland trail.

Monitoring over several years is needed to determine the rate at which soil changes are occurring and the level of use which can be sustained.

Strand lines, the Christmas Lake esker and the Gordon Point beach ridge show a slight deflation of the soil where use has occurred but no tendency to soil displacement or rut formation. The appearance of the trails at these areas resistant to soil displacement is typified by Figure 23.

Vehicle traffic caused some drainage across site 7 from the slightly elevated area to the east. In several cases, water was slightly rechanneled by ruts which crossed its former path. There were no examples of currently-used

Figure 23: A dry stretch of the coastal trail.

trails contributing to water erosion or extensively altering the pattern of surface runoff.

Several abandoned military trails through a wooded area between the NRC launch site and the Christmas Lake esker carried water with a slight but noticeable current during the last part of July. This water drained into extensive sedge meadows and boggy terrain lying west of the Christmas Lake esker about 2 km south of the coastal trail.

6.2 IMPACTS ON VEGETATION

This summary gives the degree of similarity between the plant communities of the impacted and undamaged portions of each site. The five species or types of ground cover with the highest average relative cover values from each category of vehicle impact are listed. Where the same species/type is found in both the impacted and undamaged categories, a t-test comparison was made using the cover values for the population of quadrats comprising each category; the t-value determined and the critical value of t are listed to show whether the species/types exhibited similar cover values at the 0.05 level.

In cases where fewer than five species/cover types were found in a given category of vehicle impact, there will of course be less than five listed. Similarly, where two or more species/cover types had the same relative cover values, both are listed. Consequently the listing of dominant cover types for a given category may have more than five types listed.

This process of determining similarity is shown graphically in Figure 24.

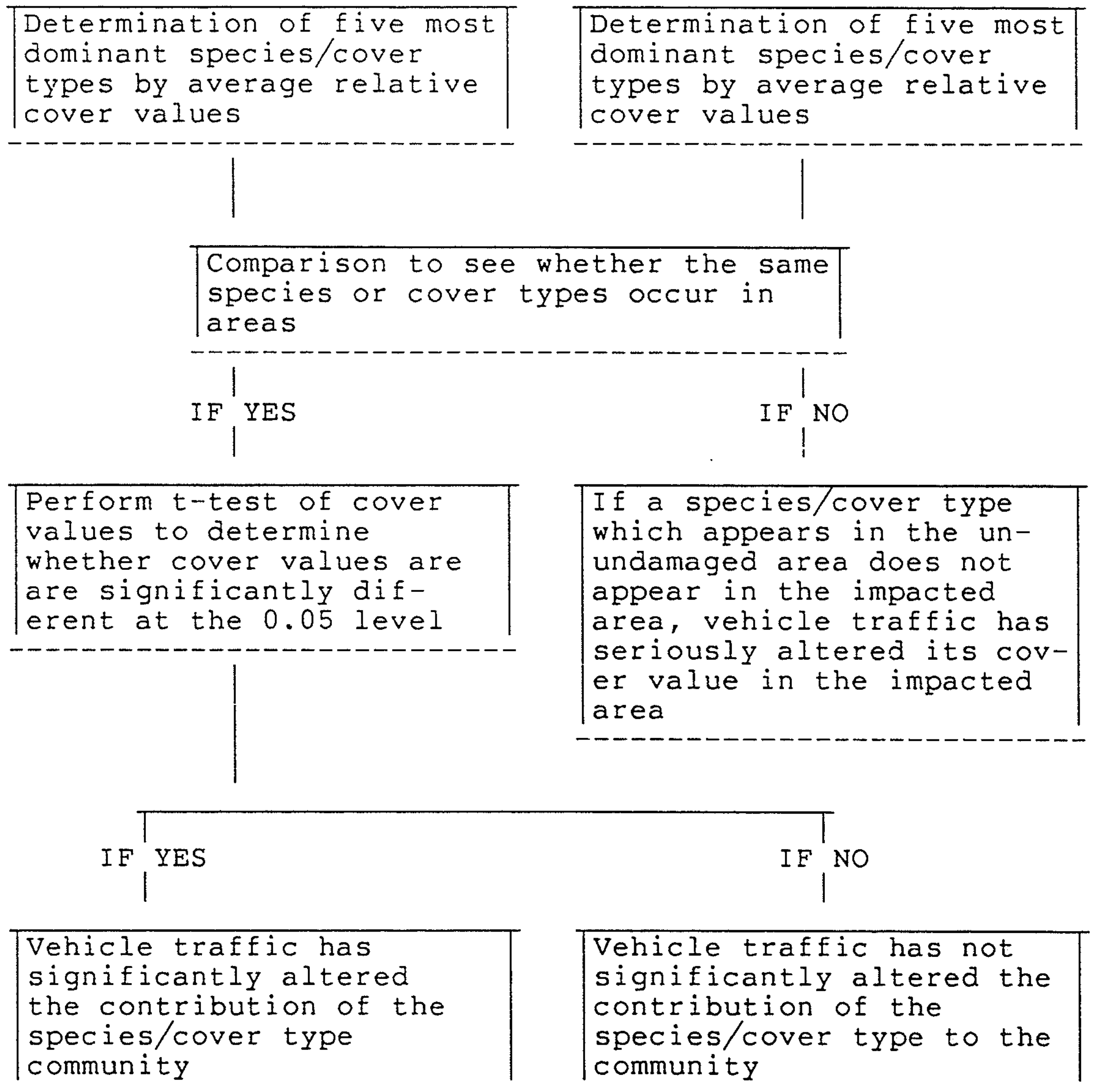

Figure 24: Method of deciding plant community similarity by relative cover values.

The five dominant cover types in each impact category at each site are shown in Appendix J along with the t-test comparison of their cover values where the same cover types were found in both impacted and undamaged areas.

At most points along the coastal trail within the area studied, the native vegetation is a mixture of lichen and heath species which are supported by a layer of peaty soil. The exceptions to this are lakeshore areas or the bottoms of small steep gullies which are dominated by *Carex* spp. and *Eriophorum* spp. and on beach ridges and eskers which are dominated by *Dryas integrifolia* and *Saxifraga tricuspidata*.

Undisturbed vegetation along the portions of the inland trail examined west of the Christmas Lake esker were dominated by *Carex* spp. and *Eriophorum* sp., with intermittent stands of *Salix* spp. where relief was more varied. To the east of the Christmas Lake esker undisturbed cover is dominated by lichens with interspersed heath species. This vegetation is supported on small hummocks and palsas 15-30 cm high, suggesting the presence of a high subsurface ice content. Where vehicle use has occurred in the past, cover is frequently dominated by *Carex aquatilis*.

At the two sites along the inland trail the 'natural' vegetation appears to be *Carex aquatilis*. Closer examination showed that the broad area of *Carex aquatilis* contains numerous dispersed tire tracks and shallow ruts apparently resulting from military vehicles while the peat hummocks and lichen cover to the north of the trail does not. Thus relatively low levels of disturbance appear to have allowed the collection of water to alter the habitat along this part of the trail.

In gully bottoms and along pond edges habitat is moist and the density of plants and grasses is quickly reduced, leaving churned bare mud and water as the dominant ground cover.

At mesic sites, vehicle use quickly removes the lichen component of the ground cover, leaving the more rugged heath species such as <u>Arctostaphyllos uva-ursi</u> and <u>Ledum decumbens</u>. Continued use, particularly if water is able to collect, leaves a centre strip which has essentially the same species composition as the undamaged area, but of reduced density.

At sandy, xeric sites the vegetation in the wheel paths is totally removed, leaving an undamaged centre strip and sharp boundaries with the undamaged area adjacent to the trail.

On the inland trail, abandonment has been incomplete since some travel over the older tracks may occur depending on the condition of the adjacent younger tracks. The edges of abandoned tracks have been colonized by low densities of sedges, but little or no vegetation is found at the trail centre.

Inspection of the types of cover and relative cover values remaining after each type of vehicle impact supports the findings of the literature review:

1. Species diversity is reduced by vehicle traffic (note that some sites no longer had five species/types to be measured, even counting bare ground and water, while most of the sites had undamaged areas with at least 10 species).

2. The distribution of importance within the community is frequently affected. In most of the undamaged portions examined, the average relative cover values for 3 or 4 of the species (e.g. the three major generał of lichens) are similar, while in the impacted areas one cover type (especially bare ground, water or *Carex aquatilis*) has a very high value while the other types have very low values.

3. Heath species such as *Arctostaphyllos rubra* and *A. uva-ursi*, *Vaccinium uliginosum* and *Empetrum nigrum* appear to resist removal better than other species.

4. Moisture tolerant species such as *Carex aquatilis* and *Senecio congestus* are early colonizers or recolonizers of disturbed ground. Depending on site characteristics following impact, early-succession species such as *Carex* spp. may remain dominant in the plant community for many years following the cessation of direct impacts such as continued traffic.

6.3 EFFECTS OF CURRENT TOURIST AND RECREATIONAL USERS

6.3.1 Recreational Users

Recreational use by ATCs for summer touring and fall hunting is not presently a serious cause of impacts to soil and vegetation although concentrated use at a few junction points along the trails may result in severe localized soil damage, with peaty soils being churned into a slurry.

ATC users observed during the summer of 1983 remained on existing trails. Most of the ATC tracks observed were also on or closely parallel to existing tracks.

The recreational use of 4WD vehicles has not had a major effect on trail conditions. Most use appears to follow existing trails and occur after the ground is frozen. However, observation of older tracks of military origin suggests that potential for damage over longer periods of time is considerable in wet areas.

6.3.2 Churchill Wilderness Encounter

Summer use is currently following an unofficial designated route system since the existing trails are seldom departed from. Departures from the existing segments of the coastal trail were minor efforts to bypass temporary mudholes caused by heavy rain.

On the inland trail, the Trackmasters are probably responsible for the younger of the two parallel main sets of tracks, although the earliest origin of these younger tracks may be military. Most of the impact on this trail appears to be caused by late spring and early summer Trackmaster use after the original military trail became impassable. The present level of use has so far caused only minor thermokarst development (small wet spots and slightly sunken ruts) on the newer trail segments examined. Monitoring over several years is required to determine whether the trail segments underlain by till-free soil can sustain the present intensity of traffic without further deterioration.

