A REVIEW OF THE BASELINE DATA RELEVANT TO THE DOCUMENTATION AND EVALUATION OF THE IMPACTS OF OIL SANDS DEVELOPMENTS ON BLACK BEAR 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 the human and natural environment of the Athabasca 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 development, 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 the black bear population to varying degrees through alteration of habitat, disturbance factors, and increased exploitation. Black bear research in the AOSERP study area (Figure 1) has not been extensive. One field study documented radio locations of four cubless females in the Fort Hills area (Fuller and Keith in prep.). Young (1978) categorized habitat in all townships within the AOSERP study area from forest cover series maps (1:126,720 scale) and calculated black bear densities. This was a comparative study based on known densities in similar habitats near

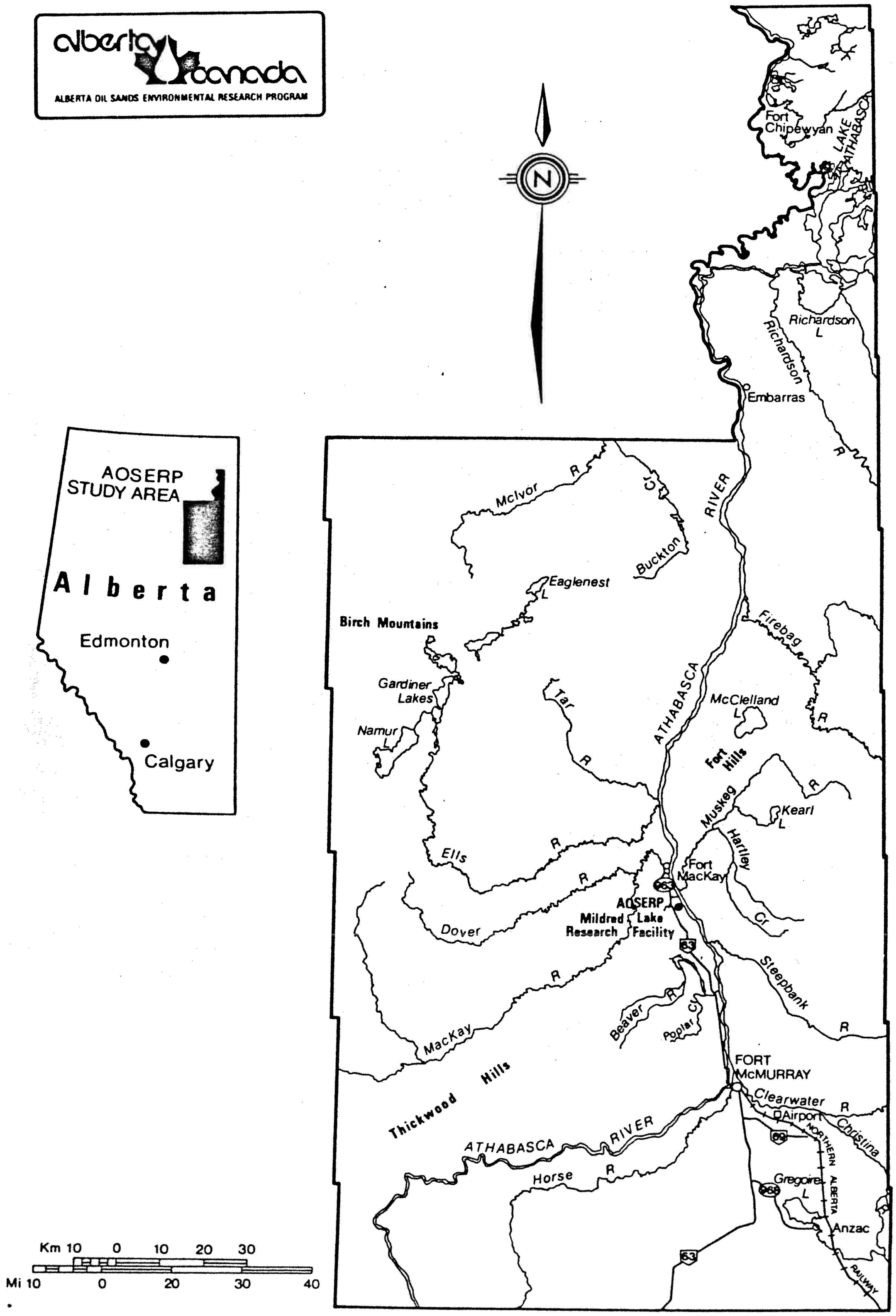

Figure 1. Location of the AOSERP study area.

Cold Lake, Alberta. In addition, black bear research near Cold Lake (approximately 144 km south of the AOSERP study area) was initiated by Alberta Recreation, Parks and Wildlife in 1968 and continued by the University of Wisconsin with financial support from AOSERP. Kemp (1972, 1976) and Ruff (1978) produced reports based on this work; however, a good deal of information is, as yet, unavailable. The general objective of this study is to complete an analysis of the applied research necessary to evaluate the responses of black bears to oil sands development.

The objective of this report is to provide a review of the available baseline data which are relevant to the documentation and evaluation of the impacts on black bear which would result from oil sands development in the Athabasca Oil Sands area. This review forms the basis of evaluation of the state of baseline knowledge of black bears in the AOSERP study area and a statement of the research which should be completed in order to provide the data; this analysis has been submitted as a separate volume.

1.1 APPROACH TO IMPACT ANALYSIS

In order to determine what baseline data are relevant to the documentation and evaluation of impacts on black bears 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 black bear 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 which will be involved in interactions with the project's components, and an estimation of the magnitude of those changes in the environmental components which will result from interactions with the project.

