AN ASSESSMENT OF THE ADEQUACY OF BASELINE DATA RELEVANT TO THE DOCUMENTATION AND EVALUATION OF THE IMPACTS OF OIL SANDS DEVELOPMENTS ON LARGE MAMMALS IN THE AOSERP STUDY AREA

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1. INTRODUCTION

Three of the tenets upon which the Canada-Alberta agreement for the Alberta Oil Sands Environmental Research Program (AOSERP) is founded are:

1. Canada and Alberta recognize the necessity of improving the scientific understanding of the *effects of the oil sands development* on human and natural environment of the Alberta Oil Sands area.
2. The results of an intensive study of the area will be useful in *predicting the effects of any proposed development* as a basis for considering future proposals.
3. The results of the study program will be utilized by Alberta in the approval process for future developments and in the environmental design of any project which might be implemented.

It is clear, therefore, that AOSERP was established with at least two major goals in mind:

1. To conduct research which will be useful in predicting the environmental effects of oil sands developments, and
2. To conduct research which will provide an understanding of the environmental effects of development such that this knowledge may be used in the environmental design of future developments.

Development of the Athabasca Oil Sands will affect large mammals (moose, caribou, and wolf) to varying degrees through alteration of habitat, disturbance factors, and increased exploitation. Large mammal research in the AOSERP study area (Figure 1) was initiated in 1975 and continued to the present date under several projects. Research emphasis from 1975-78 has been on establishing baseline states for large mammals. The general objective of this project is to complete an analysis of the applied research necessary to allow evaluation of the effects of oil sands development on large mammals.

This objective has been fulfiled in two basic stages:

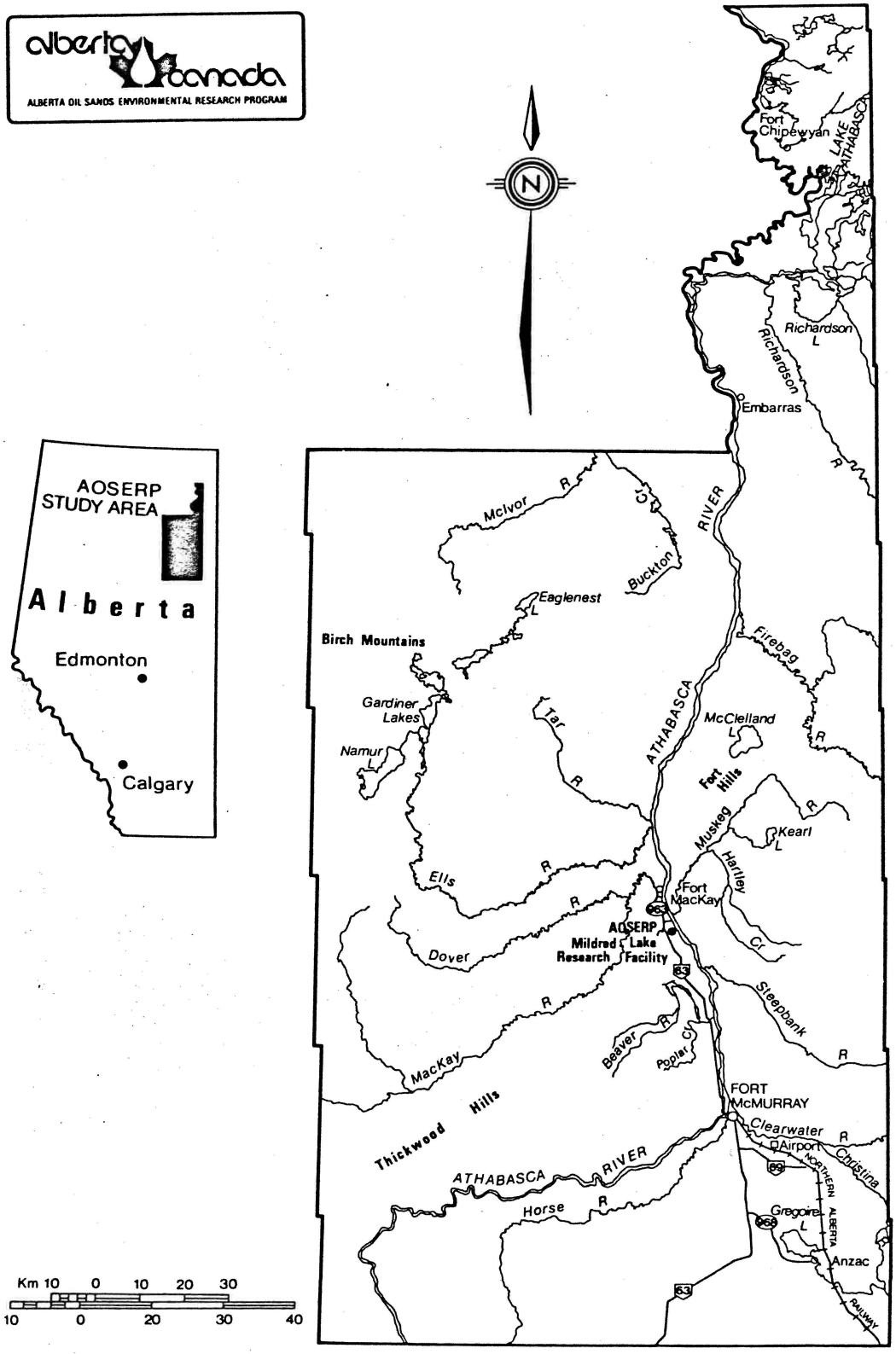

Figure 1. Location of the AOSERP study area.

(1) a review of the available baseline data which is relevant to an assessment of the effects of development on large mammals in the AOSERP study area, and (2) an evaluation of the adequacy of available baseline data and an identification of data gaps which remain.

The objective of this report is to provide an evaluation of the adequacy of the available baseline data which are relevant to the documentation and evaluation of the impacts on woodland caribou, moose, and wolves (large mammals) which would result from oil sands development in the Athabasca Oil Sands area, and recommendations for the research which should be completed to provide the missing data.

A review of the available baseline data which are relevant to the documentation and evaluation of the impacts on large mammals which would result from oil sands development has been submitted as a separate volume (Thompson et al. in prep.); this review forms the basis for the present evaluation. Since the original literature supportive of many statements in this assessment are discussed in the literature review volume, the literature review will be the primary reference of this assessment.

1.1 APPROACH TO IMPACT ANALYSIS

In order to determine what baseline data are relevant to the documentation and evaluation of impacts on large mammals, it is necessary to adopt an approach which provides a logical framework for the analysis of impacts.

The ultimate goal of any environmental impact assessment is to provide the information necessary to determine whether the structural and functional integrity of ecosystems in the vicinity of the proposed development is threatened. An environmental impact assessment involves two main stages: (1) the documentation of the impacts which will occur and (2) the evaluation of the significance of those impacts.

1.1.1 Documentation of Impacts

An environmental impact may be defined as a change in a component of the natural environment (i.e., a large mammal population) which was induced by an unnatural environmental component (i.e., oil sands development). The documentation of environmental impacts, therefore, involves a description of a development project's components, a description of those environmental components that will be involved in interactions with the project's components, and an estimation of the magnitude of those changes in the environmental components that will result from interactions with the project. In order to determine if any interaction will occur, the distribution of each species, in relation to the project, must be known; the frequency of interactions will be dependent upon the density of each species in the area subject to development.

Interactions between large mammals and development projects may be either indirect or direct (Figure 2). Indirect interactions occur through the alteration of habitats available to the population. Habitat alterations may take the form of alteration of the vegetation of an area, ranging from the complete destruction of habitat (e.g., strip-mined land) to the alteration of the vegetational characteristics of the habitat (e.g., brush clearing); habitat alterations may also take the form of a change in the structural characteristics of the habitat (e.g., construction of a road). The net result of such habitat alterations will be to alter the carrying capacity of the range. High quality habitat will generally provide either more or higher quality food and cover than will low quality habitat; therefore, higher quality habitat will typically support ("carry") greater densities of animals than will low quality habitat. Hence, alteration of habitat by a development project will ultimately affect the size of wildlife populations.

The magnitude of the effect which a given habitat alteration will produce on wildlife populations depends upon the relative amount and quality of the habitat altered and whether