As a result of the concern of the operators of CWE for the environment and their success in limiting the most potentially damaging components of their business to the frozen season, it seems evident that a system of designated routes can be formulated which preserve both the appearance of the trails and their pattern of use of these trails for tourist purposes. Similarly, it should be possible to change the pattern of traffic for scientific purposes which is presently the major activity during the damage-prone spring season. This would also require consultation with the major scientific users.

6.3.3 Tundra Buggy Tours Ltd.

Summer use (the period from July to mid-September) is the major cause of concern related to this vehicle. Due to its great weight and high ground pressure, organic soils are rapidly displaced by the Tundra Buggy. Consequently, this machine is the main cause of deterioration on the wetter parts of the coastal trail where it operates during the unfrozen season. There is less cause for concern on well-drained parts of the trails, especially those with gravelly or stony soil. Ruts at those parts of the trails which are most affected appear to be of stable maximum depth and not prone to progressive changes.

Summer use shows the need to improve the aesthetic appearance of the trails required for summer use by the Tundra Buggy. The operators of this machine have always held closely to the existing trails during summer use; very few shortcuts or detours were observed. As well, Mr. Bukowsky has attempted in the past two years to keep centre ridges on the tracks pushed down and ruts as gently sloped as possible to discourage the formation of steep-sided ruts and pools.

Despite these efforts to reduce damage, it is unlikely that the appearance of problem spots along the present trail can be improved if use continues early in the summer since these organic soils are necessarily soft and wet until midsummer or after heavy rains. The appearance and trafficability of the coastal trail improves markedly later in the summer as the soil dries.

Given these conditions, the number of options which are available to reduce the impact of the Tundra Buggy operation are:

1. Use a different type or size of vehicle.
2. Discontinue use of the present vehicles except when the ground is frozen.
3. Strengthen and improve the portions of the trail where damage is severe or recurring.
4. Relocate these sensitive segements of the trail to soils which are more resistant to the effect of wheeled vehicles.

In view of the large amount of money invested in the Tundra Buggy operation and the seasonal nature of the tourism business in Churchill, the first two options would be economically contentious. Improving the trails as a general solution must be approached cautiously due to the expense and potential environmental and aesthetic impact involved in upgrading the many spots along the coastal trail which are currently unattractive as a result of ruts and standing water. However, some improvements could be useful at specific problem locations to remove the necessity for unplanned detours around them. This could be done in conjunction with improvements to allow ATC users to stay on the trails.

The most easily-instituted solution is to examine the area around each location on the trail which is currently a problem and attempt to choose a detour which is better drained, higher and has less a organic soil composition. In some cases these alternate locations exist close by, having been unused when the trails were originated because of the ease and maintenance considerations mentioned in the earlier section on military use. Lake bottoms may also provide alternate routes to bypass problem areas; the Tundra Buggy already uses two large ponds to bypass the boggy ground at the west end of the coastal trail where the machine is parked, and both the Tundra Buggy and the CWE van used a pond to bypass study site 7 during the summer of 1983. Since most of the ponds in the area between Launch and Gordon Point appear to have stony bottoms, this possibility could be investigated wherever it presents itself.

6.4 ECONOMIC IMPORTANCE OF VEHICLES WITHIN THE W.M.A.

The Wildlife Management Area is the setting for a substantial portion of the Churchill tourist economy. Several jobs and a great deal of money are related directly to wildlife which is best viewed in the W.M.A.

All of the tours given with the Tundra Buggy are within the W.M.A., as well as most if not all of the special charter trips. At 1984 levels of approximately 850 passenger-days per year at a price of $50 each, passenger revenue totals about $42,500 per year. Assuming about 3 days per year of special charters at $800 per day, another $2,400 is obtained. This revenue supports two direct jobs plus a portion of the jobs of the bus drivers who bring the passengers from Churchill to the machine and back. Business is expected to continue to expand (R. Bukowsky, personal communication).

Churchill Wilderness Encounter has taken an average of 1200 people per year into the W.M.A. for the past several years. At a price of $85 per person for either the van tour in summer or the Trackmaster tour in fall, this amounts to $102,000 per year. Charters related to research or hunting add several thousand dollars more. Three full-time and four seasonal jobs are maintained. As with other parts of the tourism-based economy in Churchill, this market seems likely to grow.

Thus the direct spending related to the use of the larger vehicles in the W.M.A. is currently between $150,000 and $200,000 per year with good potential for expansion.

This spending is presumably multiplied to some extent by the stimulus it provides to the local economy in indirect ways, such as providing indirect jobs. Similarly, the biological research which is supported through the use of vehicles contributes directly and indirectly to the local economy. The contribution made by the use of ground vehicles (ATC and Argo use in the field and Trackmaster charters for equipment moving) is a small proportion of the total amount spent on research, but is important in the sense that it makes research more convenient and allows more effort to be expended on actual research and less on support of the research.

6.5 POTENTIAL FOR NEW OR MODIFIED VEHICLES

The degree of impacts currently occurring could be reduced by modification of the types of vehicles currently being used in the Churchill area.

One such modification which has been considered is the installation of larger, lower-pressure tires on the van used by Churchill Wilderness Encounter (M. Reimer, personal communication). This would reduce impacts on the trail segments which are currently being used and would allow travel on the coastal trail beyond the Christmas Lake esker. It is difficult to estimate the effects of such a change since the van, even with larger tires, would have a relatively high ground pressure and relatively low ground clearance and might produce effects similar to the Tundra Buggy if used in similar soils. Thus the expansion of the area used by the van should be approached cautiously and await relocation of the worst segments of the trail as has been suggested for the Tundra Buggy operation.

Another suggestion which has been made is to replace the present wheeled and tracked vehicles for tourist use with ground effect vehicles (hovercraft). Churchill Wilderness Encounter has such a vehicle, which was purchased primarily for river use during whale tours on the Churchill River. However, the use of hovercraft is complicated in that they must be registered as ships for use over water and as aircraft for use over land (Transport Canada 1979) and the operator must be licensed to operate both classes of vehicle.

The noise associated with hovercraft could also be a problem, since loud or penetrating noises may harass wildlife or cause birds and mammals to move away from the vehicles carrying the tourists. The long-term effect of ground-effect vehicles on vegetation is unknown; while no soil disruption occurs, there is concern that flowers and seeds are stripped off by passage, reducing reproductive viability (Leitch 1975). This is presumably a less serious problem in arctic areas where many species reproduce vegetatively.

Another potential approach is the replacement of the steel and rubber tracks on existing tracked vehicles with all-rubber tracks having pneumatic cleats and hard rubber grouser bars. Such a change could be useful if the summer use of the Trackmasters is expanded.

The use of vehicles with very low pressure, smooth wheels such as that examined by Bellamy et al. (1971) might complement or replace portions of existing operations.

Chapter VII

RECOMMENDATIONS FOR USE

Based on the information collected regarding soil, vegetation and the patterns of use for the types of vehicles detailed earlier, the following conclusions were drawn:

7.1 RECOMMENDATIONS REGARDING PRESENT USERS

7.1.1 Recreational Users

1. Minor trail improvements such as the placement of corduroy at the worst mud holes along the coastal trail to Gordon Point should be made to encourage staying on the trail.
2. No additional restrictions are needed at the present time, although it would be beneficial to have this traffic remain on existing routes.
3. If the use of ATCs in the area continues to grow, it may eventually be necessary to designate routes and seasons of use. In this event, the existing coastal trail is recommended as the basis of an east-west route to Cape Churchill while the Christmas Lake esker would form a north-south route. Use commencing in mid- to late July would avoid much of the potential traffic over soils still saturated from runoff. The

onset of deep snow limits the season of use in the fall without imposing a calendar restriction.

4. It is recommended that the Christmas Lake esker plus the coastal trail as far east as Cape Churchill be adopted as interim designated routes for recreational 4WD vehicles and that the season of use commence no earlier than October 15 and end no later than May 15 each year. Further study is required to determine if a permanent system of designated routes are necessary.

5. A greater effort must be made to communicate the concerns and objectives of the Wildlife Branch to local residents. This should be done with public meetings and/or brochures made available at places where ATVs are sold and with hunting licenses or other sporting goods (see recommendation on Community Liaison).

7.1.2 Churchill Wilderness Encounter

1. It is recommended that the Christmas Lake esker plus the existing inland trail system be adopted as a designated route for tracked vehicle use to prevent the spread of impacts to areas which are presently off-trail. Frozen soil or snow could allow departure from this designated route during the October 15-May 15 season if necessary.

2. The use of wheeled vehicles should be restricted to the coastal trail, leaving the inland trail as undisturbed as possible since the tracked vehicles currently being used on it are better able to avoid rut formation through soil displacement than any presently used wheeled machine. The existing coastal trail should be adopted as a designated route for summer travel to Gordon Point for any future use of wheeled vehicles. During the October 15-May 15 season the entire coastal trail to Cape Churchill should be available. As well, the Christmas Lake esker should be available to wheeled vehicles as a north-south designated route during all seasons.

3. Spring and fall use of the inland trail in support of research activities and tourist use during the bear season should be scheduled to maximize use when the upper soil horizons are sufficiently frozen to prevent a fully loaded Trackmaster from breaking the surface. It is therefore recommended that these movements be carried out no earlier than October 15 and no later than May 15.

7.1.3 Tundra Buggy Tours Ltd.

1. It is recommended that the existing route along the coastal trail to Gordon Point be adopted as a designated route for summer use, with maximum use being

made of beach ridges, rocky areas, and firm lake bottoms wherever these features can be used to bypass areas of wet organic soil which are found on the existing trail.

2. These deviations from existing routes should be made by previous consultation with the Wildlife Branch. These detours should be maintained for several years to test their feasibility and to monitor revegetation on the sites which they would replace.

3. The Christmas Lake esker should also be available to the Tundra Buggy operation as a designated route for north-south travel during all seasons.