Interactions between black bears 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 physical characteristics of the habitat (e.g., construction of a road) or the establishment of artificial food sources (e.g., garbage dumps). The net result of such habitat alterations will be to alter the carrying capacity of the habitat. 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 the black bear population.

The magnitude of the effect which a given habitat alteration will produce on the black bear population depends upon the relative amount and quality of the habitat altered and whether the alteration is detrimental or beneficial. Therefore, the magnitude of the change in the black bear population which will result from the alteration of habitat by an industrial project may be estimated from a knowledge of the seasonal black bear habitat selection patterns.

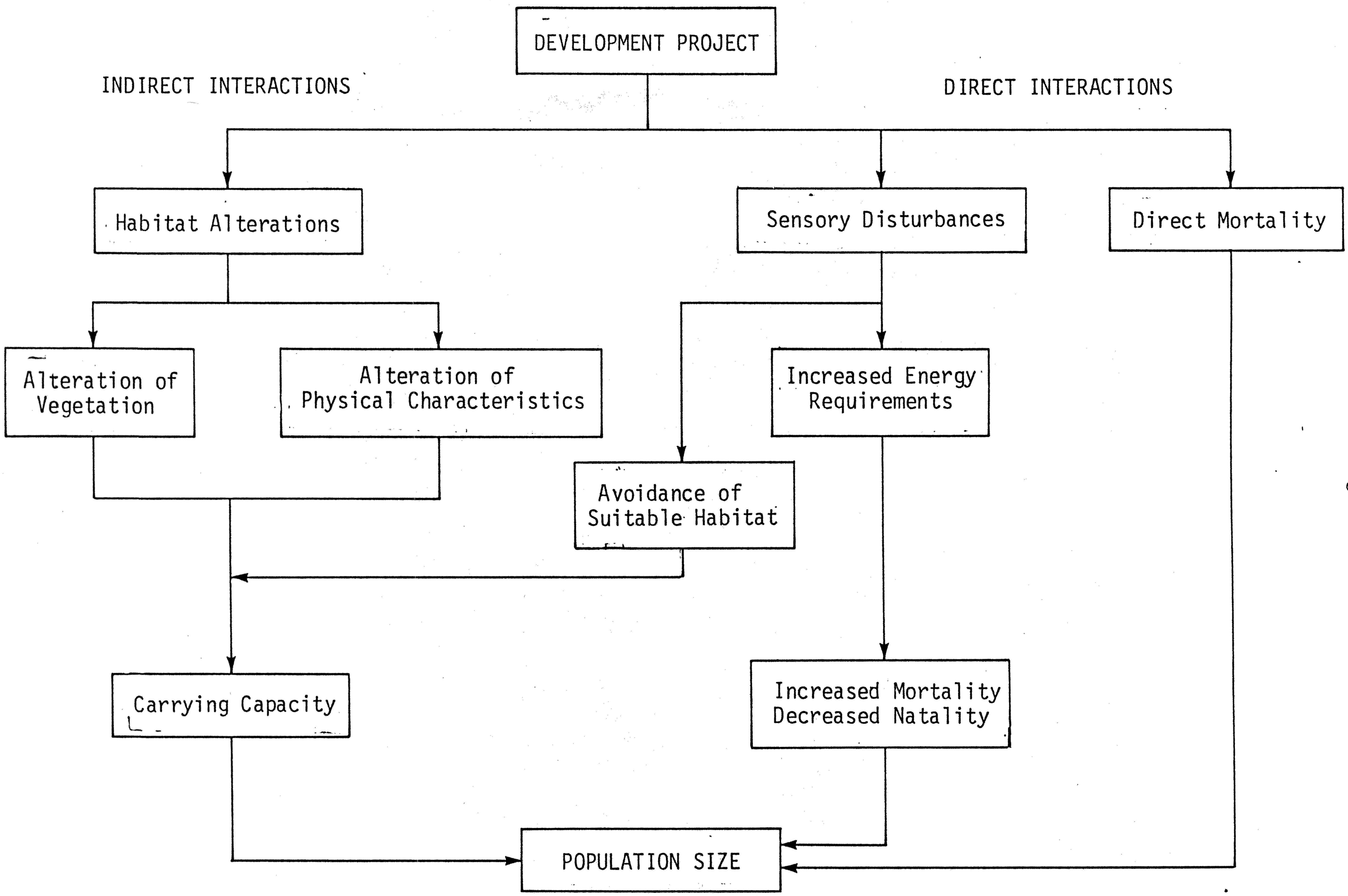

Figure 2. A conceptual approach to the documentation of the impacts of development projects on wildlife populations.

Direct interactions between black bear 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 due to the passive avoidance of suitable habitat by bears. Active avoidance of discontinuous, intolerable sensory disturbances (e.g., aircraft overflights) will result in increased energy expenditure. The effects of an increased expenditure of energy may be mainfested in increased mortality of individuals through starvation, predation, disease, etc., or in decreased production of young through decreased 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 bears may also result from causes such as collisions with vehicles, poisoning, accidents and hunting. Therefore, sensory disturbances to and direct mortality of bears which are induced by a development project will ultimately affect the size of the black bear population.

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, therefore, evident that two major types of baseline data are required prior to the documentation of the impacts which any development project will produce on black bear populations: (1) a knowledge of the seasonal population dispersion (habitat use, population movements) in relation to the proposed project and (2) a knowledge of the susceptibility of black bear to disturbances produced by the proposed project.

This report is not concerned with documentation of the impacts which will be produced by any specific project proposal but, rather, with the review of the data which would be required to document the impacts of any development which may be proposed in the future. Therefore, this report will simply review the current state of knowledge of the seasonal population dispersion (habitat use and movements) and susceptibility to disturbances of the black bear population in the AOSERP study area.