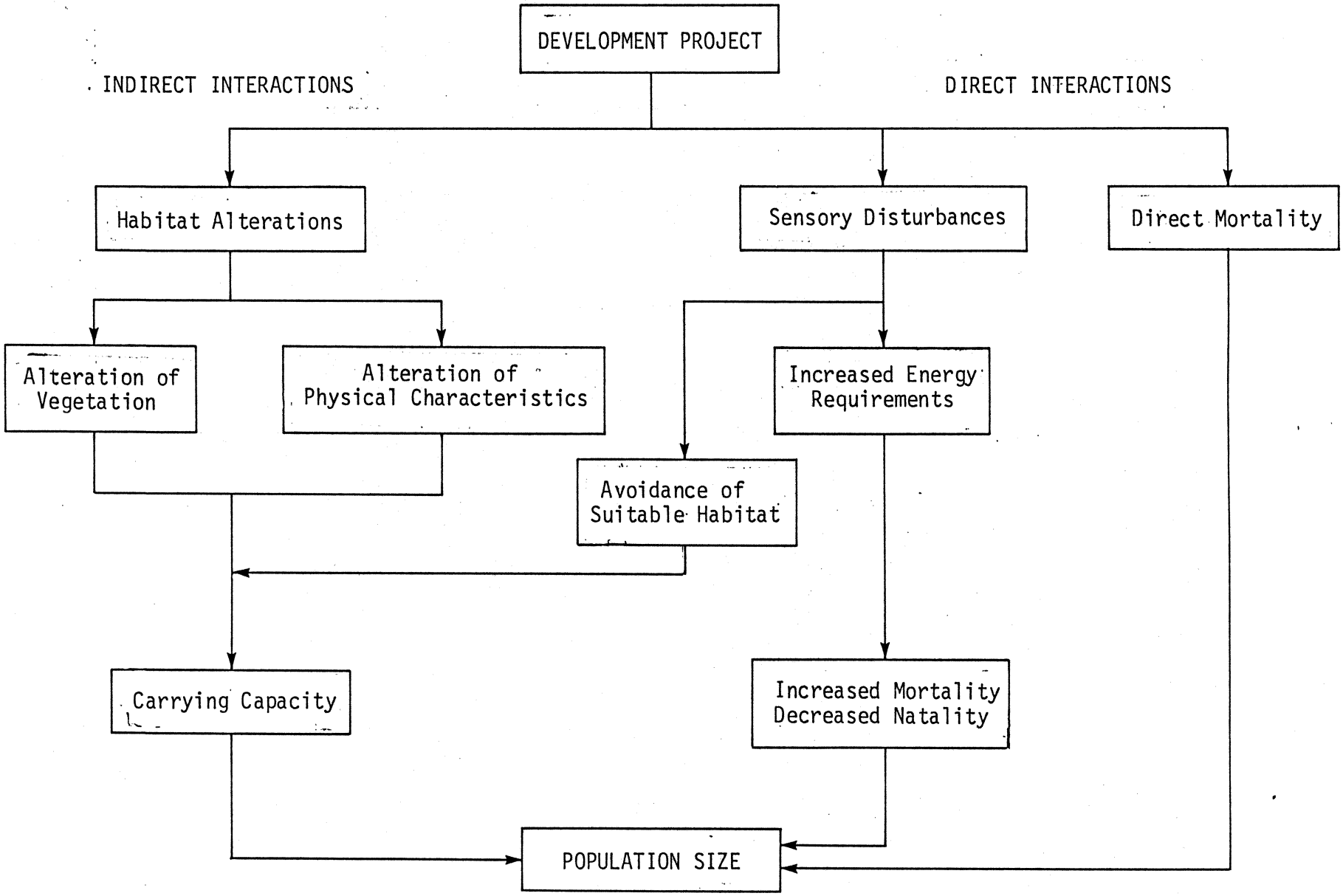

Figure 2. A conceptual approach to the documentation of the impacts of development projects on wildlife populations.

the alteration is detrimental or beneficial to the wildlife population in question. Therefore, the magnitude of the change in wildlife populations which will result from the alteration of habitat by an industrial project may be estimated from a knowledge of the seasonal wildlife habitat selection patterns, particularly the proportion of time which is spent by the population in each of the available habitat types during each season (seasonal density).

Direct interactions between wildlife populations and development projects may occur in two ways: (1) sensory disturbances, and (2) direct mortality. Continuous, intolerable sensory disturbances (e.g., continuous loud noise) may produce a reduction of the carrying capacity of the area because of the passive avoidance of suitable habitat by wildlife. Active avoidance of intolerable discontinuous sensory disturbances (e.g., aircraft overflights) will result in increased energy expenditure. The effects of an increased expenditure of energy may be manifested in increased mortality of individuals through starvation, predation, disease, etc., or in a decreased production of young through a decrease in pregnancy rates, increased abortions or absorbtion of embryos, and decreased likelihood of survival of young. Active avoidance of sensory disturbances may also result in injuries causing deaths. Direct mortality of wildlife may also result from causes such as collisions with vehicles, poisoning, accidents, and hunting. Therefore, sensory disturbances to, and direct mortality of wildlife which is induced by a development project will ultimately affect the size of wildlife populations.

The change in population size which will result from habitat avoidance will depend on the amount of habitat avoided, the season and duration of avoidance, and the number of animals normally dependent upon the habitat which is avoided. The numbers of animals which undergo stress reactions to sensory disturbances or are killed or injured by collisions with vehicles will depend upon the density of animals expected to be in the

vicinity of disturbances and the types and magnitude of disturbances which are produced by the specific development project.

It is evident, therefore, that two major types of baseline data are required to enable documentation of the impacts which any development project will produce on large mammal populations: (1) a knowledge of the seasonal population dispersion (distribution, habitat use, and movements) in relation to the proposed project and (2) a knowledge of the susceptibility of wildlife species to disturbances (sensory disturbances, habitat alterations) produced by the proposed project.

We anticipate that the most significant impacts which oil sands development will have on large mammal populations will be those resulting from habitat loss or alteration; this will include habitat made unuseable by terrain alterations and intolerable sensory disturbance. Therefore, a knowledge of the seasonal density of each species of large mammal within each of the habitat types on the AOSERP study area and of the sphere of influence of various types of sensory disturbance are considered to be the most critical data required to allow documentation of the impact of oil sands developments on large mammals.

1.1.2 Evaluation of Impacts

Once the impacts produced by a development project have been documented their significance must be evaluated. The most meaningful and practical way to evaluate environmental impacts on large mammals is to consider the magnitude and duration of changes in population numbers.

Not all changes in population size are reasons for concern. Natural fluctuations in population size occur within each year as a result of mortality of some animals and production of young, and between years as a result of the imbalance between mortality and recruitment. As populations and ecosystems are adapted to these natural changes in population size, their

structural and functional integrity is not threatened by changes of the magnitude and duration that they experience under natural conditions. Therefore, changes in population size induced by man's activity which do not increase the amplitude of population fluctuations beyond their natural limits can be considered of minor significance to populations and ecosystems; major impacts are those which do increase population fluctuations beyond their natural limits.

To determine whether an impact on an animal population is likely to be major or minor, the expected magnitude and duration of population change must be compared with the population dynamics of the population. A minor impact on a species characterized by a high reproductive potential and large fluctuations in population levels could involve a much greater proportion of the population than a minor impact on a species characterized by a low reproductive potential and small fluctuations in population levels.

It is evident, therefore, that a knowledge of natural fluctuations in population levels, which can include a knowledge of aspects of population dynamics, such as the annual recruitment and mortality rates and the reproductive potential, is essential in the evaluation of impacts produced by any project. Therefore, this report will review the current state of knowledge of population dynamics of woodland caribou, moose, and wolf; these data are required to allow an evaluation of impacts produced by any oil sands development which may occur on the AOSERP study area.

1.1.3 Summary

The three basic types of biological data which are required to complete the documentation and evaluation of impacts of oil sands developments on large mammals are:

1. Knowledge of the seasonal population dispersion (including the distribution, habitat use, and movement patterns of individuals of the population),

2. Knowledge of the potential impacts of development projects (including effects of sensory disturbances, agents of direct mortality, and habitat alterations), and
3. Knowledge of the population dynamics (including density, natality, and mortality).

The data available for each species of large mammal in the AOSERP study area will, therefore, be assessed under these three major headings. The adequacy of the available data in each category are summarized in Table 1.

Table 1. Adequacy of available data relevant to the documentation and assessment of the impacts of oil sands developments on large mammals in the AOSERP study area.

Topic	Moose	Woodland Caribou	Wolf
Seasonal Population Dispersion			
Distribution on the AOSERP Study Area	Adequate	Major Gap	Adequate
Habitat Use	Major Gap	Major Gap	Major Gap
Movement Patterns	Adequate	Adequate	Minor Gap
Potential Impacts of Development			
Sensory Disturbances	Major Gap	Major Gap	Minor Gap
Direct Mortality	Minor Gap	Minor Gap	Minor Gap
Habitat Alterations	Adequate	Adequate	Adequate
Population Dynamics			
Density	Major Gap	Major Gap	Major Gap
Natality	Adequate	Adequate	Adequate
Mortality	Adequate	Adequate	Adequate

2. MOOSE

2.1 Population Dispersion

2.1.1 Distribution on the AOSERP Study Area

The knowledge of the distribution of moose over the AOSERP study area is excellent--the moose is known to occur throughout the study area. Therefore, no studies are required to document the distribution of moose on the AOSERP study area.

2.1.2 Habitat Use

As noted in the literature review the habitat selection patterns of moose do not show significant variation throughout the range of the species; indeed, the data which have been gathered in the AOSERP study area concerning habitat use of moose are generally similar to those reported from elsewhere in the species range. Thus, current knowledge of the general habitat selection patterns of moose on the AOSERP study area is good. However, knowledge of the general habitat selection patterns do not, in themselves, provide an adequate data base for the documentation of impacts.

The number of animals lost to the population as a result of habitat loss will depend on the amount of habitat lost, the season and duration of loss, and the numbers of animals normally using the areas when the habitat is unavailable. Therefore, knowledge of the seasonal density of moose in each habitat type on the AOSERP study area is essential to be able to document the impacts of oil sands development on moose. The data collected within the AOSERP study area concerning the seasonal density of moose in each habitat type are not adequate to complete an assessment of the impact of oil sands development.

The data necessary to determine the level of habitat use is the proportion of time spent in each habitat type by members of a population during each season. The use of any direct observation method (i.e., aerial survey, radio-relocations, etc.) to determine the level of habitat use is subject to

considerable error since each relocation or observation point consists, in essence, of the fact that an animal was in a specific cover type at a specific time. Therefore, unless continuous records are kept of the location of the animal, the data may not reflect the actual time spent by the animal in each cover type; this is especially true where the relocation points are not taken in a highly systematic manner in all seasons, at all times of day, and in all weather conditions. Additional problems may occur if the data are gathered from a study sample of radio-collared animals which do not reflect the age and sex composition of the general population. The majority of the habitat selection work which has been conducted on the AOSERP study area has been done by means of direct observation.