4. Travel off these designated routes should not commence in the fall until the ground is frozen and until sufficient snow cover exists to protect vegetation. The October 15-May 15 period is recommended for travel along the coastal trail to Cape Churchill if such travel cannot be done on the sea ice.

5. Any off-trail land travel should be located as completely as possible along unvegetated areas such as beaches or frozen lakes.

6. The present practice of avoiding summer use of the inland trail should be continued. Due to wetness and soil conditions along much of its length, no commercial wheeled vehicles should be permitted unless the soil is firmly frozen.

7.1.4 Research Users

1. Research users of the W.M.A. who require the overland transport of materials or persons using chartered vehicles should arrange for these movements to be complete before the date of last frost in the spring, and preferably during late winter when snow cover is maximized. For planning purposes, the recommended season is October 15-May 15.
2. During the unfrozen season, activities requiring the movement of materials or large numbers of persons should take advantage of the frequent fixed-wing resupply flights and helicopter movements associated with research in the area rather than using ground vehicles.

7.2 NEW COMMERCIAL OPERATIONS

1. No new commercial ventures (including tourist operations) which require the use of off-road vehicles should be permitted in the W.M.A. until the carrying capacity of existing trails is known and mechanisms exist to monitor and control environmental impacts of vehicle use.

7.3 COMMUNITY LIAISON

1. A more formal method of consultation is needed between representatives of the provincial government and local users of the W.M.A. The re-establishment of a local advisory committee on the W.M.A. should be considered. It is recommended that the committee include the local wildlife technician or Conservation Officer along with a representative from the planning component of the Wildlife Branch and a representative of the Tides and Tundra Wildlife Association along with other members of the public. This group would serve as a clearinghouse for questions involving the W.M.A. and would advise the Director of the Wildlife Branch on designated routes, seasons of use and requests for new permits involving use of the W.M.A..
2. A public relations and education campaign directed at recreational users should be undertaken to provide information about the most resistant trail segments available, encouraging responsible driving techniques (staying on existing trails, using low speed and low gears in wet areas, gentle turning radii when off trails, etc.) and suggesting seasons of use when trails are dry or frozen.

7.4 GUIDELINES FOR VEHICLE USE

There are presently no explicit guidelines available to users of off-road vehicles in the Churchill area which deal with the relationship between vehicles and the management objectives of the Wildlife Branch. While some aspects of the regulation of off-road vehicle use may be inferred by reading the Cape Churchill W.M.A. Management Plan (Teillet 1983) and Manitoba Regulation 251/83, these documents are not easily available to casual recreational users of the W.M.A.

Similarly, the planning of future tourist development or resource extraction would be aided by the adoption of written uniform standards of vehicle use including the patterns and amount of use sustainable and the types of vehicles permitted for these uses.

Based on the information collected on commercial and recreational off-road vehicle use during the 1983-84 period, the guidelines for future use of the W.M.A. should include:

1. The establishment of designated routes for all commercial activity and for recreational use of 4WD trucks. The basis of the designated route system would be the existing coastal, inland, and Christmas Lake esker trails. The allocation of these trails would be:

   A. Coastal Trail--Reserved for wheeled vehicles east of the Christmas Lake esker. The portion between the west end of the trail and the Christmas Lake esker should also be open to tracked vehicles to allow easy access to the Christmas Lake esker and thence to the inland trail. The present practice of not travelling east of Knights Hill during the summer season should be continued and formalized.

B. Inland Trail--Reserved for tracked vehicles during the unfrozen season. Use of wheeled commercial vehicles or private 4WD vehicles would be permitted following firm soil freezing.

C. Christmas Lake Esker Trail--Available for both wheeled and tracked vehicles.

2. Designated routes would be considered corridors of use rather than as rigidly-defined linear entities. This would allow seasonal or permanent deviations if necessary from the existing trails in consultation with the Wildlife Branch.

3. Usage of particular segments of the trails would depend on season. While the Christmas Lake esker trail can be used in all seasons, travel on the coastal trail east of Gordon Point and commercial use of the inland trail should be during the October 15-May 15 season only to ensure more resistant soil conditions. These suggested dates would be subject to negotiation between users and the Wildlife Branch.

4. A formal process of consultation would be established between the Wildlife Branch and existing commercial and scientific users of the W.M.A. to identify possible permanent changes in trail locations and other management measures which would reduce future impacts of vehicle use.

5. Pending further research to control impacts, the use of additional large wheeled vehicles would be discouraged during the unfrozen season. The use of conventional-type vans (which are essentially self-limited in where they can be used) and vehicles with flexible track elements would be encouraged. As presently-used vehicles are lost to attrition, they would be replaced with vehicles whose ground pressure does not exceed that of a Trackmaster (0.1 kg/sq. cm) or a large ATC (0.2 kg/sq. cm) (see Appendix G.)

6. The granting of permits for future commercial use would be conditional on agreement to participate in future research to determine the carrying capacity of different habitat types and comparison of impacts between types of vehicles which may be used.

7. A clear summary of laws and regulations governing the use of vehicles in the W.M.A. would be readily available to the public in Churchill as part of the guidelines. Local recreational and commercial users would be made aware of whom to contact for information regarding vehicle use in the W.M.A. as well as the procedure for appeal of regulatory decisions.

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Appendix A

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ALUR=Arctic Land Use Research reports series

ATC=All-Terrain Cycle

ATV=All-Terrain Vehicle

CN=Canadian National Railway

CRR=Churchill Rocket Range

CWE=Churchill Wilderness Encounter

DIAND=Department of Indian Affairs and Northern Development

DNRL=Defence Northern Research Laboratory

EH=a description of a vegetation community by Bellamy _et al._ (1971) typified by woody shrubs up to .6 m high (E) and leathery to crisp mats of lichen up to 10 cm high (H)

FI=a description of a vegetation community by Bellamy _et al._ (1971) typified by sedges and grasses up to .6 m high (F) and soft mats of moss up to 10 cm high (I)

4WD=Four-Wheel Drive vehicle

GMC=General Motors Corporation

IGY=International Geophysical Year

JSES=Joint Services Experimental Station

L.G.D.=Local Government District

Mil=Military

NWT=Northwest Territories

NRC=National Research Council

Pers. Comm.=personal communication

psi=pounds per square inch (tire pressure)

RCASC=Royal Canadian Army Service Corps

TB=Tundra Buggy

TM=Trackmaster

U.D.=undamaged portion of a study site (no visible vehicle impacts)

USAF=United States Air Force

W.M.A.=Wildlife Management Area

X-C=Cross-country (skiing)

Appendix B

RESIDENT QUESTIONNAIRE

This questionnaire was mailed December 16, 1983. A reminder letter was mailed to each household which had not responded by January 17. A second copy of the questionnaire with a new cover letter was sent to each household which had not responded by February 9.

Churchill Residents'
All-Terrain Vehicle Survey Checkoff #

1) How frequently do you participate in the following outdoor activities? Please check appropriate column for each activity.

	Never	1-3 weeks per year	4+ weeks per ye
1. Hunting	___	___	___
2. Fishing	___	___	___
3. Snowmobiling	___	___	___
4. Bird watching	___	___	___
5. Off-road all-terrain vehicle use (3-wheelers, trail bikes, etc.)	___	___	___
6. Use of 4-wheel drive vehicles off-road	___	___	___
7. Wildlife photography	___	___	___
8. Cross-country skiing	___	___	___
9. Other (please specify)	___	___	___

2) Please give the number of members of your household in each age and sex category.

Age	Male	Female
1. 0-14 years	___	___
2. 15-24	___	___
3. 25-34	___	___
4. 35-44	___	___
5. 45-54	___	___
6. 55-64	___	___
7. 65+	___	___

3) Are you a permanent resident of Churchill? 1. Yes ___ 2. No ___

4) What is your primary occupation? ______________________

5) What level of education have you completed? Please check.

1. Grade 8 or less ___
2. Grade 9-11 ___
3. Grade 12-13 ___
4. University courses ___
5. University degree ___
6. Other (e.g. trade or technical certificate) ___

6) Are you a member or former member of a naturalist or conservation organization? Please check any organization with which you have been involved.

1. Manitoba Wildlife Federation ___
2. Canadian Wildlife Federation ___
3. Manitoba Naturalists Society ___
4. Ducks Unlimited ___
5. Canadian Arctic Resources Committee ___
6. Audubon Society ___
7. Other (please specify) ___

(over please)

7) How many of each type of vehicle listed do you own?

Type	Number
1. 4-wheel drive truck	_____
2. Snowmobile	_____
3. Trail or minibike	_____
4. All-terrain cycle (3-wheeler)	_____
5. Other (e.g. Argos, Bombardiers--please list)	_____

8) Please estimate the number of times each year members of your family visit the Cape Churchill Wildlife Management Area for each purpose.

	Number of visits
1. Sightseeing/tourism	_____
2. Observing wildlife	_____
3. Hunting	_____
4. Fishing	_____
6. Trapping	_____
7. Cross-country skiing	_____
8. Recreational off-road vehicle driving	_____

9) Are any of your vehicles used off-road in the Wildlife Management Area? 1. Yes ___ 2. No ___. If yes, please estimate the number of visits with each type of vehicle for each season.

Type	When ground frozen	When ground unfrozen
1. 4-WD truck	_____	_____
2. Snowmobile	_____	_____
3. Trail or minibike	_____	_____
4. All-terrain cycle	_____	_____
5. Other (please specify)	_____	_____

If you use off-road vehicles in the Wildlife Management Area, please complete questions 10-14. If you do not, the questionnaire is completed. Thank you for your help.

---

10) How vulnerable to vehicle damage are the soil and vegetation in each season? Please circle the degree of vulnerability for each season.

Season	Most vulnerable				Least vulnerable
1. When ground frozen	1	2	3	4	5
2. When ground unfrozen	1	2	3	4	5

11) What types of use have you observed to have the most impact on soil or plant cover in the Churchill area? Please circle the level of damage caused by each type of vehicle.