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 black bears 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 fluctuations beyond their natural limits can be considered of minor significance to populations and ecosystems; major impacts are those which do increase fluctuations beyond their natural limits.

To determine whether an impact is likely to be major or minor, the expected magnitude and duration of population change must be compared with the 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 black bears; these data are required to allow an evaluation of impacts produced by any oil sands development which may occur on the AOSERP study area.

2. POPULATION DISPERSION

2.1 DISTRIBUTION IN RELATION TO HABITAT

Habitat utilization is influenced by the seasonal variability of food and cover; by movement patterns in spring, summer, and fall; and by denning requirements in late fall and winter.

2.1.1 Influence of Food Habits on Habitat Selection

Numerous food habits studies have shown that changes occur in the annual and seasonal use of various plant and animal foods (Table 1). This variability in the use of food items does not necessarily reflect a change in habitat use. It can be indicative of a change in the use of forage species within a single habitat or the use of different habitats with changes in the availability of preferred foods. Many food habits studies are not able to specify what causes these changes. Documentation of these studies is desirable because of the possibility that a change in food species utilization was concurrent with a change in habitat.

From Table 1, the trend appears to be the use of herbaceous material (mainly grasses and sedges) in the early spring, the addition of the fruit and mast of shrub species as they become available in summer, increased fruit-mast consumption in the autumn, and opportunistic use of animal material (usually insects) during summer.

Some authors have correlated changes in food habits with changes in food abundance. Annual variability in food supply was shown to affect habitat use by black bears near Cold Lake, Alberta (Ruff 1978). Although use by adult males remained essentially the same in two study years, adult females showed a significant shift in habitat between years, apparently in response to variation in the distribution and abundance of blueberries. Cottam et al. (1939) found that fruit was used more when mast crops failed. Lindzey et al. (1976) noted an influx of bears into areas of high acorn, berry, and apple production, especially

Table 1. Summary of black bear food habits from selected North American studies.

Data Source, Location (Habitat)	Methods	MAJOR FOOD ITEMS Spring	Summer	Autumn	Remarks
Cole (1975), Peace River, Alberta (farmland - boreal forest)	- scat analysis (n=48) - % volume - % samples - % occurrence of total items	herbs (grass, grain, horsetail, dandelion, sarsaparilla), ants, beehive material, early fruit (dogwood, buffalo berry)	ants, herbs (grass, vetchling, grain, sarsaparilla), beehive material, fruit (saskatoon)		
Nagy and Russell (1978), Swan Hills, Alberta (boreal forest)	- scat analysis (n=137) - % volume estimated - % importance by month	herbs (horsetail, grass, sedge, other)	fruit (honeysuckle, current, cranberry, blueberry), herbs (sweet clover, monocots), insects (ants, beetles)	fruit (honeysuckle, current, cranberry, blueberry), herbs (sweet clover)	- fruit consumed when available - sympatric population of grizzly bears utilize the same food items
Norstrom (1974), Peace River, Alberta (farmland - boreal forest)	- stomach analysis (n=44) - % volume - % samples - % occurrence of total items	beehive material, ants, herbs (cereal crops, grass, sedge, vetchling), willow, poplar, mammal remains	ants, beehive material, herbs (cereal crops, vetchling), fruit (saskatoon, dogwood, snowberry), mammal remains		- samples from nuisance bears removed following damage to beeyards
Ruff (1978), Cold Lake, Alberta (boreal forest - aspen parkland)	- scat analysis (n=212) - frequency of occurrence - % dry weight	herbs (vetchling, horsetail, grass, dandelion), aspen, willow, insects	herbs (vetchling), fruit (sarsaparilla)	herbs (vetchling), fruit (blueberry, bearberry), beaked hazel nuts	- 1975: high use and high production of blueberries - 1976, 1977: little to no use and a nearly complete crop failure of blueberries
Bennett et al. (1943), Pennsylvania	- scat analysis (sample size not stated) - % volume		fruit (wild cherry, blackberry), mast (acorns), animal matter (wax, bees, woodchuk)	mast (acorns, beechnuts), fruit (apples, wild grape)	
Bigelow (1922), Lake Nipigon, Ontario (boreal forest)	- stomach analysis (n=1) - observation		hornets nests (paper, larvae, adults), beetle larvae, ants (mostly pupae)		- refers only to insect food
Chatelain (1950), Alaska	- scat analysis (n=290) - frequency of occurrence	herbs (grass, sedge, horsetail), fruit (cranberry, crowberry, blueberry), insects, rodents, adult and calf moose	herbs (grass, sedge, horsetail), fruit (cranberry, crowberry, blueberry), insects, rodents, salmon, moose calf	herbs (grass, sedge, horsetail), fruit	- study area was the Kenai National Moose Range - no attempt was made to distinguish between black and grizzly bear scats
Cottam et al. (1939), George Washington National Forest	- stomach analysis (n=25)			mast (oak), fruit (blueberry, grape, greenbriar, chokecherry, mountain winter, tupelo)	- mast preferred; failure of mast crop increased fruit consumption - hunter-killed bears
Hatler (1967, 1972), Alaska (boreal forest)	- stomach (n=23), intestine (n=16) and scat (n=44) analyses - ocular estimates - % volume in categories - frequency of occurrence	herbs (horsetail, grass, other), fruit (cranberry)		fruit (blueberry, cranberry), herbs (horsetail, lupine)	- use of good blueberry crops on old burns - all but 3 gut samples were from hunter-killed bears - seasonal divisions: spring/early summer and late summer/autumn
Juniper (1978), Quebec (transition hardwood - boreal forest)	- stomach analysis (n=30) - % volume	mostly vegetation, some animal matter, trace insects			- spring/summer data - hunter-killed bears
Lindzey and Meslow (1976), Washington (spruce/hemlock)	- scat analysis (sample size not stated) - % volume - % frequency - vegetation transects made			dried grass, fruit (huckleberry)	- dried grass was available all summer but first observed in scats early September - 30-35% of the huckleberry crop was available 25 October; this decreased to 2-5% by 25 November
Lloyd and Fleck (1977), British Columbia (spruce/fir)	- scat analysis (n=130) - % volume - % frequency - importance value (= % volume x % frequency)	herbs (grass, sedge, horsetail)	herbs (angelica, horsetail, cow parsnip, grass, sedge, vetch), fruit (huckleberry, buffaloberry), ants		- black and grizzly bear scats were not separated

continued...