Nowlin (in prep.) reports on the habitat use of moose in the AOSERP study area as determined by radio-telemetry. This study has several major weaknesses. The study was based upon a total of 95 relocations of six mature moose (four females and two males) during the fall period and 116 relocations of 10 mature moose (seven females and three males) during the winter period. Therefore, the data base of this study must be considered to be extremely limited, and probably inadequate, especially in view of the complicated analysis which was subsequently performed (10 habitat types x 4 categories of use x 2 seasons). Nowlin (in prep.) himself comments on the inadequate sample sizes obtained. The data base consisted of radio-relocations which were gathered only during the daylight period, yet Nowlin (in prep.) shows that moose select different habitat types for bedding than for other activities; therefore, the data do not accurately reflect the daylong level of habitat use. The study population (radio-collared animals) does not appear to reflect the age and sex ratios which occurred in the population, since no calves or yearlings were represented; moreover, the composition of the study sample was itself altered during the course of the study. The accuracy of the radio-relocations points was apparently only to within 30 m; this was often insufficient to accurately place the moose within a specific habitat type since more than one

type often occurred with a 30 m radius of the point. The study was conducted only during the fall and winter period and the winter was considered to be atypical due to a lack of snow cover (Nowlin in prep.). Similarly, the moose habitat selection data reported by Hauge et al. (in prep.) suffer from the general problems associated with radio-telemetry studies of hab itat use: the relocation data do not appear to have been collected in a systematic manner and are therefore, not representative of the entire study period; the numbers of relocations are generally small; and the study population was not representative of the population in the study area.

It should also be stressed that the vegetation of the AOSERP study area had not been mapped at the time when all of the above data concerning moose habitat use were collected. In most instances the habitat types defined during studies of moose habitat use on the AOSERP study area are not equivalent to those which were ultimately mapped by Thompson et al. (1978). Therefore, the habitat use data which are available cannot be strictly related to the existing vegetation maps of the AOSERP study area and, thus, may not be used as the basis for an integrated evaluation of the effects of oil sands development based upon the vegetation maps of the study area.

Because of the problems which are discussed above we consider that none of the studies which has been conducted to date are adequate to determine the relative level of use of each habitat type by moose on the AOSERP study area and that a study is required to fill this data gap prior to completion of a documentation of the impacts produced by development of oil sands areas.

2.1.3 Movement Patterns

The knowledge of movement patterns of moose on the AOSERP study area appears to be adequate for an assessment of the effects of oil sands development. As noted in the literature review (Thompson et al. in prep.) the movement patterns of moose in the AOSERP study area conform to the basic movement patterns

which have been reported for other populations of moose inhabiting areas similar to the AOSERP study area. Therefore, no further data are required to document the effects of oil sands developments on moose.

2.2 POTENTIAL IMPACTS OF DEVELOPMENT PROJECTS

2.2.1 Sensory Disturbances

Knowledge of the reactions of moose to various forms of sensory disturbance appears to be almost totally lacking (see Thompson et al. in prep.). Few quantitative data exist concerning the reactions of moose to various sources of sensory disturbances which will occur during oil sands development (mobile equipment, stationary equipment, human presence). In general, the responses of most species of ungulates to sensory disturbances appear to be basically similar. It is, therefore, unlikely that the reactions of moose to disturbance are substantially different from those of other ungulates (Thompson et al. in prep.). However, the data which are available concerning either the sphere of influence or the magnitude of the effects of various forms of sensory disturbances on moose are not generally adequate to complete an analysis of the effects of oil sands development. As noted in the literature review, sensory disturbances will produce two major effects: (1) alteration of the energy which is expended by the animal as a result of stress reactions and (2) avoidance of habitat because of intolerable sensory disturbances. It is our opinion that the most significant effect which the sensory disturbances that are associated with oil sands development will produce will be to reduce the availability of habitat due to avoidance of areas by moose. Therefore, we consider that a major data gap exists and that a study should be initiated to document the sphere of influence of various sources of sensory disturbance within which the use of habitat by moose will be affected and the magnitude of the effect of these disturbances. These studies will be required prior to completion of an analysis of the effects of oil sands developments on moose.

2.2.2 Direct Mortality

Direct physical harm causing death of or injury to animals may result from collisions with vehicles, accidents, such as entanglement with wire, contact with or ingestion of environmental contaminants, or the recreational activities of employees of a development project.

The number of animals that are likely to die as a result of collisions, accidents, ingested toxic materials, and hunting induced by a development project cannot be objectively estimated. A guess can, however, usually be supported to some degree by experience with similar projects and a knowledge of population dispersion in relation to the proposed project. For example, it appears that the impacts which highways and similar corridors will have on ungulate populations are a function of the location of the road relative to ungulate habitat and movements as well as the operation and maintenance procedures (Thompson et al. in prep.). Similar relationships likely hold for the other forms of direct mortality; for example, the increases in level of hunting which will occur will be a function of the number of people attracted to the area by the project, the amount of increased access provided by the project, and the location of project facilities relative to areas of ungulate abundance.

Therefore, the ability to be able to estimate the magnitude of the direct mortality which will result from a development project depends primarily upon a knowledge of the seasonal population dispersion and upon experience gained from other projects.

The potential for increased moose mortality resulting from increased recreational hunting can be controlled through the development of appropriate management practices by the responsible provincial government agencies. Therefore, since we do not believe that AOSERP has a mandate to provide data for management purposes, no further research needs to be conducted on this topic. However, if AOSERP is required to provide the data required for the management of moose mortality which would result from the anticipated increase in recreational hunting, then the existing

data are not adequate and information concerning the following knowledge gaps is required: (1) the current levels of hunter harvest, (2) the anticipated increase in hunter harvest induced by oil sands developments, and (3) the harvestable surplus of moose on the AOSERP study area.

Thus, although we have identified a minor gap as existing in knowledge of this factor (Table 1), this gap will be adequately filled once additional data concerning the seasonal population dispersion, particularly the habitat use, of moose are collected.

2.2.3 Habitat Alterations

The major types of habitat alterations which will occur on the AOSERP study area will relate to vegetation removal (e.g., clearing and strip-mining); these areas will eventually be reclaimed, producing, in essence, early seral vegetation. Other areas of vegetation destruction (e.g., fire) may not be reclaimed; these disturbances will also result in early seral habitat. It is well known that vegetation alteration which produces seral habitats typically results in increased local densities of moose once browse production has increased sufficiently (Thompson et al. in prep.). What is not known however, is the efficiency of revegetation with respect to the creation of moose habitat, what effect, if any, moose browsing will have on the success of a reclamation project, and whether moose populations can be enhanced through the selection of an appropriate reclamation plan. We recommend that research be initiated to determine the efficiency of reclamation with respect to the creation of habitat, the effects of moose on a reclamation program, and the effects of the reclamation program on the moose population.

The effect of physical alterations of habitat (e.g., roads) is not well known. However, the major impacts of physical alterations are likely to be due to the associated sensory disturbances. Moose appear to be relatively sedentary, and any movements which occur are undertaken by individual moose rather than in herds as a population. Therefore, the potential for

physical alteration to produce barriers to movement of moose or to alter tha ability of moose to exploit the habitat is relatively small.

2.3 POPULATION DYNAMICS

2.3.1 Density

The density of moose within the AOSERP study area appears to have been documented only in selected portions of the study area, primarily the Bitumount area and Syncrude Lease No 17; it appears that there has never been a systematic survey of the entire AOSERP study area. Therefore, the relative density of moose in various portions of the study area is not known. Despite the fact that the data which are available appear to be in close agreement (Thompson et al. in prep.) we feel the potential for variation in density of moose within the various physiographic regions of the study area, and therefore the potential for variation in the level of impact which would result from development, is sufficient to justify completion of a study designed to determine the relative density of moose within various portions of the AOSERP study area.

2.3.2 Natality

We feel that sufficient baseline data are available concerning the natality of moose to complete an analysis of the impacts of oil sands developments on moose. As noted in the literature review, the productivity of most North American moose populations is relatively similar (Thompson et al. in prep.). The moose is a species which is adapted to the exploitation of rapidly created seral habitats and is capable of rapid recovery from natural or man-induced reductions in population levels; moose populations naturally experience great fluctuations in population density, which appear to be related to the quality of the available habitat (Thompson et al. in prep.). Thus, the productivity of moose populations is potentially great and natality is responsive to changes in habitat availability.

2.3.3 Mortality

The data concerning mortality of moose on the AOSERP study area appears to be adequate to complete an analysis of the impact of oil sands development on moose populations. Fuller and Keith (in prep. a) conclude that hunting accounts for almost all of the mortality, exclusive of wolf predation, sustained by the moose population of the Muskeg River drainage. Since the moose population of the AOSERP study area appears to be stable or slightly declining (Hauge et al. in prep.) it would appear that the population is currently sustaining a maximum level of harvest. Therefore, it appears that a potential exists for overharvest of moose by hunters, particularly in view of the increased human populations in and ease of access to the study area which would result from any development. However, as noted earlier (see 2.2.2), since regulations could be formulated by the responsible provincial agencies to prevent any such overharvest, we do not feel AOSERP requires further data on this aspect of moose mortality.

2.4 SUMMARY

In summary, we consider that the following data gaps exist, and remain to be filled before a documentation and assessment of the impacts of oil sands developments on moose could be completed:

1. A major data gap exists in knowledge of the seasonal level of use of each habitat type on the AOSERP study area,
2. A major data gap exists in knowledge of the sphere of influence which the various types of sensory disturbances have on moose, and
3. A major data gap exists in knowledge of the relative density of moose in all portions of the AOSERP study area.

It appears that the major thrust of the research which has been carried out on the AOSERP study area has been toward gaining a knowledge of population dynamics of moose. The data

on population dynamics of moose are excellent and will allow evaluation of impacts to be completed; however, relatively little effort appears to have been expended in gathering the types of data which are relevent to the inital documentation of the impacts. Therefore, most of the data gaps occur under the topics of seasonal population dispersion and susceptibility to impact from development. Research proposals have been included which will provide data relevant to these gaps.

3. WOODLAND CARIBOU

3.1 POPULATION DISPERSION

3.1.1 Distribution on the AOSERP Study Area

Current knowledge of the distribution of woodland caribou on the AOSERP study area is not adequate to document the impacts which would result from oil sands development. Fuller and Keith (in prep. b) studied the woodland caribou in the Birch Mountains and report that caribou are also present in the extreme southern part of the AOSERP study area; however, occurrence of woodland caribou in the remainder of the study area does not appear to have been documented. We therefore feel that a study should be conducted to document the occurrence of woodland caribou within the AOSERP study area.