Type	Most impact				Least impact
1. Large tracked or wheeled vehicles	1	2	3	4	5
2. All-terrain cycles	1	2	3	4	5

11) continued

	Most impact				Least impact
3. Snowmobiles	1	2	3	4	5
4. 4-wheel drive trucks	1	2	3	4	5
5. Trail or minibikes	1	2	3	4	5
6. Other (please specify)	1	2	3	4	5

12) If the effects of off-road vehicle use must be lessened, what methods would you prefer to reduce damage or confine it to certain areas? Please circle the number indicating your reaction to each suggestion.

Method	Strongly favour				Strongly oppose
1. Limiting travel in the Management Area during the most vulnerable season of the year	1	2	3	4	5
2. Closure of the Management Area to certain types of vehicles	1	2	3	4	5
3. Closure of the Management Area to all motorized vehicles	1	2	3	4	5
4. Establishment of an approved trail system (designated routes)	1	2	3	4	5
5. Construction or improvement of trails to points of interest	1	2	3	4	5
6. Other (please specify)	1	2	3	4	5

13) Would you favour the establishment of an advisory committee made up of local recreational users, tourist operators, and representatives of the Department of Natural Resources to help the provincial government study management options for the Cape Churchill Wildlife Management Area? 1. Yes ___ 2. No ___.

14) Comments and suggestions(please continue on back if necessary):

-Thank You-

Appendix C

SUMMARY OF QUESTIONNAIRE RESULTS

C.1 INTRODUCTION

The following information is a summary of the output generated by the BMDP P4F data program used to analyze the questionnaire of Churchill residents. The frequency, mean, and standard deviation of responses are shown for each variable (question or subquestion) along with a breakdown of the distribution of response where the question involved chosing a reaction on a 1 to 5 scale. The program attempts to calculate mean and standard deviation etc. even for questions which are coded rather than reflecting a range of continuous numeric data. Thus for coded questions such as age, sex and occupation, such calculations should be ignored and only the category frequency table should be used.

C.2 EXPLANATION OF ABBREVIATIONS USED IN PROGRAM

The information used for analysis in BMDP programs is described and defined by a variable name which allows the user to separate the answers to different questions. Each piece of information must have an unambiguous name of eight characters or less; thus some questions have easily recognizable variable names (e.g. AGE or SEX) while others must be abbreviated.

The value attached to a particular variable may be numbers or codes indicating a particular condition or range of numbers. For example, the variable NATUR which describes membership in naturalist or conservation- oriented organizations had codes of 1-7 to specify particular organizations, while for other questions, such as the number of visits to the WMA for some purpose, the user might simply specify a number e.g. '10' or '1 to 3 visits per year'. The type of answer requested was specified in each question.

A total of 54 variables were required to define all the information analyzed using these programs. For most questions, each question category was a variable (e.g. the number of times per year the respondent went hunting); for question 2, two variables (AGE and SEX) were entered separately from the combined data of the questionnaire. The first variable (IDNO) represents the identity of the respondent and is an assigned number, not dependent on the information the respondent gave. Identification numbers were used for convenience in determining which households required followup questionnaires and to protect the confidentiality of information.

The abbreviations of the variables used are listed by question number:

Question 1:
HUNT: Frequency of hunting
FISH: fishing
SNOWMOB: snowmobiling
BDWATCH bird watching
ORV: off-road vehicle use
FWHEEL: off-road 4-wheel drive use
PHOTO: wildlife photography
SKI: cross-country skiing
OTH: other (user specified) activities

Question 2
SEX: sex of respondent
AGE: age of respondent (sex and age of other reported family members was tallied separately)

Question 3
RES: whether respondent is a permanent resident of Churchill

Question 4
JOB: occupation as described by respondent

Question 5
EDUC: level(s) of education completed

Question 6
NATUR: membership in naturalist or conservation organizations

Question 7
TRUCK: number of 4-wheel drive trucks owned
SNOW: snowmobiles owned
TRAILB: trail or minibikes owned
ATC: all-terrain cycles owned
OER: other (user specified) vehicles owned

Question 8
TOUR: number of visits to WMA per year for sightseeing/tourism
WLDL: observing wildlife
HUN: hunting
FIS: fishing
TRAP: trapping
XC: cross-country skiing
RECDRV: recreational off-road vehicle driving

Question 9

INWMA: whether vehicles listed in 8) used in WMA

FFTRUCK:	#visits with 4WD trucks when ground	frozen
UFTRUCK:		unfrozen
FSNOMO:	snowmobiles	frozen
USNOMO:		unfrozen
FTRMB:	trail/minibikes	frozen
MB:		unfrozen
FCYC:	all-terrain cycles	frozen
UCYC:		unfrozen
FOTH:	other vehicles	frozen
UOTH:		unfrozen

Question 10

FROZ: vulnerability to damage when ground frozen
UNFROZ: vulnerability to damage when ground unfrozen

Question 11

TRWHL:	level of damage caused by large tracked and wheeled vehicles
ATCYC:	all-terrain cycles
SNOBL:	snowmobiles
FWD:	four-wheel drive trucks
TRBK:	trail or minibikes
OTER:	other vehicles

Question 12

SEAS:	reaction to seasonal closure of WMA
CLSSM:	closure of WMA to some vehicle types
CLSALL:	closure of WMA to all motorized vehicles
DESRT:	designated route system
IMPROV:	construction/improvement of trails
OTHER:	respondent-suggested course of action

Question 13

COMMITT: whether respondent is in favour of advisory committee

C.3 THE BMDP P4F CROSSTABULATION PROGRAM

The P4F program produces crosstabulations of requested variables and calculates various measures of the relationships between them; in this case, all comparisons made were the effects of various demographic and recreational factors on the attitudes of the respondents to proposed management options.

The program statement used was:

```
//AWEBB$ JOB ',,','A.WEBB'
// EXEC BIMED,PROG=BMDP4F
//FT08F001 DD DSN=AWEBB.EXAMPLE,DISP=OLD
//SYSIN DD *
/ CONTROL COLUMN = 72.  / END
/ PROBLEM  TITLE IS 'CHURCHILL ORV QUESTIONNAIRE ANALYSIS'.
/ INPUT  VARIABLES ARE 54.
FORMAT IS '(A3,20F1,7F2,1F1,10F2,15F1)'.
CASES ARE 141.
/ VARIABLE  NAMES ARE IDNO, HUNT, FISH, SNOWMOB, BDWATCH,
ORV, FWHEEL, PHOTO, SKI, OHR, SEX, AGE, RES, JOB, EDUC,
NATUR, TRUCK, SNOW, TRAILB, ATC, OER, TOUR, WILDL, HUN, FIS,
TRAP, XC, RECDRV, INWMA, FFTRUCK, UFTRUCK, FSNOMO, USNOMO, FTRMB,
MB, FCYC, UCYC, FOTH, UOTH, FROZ, UNFROZ, TRWHL, ATCYC, SNOBL,
FWD, TRBK, OTER, SEAS, CLSSM, CLSALL, DESRT, IMPROV, OTHER, COMMITT.
BLANKS ARE MISSING.
USE=2 TO 54.
LABEL IS IDNO.
/ GROUP
CODES (2) ARE 1,2,3.
NAMES (2) ARE 'NEVER', '1 TO 3', '4+'.
CODES (3) ARE 1,2,3.
NAMES (3) ARE 'NEVER', '1 TO 3', '4+'.
CODES (4) ARE 1,2,3.
NAMES (4) ARE 'NEVER', '1 TO 3', '4+'.
CODES (5) ARE 1,2,3.
NAMES (5) ARE 'NEVER', '1 TO 3', '4+'.
CODES (6) ARE 1,2,3.
NAMES (6) ARE 'NEVER', '1 TO 3', '4+'.
CODES (7) ARE 1,2,3.
NAMES (7) ARE 'NEVER', '1 TO 3', '4+'.
CODES (8) ARE 1,2,3.
NAMES (8) ARE 'NEVER', '1 TO 3', '4+'.
CODES (9) ARE 1,2,3.
NAMES (9) ARE 'NEVER', '1 TO 3', '4+'.
CODES (10) ARE 1,2,3.
NAMES (10) ARE 'NEVER', '1 TO 3', '4+'.
CODES (11) ARE 1,2.
NAMES (11) ARE 'MALE', 'FEMALE'.
CODES (12) ARE 1,2,3,4,5,6,7.
NAMES (12) ARE '14LES','15-24','25-34','35-44','45-54','55-64','65+'.
CODES (13) ARE 1,2.
NAMES (13) ARE 'PERMANENT', 'NONPERMANENT'.
CODES (14) ARE 1,2,3,4,5,6,7,8.
NAMES (14) ARE 'SSERV','CLER','INDTEC','PROF','HEE','ADMIN','RET',
   'OTH'.
CODES (15) ARE 1,2,3,4,5,6.
NAMES (15) ARE '8ORLESS', '9TO11', '12/13', 'UC', 'UD', 'TECH'.
CODES (16) ARE 1,2,3,4,5,6,7.
NAMES (16) ARE 'MWF', 'CWF', 'MNS', 'DU', 'CARC', 'AUD', 'OTHR'.
CODES (29) ARE 1,2.
NAMES (29) ARE 'YES', 'NO'.
CODES (40) ARE 1,2,3,4,5.
```

```
NAMES (40) ARE '1','2','3','4','5'.
CODES (41) ARE 1,2,3,4,5.
NAMES (41) ARE '1','2','3','4','5'.
CODES (42) ARE 1,2,3,4,5.
NAMES (42) ARE '1','2','3','4','5'.
CODES (43) ARE 1,2,3,4,5.
NAMES (43) ARE '1','2','3','4','5'.
CODES (44) ARE 1,2,3,4,5.
NAMES (44) ARE '1','2','3','4','5'.
CODES (45) ARE 1,2,3,4,5.
NAMES (45) ARE '1','2','3','4','5'.
CODES (46) ARE 1,2,3,4,5.
NAMES (46) ARE '1','2','3','4','5'.
CODES (47) ARE 1,2,3,4,5.
NAMES (47) ARE '1','2','3','4','5'.
CODES (48) ARE 1,2,3,4,5.
NAMES (48) ARE '1','2','3','4','5'.
CODES (49) ARE 1,2,3,4,5.
NAMES (49) ARE '1','2','3','4','5'.
CODES (50) ARE 1,2,3,4,5.
NAMES (50) ARE '1','2','3','4','5'.
CODES (51) ARE 1,2,3,4,5.
NAMES (51) ARE '1','2','3','4','5'.
CODES (52) ARE 1,2,3,4,5.
NAMES (52) ARE '1','2','3','4','5'.
CODES (53) ARE 1,2,3,4,5.
NAMES (53) ARE '1','2','3','4','5'.
CODES (54) ARE 1,2.
NAMES (54) ARE 'YES', 'NO'.
/ TABLE COLUMN IS SEAS, CLSSM, CLSALL, DESRT, IMPROV, COMMITT.
        ROW IS HUNT, FISH, SNOWMOB, BDWATCH, ORV, FWHEEL.
        CROSS.
/ PRINT EXPECTED.
        ROWPERCENT.
        COLPERCENT.
        TOTPERCENT.
/ STATISTICS CHISQ.
/ TABLE COLUMN IS SEAS, CLSSM, CLSALL, DESRT, IMPROV, COMMITT.
        ROW IS PHOTO, SKI, OHR, SEX, AGE, JOB, EDUC.
        CROSS.
/ END
        [--Data for First 140 Cases Inserted Here--]
12111 1364  2 2 0300010000001010000051000000005    5315515 135111/
/ FINISH
/*
//
```