Table 1. Concluded.

Data Source, Location (Habitat)	Methods	MAJOR FOOD ITEMS Spring	Summer	Autumn	Remarks
McIlroy (1970), Alaska (spruce/hemlock)	- scat analysis (n=326) - ocular estimates - % volume in categories - frequency of occurrence	herbs (grass, horsetail, sedge, ferns, raspberry), salmon	herbs (horsetail, sedge, ferns, raspberry), kelp, salmon, fruit (blueberry, raspberry)		
Murie (1937), Wyoming	- observation - scat analysis (n=64)		58/64 scats contained only crickets and grasshoppers		- during a summer of unusual abundance of crickets and grasshoppers
Piekielek and Burton (1975), California (pine/fir)	- scat analysis (n=106) - frequency of occurrence - % volume		fruit (manzanita, dogwood), herbs (grass, forbs)	fruit (manzanita), mast (acorn), salmon (minor component)	- many fall samples were from a salmon spawning area
Poelker and Hartwell (1973), Washington (hemlock/fir)	- stomach (n=555) and scat (n=227) analyses - % frequency - % composition	sapwood, herbs (skunk cabbage, others)	fruit (salal, huckleberry), fungus, herbs (skunk cabbage, others)	fruit (salal, huckleberry), fungus, herbs (skunk cabbage, cascara)	- 10 most important food items (unranked) - false dandelion, salmonberry, grass, salal, devils club, skunk cabbage, cascara, huckleberry, fungus, sapwood - variable use among years and habitat
Spencer (1966), Maine	- scat (n=377) and stomach (n=108) analyses - % volume - % occurrence	herbs (grass, sedge, forbs), insects, garbage, carrion	fruit (blueberry, raspberry, blackberry, wild cherry), mast (hazel nut)	mast (beechnut, acorn), fruit (apples)	
Tisch (1961), Montana (spruce/fir)	- scat (n=815) and stomach (n=4) analyses - ocular estimates - % volume in categories - frequency of occurrence	herbs (grass, umbells, horsetail, clover, dandelion), ants	herbs (cow parsnip, horsetail), fruit blueberry, honeysuckle, saskatoon), ants	fruit (blueberry, dogwood, saskatoon, mountain ash), pine nuts, herbs (angelica, woodrush)	- there was some correlation between availability and intake of huckleberry but none between pine nut availability and intake

in years of natural food shortages. Tish (1961) and Ruff (1978) found that huckleberries and blueberries had high use in years when they were abundant, and none or little use when the crop failed or was reduced. Murie (1937) reported that in a year of unusual cricket and grasshopper abundance, bears were observed in open rather than forested areas.

Several authors have documented changes in habitat use with season. The phenological development of seven key food plants governed the movements and habitat preferences of black bears in Idaho (Amstrup and Beecham 1976). The period when vegetative growth of forbs (prairie parsley, onion, and waterleaf) was greatest (June) and when fruit of shrubs was ripe (cherry--August/September/October, huckleberry and mountain ash--August/September) corresponded to the times bears were most frequently associated with specific species. In California, average movements of 14.5 km from summer to winter ranges appeared to correspond with the exhaustion of manzanita berries in the summer range and plentiful salmon, acorns, and berries in the winter range (Piekielek and Burton 1975).

2.1.2 Distribution in Relation to Vegetation Cover Types

Jonkel and Cowan (1971) found that, in Montana, bears maintained permanent home ranges in heavily forested, low elevation regions and made seasonal use of thinly forested and high elevation regions when they were snow-free. Hatler (1967) related elevational changes in bear distribution to season. During May to mid-June, lowlands such as river bottoms and lake shores were most often used; during mid-June to early August, movements were made to alpine areas; and during late fall, there was a return to low elevation, forested areas. Jonkel and Cowan (1971) found that the importance of different understory associations of the spruce-fir forest varied with season: *Pachistima* was used during all seasons, *Menziesia* and *Xerophyllum* in the fall, dry meadows during spring, and snowslide areas and stream bottoms in early to mid-summer. Beeman (1975) felt that in Tennessee, the close association of various habitat types allowed black bears to confine their movements to relatively small areas and that closed oak forest was preferred in all seasons. Avoidance of non-forested areas was noted by Erickson (1965), Herrero (1972), and Ruff (1978).

In studies near Cold Lake, Alberta Ruff (1978) found that different sex and age class bears selected different habitat types. In all seasons, adult bears selected for aspen and against muskeg. Generally, adult males selected for aspen and against pine, mixed-forest, and muskeg and adult females selected for mixed-forest and against muskeg. Subadults were less selective than adults but most similar to adult females. This selection was related to food availability; aspen cover contained the greatest number of preferred forage species (Ruff 1978). Young (1978) calculated expected black bear densities in each of four cover types in the Cold Lake area: 1.67 km^2 per bear in deciduous cover, 2.44 km^2 per bear in deciduous/coniferous cover, 4.55 km^2 per bear in coniferous cover, and 5.56 km^2 per bear in muskeg.