3.1.2 Habitat Use

The available data concerning habitat use of woodland caribou in the AOSERP study area are not adequate to complete an assessment of the impact of oil sands development projects. The reasons for this assessment are similar to those outlined in the assessment of adequacy of moose habitat use data (2.1.2): (1) the data were collected by means of direct observation, (2) sample size is limited, (3) data were not systematically collected, (4) the sampling basis (radio-tagged caribou) does not appear to be representative of the entire population in terms of their age and sex ratios, and (5) the vegetation communities used during collection of habitat use data were not those which were ultimately mapped and may not be equivalent to the vegetation communities which were mapped.

However, as was the case for moose, the general pattern of habitat selection by woodland caribou in the AOSERP study area appears similar to that reported from elsewhere in the species range. Thus, the major data gap which remains is to determine the proportion of time which is spent by woodland caribou in each habitat

type on the AOSERP study area during each season (seasonal density). However, until the distribution and density of woodland caribou is established for various portions of the study area, we cannot recommend that a woodland caribou habitat use study be conducted; such a study is likely not warranted unless populations of caribou exist in those areas of the AOSERP study area which will be subject to development activities.

3.1.3 Movement Patterns

Current knowledge of woodland caribou movements on the AOSERP study area appears to be adequate for an analysis of the effects of oil sands development. Movements of woodland caribou appear to be relatively small in extent and are undertaken independently by individuals rather than as a herd by the entire population (Thompson et al. in prep.). Therefore, no further studies concerning movements of woodland caribou are required.

3.2 POTENTIAL IMPACTS OF DEVELOPMENT PROJECTS

3.2.1 Sensory Disturbances

Current knowledge of the reactions of woodland caribou to various forms of sensory disturbance appears to be almost totally lacking (see Thompson et al. in prep.). Considerable quantitative data exist concerning the reactions of barren-ground caribou; however, even for the barren-ground caribou few quantitative data exist concerning the sphere of influence or magnitude of the effects of various forms of sensory disturbance. Moreover, the applicability of behavioural data collected concerning the barren-ground caribou, dwelling in open habitats, to woodland caribou, dwelling in forested habitats, is questionable. Therefore, a major data gap exists in our knowledge of the effects of sensory disturbances on woodland caribou. Despite the fact that this data gap exists, the requirement for further studies designed to fill this gap cannot be assessed prior to a knowledge of the distribution and density of woodland caribou in the AOSERP area; such studies are likely not warranted if woodland caribou

populations are confined to portions of the AOSERP study area which are not likely to be subject to development.

3.2.2 Direct Mortality

As detailed in the section concerning direct mortality of moose (2.2.2) the ability to estimate the magnitude of direct mortality which will result to woodland caribou from oil sands development depends primarily upon a knowledge of the seasonal population dispersion and upon experience gained from other projects.

Any potential impacts which would result to woodland caribou populations from increased recreational hunting could be easily mitigated by the development of appropriate management plans by the responsible government agencies. Therefore, since we do not believe that AOSERP has a mandate to provide data for management purposes, no further research needs to be conducted on this topic. However, if AOSERP is required to provide the data required for the management of woodland caribou mortality which would result from the anticipated increase in hunting, then the existing data are not adequate and information concerning the following knowledge gaps is required: (1) the current levels of hunter harvest, (2) the anticipated increase in hunter harvest induced by oil sands developments, and (3) the harvestable surplus of woodland caribou on the AOSERP study area.

3.2.3 Habitat Alterations

As noted in the section concerning habitat alterations for moose (2.2.3) most habitat alterations on the AOSERP study area will result in seral habitats; it is well established that this will be detrimental to woodland caribou populations (Thompson et al. in prep.).

The effects of physical alterations, such as roads, is not well known. However, since the major effects of such alterations typically result from the production of barriers to or deflections of movements and since woodland caribou on the AOSERP

study area are relatively sedentary (Thompson et al. in prep.) the potential effects of physical alterations will likely be confined to the loss of habitat required to construct them and the associated sensory disturbances.

Therefore, the data base concerning habitat alterations appears to be adequate.

3.3 POPULATION DYNAMICS

3.3.1 Density

The density of woodland caribou within the AOSERP study area has been documented only for the Birch Mountains area despite the fact that woodland caribou are known to exist elsewhere in the study area (Thompson et al. in prep.). We feel that the potential for variation in density of woodland caribou within the various physiographic regions of the study area, and, therefore, the potential for variation in the level of impact which would result from development, is sufficient to justify completion of a study designed to determine the relative density of woodland caribou within various portions of the AOSERP study area. Moreover, the results of such a study will be required prior to assessment of the requirements for further studies concerning the habitat use of, and effects of sensory disturbances on, woodland caribou.

3.3.2 Natality

Current baseline data concerning natality of woodland caribou are sufficient to complete an analysis of the impacts of oil sands developments. As noted in the literature review, the productivity of woodland caribou populations does not appear to show much variation (Thompson et al. in prep.). Therefore, while little data are available from within the AOSERP study area, natality rates which have been documented for other caribou populations are likely applicable and sufficient.

3.3.3 Mortality

Fuller and Keith (in prep. b) indicate that the woodland caribou population on the AOSERP study area may be declining. As noted in the literature review, wolf predation and human hunting are generally thought to be major factors influencing the growth of caribou populations (Thompson et al. in prep). Fuller and Keith (in prep. a, b) consider predation by wolf is probably a minor mortality factor, while natives from Fort MacKay probably kill no more than 5 to 10 caribou per winter over the entire study area. It appears, therefore, that the current mortality levels of woodland caribou are either at or just above the maximum level which can be supported. Therefore, it appears that a potential exists for overharvest of woodland caribou by hunters, particularly in view of the increased human populations in, and ease of access to, the study area which would result from any development. However, as noted earlier (see 3.2.2), since regulations could be formulated by the responsible government agencies which would prevent any such overharvest, we feel that no additional data are required by AOSERP.

3.4 SUMMARY

In summary, we consider that the following data gaps exist and remain to be filled before a documentation and assessment of the impacts of oil sands developments on woodland caribou could be completed:

1. A major gap exists in knowledge of the distribution of woodland caribou on the AOSERP study area, and
2. A major gap exists in knowledge of the density of woodland caribou in various portions of the AOSERP study area.

A research proposal has been included in this report to provide data relevant to these knowledge gaps.

If data on the distribution and density of woodland caribou indicate that populations exist in portions of the AOSERP study area where they would be subject to the effects of oil sands development,

then two other major data gaps would exist and remain to be filled before documentation and assessment of the resulting impacts could be completed:

1. A major data gap exists in knowledge of the seasonal level of use of each habitat type on the AOSERP study area, and
2. A major data gap exists in knowledge of the reactions of woodland caribou to sensory disturbances and the sphere of influence of the various types of sensory disturbances.

Research proposals concerning these data gaps have been deferred pending data on the distribution and density of the woodland caribou on the AOSERP study area.

4. WOLF

Population studies of wolves began in October 1975 in the Swan Hills of central Alberta. Techniques were developed for conducting wolf and prey base research, including radio-tracking of individuals and scat analysis, which were then applied to research conducted on the AOSERP study area in north-eastern Alberta, starting in March 1976. Research efforts were terminated during the fall of 1976 in the Swan Hills, while they continued until December 1977 in the AOSERP area (Fuller and Keith in prep. a, c).

The specific objectives of these investigations were to determine wolf densities, distribution and movements relative to both moose and woodland caribou populations, rates and principal determinants of natality and mortality, food habits of wolves, and their predation rate on the large ungulates. The stated purpose was to quantify wolf-ungulate interactions for management (Fuller and Keith in prep. a).

The purpose of this critique is not to assess whether Fuller and Keith attained their objectives, but to evaluate the state of completion of baseline research in the AOSERP study area with respect to the data required to evaluate an assessment of the impact of large development projects on wolves. As with the moose and woodland caribou research, there are three types of biological data needed to document and assess the impact of oil sands development: seasonal population dispersion, the potential impacts of large development projects, and the population dynamics.

4.1 SEASONAL POPULATION DISPERSION

As discussed in the critiques of moose and woodland caribou research, there are three major facets of seasonal population dispersion which must be considered: distribution, habitat use, and movements. Because wolves prey upon ungulates that prefer to forage in certain types of habitat, they are indirectly associated with the habitats preferred by their prey. This renders an interpretation of seasonal population dispersion of wolves in a broader manner than for the moose and woodland caribou.

4.1.1 Distribution on the AOSERP Study Area

Wolves are known to occur throughout the AOSERP study area as evidenced by general observations and from trapper responses to a questionnaire (Fuller and Keith in prep. a, c). On the comparative study area, Swan Hills, wolves also appeared to be widely distributed (Fuller and Keith in prep. c). Wolves remain in the study areas throughout all seasons. Therefore, there is no requirement for additional data concerning distribution of wolves.

4.1.2 Habitat Use

As indicated in the literature review, there are considerable differences between summer and winter in food habits, foraging movements, territory size, and general activity of wolves, and in many cases these differences can be related to differences in the availability of prey within the pack territory (Banfield 1951; Jordan et al. 1967; Pimlott et al. 1969; Mech 1970; Van Ballenberghe et al. 1975; Voight et al. 1976; Mech 1977a, b, c; Theberge et al. 1978). In other words, the wolves respond to the habitat-related differences in the prey base. Furthermore, during the summer, wolves are tied to specific types of habitats which provide suitable pup-rearing areas--den sites and rendezvous sites (Joslin 1967; Kolenosky and Johnston 1967; Carbyn 1974). Therefore, any consideration of "habitat use" by wolves must deal with prey use, as well as specific habitat use for pup-rearing.

Knowledge of habitat and prey use is of cardinal importance for making any assessment of the impact of a large development on wolves because all such developments involve some degree of habitat disturbance, both in construction and operation of the development project itself, and in ancillary support developments. Not only must one know the natural variation in specific habitat use of the wolf, but one must also know the habitat use preferences of the wolves' prey for changes in habitat availability may affect prey availability, which has a direct effect upon the wolf population dependent on that prey base.