C.4 CALCULATION OF CHI-SQUARE VALUES

A Pearson Chi-square test (Thorndike 1982)is used to test the independence of two populations of samples using the null hypothesis

$$P1 = P2$$

and the alternative hypothesis

$$P1 \neq P2$$

That is, if the calculated X^2 value does not exceed the critical value for samples of that size, the two populations are believed to be subsamples of the same population.

For all comparisons of the independence of variables, an alpha- uncertainty level of .05 was used. This represents the possibility of a type I error. The critical value of X^2 then varies depending on the number of degrees of freedom for the crosstabulation formed. For any such crosstabulation, the number of degrees of freedom depends on the number of classes into which each variable is divided (number of rows and columns in the table). The number of degrees of freedom is equal to

$$(\#rows-1)(\#columns-1)$$

(Thorndike 1982).

The number of degrees of freedom for crosstabulations formed by this program ranged from 1 to 24.

Critical X^2 values for the various tables are those calculated by Thompson (1941).

Due to the large number of cross-tabulations requested (78) and the calculation of tables of observed, expected and excluded values, the crosstabulation output of the P4F program has been excluded from this report. A copy may be obtained by writing to the Natural Resources Institute, University of Manitoba, Winnipeg Man. R3T 2N2.

A brief summary of responses not already discussed is shown in the following section.

C.5 SUMMARY OF QUESTIONNAIRE RESULTS

C.5.1 Demographic Information

Respondents were asked to list the age and sex composition of their households to estimate future numbers of potential recreational vehicle users. The results are shown in Table 10.

Making the assumption that the users of off-road vehicles will be between the ages of 14 and 55, there are about 160 male and 176 female residents who are potential users, while many of the 62 male and 51 female residents who are under the age of 14 will also be users in the future.

TABLE 10

Composition of respondents' families by age and sex.

AGE GROUP	M	F
14 or less	62 (12.5%)	51 (10.3%)
15-24	53 (10.7)	81 (16.4)
25-34	54 (10.9)	92 (18.6)
35-44	43 (08.7)	19 (03.8)
45-54	10 (02.0)	14 (02.8)
55-64	5 (01.0)	6 (01.2)
65 or more	2 (00.4)	3 (00.6)
	229 (46.3%)	266 (53.7%)

The composition of respondents by occupation is shown in Table 11.

Another question asked respondents to list the categories of education they had completed. 127 (90.0%) responded. Their responses are shown in Table 12.

TABLE 11

Occupations of respondents.

Occupational Group		%*	Number
Sales and service (See note	1)	13.8%	(16)
Clerical	(2)	7.1	(09)
Industrial/Technical	(3)	32.6	(41)
Professional		0.8	(01)
Health/Education	(4)	14.3	(18)
Administrative/Managerial	(5)	19.0	(24)
Retired		2.4	(03)
Other	(6)	11.1	(14)
			126

*Percentage of 126 responses to this question.

Note 1. Typical jobs include store workers, cashiers, etc.
2. Book keepers, payroll clerks, etc.
3. Various licensed trades e.g. carpenters, welders, etc. Also persons associated with aircraft operation and maintenance, meteorology and communications.
4. Nurses, teachers, social workers and related activities.
5. Owners/Managers of businesses or government agencies.
6. Includes self-employed people except those in lice trades; trappers and guides; all those who listed categories not already described.

TABLE 12

Level of Education	Number	% of Respondents
Grade 8 or less	12	9.5%
Grade 9-11	22	17.3
Grade 12-13	22	17.3
Some university courses	10	7.9
University degree	16	12.6
Trade or technical certificate	45	35.4
	127	

C.5.2 Recreational Activities

Respondents were asked to estimate the number of weeks per year during which they participated in various outdoor activities. All of these activities (hunting, fishing, snowmobiling, bird watching, off-road vehicle driving, wildlife photography, cross-country skiing, and other (user specified activities) are possible both inside and outside the WMA. The response categories provided were 'never', '1-3 weeks per year', and '4+ weeks per year'.

The results of this question by category and percent of respondents in each frequency range per question are shown in Table 13.

Using these statistics, the respondents are interested in the listed activities in the order of preference shown in

TABLE 13

Frequency of selected recreational activities.

Activity	Frequency (weeks/year)	Number of Respondents	Percent of Respondents*
Hunting			
	NEVER	53	40.2
	1 TO 3	50	37.9
	4+	29	22.0
Fishing			
	NEVER	42	32.1
	1 TO 3	62	47.3
	4+	27	20.6
Snowmobiling			
	NEVER	41	30.8
	1 TO 3	30	22.6
	4+	62	46.6
Bird Watching			
	NEVER	77	65.3
	1 TO 3	32	27.1
	4+	9	7.6
Off-Road ATV Use			
	NEVER	65	48.9
	1 TO 3	35	26.3
	4+	33	24.8
Off-Road Four-Wheel Drive Truck Use			
	NEVER	90	73.8
	1 TO 3	16	13.1
	4+	16	13.1
Wildlife Photography			
	NEVER	48	41.0
	1 TO 3	55	47.0
	4+	14	12.0
Cross-Country Skiing			
	NEVER	97	83.6
	1 TO 3	15	12.9
	4+	4	3.5
Other**			
	NEVER	31	67.4
	1 TO 3	8	17.4
	4+	7	15.2

*% of respondents to that activity. E.g. regarding hunting, there were 131 responses so the percentage who never hunt is 53/131=40.2

**Respondents specified activities including hiking, jogging, berry picking and flower collecting/photography.

TABLE 14

Number of participants reporting selected recreational activity.

Activity	Number of Participants
Snowmobiling	92
Fishing	89
Hunting	79
Wildlife Photography	69
ATV Use	68
Bird Watching	41
Off-Road 4WD Use	32
Cross-Country Skiing	19
Other	15

Table 14. Many respondents participate in more than one of these activities.

Appendix D

CLIMATIC AVERAGES FOR CHURCHILL

The following climatic data is based on the 30 year recording period 1951-80 for the Churchill A weather station located at the airport (58o 45' N, 94o 04' W, elevation 29 m).

Mean Daily Temperature (Degrees Celsius)

Month											
Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
-27.5	-25.9	-20.4	-10.1	-1.5	6.2	11.8	11.3	5.4	-1.5	-12.1	-22.7

Average mean yearly temperature: -7.2

Source: Environment Canada 1982a

Precipitation (cm)

Month											
Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.5	1.3	1.8	2.3	3.2	4.4	4.6	5.8	5.1	4.3	3.9	2.1

Total=40.23 cm

Source: Environment Canada 1982b.

Snowfall (cm)

Month											
Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
16.9	14.6	18.6	22.3	19.5	3.5	0.0	0.0	6.4	29.3	4.1	22.8

Total=199.5 cm

Source: Environment Canada 1982b

Average and Extremes for Frost Incidence[1]

Average Frost-free period (days): 76
Average date of last spring frost: June 24
Average date of first fall frost: September 9
Shortest recorded frost-free period: 14 days (July 2-17)
Longest recorded frost-free period: 108 days (June 12-September 29)
Earliest recorded first fall frost: July 18
Latest recorded first fall frost: September 29

1. Extremes based on record of 36 years (1945-81).

Source: Environment Canada 1981B

Probability of Fall Frost

	Probability of Frost on or before indicated date						
Date	Aug. 20	Sep. 4	Sep. 8	Sep. 12	Sep. 16	Sep. 17	Sep. 29
	10%	25%	33%	50%	66%	75%	90%

Source: Environment Canada 1981B.

Snow Cover Records[2]

Occurance of 2.5 cm of Continuous Snow Cover or More

	First Date	Days of Snow Cover	Last Date
Early/minimum	Sept 18	175	April 24
Latest/maximum	Nov 9	238	June 9
Median	Oct 14	213	May 27
Mean	Oct 15	209	May 28

Source: Potter 1965.

Snow Cover Depth in cm at Month End[2]

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Total
Minimum	00.0	00.0	05.0	15.0	17.5	25.0	22.5	00.0	00.0	30.0
Maximum	00.0	37.5	57.5	75.0	82.5	100.0	112.5	105.0	60.0	135.0
Median	00.0	05.0	25.0	37.5	45.0	50.0	25.0	27.5	00.0	60.0
Mean	00.0	---	27.5	40.0	47.5	55.0	55.0	35.0	00.0	70.0

Source: Potter 1965.

2. Based on the 1945-65 period.

Appendix E

LAND USE ALLOCATIONS IN THE W.M.A.