Little work has been conducted on the AOSERP study area itself. Fuller and Keith (in prep.) found that most locations of four radio-collared females were made in either mature aspen stands or mixed aspen/jackpine. Based on a comparison with habitat use near Cold Lake, Young (1978) felt that the most productive bear habitat in the AOSERP study area would be found along the eastern and southern edges of the Birch Mountains and near Gregoire Lake (both areas of abundant deciduous cover). The poorest potential was thought to be in the Thickwood Hills (due to large areas of open muskeg) and in the northeast corner of the study area (due to muskegs, rock barrens, and marshes).

2.2 MOVEMENTS

Information on movements of black bears has been presented in the literature in a variety of ways. Linear movements have been cited as average maximum or daily movements. The time interval between locations was not always specified and often only two locations per bear were available. Data came from hunter returns and telemetry or recapture studies for both nuisance and wild bears. Areal measurements have been referred to as home ranges, occupied areas, or activity areas and size was calculated by various means. Two groupings were possible: (1) studies citing the area of the central portion of all locations as home range and (2) studies citing an occupied or activity area as including all locations. Within this second category are studies which incorporated all points in a circular measurement of range. Comparisons of various studies are limited by these constraints.

2.2.1 Linear Movements

Calculations of average and maximum distances that bears moved required relatively few locations and these were often made at irregular intervals. Maximum and average movements ranged from 1.17 to 25 km (Table 2). Maximum movements of males were 6.28 to 25 km; average movements of males were 7.05 to 21.6 km and of females, 3.29 to 21.28 km. The longest movements reported were for nuisance bears; average movements of 21.28 to 21.60 km and maximum movements of 25 km were reported for bears in Michigan (Harger 1970) and Alberta (Gunson and Pipella 1977), respectively. Wild bears had much smaller movements; 1.7 to 7.05 km was the average distance moved in Pennsylvania (Alt et al. 1976) and 2.57 to 6.28 km was the maximum recorded in Montana (Jonkel and Cowan 1971).

Calculations of daily movements required a series of locations made at regular intervals. Daily movements ranged from 0.8 to 1.7 km (Table 2). Mean daily movements of males were similar (1.5 and 1.7 km) in Idaho (Amstrup and Beecham 1976) and Alberta (Ruff 1978), respectively. The AOSERP study (Fuller and Keith in prep.) did not document linear movements of black bears.

2.2.2 Home Range Size

The home range sizes most frequently reported were between 2.35 and 196 km^2 (Table 2). The smallest home ranges (2.35 to 13.44 km^2) were in Pennsylvania and Washington

Table 2. Summary of black bear home range and movement data from selected North American studies.

Data Source (Location)	Range (km^2)[a, b, c]	Movements (km)[d, e, f]	Remarks
Fuller and Keith (in prep.) (AOSERP study area)	adult females without cubs: 9.1[a] (n=4)		range 7.1-12.8 km^2
Gunson and Pipella (1977) (Peace River, Alberta)	males:153[b] (n=3)	males:25[d]	non-translocated nuisance bears aged 2, 4, and 5
Nagy and Russell (1978) (Swan Hills, Alberta)	males:151[a] (n=9) females:123[a] (n=4)		males: range 13-443 km^2 females: range 71-246 km^2
Ruff (1978) (Cold Lake, Alberta)	postremoval-males:119[b] (n=28) -females:19.6[b] (n=17) recovery-males:175[b] (n=28) -females:32.4[b] (n=28)	males:1.7[e]	- home range is 40% smaller than occupied area for males but the same size for females - males of different ages overlapped extensively - female ranges decreased slightly with increased density and females appeared territorial toward one another - rate of movement declined May through November - the movement rates for females were similar to those of males but proportionally less
Alt et al. (1976) (Pennsylvania)	adult, subadult males: 196[a] (n=5) adult females with cubs: 45[a] (n=7) solitary females:20[a] (n=7) adult females:38[a] (n=8) yearling females:43[a] (n=1) yearling males:767[a] (n=1)	adult males:7.05[f] solitary females:3.29[f] females with cubs:1.17-2.76[f]	- adult males:range 100-400 km^2 - adult females:range 25-80 km^2 - movements of females with cubs increased July to September - seasonal home ranges were influenced by food availability
Amstrup and Beecham (1976) (Idaho)	adult males:112.1[a] (n=2) adult females:48.9[a] (n=27)	all bears:1.3[e] adult males:1.5[e] adult females:1.15[e] yearlings:0.8[e]	- range, both sexes 16.6-130.3 km^2 - uniform home ranges and activity centres suggest the maintenance of home ranges from year to year
Erickson and Petrides (1964) (Michigan)	summer:15.5[b] annual:38.9[b]		- ranges of adult males were 1/3 larger, adult females 1/3 smaller than average
Eveland (1973) (Pennsylvania)	solitary cubs:4.80[b] 1.5 year old females:5.76[b] 1.5 year old males:8.48[b] subadult males:13.44[b] adult females with cubs:4.96[b] solitary adult females:8.00[b] adult males:11.36[b]		- 85 observations of 16 non-translocated bears
Harger (1970) (Michigan)		adult males:21.60[f] (n=16) adult females:21.28[f] (n=8)	- non-translocated nuisance bears
Jonkel and Cowan (1971) (Montana)	adult females:5.18[b] adult males:30.96[b]	adult females:2.57[d] (n=31) adult males:6.28[d] (n=16)	- habitat and home ranges were strongly linear - true home range sizes were masked by great elevational extremes within the ranges of individuals - home range assumed to be circular and calculated from maximum movements
Lindzey (1976) Lindzey and Meslow (1977b) (Washington)	males:5.05[a] (n=8) females:2.35[a] (n=8)		- seasonal use of home range by males varied more than females - home range size was considered small due to richness of habitat - temporal separation of bears with overlapping home ranges occurred
Piekielek and Burton (1975) (California)	summer:12.9-25.9[a]		- home range sizes did not appear to be differentiated by sex or age class, although females with cubs appeared to have smaller yearly ranges than other sex and age classes
Poelker and Hartwell (1973) (Washington)	males:51.5[b] (n=5) females:5-28[b] (n=4)		- no overlap of adult males was noted but adult females overlapped with males and occasionally other females