Investigations of the habitat use of wolves during the Swan Hills supplementary study were essentially nonexistent. No description of the habitats in which radio-collared wolves were located was provided nor was there any attempt to relate the occurrence of wolves to the habitat use of the prey. Food habits analysis was extremely cursory, and due to the inability of the researchers to locate any pup-rearing areas, the variability of the diet was not adequately examined. Both the Swan Hills and the AOSERP study area are composed largely of boreal mixedwoods, but due to the inadequate data gathering at the former location, the objective of developing a comparative approach (Fuller and Keith in prep. a, c) was not fulfilled. Therefore, the analysis of habitat use of wolves in the boreal mixedwood region in Alberta depends upon data collected in the AOSERP study area.

Even in the AOSERP study area, where research efforts were concentrated, little information was gathered on baseline habitat use and food habits. Most of the useful information on wolf population ecology was obtained from one pack out of 18 packs postulated for the entire AOSERP study area (Fuller and Keith in prep. a, c). Fuller and Keith report that radio-collared wolves' locations were mapped, distances between locations computed, and one rendezvous site located and examined. However, they do not present either a map of locations, or a table of distances moved within the pack territory, nor do they describe the rendezvous site, indicate its location, or the availability of such sites within the pack territory.

Spot locations obtained using radio-tracking methods are useful for habitat analysis only if a large sample size is obtained which includes good representation from all periods of the day and throughout the year. During the winter, observations of wolf-killed moose and their locations in a pack territory would indicate the importance of certain localities as foraging areas for the wolves. For the purpose of establishing pack home range, it is adequate to obtain locations once daily, or even less

frequently as Fuller and Keith (in prep. a) have done for one pack in the AOSERP study area. Regarding the locations of wolf-killed moose, Fuller and Keith (in prep. a) state that 81 percent of these occurred in lowland areas, despite substantial (40 percent to 61 percent) distribution of moose in upland areas (Hauge et al. in prep.). This is a significant observation, but in order to fully relate wolf predation to moose distribution, a more detailed habitat analysis for locations of kills and living animals is required. It is inadequate simply to describe wolf radio-relocations as occurring in upland habitat types (49 percent), lowland habitat types (41 percent), and cutlines (10 percent) as Fuller and Keith (in prep. a) have done.

Investigations of the summer habitat use of wolves on the AOSERP study area were conducted only indirectly through scat analysis for diet. Only three pup-rearing areas were examined in the entire 25,000 km^2 study area; one den site and two rendezvous sites were examined. This is an inadequate sample to accurately reflect the diet and, hence, the dependence of the wolves upon prey utilizing different habitats. The abundance and availability of prey has been shown to largely determine the abundance of and health of wolves depending upon that prey base (Thompson et al. in prep.). It was also shown in the literature review that summer food habits are rather variable. With a biological parameter that exhibits considerable variation, such as diet, it is essential to sample the variability adequately in order to fully comprehend the interelationships involved.

The physical characteristics of den sites and rendezvous sites, as discussed in the literature review, indicate selection for certain types of areas for rearing of pups. The abundance and continuing availability of such locations are critical to the successful breeding of a wolf pack. These facets of pup-rearing sites were not examined by Fuller and Keith (in prep. a, c).

It is clear, then, that habitat use is an important facet of wolf population ecology. However, due to inadequate treatment in past studies, habitat use represents a major gap

in the baseline knowledge of wolf populations in the AOSERP study area. Further investigation is required in order to complete the research needed to evaluate an assessment of the impact of oil sands development on wolves.

4.1.3 Movements

Wolves do not make long distance, *en masse* migrations except in areas where they follow ungulate prey that make extensive migrations (Cowan 1947; Kuyt 1972). In areas where the prey is relatively sedentary, as in the AOSERP study area, wolves generally remain within the pack territory, although movements inside the territory are quite extensive for hunting their ungulate prey (Mech 1966, 1970; Kolenosky and Johnston 1967). Pathways for hunting wolves consist of ridges, lake shores, river valleys, frozen watercourses, ungulate trails, cutlines, road verges and other man-made trails (Stenlund 1955; Mech 1970; Peters and Mech 1975).

A proliferation of man-made trails may change the pattern of wolf movements when hunting; however, as wolf movements do not commonly follow a predictable or regular pattern (Mech 1970) this is unlikely to be an area of concern. The selection of prey in specific habitats is of more concern and the end result of movements by wolf packs.

No data are presented on wolf movements in the AOSERP study area, except for mean daily distances travelled in winter (9.0 km) and mean distances between winter wolf kills (43 km) (Fuller and Keith in prep. a). Fuller and Keith document a high use of cutlines, as demonstrated by radio-relocations, which is in agreement with the general literature.

Movements are not a major area of concern with wolf packs that establish territories within which they conduct all their activities. Therefore, despite an absence of much information for the AOSERP study area wolves, only a minor gap exists in the baseline knowledge of wolf movements. As a result of investigations into habitat use by wolves, the salient points of wolf movement

could be obtained to fill this minor gap and, consequently, aid in completion of research necessary for assessment of the impact of oil sands development on wolves.

4.2 POTENTIAL IMPACTS OF DEVELOPMENT PROJECTS

4.2.1 Sensory Disturbances

Little information has been published concerning the effects of sensory disturbances on wolves. Carbyn (1974) suggested that wolves may have initially tended to avoid busy highways in Jasper National Park since, despite the fact that elk and deer frequently travelled along road-edges, wolves rarely killed prey in these areas. However, wolves seem to have become accustomed to highways as the number of wolves scavenging at road kills along the major highways in Jasper National Park has increased in recent times. Wolf predation along highways was observed only along the highways with much less traffic in Jasper National Park (Carbyn 1974). Mech (1966) discovered that wolves readily become accustomed to the regular flight of a small plane above them.

Sensory disturbances are unlikely to directly effect a significant change in wolf behaviours. One exception is the effect of increased human activity near den sites; such activity and increased vehicular traffic have been associated with the desertion of three out of four traditional den sites found deserted in Jasper National Park (Carbyn 1974). Further, there may be an indirect effect upon wolves arising from sensory disturbances, significantly disrupting distribution patterns of the prey. This indirect effect apparently has not been examined in wolf studies in general.

No investigation of the potential impact on wolf populations of sensory disturbances produced by oil sands development has been conducted (Fuller and Keith in prep. a, c). However, this represents only a minor gap in knowledge, since the concern is basically with the changes which may occur in the distribution

of prey. This is comparable to the effect that habitat alterations might have on prey availability and is discussed under the topic of habitat alterations. Therefore, an extensive study of the direct effects of sensory disturbance upon wolves is probably not warranted.

4.2.2 Direct Mortality

There are two major mortality factors that may increase with development. One is accidental death, which may occur as a result of increased traffic on transport corridors in the development area or from other hazards. Wolves killed by vehicles are an uncommon mortality factor, the rate of which will depend upon the frequency and speed of vehicles on the roads, the frequency of road-killed prey animals to which the wolves are attracted for scavenging, and the density of the wolf population in the area. On 120 km of two major highways passing through Jasper National Park, less than one wolf was killed per year (Carbyn 1974). Such mortality levels are insignificant, although, because wolves are killed when scavenging, an increased dependence on such food sources may result in increased mortality.

The second major mortality factor that may change with development is human exploitation. An increased human population base may result in more wolves being taken. Over-exploitation resulting in strong population depression has been recorded for some Alaskan wolf populations (Rausch 1969; Stephenson 1978), but the wolf populations can return to former levels with proper management (Stephenson 1978). Fuller and Keith (in prep. a) did not report any accidental or road deaths of wolves, but did determine that trappers took between 15 and 20 wolves annually.

Management-related problems, such as potential increased exploitation of wolves, appear to fall outside of AOSERP's mandate. Further, since road deaths and other accidental mortalities appear to be generally uncommon, there is only a minor gap in the direct mortality information required to evaluate an assessment of the

impact of oil sands development. Further study of direct mortality factors could be limited to documenting any occurrences of accidental deaths and identifying sources of mortality in the development area.

4.2.3 Habitat Alterations

As indicated above, this is probably the single, most important aspect of wolf population ecology that should be considered when examining the impact of development projects. This is also the area where least is known of the effects on a wolf population. With regard to oil sands development, the primary concern is with the complete removal of habitat as a result of open pit mining methods and tailings pond construction.

The direct result of such habitat removal is likely to be loss of prey to the packs whose territories are overlapping the development area. Such a loss may be in direct proportion to the density of the prey animal. It is known that wolves occur in low densities in areas with low ungulate prey densities (Banfield 1951; Stenlund 1955; Mech 1970), and also that wolf populations will decline if a major decline occurs in its primary ungulate prey population (Fau 1977; Mech 1977a, b, c). As inferred earlier, sensory disturbance of prey animals may produce results comparable to habitat alteration by frightening animals from suitable habitat. The end result to wolves is the same as habitat removal.

Habitat alteration may also bring about changes which increase interpack interaction. Social strife has been known to increase when wolves were forced, by a decline in prey, to trespass frequently (Mech 1977a, b, c). Mortality that occurs as a result of interpack strife is generally quite low (Mech 1970), but due to the social infrastructure of a wolf population an artificial disruption in prey density may affect mortality of wolves more heavily through social stress than through starvation.

On the other hand, habitat alterations which result in the production of seral vegetation communities would result

in increased moose populations. Therefore, some forms of habitat alterations may also be beneficial to wolves.

A further concern with habitat alteration concerns the removal of traditional pup-rearing areas, which would clearly affect wolf packs to some degree. A wolf pack in any one year may use more than one den site for breeding and often uses several rendezvous sites for pup-rearing (Joslin 1967; Mech 1970). While a wolf pack may not be restricted to only single, critical sites, the abundance and availability of such important pup-rearing sites may be critical and possibly could be affected by habitat alteration.

As noted above, Fuller and Keith (in prep. a) do not deal at any length with habitat use by wolves. In order to fully assess the effect of habitat alteration, considerable effort must be expended upon analysis of habitat use and habitat availability. Therefore, there is a major gap in knowledge of the potential impact of oil sands development with regard to habitat alterations. Further study is needed to examine this aspect of the baseline knowledge required to evaluate an assessment of the impact of oil sands development on wolves.