Portions of the W.M.A. which are not fully under the control of the Department of Natural Resources due to prior commitments or overlapping jurisdiction with other designated lands are listed below (paraphrased from Teillet 1983).

1. L.G.D. of Gillam. Approximately 1400 square kilometers in the southwest of the W.M.A. falls within the L.G.D. The government district retains certain rights to tax development occurring within its boundaries.

2. Manitoba Hydro. Two portions of the W.M.A. fall within the water power reserves controlled by Manitoba Hydro. Approximately 555 square kilometers in the northwest part of the W.M.A. are within the Churchill River Water Power Reserve. Some 4000 square kilometers in the southern part of the W.M.A. fall within the Nelson River Water Power Reserve. These reserves are permanent reservations placed on Crown lands by Manitoba Hydro in order to control development for purposes of hydro-electric generation (including dam construction) and water control. Construction within these reserves requires hydro approval and is usually restricted below stated severance lines or high water marks.

3. National Research Council (N.R.C.). Two areas within the W.M.A. are leased to the N.R.C. for purposes of atmospheric research A 790 square kilometer area is under lease for rocket launch, monitoring, control and administration. During the operation of this lease, NRC has total control over all the land use, access and development in this area. The majority of the remaining land in the W.M.A. is also under lease to NRC. This second and larger area is a rocket impact and recovery area. The principal restriction this area is a ban on air traffic in the area during launching periods.

Appendix F

MANAGEMENT ZONES IN THE CAPE CHURCHILL W.M.A.

The management zones into which the W.M.A. is divided are given by Teillet (1983) as:

Zone 1: Polar Bear Denning Area
Objectives: protection of denning polar bears and denning habitat.
Development Level: low
Use Level: low
Area: 9510 sq. km

Zone 2a: Special Protection Area
Objectives: protection of upland bird habitat and unique features at Twin Lakes Hill.
Development Level: intermediate
Use Level: low-intermediate
Area: 17 sq. km

Zone 2b: Special Protection Area
Objectives: protection of La Perouse Bay snow goose colony and Cape Churchill area polar bear staging habitat.
Development Level: low-intermediate
Use Level: low
Area: 350 sq. km

Zone 3: Public Use Area
Objectives: protection of migratory bird habitat and encouragement of ecological research and nature-oriented tourism.
Development Level: intermediate
Use Level: intermediate to high
Area: 650 sq. km

Zone 4: General Management Area
Objectives: management of caribou, other species and their habitats.
Development Level: intermediate
Use Level: intermediate
Area: 5400 sq. km

Zone 5: Resource Development Area
Objectives: to allow infrastructure development and non-wildlife resource extraction in the context of wildlife management.
Development Level: high
Use Level: high
Area: 2850 sq. km

These terms are defined as:

Development Levels:	
Low--	*no permanent structures or facilities *no improved access *no mineral extraction
Intermediate--	*structures may be allowed *access may be improved
High--	*road construction permitted *mineral extraction permitted *commercial and residential structures possible
Use Levels:	
Low--	*extensive recreational use (subject to limits) *extensive renewable resource harvest (under permit) *research activities (under permit) *restricted travel
Intermediate--	*extensive recreational use *extensive renewable resource harvest (under permit) *research activities may be limited *travel may be restricted *intensive recreation may be permitted
High--	*authorized resource harvesting *recreational use (extensive or intensive) *research activity

Appendix G

VEHICLE SPECIFICATIONS AND GROUND PRESSURES

This appendix presents data regarding the unusual vehicles used off-road in the W.M.A. (the Trackmasters and the original Tundra Buggy) during the summer of 1983. Specifications for other commonly-used vehicles (ATCs, 4WD trucks, etc.) can be determined if required, so that only the gross vehicle weights and bearing areas are listed for these machines.

Unless otherwise indicated, measurements were made or calculated by the author.

G.1 VEHICLE SPECIFICATIONS

G.1.1 The Tundra Buggy

The specifications collected for the Tundra Buggy were:

1. Weight: Tare=7,300 kg* (est. by R. Bukowsky, pers. comm.)

   Gross=9,500 kg (with 29-70 kg persons and 300 l of gasoline aboard)

2. Outer Track Width: 3.55 m
3. Inner Track Width: 1.41 m
4. Wheel Base: 4.64 m
5. Tire Size: Goodyear 66x43 25NHS 6pr

   Height: 590 cm

   Width: 107 cm

Tread Pattern: chevron-type alternating lugs, 45 l x 5w x5h cm

6. Ground Clearance: Front differential 53 cm

   Rear differential 51 cm

   Chassis 109 cm

7. Passenger Capacity: 28 passengers plus driver; usually one guide/bear monitor in later season.

8. Speed: 10 km/h average on trails; maximum speed on road 30 km/h (ests.)

9. Ground Pressure at G.V.W.(on firm surface): 0.9 kg/sq. cm**

* The second Tundra Buggy has a tare of 9,270 kg (R. Bukowsky, personal communication).
**Measurement of tire bearing surfaces on a firm surface showed that about an area of about 25x107 cm was in contact with the ground for each wheel. This gives a total surface of 10,700 sq. cm.

G.1.2 Thiokol Trackmaster 4T10

Specifications collected were:

1. Weight*: Tare=2,100 kg

   Gross=3,580 kg

2. Outer Track Width: 2.41 m

3. Inner Track Width: 1.02 m

4. Wheel Base (Drive sprocket to passive sprocket): 3.2 m

5. Track Dimensions (each side):

   Total Width:70 cm

   Width of Rubber Portion (each side): 26.5 cm

   Gap between Rubber Portions: 17 cm

Dimensions of Grouser Bars: 43 cm l x 4w x 3h

Top Height of Track Surface: 72 cm

6. Clearance: Floating Axles=20 cm

   Differential=21 cm

7. Passenger Capacity: 7 plus driver

8. Speed: 5-10 km/h depending on trails (est.)

9. Ground Pressure at G.V.W.: 0.11 kg/sq. cm**

*Specified on vehicle identification plate

**The area of the tracks in contact with the soil depends on the uniformity of the soil surface. For this calculation it was assumed that the full width of each track contacted the soil for an average length of 3.0 m. Thus the rubber portions of the track would contribute a total area of 4 x 300 x 26.5 cm, while the grouser bars would each contribute 17x4 cm (the area exposed between the rubber portions of the tracks) with the assumption that a total of 20 such bars are contacting the ground at any given time.

G.1.3 GMC 30 4WD Van

The GMC 4WD van being used by CWE is of conventional construction with large snow tires on all four wheels.

Statistics collected were:

G.V.W.=3270 kg. (specified on vehicle identification plate)

Tire Width (bearing portion)=30 cm.

Ground pressure at G.V.W.= 1.82 kg/sq. cm*.

*Wheel area bearing on firm ground is 15x30 cm when inflated to 30 psi. Therefore total bearing area is 15x30 cm x 4 wheels=1800 sq. cm.

G.1.4 All-Terrain Cycles

Weights and tire dimensions vary somewhat according to the make and model employed, as well as the pressure to which the tires are inflated. These statistics given are for a Honda 200E, which is one of the largest vehicles of this type in common use.

All the ATCs observed in the W.M.A. or in the town of Churchill were of the three-wheeled type.

Statistics collected were:

Tare=170 kg.

G.V.W. (With 70 kg rider and 8 l of gas)=247 kg.

Ground pressure=0.22 kg/sq. cm**.

**Wheel area bearing on firm ground is about 25x15 cm when inflated to 2.5 psi recommended pressure. Therefore the total bearing area is 25 x 15 cm x 3 wheels= 1125 sq. cm.

Appendix H

LIST OF PERSONAL COMMUNICATIONS

The following persons kindly provided information quoted in personal communications:

1. Mr. Roy Bukowsky--Co-owner, Tundra Buggy Tours Ltd.
2. Mr. Al Chartier--Co-owner, Churchill Wilderness Encounter
3. Mr. Mike Reimer--Guide, Churchill Wilderness Encounter
4. Mr. Arvids Silis--Graduate Student, Climatology program, Department of Geography, McMaster University.
5. Mr. Dan Teillet--Resource Planner, Manitoba Department of Natural Resources (Wildlife Branch)
6. Mr. Ian Thorleifson--Wildlife Technician, Manitoba Department of Natural Resources (Wildlife Branch)

In addition, Dr. Ed Zipf of the National Aeronautics and Space Administration auroral research project is quoted. He was interviewed by radio station CBW in Winnipeg on February 20, 1984.

Appendix I

SUMMARY OF ROD PENETRATION TESTS

A brief summary showing rod penetration depths at the impacted and undamaged portions of each site is shown in Tables 16 to 28.

A brief description of the sites is given in Section 2.1. For ease of comparison, these sites have been grouped by their general soil characteristics. Their locations as defined by 1:50,000 NTS map grids are shown in Table 15.

The vehicle type abbreviations used are defined in Appendix A.

TABLE 15

Site characteristics and grid locations.

Site Description	Site Number(s)	Grid Location
Beach ridge with sandy soil, shallow organic layer	3	538132
	4	538133
	12	570160
Shallow organic soil in slight depressions	1	524128
	2	530129
15-30 CM thick peat soil (site 5 ground cover=willows; others=lichens)	5	540130
	6	542132
	8	552133
Lake shore with wet organic soil grading into ridge	7	545132
Shallow organic soil with intermittent ponds	9	577150
Deep organic soil with some underlying ice-rich soil and standing water	10	570112
	11	576113
Muskeg with small hummocks and willow-birch cover	RF	335096

TABLE 16

Summary of rod penetration at Site 3.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	3	15	9.6	1.78	--	--
Mil/Combined civilian	3	22	5.7*	2.21	5.93	2.145

*note that there has been a significant decrease in penetration depth at the 0.05 level.