[a] Home range (the central portion of the range)
[b] Occupied or activity area (contains all locations within the range)
[c] n = sample size
[d] Average of maximum movements made by bears during one season.
[e] Average daily movements.
[f] Average of all movements of bears during one season.

(Eveland 1973; Lindzey 1976; Lindzey and Meslow 1977b); however, Poelker and Hartwell (1973) and Alt et al. (1976) cited values equal to or greater than the median home range size for these same states (20 to 196 km^2).

There was equal variability in black bear home ranges reported from Alberta (9.1 to 175 km^2). The smallest was reported for the AOSERP study area by Fuller and Keith (in prep.) for four cubless females. Gunson and Pipella (1977) and Nagy and Russell (1978) documented much larger home ranges for males near Peace River and Swan Hills; home range sizes of females were also large in Swan Hills. Ruff (1978) did not present premanipulation data for Cold Lake but found large post removal and recovery home ranges for males (119 and 175 km^2) and smaller ranges for females (19.6 and 32.4 km^2).

2.2.3 Overlap of Home Ranges

Temporal separation of individuals (both sexes, all ages) with overlapping home ranges was reported by Lindzey (1976) and Lindzey and Meslow (1977b) for an island population of bears in Washington. Poelker and Hartwell (1973) obtained different results for a mainland Washington population; home ranges of males did not overlap but those of females overlapped with members of both sexes.

Further variability was added with the results of Ruff (1978) in Alberta who found that the ranges of males of different ages overlapped but not those of females. He concluded that the regulatory effect of adult males on the population did not involve overt defense of the home range and exclusion of subadults.

2.2.4 Homing Ability

The ability of translocated black bears to return home has been documented in several studies. Returns of over 80 km to the original capture site were reported in British Columbia (Rutherglen and Herbison 1977). Sauer et al. (1969) found that the number of bears which returned home was related to the distance displaced; the homing success of bears moved more than 63.9 km decreased sharply. This conflicted with the findings of Harger (1970) who stated that there was no decrease in homing with increased displacement. Homing success was related to age class; 36 of 44 adults showed the ability to home but cubs and yearlings showed much less ability. Harger (1970) also found that bears that homed had a greater chance of survival than those that did not.

In the Peace River area, four bears homed from distances of 22.9 to 36.8 km, while three bears displaced 48.3 to 101 km did not home (Gunson and Pipella 1977). This supports the findings of Sauer et al. (1969); however, a comparison to Harger's (1970) findings is not possible as the ages of the displaced bears was not stated.

2.3 DENNING

The negative energy budget of black bears is a critical aspect of the winter denning period. Knowledge of the type of habitat used and the length of the inactive period is essential to determine potential impacts.

2.3.1 Denning Habitat

Table 3 gives a summary of black bear denning habits. Lindzey (1976) found that the state of regeneration after logging operations affected selection of denning habitat. Adults and yearlings made differential use of areas logged 18 to 20 and 7 to 9 years previous to the study; adults preferred the former and yearlings the latter.

Ruff (1978) found that the proportion of vegetation cover available to bears differed significantly from the proportion of dens found in each type. Bears selected for mature stands of spruce and aspen and against muskeg. This was similar to habitat selection at other times of the year.

Fuller and Keith (in prep.) radio-tracked four cubless females in the AOSERP study area and found that they denned in either aspen or jackpine stands. This was similar to the habitat used by these bears prior to denning.

Table 3. Summary of black bear denning habits from selected North American studies.

Data Source (Location)	Denning Chronology	Denning Habitat	Remarks
Fuller and Keith (in prep.) (AOSERP study area)	- entrance: last 2 weeks of October	- either aspen or jackpine stands	- telemetry data on 4 cubless females only
Ruff (1978) (Cold Lake, Alberta)	- entrance: 1975, a 4-week period beginning 7 October; 1976, a 5-week period beginning 1 October - emergence: 28 March-14 April - adult females first to appear, then subadults, finally adult males	- selected den sites on the periphery of summer range (n=50) - proportions of cover types used differed from those available: selection for mature stands of spruce/aspen and avoided muskeg - 34 of 38 first dens were dug under the rootmass of trunk of a fallen or leaning tree, into hill sides or into level ground	- denning chronology may have been affected by food availability
Alt et al. (1976) (Pennsylvania)	- entrance: 27 October-7 December, solitary adult females - males and females with off-spring generally entered after this date		
Amstrup and Beecham (1976) (Idaho)	- entrance: 9 October-7 November - emergence: 11-30 April		
Beeman (1975) (Tennessee)	- denning from early December through March	- cavities high in over-mature trees were preferred	
Erickson (1964b) (Michigan)	- females with cubs denned 2 weeks earlier than adult males	- holes beneath logs or fallen trees, or in hills were preferred sites	- mean hibernal weight loss was 20% of prehibernal weight - 37% of bears killed 15-30 November were in dens - females lined a higher proportion of dens with leaves, grass and ferns than did males
Jonkel and Cowan (1971) (Montana)	- entrance: late October-early November - emergence: mid-April-mid-May	- base of hollow tree, under fallen logs, in rock caves, under a cabin and under-ground dens dug or enlarged were used	- early snowmelt is related to early emergence - 1/3 of bears lined dens, 1/3 were females
Lindzey (1976), Lindzey and Meslow (1976) (Washington)	- entrance: 21 October-29 November - adult females entered first, then yearlings, and, finally, adult males - remained in dens an average of 126 days	- natural cavities under stumps or snags were pre-ferred - adults denned in areas cut more than 18-20 years previous to the study and yearlings in areas cut more than 7-9 years previous	- adult females remained near the den site for about 3 weeks after emergence