4.3 POPULATION DYNAMICS

Baseline knowledge on the population dynamics of wolves is of primary importance to the evaluation of documented or potential impact. This information is required for comparison with the natural fluctuations with which wolf populations are able to cope. The major components of population dynamics are density, mortality, and natality.

4.3.1 Density

Fuller and Keith (in prep. c) determined the density for the Swan Hills wolf population to be 1 wolf per 65 km^2 and for the AOSERP study area to be 1 wolf per 100 km^2. Subsequent research (Fuller and Keith in prep. a) indicated that the density on the AOSERP study area was 1 wolf per 165 km^2. In neither report do Fuller

and Keith provide adequate detail of their results, to permit an evaluation to be made of the accuracy of their density estimates. Observations of groups of wolves reveal that packs are often split up and that radio-tracking methods are often essential to obtain pack numbers (Van Ballenberghe et al. 1975; Mech 1977a, b, c). More widespread radio-tracking would be required to establish pack numbers and the territory sizes in the AOSERP study area.

On the basis of estimates by Fuller and Keith (in prep. c, d) and Hauge et al. (in prep.) the ratio of wolves to moose, the primary ungulate prey, is 1:100 in the Swan Hills and 1:53 in the overall AOSERP study area (1:32 for an intensively studied pack). The early estimate of 1:20 for the wolf:moose ratio on the AOSERP study area (Fuller and Keith in prep. c) was apparently too low. The less favourable ratio for the AOSERP study area wolf population reflects the larger territories occupied by packs and indicate that this population would be more severely affected by the impact of a large development project than would a population in Swan Hills.

Because of the unsupported documentation of most pack sizes and nearly all territory boundaries, it appears that there is a major gap in the knowledge of the true population density of wolves in the AOSERP study area. Therefore, further study is warranted to complete baseline research required for impact assessment.

4.3.2 Natality

The natality of wolves has been examined for a number of North American populations. The average litter size per adult female wolf ranges from 4.0 to 6.5 (Mech 1970). The proportion of females that successfully breeds in a population may vary from 59 percent in a population under natural control (Pimlott et al. 1969) to 89 percent in an exploited population (Rausch 1969). Wolves, therefore, have the reproductive potential to reproduce at a faster rate than their ungulate prey and will

respond to exploitation by increasing the number of young. Age class data suggest that increased survival of pups (less *in utero* or early post-natal mortality) occurs in exploited populations (Mech 1970).

Fuller and Keith (in prep. a, c) obtained information on litters in three packs. Average litter size of young pups was 4.6. No further productivity data were gathered. However, because it has been shown that wolves generally have a substantial reproductive potential and have been able to rapidly reproduce after severe over-exploitation (Stephenson 1978), further investigation of natality is not needed on the AOSERP study area. Essentially no data gap exists for natality in so far as the need for baseline research to assess the impact of oil sands development has been satisfied through general literature.

4.3.3 Mortality

Factors of mortality, other than human exploitation, are widespread and should not change as a result of large development projects. Numerous factors have been recorded, such as disease, parasites, malnutrition, and hunting hazards (Mech 1970), but it has been impossible to provide much information on the proportion of a wolf population that dies from these various factors. Generally, there does not appear to be a large mortality rate caused by these natural mortality factors (Mech 1970).

Fuller and Keith (in prep. a, c) documented the death of a litter of three pups for unknown causes, one adult that apparently died of starvation, and another that was likely killed by a resident pack. In addition to these deaths, an average of 15 to 20 wolves were trapped annually on the AOSERP study area. Further deaths undoubtedly occur from natural mortality factors in the AOSERP study area, but they are likely to be minimal especially compared with the trapping mortality. The responsibility for management of wolf populations does not rest with AOSERP; any potential for overharvest of wolves resulting from increased access or human populations could be easily mitigated by adoption of an appropriate management plan by the

responsible government agency. Therefore, since we do not believe that AOSERP has a mandate to provide data for management purposes, no further research needs to be conducted on this topic. However, if AOSERP is required to provide the data needed for the management of wolf mortality which would result from the anticipated increase in access and human populations, then the existing data are not adequate and information concerning the following knowledge gaps is required: (1) the current levels of hunter harvest, (2) the anticipated increase in hunter harvest induced by oil sands developments, and (3) the harvestable surplus of wolf on the AOSERP study area. Further investigation of the mortality of wolves on the AOSERP study area is probably not necessary. Adequate knowledge is currently available from local and general literature concerning the mortality of wolves.

4.4 SUMMARY

In summary, we consider that the following data gaps exist and remain to be filled before a documentation and assessment of the impacts of oil sands developments on wolves could be completed:

1. Habitat use by wolves, specifically related to habitat and prey distribution, and to the nature of movements within pack territories;
2. Potential impact of development projects primarily through habitat alteration and secondarily through sensory disturbances upon prey as well as wolves, and through direct mortality; and
3. Population density, specifically pack sizes, territory sizes, and number of packs as they reflect upon population dynamics.

A proposal for studies which will provide data concerning each of these data gaps has been included in this report.

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6. APPENDICES

Our assessment of the adequacy of current baseline data has revealed that gaps exist in the baseline data which are currently available for the AOSERP study area which we feel are required for documentation and evaluation of the impacts of oil sands development on moose, woodland caribou, and wolves. Therefore, we have attached major research proposals for studies which we feel will fill the major data gaps.

The primary thrust of AOSERP baseline research on large mammals has to date been directed towards a knowledge of the population dynamics. Therefore, the major emphasis of these proposals is toward a knowledge of the population dispersion (especially distribution and habitat use). However, in two cases, we have been able to effectively combine the required baseline studies with applied research concerning the effects of disturbance.

6.1 A PROPOSAL FOR A STUDY OF THE DISTRIBUTION AND ABUNDANCE OF MOOSE AND WOODLAND CARIBOU ON THE AOSERP STUDY AREA

6.1.1 Introduction

The state of baseline knowledge of large mammals on the AOSERP study area has been recently reviewed by Thompson et al. (in prep.); they concluded that major data gaps existed in knowledge of the relative density of moose in various portions of the AOSERP study area and in knowledge of both the distribution and density of woodland caribou within the study area. The moose surveys which have been conducted on the AOSERP study area have basically been confined to the Bitumount and Syncrude Lease site portions of the study area; however, the potential exists for significant differences in moose densities in various portions of the study area, and, therefore, in the relative magnitude of the impacts which would be produced by developments (Thompson et al. in prep.). Therefore, data concerning the relative density of moose on various portions of the AOSERP study area are required prior to completion of an analysis of the effects of oil sands development on moose.

Fuller and Keith (in prep.) conducted studies of woodland caribou only in the Birch Mountains portion of the AOSERP study area; this area was selected because caribou appeared to be more numerous in the Birch Mountains than in other portions of the AOSERP study area. Therefore, the population densities which were obtained by Fuller and Keith are not representative of the AOSERP study area. Moreover, the distribution of woodland caribou within the AOSERP study area appears to be unknown (Thompson et al. in prep.). Therefore, data concerning both the distribution and relative density of woodland caribou are required prior to completion of an analysis of the effects of oil sands development on woodland caribou. Data on the distribution and relative density of woodland caribou on the AOSERP study area are also required for an assessment of the requirement for further research on woodland caribou in the AOSERP study area (Thompson et al. in prep.).

The following approach outlines a program which will provide a scientifically sound, cost/time effective program of research which will provide data relevant to the above data gaps.

6.1.2 Objectives

The objectives of this study are:

1. To determine the distribution of woodland caribou within the AOSERP study area,
2. To determine the relative densities of woodland caribou in various portions of the AOSERP study area, and
3. To determine the relative densities of moose in various portions of the AOSERP study area.

6.1.3 Technical Proposal

Information concerning the distribution and density of woodland caribou and the density of moose in various portions of the AOSERP study area will be collected by an aerial survey during February 1979.

6.1.3.1 Subdivision of the Study Area. The AOSERP study area will be subdivided into four strata based upon the major physiographic regions represented in the area (Alberta High Plains, Saskatchewan Plain, Great Slave Plain, and Canadian Shield). These subdivisions will provide the basis for determination of the variation which exists in densities of large mammals within the study area.

6.1.3.2 Aerial Survey Methodology. A STOL equipped Cessna 185 aircraft will be used for all surveys. The primary operations base will be the AOSERP Mildred Lake Research Facility.

Transect surveys will be designed to sample the entire land mass within the study area (Figure 1) and are modelled after the method of Miller et al. (1973). Transect width will be controlled through the use of markers placed at the appropriate location on the windows and wing struts of the aircraft. The effective coverage of the study area will be 25 percent. Transects will be spaced at 3.2 km intervals with a transect width of 0.8 km. Animals will be counted as "on transect" if they are within this 0.8 km strip; animals observed outside this strip will be recorded separately as "off transect". Parallel, east-west transect lines will be flown. Surveys will be flown at 90 m above the ground and an air speed of 150 km/h.

Survey data will be recorded on portable audio-tape recorders. Each time animals or animal sign (e.g., tracks) are encountered, the observation will be recorded as a checkpoint (e.g., checkpoint 1) and the checkpoint number will be plotted on the appropriate 1:50,000 scale topographic map. For each observation, data recorded will include date, time, species, total number of animals, animal(s) on or off transect, and animal sex and age (when identified).

Survey flights will be carried out with two observers in addition to the pilot. The front right observer will assist in navigation and will plot checkpoints on the map.

6.1.3.3 Results. The observed densities of moose and woodland caribou will be calculated separately for each species within each of the four strata. The observed density will be calculated by dividing the total number of animals on transect within a stratum by the proportion of the stratum surveyed.