TABLE 17

Summary of rod penetration at Site 4.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	3	17	10.7	4.05	--	--
4WD	3	9	10.2	4.37	0.29	2.306

TABLE 18

Summary of rod penetration at Site 12.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	3	15	7.5	3.30	--	--
Combined trail (various vehicles)	3	6	7.3	1.49	0.19	2.571

TABLE 19

Summary of rod penetration at Site 1.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	5	25	11.6	5.57	--	--
TB/Mil	5	30	14.3	7.08	1.55	2.064
ATC	4	20	12.3	6.57	0.46	2.093
4WD	3	13	15.2	5.64	1.83	2.179

TABLE 20

Summary of rod penetration at Site 2.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	3	15	11.5	9.34	--	--
TB/Mil	3	14	29.4	16.92	3.48	2.160
TM	2	11	9.7	11.10	0.10	2.228
ATC/TM	1	3	6.3	0.94	2.10	4.303

TABLE 21

Summary of rod penetration at Site 5.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	3	17	23.9	4.47	--	--
Combined Military/ Civilian	3	19	27.0	11.07	0.29	2.120

TABLE 22

Summary of rod penetration at Site 6.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	3	14	15.4	4.53	--	--
ATC	2	3	11.3	5.56	1.20	4.303
Combined trail (various)	3	13	17.5	7.76	0.88	2.179
Abandoned Military/TB	3	11	18.1	2.59	1.87	2.228

TABLE 23

Summary of rod penetration at Site 8.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	6	30	20.6	5.54	--	--
Abandoned military/TB	6	42	23.3	8.52	1.63	2.045
TB	7	30	25.1	6.22	3.15	2.045
Trackmaster	6	24	21.8	4.99	0.84	2.069

TABLE 24

Summary of rod penetration at Site 7.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	15	73	9.2	2.89	--	--
Lakeshore*	6	29	18.8	3.78	3.23	2.048
TB	15	90	23.2	6.99	4.80	2.000
Abandoned TB/Mil	15	75	21.8	9.31	4.09	2.000
ATC/TM	13	38	9.4	8.32	0.06	2.021

*The lakeshore area lies between the open water of a pond and the trail used by the Tundra Buggy and some former military use; while this area is not directly affected by any vehicle, it contains saturated organic soil and is vulnerable if existing trails spread onto it. It is not clear whether the adjacent vehicle use is responsible for the significant depth of thaw, or whether this is the result of an absence of stones and till compared with the undamaged area which lies farther from the water.

TABLE 25

Summary of rod penetration at Site 9.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	12	60	11.2	6.3	--	--
TB	12	104	12.5	7.51	1.13	2.000
Military	10	74	14.2	9.28	2.15	2.000
ATC	7	36	25.5	18.26	4.43	2.042
4WD	10	139	22.5	59.31	2.212.000	

TABLE 26

Summary of rod penetration at Site 10.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	5	25	31.5	9.19	--	--
TM	5	18	34.9	14.20	0.89	2.101
Abandoned military/ TM trail	5	23	44.3	12.01	4.12	2.074
4WD Area	5	80	43.0	11.56	5.12	2.064

TABLE 27

Summary of rod penetration at Site 11.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Observed t value	Critical t
Undamaged	5	25	12.9	5.09	--	--
TM/ATC	5	16	16.2	18.32	0.70	2.131
Abandoned military/ TM trail	5	11	11.2	7.51	0.94	2.064
Military	3	11	12.6	6.70	0.11	2.228

TABLE 28

Summary of rod penetration at the River Flat Site.

Trail Class	#Transects where class found	#Observations	Average Depth (cm)	Standard Deviation	Obser- ved t value	Crit- ical t
Undamaged	4	20	43.0	10.37	--	--
ATC	4	26	41.7	8.76	0.42	2.093

Appendix J

DOMINANT COVER TYPES OF IMPACTED AND UNDAMAGED PLANT COMMUNITIES

Plant data is organized by the general characteristics of the conditions at each site.

1. Sites which are elevated and well drained, remaining dry for most of the year (Sites 3,4 and 12).

2. Sites which are seasonally wet due to lower elevation and a greater proportion of organic soil (Sites 1,2,5,6 and 8) but which are dry when runoff or rainfall are low.

3. Sites which remain wet for most of the year due to low elevation, drainage from other areas and high proportions of organic soil (Sites 7,9,10,11, River Flat and Dene Village).

The degree of similarity of dominant cover types are shown in Tables 29 to 42.

Table 29

Dominant cover types of Site 3.

Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Cladina sp.	31.0
Calamagrostis sp.	17.0
Cetraria sp.	12.3
Arctostaphyllos rubra (Rehd.&Wils.) Fern.	9.3
Ledum decumbens (Ait.) Lodd.	4.0

Site 3
Vehicle Type: Combined Trail

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calcul- ated t value	Critical t value
Bare ground	71.3	no		
Dryas integrifolia M. Vahl	11.3	no		
Unidentified mosses	3.7	no		
Carex sp.	3.0	no		
Puccinelia sp.	1.7	no		

Table 30

Dominant cover types of Site 4.

Site 4
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Cladina sp.	36.7
Cladonia sp.	21.3
Unidentified lichens	13.0
Cetraria sp.	10.0
Ledum decumbens	4.7

Site 4
Vehicle Type: 4WD (some ATC and Military use has occurred)

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calcul- ated t value	Critical t value
Bare ground	53.0	no		
Carex sp.	26.7	no		
.us Juncus sp.	8.7	no		
Calamagrostis deschamp- sioides Trin.	5.3	no		
Arctostaphyllos rubra	2.0	no		
Salix sp.	2.0	no		

Table 30 continued

Site 4
Vehicle Type: 4WD Area (dispersed tracks)

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
<u>Carex</u> sp.	18.0	no		
<u>Dryas</u> <u>integrifolia</u>	16.0	no		
<u>Arctostaphyllos</u> <u>rubra</u>	13.7	no		
<u>Vaccinium</u> <u>uliginosum</u> L.	11.0	no		
Bare ground	10.3	no		

Table 31

Dominant cover types of Site 12.

Site 12
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Mosses	40.0
Bare ground	30.7
<u>Salix glauca</u>	20.7
<u>Epilobium angustifolium</u> L. var. <u>intermedium</u> (Wormske) Fern.	8.3
<u>Elymus arenarius</u> L. ssp. <u>mollis</u> (Trin.) Hult.	5.7

Site 12
Vehicle Type: Combined trail

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	77.7	yes	3.358	3.182
Mosses	3.7	yes	7.146	3.182
<u>Potentilla multifida</u> L.	3.3	no		
<u>Rubus chamaemorus</u> L.	3.0	no		
<u>Achillea borealis</u>	2.7	no		

Table 32

Dominant cover types of Site 1.

Site 1
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Cetraria sp.	15.4
Cladina sp.	10.4
Bare ground	10.2
Arctostaphyllos rubra	7.2
Cladonia sp.	7.2
Carex sp.	5.8

Site 1
Vehicle Type: Tundra Buggy

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calcul-ated t value	Critical t value
Bare ground	75.4	yes	2.708	2.776
Carex sp.	1.4	yes	1.987	3.182
Arctostaphyllos rubra	0.4	no		
Eriophorum sp.	0.4	no		
Senecio congestus (R. Br.) DC.	0.4	no		
Stellaria longipes Goldie	0.2	no		

Table 32 continued

Site 1
Vehicle Type: ATC

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	23.4	yes	0.928	2.776
Water	14.6	no		
Arctostaphyllos uva-ursi (L.) Spreng. var. *coactilis* Fern. & Macbr.	2.8	no		
Carex sp.	2.4	yes	0.623	2.776
Carex aquatilis Wahlenb.	2.0	no		
Empetrum nigrum L.	2.0	no		

Site 1
Vehicle Type: 4WD

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Carex sp.	20.4	yes	3.02	2.262
Bare ground	9.8	yes	2.520	2.776
Empetrum nigrum	7.8	no		
Arctostaphyllos rubra	5.2	yes	1.759	2.776
Eriophorum scheuchzeri Hoppe	5.0	no		
Salix glauca	5.0	no		

Table 33

Dominant cover types of Site 2

Site 2
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Arctostaphyllos uva-ursi	13.7
Ledum decumbens	12.7
Cladina sp.	12.3
Cetraria sp.	11.7
Carex sp.	8.3

Site 2
Vehicle Type: Tundra Buggy

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Water	51.3	no		
Bare ground	46.3	no		
Carex aquatilis	2.0	no		
Mosses	0.3	no		

Table 33 continued

Site 2
Vehicle Type: Trackmaster

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	57.0	no		
Carex aquatilis	11.5	no		
Arctostaphyllos uva-ursi	6.0	yes	1.407	12.706
Salix glauca	15.0	no		
Carex sp.	14.0	no		

Table 33 continued

Site 2
Vehicle Type: ATC

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value

?

Note: ATC impacts were found in only one of the three transects; the values listed are not averages for this site and impact category.

Bare ground	65.0	no		
Carex sp.	11.0	no		
Arctostaphyllos rubra	7.0	no		
Calamagrostis deschampsioides	5.0	no		
Salix glauca	5.0	no		
Polygonum vivoparum L.	1.0	no		
Mosses	1.0	no		

Site 2
Vehicle Type: 4WD

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value

Note: 4WD impacts were found in only one of the three transects; hence the values listed are not averages for this site and impact category.

Carex sp.	46.0	no		
Mosses	34.0	no		
Eriophorum scheuchzeri	9.0	no		
Bare ground	6.0	no		
Salix glauca	3.0	no		

Table 34

Dominant cover types of Site 5.

Site 5
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Salix glauca	34.3
Empetrum nigrum	6.3
Betula glandulosa Michx.	5.3
Arctostaphyllos uva-ursi	5.0
Carex sp.	4.3

Site 5
Vehicle Type: Combined trail

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	89.7	no		
Petacites saggitatus (Pursh) Gray	2.7	no		
Equisetum sp.	2.3	no		
Salix glauca	1.7	yes Only 1 individual		
Epilobium angustifolium	1.3	no		

Table 35

Dominant cover types of Site 6.