In general, preferred sites were holes beneath logs or tree trunks, dens dug into hillsides, or cavities high in over-mature trees (Erickson 1964b; Jonkel and Cowan 1971; Beeman 1975; Lindzey 1976; Lindzey and Meslow 1976; Ruff 1978).

2.3.2 Denning Chronology

Generally, denning extended from October through April (Table 3). The shortest inactive periods were in Tennessee--December through March (Beeman 1975)--and Washington--126 days (Lindzey 1976). Latest emergence was in mountainous regions in Idaho and Montana (30 April to mid-May) (Jonkel and Cowan 1971).

Bears in Alberta submerged in October (Fuller and Keith in prep.; Ruff 1978) and emerged 28 March through 14 April (Ruff 1978). These data indicate that the denning period increases in length from the south to the northern and mountainous areas.

Adult females den prior to other black bears (Erickson 1964b; Alt et al. 1976; Lindzey 1976; Ruff 1978).

3. POTENTIAL IMPACTS OF LARGE DEVELOPMENT PROJECTS

3.1 ALTERATION OF HABITAT

Land-clearing operations resulting from logging, fire, road construction, or drilling as well as the establishment of garbage dumps for the use of the people associated with such developments can alter natural habitat. The manner in which black bears use and respond to the altered habitat may, consequently, be affected.

3.1.1 Effects of Logging and Fire

The effects of habitat alteration as a result of logging and forest fires have been commented on by a number of authors. Leopold (1923) suggested that increased numbers of berries resulted from greater amounts of sunlight reaching the ground after the trees were removed. The use of recently logged areas and old burns was related to food supply. Berry-producing shrubs were 7 to 8 times more abundant and berry production per plant was much higher in recently logged areas in Washington (Lindzey and Meslow 1977a). This increase was also noted by Edwards (1954), Lauckhart (1955), Scotter (1964), and Jonkel and Cowan (1971). Rowe and Scotter (1973) found that certain species (including blueberry, mountain cranberry, and bearberry) regenerated rapidly after a fire and that bears made extensive use of burns. Lauchkart (1955) suggested that the latter stages of the succeeding growth crowded out berry-producing plants, increased competition, and forced bears to use food of lower nutritional value. Jonkel and Cowan (1971) found that recently logged areas were completely avoided. This in agreement with Lindzey and Meslow (1977a) who found that areas clearcut 14 to 22 years prior to their study were used more than expected while those logged 5 to 11 years previously were used less. This selection may have been based on the greater availability of cover in older areas even though food was less abundant. An area that had been cleared and burned a year previously had a rich herb layer but was used for travel rather than feeding and most sign was found within 10 m of forest cover (Lloyd and Fleck 1977). They recommended that strips of forest 4-5 chains in width be left around bear trails, snowslide areas, and mountain meadows.

3.1.2 Effects of Oil Developments

Changes in use of habitat altered during oil exploration have been documented in two Alberta studies. Although there was no predevelopment data for the Swan Hills area, it was found that most radio-collared black bears restricted their movements to developed areas (Nagy and Russell 1978). These areas had been reseeded to sweet clover and grass and were transected with natural stands of spruce, pine, aspen, and birch. They noted that sweet clover remained lush long after the natural vegetation had cured and felt that this improved habitat may have contributed to the expansion of the black bear population. Jonkel and Cowan (1971) found that roadsides seeded with sweet clover and orchard grass were used 13 times as much as non-seeded roadsides. A comparison of demographic parameters prior to and during minimal oil developments showed that density and numbers were not affected by that level of development (Ruff 1978). One aspect of development seemed to create favourable habitat. Establishment of roads and earthen pads in a treed muskeg area created travel lanes and upland habitat attractive to bears, which had previously avoided muskeg; both males and females denned in the area.

3.1.3 Effects of Garbage Dumps

Garbage dumps can be a rich source of food for bears that occupy nearby areas (Nagy and Russell 1978). Such sites attract bears from a large area and concentrate them at one site (Retfalvi 1972; Cole 1976). Ruff (1978) observed as many as 17 bears during a single visit to a dump. When it was closed both the number of sightings and number of problems were reduced. The largest concentrations Retfalvi (1972) observed were at the oldest and largest deposits.

Differential use of dumps by sex and age class of bears occurred near Cold Lake, Alberta; Ruff (1978) found that subadult males used dumps twice as frequently as adult males. Rogers et al. (1976) found that the sex ratio changed with age in dump-using bears. Cubs using dumps were 59 percent male, bears 1-7 years were 76 percent male, and bears 8 years plus were 25 percent male. They suggested that this was due to differential mortality of older, more wide-ranging males which found and used dumps more often than sedentary females. Refalvi (1972) noted that large bears appeared less often and stayed for shorter periods than immature bears and females with young. He also felt that use of dumps by family groups would habituate the young.