The data collected during the above survey will *not* provide the statistically valid estimates of population *numbers* which would be required if AOSERP's objective were to provide data for ungulate management or to conduct research into population dynamics; however, these objectives are not part of the AOSERP mandate. The data collected during the above survey *will* provide valid estimates of the relative population density which are required prior to completion of an analysis of the effect of oil sands development on ungulates. Since this is the major objective of AOSERP we have utilized fixed-wing aircraft and a line transect method of aerial survey rather than the helicopter-random quadrat census method of Cook and Jacobson (in prep.). The costs involved in utilizing the method of Cook and Jacobson (in prep.), both in terms of logistics and personnel, are much greater than are the costs for the method we have selected. Therefore, despite the fact that greater precision would result from use of the random-quadrat method, we believe that, since the level of precision of data gathered during the proposed study will be adequate for AOSERP's requirements, these significantly greater costs cannot be justified.

The final product of this portion of the study will consist of a report. The discussion of the results of the aerial survey will be addressed specifically to the objectives as outlined. This report will contain a map of the study area illustrating the transect lines flown and locations of all animals observed.

6.1.4 Literature Cited

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6.1.5 Scheduling

This study has been scheduled to begin on 1 February 1979. Field work will require 3 weeks. The final report for this study will be completed by 15 April 1979.

6.1.6 Budget

The total budget for the above survey is anticipated to be between $30,000.00 and $35,000.00, based on 1978 costs.

6.2 A PROPOSAL FOR A STUDY OF HABITAT USE AND THE EFFECTS OF SENSORY DISTURBANCES ON HABITAT USE OF MOOSE IN THE AOSERP STUDY AREA

6.2.1 Introduction

Three major types of biological data are required to complete an analysis of the responses of large mammals to oil sands development: the level of habitat use by large mammals, the potential impacts of large development projects on large mammals, and the ability of large mammal populations to recover from any losses they may sustain. Thompson et al. (in prep.) have recently reviewed the data which are available for large mammals in the AOSERP study area; they conclude that two of the major data gaps which remain to be filled prior to completion of an analysis of the effects of oil sands developments on large mammals

are data concerning the seasonal level of use of each habitat type by moose on the AOSERP study area and the effects of sensory disturbances on moose. The knowledge which is essential to determine the level of habitat use is the proportion of time spent in each habitat type during each season by members of the moose population.

The major effect which sensory disturbances will have on large mammals in the AOSERP study area is to alter their ability to utilize habitat. It has been repeatedly shown that ungulates will avoid areas where they are subject to intolerable levels of sensory disturbances, such as the noises produced by compressor stations, roadways, and various other industrial activities (Thompson et al. in prep.). However, despite the fact that the qualitative relationships between sensory disturbance and ungulate habitat use are known, virtually no quantitative studies have ever been completed concerning the effects of large developments on ungulate habitat use; the data are particularly weak concerning the effects on moose and woodland caribou. Since one of the major effects of industrial activities in the AOSERP study area will undoubtedly be to produce various sensory disturbances, a quantitative knowledge of the effects of various sensory disturbances and habitat alterations on the habitat use patterns of ungulates on the AOSERP study area is essential to the completion of an analysis of the effects of oil sands developments on large mammals. However, since both the distribution and density of woodland caribou on the AOSERP study area are unknown (Thompson et al. in prep.), a higher priority should be given to disturbance studies of moose until it is determined whether populations of woodland caribou are located in areas where they would be subject to disturbances.

This proposal outlines a program designed to quantify the level of use of each habitat type by moose in the AOSERP study area, and the effects that various types of sensory disturbances which are occurring in the AOSERP study area will have on the habitat use patterns of moose.

6.2.2 Objectives

The objectives of this study are:

1. To document the level of use of each habitat type on the AOSERP study area by moose during the winter and summer;
2. To assess quantitatively the effects of roadways, strip-mining operations, and plant operations on the level of habitat use by moose; this involves examination of the sphere of influence of these disturbances and the resultant magnitude of change of level of habitat use; and
3. To determine the significance of such disturbances to the moose population in the AOSERP study area.

6.2.3 Approach

The approach which will be used in this study is experimental: we will compare the level of use of various habitat types by moose in areas subject to various disturbances (experimental data) to the level of use of similar habitat types in undisturbed settings (control data). Both this approach and the methodology which we will employ have been successfully used in a study of the effect of roads on elk (Perry and Overly 1976).

6.2.4 Methods

The basic measure of the level of use which is received by an area will be the density of pellet-groups. Ungulate pellet-group counts have been successfully employed by many researchers as an index of the relative level of use between areas (Bennett et al. 1940; Rogers et al. 1950; Eberhardt and van Etten 1956; Robinette et al. 1958; Neff 1968; Perry and Overly 1976). Pellet-groups provide a persistent record of animal presence which may be related to the actual time spent in the area, whereas visual or track counts depend on the current activity of the animal and may, therefore, be affected by the presence of the observer and weather conditions.

Table 2. Sampling scheme for collection of data.

Study Area	Disturbance Category (Distance from Disturbance)			
	High (0-0.25 km)	Medium (0.25-0.75 km)	Low (0.75-1.75)	Nil
Control	-	-	-	x
Roadway	x[a]	x	x	-
Strip-mine	x	x	x	-
Plant site	x	x	x	-

[a] x = 50 pellet plots/habitat type.

This study will employ a control versus experimental format; control data will be taken to express the level of use of each habitat type by moose which are not subject to disturbances while several sets of data will be collected from areas where moose are subject to three categories of disturbances. The three categories of disturbance which will be most representative of the types of disturbance which will be produced by oil sands development are: roadways, strip-mines, and plant sites. The basic sampling scheme for this study is shown in Table 1.

6.2.4.1 Control data

6.2.4.1.1 Selection of a study site. The control data will be collected from a study site which fulfills the following requirements:

1. The area must be at least 10 km removed from any possible source of industrial disturbance, and
2. The area must contain representative stands of the major habitat types on the AOSERP study area.

Final selection of a control study area will be made in consultation with AOSERP personnel.

6.2.4.1.2 Determination of level of use. The level of use of each habitat type will be determined separately. The habitat types which will be used as the basis for sampling will be those types which have been described and mapped in the AOSERP study area by Thompson et al. (1978).

A minimum of 50 pellet plots will be established in each habitat type; each pellet plot will be 0.01 ha in area. Randomness in plot location within a habitat type will be achieved through random selection of the distance and direction between plots. The number of moose pellet-groups within each plot will be counted. Pellet groups will be tallied only if more than half of the group is within the plot.

The level of use of each habitat type will be expressed as the number of pellet-groups per hectare.

6.2.4.2 Experimental data. Experimental data for each of the three selected disturbance categories (roadways, strip-mine, and plant-site) will be collected in a similar manner. Therefore, the procedures will only be detailed for one of the disturbance categories, roadways.

6.2.4.2.1 Selection of study area. The study area which is selected must fulfil the following requirements:

1. The study area must be adjacent to a roadway and contain representative stands of the major habitat types on the AOSERP study area;
2. The roadway should be representative of the major type of roads in the AOSERP study area with respect to its size, construction, and traffic volume; and
3. The study area should be free from forms of disturbance other than those associated with the roadway.

It is anticipated that all experimental study areas will be accessible by vehicle.

6.2.4.2.2 Determinationof level of use. The study area will be stratified into three zones to permit analysis of the effect of distance from the disturbance on level of habitat use: a high disturbance zone located between 0 and 0.25 km away from the road, a medium disturbance zone located between 0.25 and 0.75 km from the roadway, and a low disturbance zone located between 0.75 and 1.75 km from the road. A representative stand of each habitat type will be located within each of the three zones of disturbance. The level of use of each habitat type within each zone of disturbance will be determined separately. The methods used to determine the level of habitat use will be identical to those used to collect control data.

6.2.4.3 Results. The data will be analysed statistically by variables in order to determine the effects of habitat types, disturbance category, and distance from the disturbance. The

results of this analysis will be used to document both the level of habitat use by undisturbed moose, and the sphere and magnitude of the influence of each type of disturbance on moose habitat use.

The results of this study will be presented in a report addressed to the objectives of the study, which were outlined above. The report will contain maps illustrating the sampling sites which were selected.

6.2.5 Literature Cited

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Eberhardt, L., and R.C. Van Etten. 1956. Evaluation of the pellet-group count as a deer census method. J. Wildl. Manage. 20:70-74.

Neff, D.J. 1968. The pellet-group count technique for big game trend, census, and distribution: a review. J. Wildl. Manage. 32:597-614.

Perry, C., and R. Overly. 1976. Impact of roads on big game distribution in portions of the Blue Mountains of Washington. Pages 62-68 *in* S.R. Hieb, ed. Proc. Elk-Logging-Roads Symposium. Univ. of Idaho, Moscow, Idaho.

Robinette, W.L., R.B. Ferguson, and J.S. Gashwiler. 1958. Problems involved in the use of deer pellet group counts. Trans. N. Am. Wildl. Conf. 23:411-425.

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Thompson, M.D., M.C. Wride, and M.C. Kirby. 1978. Ecological habitat mapping of the AOSERP study area: Phase I. Prep. for the Alberta Oil Sands Environmental Research Program by Intera Environmental Consultants Ltd. AOSERP Rep. 31. 176 pp.

6.2.6 Scheduling

The above study would begin as soon as the ground becomes snow-free in the spring of 1979; for planning purposes we will assume a start-up date of 15 April. Field work will require 2.5 months and will be completed, depending upon the start-up date, by 30 June. The draft report will be completed by 1 October 1979.

6.2.7 Budget

The total budget for this study would be between $110,000.00 and $120,000.00, based upon 1978 costs.

6.3 A PROPOSAL FOR A STUDY OF THE EFFECTS OF RECLAMATION ON MOOSE AND THE EFFECTS OF MOOSE ON RECLAMATION

6.3.1 Introduction

Habitat loss resulting from the destruction of vegetation is likely to be one of the major impacts which oil sands developments will produce on moose. The primary strategy which will be employed to mitigate the effects of vegetation destruction will be reclamation. Although it appears that reclamation will be successful in re-establishing vegetative cover, it is not known if current reclamation efforts will be as effective in re-establishing moose habitat. Since the impact which any habitat destruction will have on moose populations ultimately depends upon the success of the reclamation effort, it is critical to determine the effectiveness of the reclamation effort with respect to the creation of moose habitat. Ideally, artificial reclamation efforts should produce habitat which is as attractive to moose as that produced by "natural reclamation", such as that following fire, within a similar time period.