Site 6
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Cladina sp.	56.0
Cetraria sp.	10.5
Ledum groenlandicum Oeder	7.5
Empetrum nigrum	6.5
Arctostaphyllos uva-ursi	6.0

Site 6
Vehicle Type: Combined trail (present use mainly Tundra Buggy and 4WD van)

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calcul-ated t value	Critical t value
Bare ground	83.3	no		
Calamagrostis deschampsioides	3.0	no		
Cladina sp.	2.0	yes	3.319	2.571
Arctostaphyllos uva-ursi	2.0	yes	0.710	4.303
Dryas integrifolia	1.7	no		

Table 35 continued

Site 6
Vehicle Type: ATC

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Note: ATC impacts were found in only one of the three transects; the values listed are not averages for this site and impact category.				
Bare ground	23.0	no		
<u>Salix glauca</u>	13.0	no		
<u>Empetrum nigrum</u>	13.0	yes	0.370	4.303
<u>Saxifraga</u> sp.	8.0	no		
<u>Arctostaphyllos rubra</u>	6.0	no		
<u>Vaccinium uliginosum</u>	6.0	no		
<u>Ledum decumbens</u>	5.0	no		
<u>Cetraria</u> sp.	5.0	yes	2.895	4.303

Table 35 continued

Site 6
Vehicle Type: 4WD (dispersed tracks)

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value	
Arctostaphyllos uva-ursi	25.7	yes	1.150	2.262	no
Empetrum nigrum	13.0	yes	1.380	2.365	no
Elymus arenarius	11.7	no			
Calamagrostis deschampsioides	11.3	no			
Salix glauca	6.0	no			

Site 6
Vehicle Type: Military

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	34.7	no		
Lycopus americana	19.7	no		
Elymus arenarius	14.3	no		
Calamagrostis deschampsioides	13.0	no		
Polygonum achoreum	7.0	no		

Table 36

Dominant cover types of Site 8.

Site 8
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Ledum decumbens	16.3
Unidentified lichens	16.0
Vaccinium uliginosum	15.0
Arctostaphyllos rubra	11.7
Cladina sp.	8.7

Site 8
Vehicle Type: Trackmaster

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	58.7	no		
Carex sp.	24.3	no		
Rubus chamaemorus	14.7	no		
Arctostaphyllos rubra	9.0	yes	1.650	4.303
Cladina sp.	8.7	no		

Site 8
Vehicle Type: Tundra Buggy

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	89.7	no		
Polygonum vivoparum	4.0	no		
Carex sp.	1.7	no		
Rubus chamaemorus	0.7	no		
Polygonum achoreum	0.3	no		

Table 36 continued

Site 8
Vehicle Type: 4WD

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Carex sp.	24.0	no		
Arctostaphyllos rubra	11.7	no		
Andromeda polifolia L.	9.7	no		
Bare ground	9.0	no		
Carex stereorhiza	9.0	no		
Vaccinium uliginosum	5.0	yes	0.317	3.182

Site 8
Vehicle Type: Military

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	47.0	no		
Mosses	11.5	no		
Calamagrostis sp.	7.0	no		
Carex sp.	4.0	no		
Stellaria longipes	1.5	no		

?

Table 37

Dominant cover types of Site 7.

Site 7
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Unidentified lichens	17.2
Dryas integrifolia	12.3
Ledum decumbens	9.7
Arctostaphyllos rubra	8.7
Vaccinium uliginosum	7.7

Site 7
Vehicle Type: Tundra Buggy

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	66.7	no		
Carex aquatilis	10.7	no		
Water	12.0	no		
Salix planifolia Pursh	3.3	no		
Salix glauca	3.0	no		

Site 7
Vehicle Type: Tundra Buggy and Military

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Water	52.7	no		
Carex aquatilis	25.7	no		
Bare ground	5.7	no		
Carex stereorhiza	4.3	no		
Salix planifolia	3.0	no		

Table 37 continued

Vehicle Type: ATC

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	75.0	no		
<u>Carex aquatilis</u>	7.0	no		
<u>Carex stereorhiza</u>	6.0	no		
Water	5.0	no		
Mosses	2.5	no		

Table 38

Dominant cover types of Site 9.

Site 9
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Carex aquatilis	12.7
Arctostaphyllos rubra	10.0
Unidentified lichens	9.7
Vaccinium uliginosum	9.7
Ledum decumbens	8.3
Andromeda polifolia	5.0

Site 9
Vehicle Type: ATC

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calcul-ated t value	Critical t value
Bare ground	75.0	no		
Water	12.7	no		
Vaccinium uliginosum	4.3	yes	2.380	2.306
Equisetum variegatum Schleich.	2.3	no		
Arctostaphyllos rubra	1.3	yes	2.924	2.447

Site 9
Vehicle Type: Tundra Buggy

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calcul-ated t value	Critical t value
Bare ground	42.0	no		
Water	20.3	no		
Mosses	4.3	no		
Anemone sp.	4.0	no		
Arctostaphyllos rubra	2.0	yes	2.980	4.303

Table 38 continued

Site 9
Vehicle Type: 4WD

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Note: 4WD impacts were found in only one of the three transects; the values listed are not averages for this site and impact category.				
<u>Salix glauca</u>	30.0	no		
<u>Carex stereorhiza</u>	28.0	no		
Sphagnum mosses	17.0	no		
<u>Carex</u> sp.	7.0	no		
Bare ground	6.0	no		

Site 9
Vehicle Type: Military

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Bare ground	44.1	no		
Water	39.0	no		
<u>Carex microglochin</u> Wahlenb.	10.0	no		
<u>Carex sterorhiza</u>	8.3	no		
Carex sp.	6.0	no		

Table 39

Dominant cover types of Site 10.

Site 10
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Cladina sp.	17.3
Mosses	9.7
Salix glauca	9.7
Arctostaphyllos rubra	8.0
Carex sp.	7.0
Empetrum nigrum	6.3

Site 10
Vehicle Type: Trackmaster

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Salix glauca	12.0	yes	0.532	3.182
Mosses	6.0	yes	1.275	2.306
Carex sp.	3.3	yes	7.690	2.179
Rubus chamaemorus	2.7	no		
Calamagrostis sp.	0.7	no		

Table 39 continued

Site 10
Vehicle Type: Military (also some Trackmaster use)

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value	
Bare ground	35.0	no			
Water	34.0	no			
Anemone sp.	19.3	no			
Carex sp.	4.0	yes	1.943	2.145	yes
:::					
Carex aquatilis	3.0	no			

Site 10
Vehicle Type: 4WD

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Water	71.5	no		
Carex aquatilis	26.5	no		
Potentilla palustris (L.) Scop. var. *parvifolia* (Raf.)Fern. & Long	5.0	no		
Bare ground	4.0	no		
Eriophorum sheuchzeri	1.7	no		

Table 40

Dominant cover types of Site 11.

Site 11
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Arctostaphyllos rubra	15.7
Cetraria sp.	14.3
Cladonia sp.	10.3
Ledum decumbens	10.0
Vaccinium uliginosum	8.3

Site 11
Vehicle Type: Trackmaster

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calcul-ated t value	Critical t value
Bare ground	28.7	no		
Arctostaphyllos rubra	16.0	yes	1.939	2.262
Carex sp.	13.0	no		
Carex aquatilis	7.7	no		
Mosses	7.3	no		

Site 11
Vehicle Type: Military

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calcul-ated t value	Critical t value
Bare ground	30.7	no		
Arctostaphyllos rubra	15.7	yes	5.819	2.306
Mosses	9.0	no		
Vaccinium uliginosum	8.3	yes	0.491	4.303
Salix glauca	6.3	no		

Table 40 continued

Site 11
Vehicle Type: 4WD

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value	
Note: 4WD impacts were found in only one of the three transects; the values listed are not averages for this site and impact category.					
Mosses	39.0	no			
Juncus sp.	16.0	no			
Salix glauca	8.0	no			
Vaccinium uliginosum	5.5	no			
Andromeda polifolia	4.0	no			
Arctostaphyllos rubra	4.0	yes	1.571	2.262	no

Table 41

Dominant cover types of the River Flat Site.

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Note: 4WD impacts were found in only one of the three transects; the values listerd are not averages for this site and impact category.				
<u>Carex</u> sp.	46.0	no		
Mosses	34.0	no		
<u>Eriophorum</u> <u>scheuchzeri</u>	9.0	no		
Bare ground	6.0	no		
<u>Salix</u> <u>glauca</u>	3.0	no		

Site: River Flat
Vehicle Type: ATC

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Water	30.3	yes	1.160	2.179
Bare ground	29.5	no		
<u>Equisetum</u> <u>variegatum</u>	20.3	no		
Mosses	8.8	yes	0.490	2.145
<u>Carex</u> <u>aquatilis</u>	7.8	yes	3.920	2.160

Table 42

Dominant cover types of the Dene Village Site.

Dene Village Site (Dry transects)
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Carex aquatilis	80.0
Salix planifolia	6.3
Senecio congestus	3.3
Equisetum fluviatile	3.3
Mosses	3.3
Salix glauca	1.7
Petacites saggitatus	1.3

Site: Dene Village
Vehicle Type: ATC (Dry Transects)

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calcul-ated t value	Critical t value
Carex aquatilis	80.0	yes	1.710	2.571
Mosses	9.3	yes	4.472	12.706
Lycopus americana	4.0	no		
Water	3.0	no		
Equisetum fluviatile	1.3	yes	3.876	4.303

Table 42 continued

Dene Village Site (Wet transects)
Undamaged Area

Five most important cover types by relative cover	Rel. Cover (%)
Carex aquatilis	62.6
Water	13.4
Salix planifolia	7.4
Mosses	4.6
Equisetum fluviatile	1.2

Site: Dene Village
Vehicle Type: ATC (Wet Transects)

Five most important cover types by relative cover	Rel. Cover (%)	Same type in undamaged trail area?	Calculated t value	Critical t value
Carex aquatilis	59.0	yes	0.623	2.262
Water	53.0	yes	3.392	2.571
Salix planifolia	3.2	yes	1.223	12.706
Eriophorum sp.	2.6	no		

Note: The Dene Village Site is sedge meadow of low relief. The "dry" transects were in an area without standing visible standing water on the soil surface; the "wet" transects were in an area covered by 1-10 cm of water.