In general, most reclamation procedures create vegetation which appears similar to the naturally occurring early seral stages; these early seral habitats are preferred by moose. Therefore, if the revegetation program is successful in the creation of preferred moose habitat, the local densities of moose may become extremely high.

Moose browsing pressure could possibly become so intense as to hinder the reclamation efforts. Therefore, to safeguard the reclamation effort, the potential effects of moose on the ultimate effectiveness of the reclamation effort should be evaluated.

This proposal offers a program designed to determine the effects of current reclamation efforts on moose populations and the effects of moose populations on reclamation efforts.

6.3.2 Objectives

The objectives of this study are:

1. To determine the availability and utilization of moose browse on naturally reclaimed habitat (e.g., old burns) and artificially reclaimed habitat of similar ages;
2. To determine the utilization of naturally and artificially reclaimed habitat of similar ages; and
3. To determine the effect of moose on the establishment of vegetation on artificially reclaimed areas.

6.3.3 Approach and Methodology

Two basic measures will be employed to quantify the quality of moose habitat: the amount and utilization of browse species suitable to moose which are available in an area and the actual level of moose use which the area receives.

It has been repeatedly shown that the availability of browse in regenerating habitats is dependent upon the length of time since the disturbance occurred (Thompson et al. in prep.); therefore the variable of length of time since disturbance will have to be controlled.

The measurement of the annual growth of the twigs on browse plants is a widely used technique to determine availability of browse and its utilization by browsing animals (Smith and Urness 1962). Browse surveys will be conducted in naturally revegetated areas and in artificially revegetated areas; the

results of these surveys will provide data required to determine both the relative availability of moose browse and the relative level of use of the available browse.

Utilization of browse is only one measure of the use of an area by moose and is not necessarily related to the length of time spent in a habitat by the animal. A second measure of habitat use, which is related to time spent in an area, is the density of pellet-groups. The pellet-group count technique has been widely used as an indicator of ungulate presence (Neff 1968). Therefore, pellet-group counts will be conducted in naturally and artificially revegetated areas to determine the level of use which each area receives.

The exclosure method will be used to quantify the effects of browsing on reclamation plots. Measurements of plant growth and vegetative cover taken both inside and outside the exclosures will be used to determine the relative progress of plant re-establishment.

Since we are currently unaware of the size, number, and location of study areas which would be suitable for the purposes of this study, we have not detailed methods nor a schedule for this study. A realistic cost estimate would also depend on more information. Details concerning selection of study areas must be worked out in consultation with individuals familiar with the reclamation efforts in the AOSERP study area; details concerning methodology, budgets, and schedules can be provided following selection of the study area(s).

6.3.4 Literature Cited

Neff, D.J. 1968. The pellet group count technique for big game trend, census, and distribution: a review. J. Wildl. Manage. 32:597-614.

Smith, A.D., and P.J. Urness. 1962. Analysis of the twig-length method of determining utilization of browse. Utah State Dep. of Fish and Game. Publ. No. 62-9. 36 pp.

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6.4 A PROPOSAL TO CONDUCT A STUDY OF WOLVES ON THE AOSERP STUDY AREA

6.4.1 Introduction

On the basis of an extensive literature review (Thompson et al. in prep.) and a thorough critique of the research conducted on wolves in the AOSERP study area (this report), three gaps were identified in the knowledge required to complete a documentation and evaluation of the impact of oil sands developments on wolves:

1. Habitat use by wolves, specifically related to habitat, prey distribution, and the nature of movements within pack territories;
2. Potential impact of development projects, primarily through habitat alteration and secondarily through sensory disturbances upon prey as well as wolves, and through direct mortality; and
3. Population density, specifically accurate pack sizes, territory sizes, and number of packs as they reflect upon population dynamics.

This proposal is for research designed to provide the data necessary to fill each of these gaps. As with any elusive wilderness carnivore, the problems associated with obtaining the critical data mentioned above are diverse and many. The most effective approach frequently depends upon innovative and costly techniques. With this in mind, every effort has been made to devise a research plan which will meet the requirements of AOSERP in a cost-effective manner.

6.4.2 Objectives

The specific objectives of this study are:

1. To examine in detail the habitat use of wolves and to relate this to both the distribution and abundance of various habitat types within the pack's range and the habitat use of the major prey species;
2. To determine the pattern of movements which results in the observed habitat selection;
3. To establish the population density of wolves by determining the number of packs, pack sizes, and territory sizes of packs inhabiting the AOSERP study area and attempting to determine what proportion of the population consists of lone wolves; and
4. To examine the potential impact of oil sands development by identifying how proposed habitat alterations and projected sensory disturbances and direct mortality may affect the wolf population of the AOSERP study area.

6.4.3 Approach

Field studies will be needed to fill the gaps in the knowledge required to complete the documentation and evaluation of the impact of oil sands development. In conjunction with the investigation of wolves, a concurrent study of prey density and dispersion is essential to provide a balanced understanding of the trophic intricacies involving the wolf in the AOSERP study area. Such a complementary study has been recommended (this report) on the basis of gaps identified in research previously conducted in the AOSERP study area.

In areas that are relatively inaccessible (as in the AOSERP study area) there are few techniques which are feasible for collecting data on wolves; the quality and breadth of data obtainable on wolves through an intensive, soundly planned radio-tracking program are much more valuable than those

obtained through other techniques (Mech 1974). Furthermore, radio-tracking is often the only workable technique in accessible areas.

6.4.4 Methods

6.4.4.1 Habitat use and movements. In order to adequately sample the variability in habitat selection of wolves, the distribution of an appropriate number of wolves must be monitored. Fuller and Keith (in prep.) have suggested that a minimum of 18 wolf packs occur on the AOSERP study area. As of December 1977, only one pack had been monitored intensively by radio-tracking during that study. We recommend that five packs, with two or more radio-collared wolves per pack, be monitored to ensure sampling of a meaningful proportion of the wolf population. Intensive searching and capturing efforts would be undertaken during winter and early spring.

6.4.4.1.1 Den and rendezvous site related habitat use. The movements of wolves near pup-rearing sites of each monitored pack would be investigated through regular aerial relocations during the summer. Two major aspects of their overall habitat use would be distinguished: habitat selection in relation to vegetational and physiographic criteria and habitat selection in relation to prey distribution.

A systematic series of regular aerial relocations of radio-collared packs will sample the majority of periods throughout the day and throughout the season. Movements can be inferred to some extent for the periods between consecutive radio-relocations of individuals. A thorough description of the vegetational and physiographic characteristics of the pup-rearing sites will be made by visiting each site after the wolves have abandoned it for the season. The distribution and abundance of suitable sites will be compared with those actually used by examining appropriate vegetational, geological, and topographical maps.

The influence of prey distribution on habitat selection by wolves will be examined by comparing the distribution of habitat for prey with that of wolves. Prey consumption will be examined through analysis of scats collected at pup-rearing sites. A broader coverage of food habits for the AOSERP study area wolves will indicate more accurately the relative dependence on particular prey species, which can vary considerably (Voigt et al. 1976). Ungulate surveys have been recommended (this report) and semi-aquatic mammal surveys are currently underway by AOSERP researchers. The information on summer habitat use, distribution, and abundance derived from these studies will enable determination of the influence of prey distribution on habitat selection by wolves.

6.4.4.1.2 Habitat use during other seasons. During the other seasons of the year, the habitat selection of the monitored wolves will be established by regular, systematically planned aerial relocations. Movements can be inferred for periods between consecutive relocations. Moose have been identified as the primary prey during the winter in that nearly all wolf kills observed in the AOSERP study area have been moose (Fuller and Keith in prep.); therefore, further intensive studies on winter predation by wolves are unnecessary. The importance of certain habitat types to wolves will be examined by a comparison of the available habitat types in the study area, and the habitat preferences of the moose as identified by other investigations with the habitat selection of wolves as quantified by frequency of visitation.

6.4.4.2 Density of wolves on the AOSERP study area. The monitoring of several packs should provide an accurate count of the pack sizes and territory sizes for some of the population. However, aerial surveying during the winter will be required to obtain counts of packs in the remainder of the study area. By sightings and comparisons of group size the relative importance of parts of the AOSERP study area can be further substantiated and more

accurate comparison with prey densities can be made than are possible with numbers largely dependent on trapper surveys (Fuller and Keith in prep.).

6.4.4.3 Potential impact of oil sands development. The ideal approach to examining the impact of this large development project on wolves would be to monitor the entire population before, after, and during development and specifically in the area of development itself. However, because this is not feasible for the AOSERP study area, the most practical approach is to infer population changes from a knowledge of wolves' relationships to their habitat and a knowledge of habitat changes expected to result from development. By determining the habitat use of wolves and assigning importance values to various habitats, the most important aspect of development, habitat removal, can be evaluated.

There may be other impacts of habitat alteration such as social disruption of packs. This, along with the effects of sensory disturbance and direct mortality, will be difficult to determine from just a knowledge of a wolf habitat selection and expected development-related habitat changes. Some insight into the extent of these types of impacts may be gained by monitoring of a radio-collared wolf pack that is nearest a mining area (such as the Syncrude Pack).

6.4.5 Literature Cited

Fuller, T.K., and L.B. Keith. in prep. Wolf population dynamics and prey relationships on the AOSERP study area in northeastern Alberta. Prep. for the Alberta Oil Sands Environmental Research Program by the Univ. of Wisconsin. AOSERP Project TF 1.1.

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Voigt, D.R., G.B. Kolenosky, and D.H. Pimlott. 1976. Changes in summer foods of wolves in Ontario. J. Wildl. Manage. 40:663-668.

6.4.6 Schedule

This study could be scheduled to begin on 1 February 1979 with field work continuing until 1 February 1980. The final draft report would be completed by 1 June 1980.

6.4.7 Budget

The budget for a study as outlined in this report would be approximately $220,000.00 to $240,000.00, based on 1978 costs, with the majority of the costs being incurred during 1979.