Positive nutritional effects have been attributed to the use of garbage as food. Rogers (1976) found that females with access to garbage produced first litters 1.2 years younger than females without access. In years of food scarcity weights of bears at dumps were higher and average litter sizes produced by females using dumps were larger than litters of females not using them (Rogers et al. 1976). Ruff (1978) found that males visited dumps more frequently in May and September when food was scarce but did not feel that the use of garbage gave black bears a nutritional advantage.

3.2 DISTURBANCE FACTORS

Information presently available seems to indicate that minor disturbances have little affect on black bears. Amstrup and Beecham (1976) found that radio-collared bears often withdrew from observers but sometimes returned to the same area within hours; the mean daily movements were not significantly different after disturbance than without it. Lloyd and Fleck (1977) found that grizzlies tended to avoid areas frequented by humans but that black bears did not. Bears which were disturbed by researchers and abandoned dens in mid-winter were considered to be at an energy disadvantage. Ruff (1978) did not use the weights of such bears to calculate mean hibernal weight loss because he attributed part of that loss to the disturbance.

Impacts of oil development were studied by Ruff (1978) near Cold Lake. The bulk of his results have not yet been published; however, some general information is available. He found that individual black bears responded to disturbance which arose from clearing, road construction, and drilling operations by avoiding the immediate vicinity totally, for a limited time or during working hours. Ruff (1978) considered these responses short-term rather than permanent. Avoidance was not always shown; some subadults used a dump near a rig without appearing to notice the workers or drilling.

3.3 INCREASED EXPLOITATION

Increased access and human population levels associated with oil exploration and development could have an effect on black bear mortality resulting from hunting and destruction of nuisance bears.

Hunting pressure can be manipulated by management practices and easily change that mortality factor in bear populations (Jonkel and Cowan 1971; Lindzey and Meslow 1977a). In addition to increased access, the amount of publicity given to an area, public education on methods of hunting bears, open or closed seasons, and length of season affect the number of people sport hunting (Jonkel and Cowan 1971). Kemp (1972) simulated the type of exploitation promoted in a trophy-hunting situation. All adult males were removed in each of two consecutive years to measure the effect of adult males on population control; both the number of subadults and the total population increased. McIlroy (1970, 1972) studied a heavily-hunted population in which the older males were subjected to similar removal pressure for longer than two years. He found that population size and density decreased. This contrasted with the results of studies by Shoesmith (1976) who found that five years of removal of problem bears and liberal sport hunting seasons and trapping regulations did not result in detrimental changes in the bear population.

The use of dumps and campgrounds by black bears increased their susceptibility to and mortality from sport hunting and control operations (Rogers et al. 1976; Nagy and Russell 1978). Erickson and Petrides (1964) found that mortality varied with wilderness categories. First year mortality and one year hunting mortality were both higher in nuisance and dump bears than in wild bears. Use of dumps by bears and their associated destruction may be associated with food availability. Ruff (1978) found that one-half of all bear destructions in four years of control operations occurred in a single year of poor berry production. It has been suggested that killing of nuisance bears is not always done of necessity; only 6 of 43 nuisance kills investigated were found to be justifiable (Erickson and Petrides 1964). They suggested that an expressed dislike of bears and/or the desire to shoot a trophy were motivating factors in the destruction of so-called nuisance bears.

Bear problems in the AOSERP study area are centred on garbage disposal but a management program could be developed to prevent conflicts (Loucks in prep.). If ignored, the number of nuisance bears could increase, along with the probability of property damage, personal injury, and the number and cost of destructions or translocations of bears (Loucks in prep.). In Yellowstone National Park, Cole (1976) documented the decline in the number of bears visiting developed areas and the number of human injuries when the following practices were introduced to try to re-educate the bears to wilderness: (1) closure of two open pit dumps, (2) fencing of three incinerators and landfill sites, (3) installation of bear-proof garbage cans, and (4) intensification of efforts to inform visitors of precautions and the consequences of feeding bears.

4. POPULATION DYNAMICS

4.1 POPULATION SIZE AND DENSITY

Black bear population studies show bear densities ranging from one bear per 0.32 km^2 and one bear per 56.80 km^2 (Table 4). The density most frequently reported was between 2 and 3 km^2 per bear. Among the greatest regional differences in bear densities were those reported from Alberta: 2.59 km^2 per bear near Cold Lake (Kemp 1972) and 56.80 km^2 per bear in the Swan Hills (Nagy and Russell 1978). Based on a comparison of the home ranges of cubless females in their study (n = 4) with other studies (unspecified), Fuller and Keith (in prep.) estimated the Fort Hills region of the AOSERP study area to have a density of 2-4 km^2 per bear. Young (1973) calculated an expected density of 3.00-5.56 km^2 per bear and total population of 5,188 to 7,431 in the AOSERP study area (29,373.2 km^2) based on black bear densities for each of five cover types near Cold Lake, Alberta and the relative proportions of these cover types (from forest cover maps) in the AOSERP study area. The upper and lower limits were based on the assumption that muskeg is either avoided or used. Estimates of potential populations of bears in specific townships ranged from 0 to 43, assuming no bears to be in muskeg, and 0 to 45, assuming 0.18 bears per km^2 of muskeg (an average potential population of 16.5 and 23.6 bears per township).

4.2 NATALITY AND MORTALITY

4.2.1 Natality

Natality rates *per se* have not been determined in most of the North American black bear studies. Age specific reproductive rates for 3, 4, and 5 year old females in Washington were 0.87, 0.234, and 1.07, respectively (Lindzey 1976). Factors influencing recruitment have been described in several studies. Litter sizes ranged from 1.6 to 2.2 cubs per adult female and ovulation rates from 1.8 to 2.4 ova per adult female (Table 5). The age at which

Table 4. Summary of black bear densities as estimated in selected North American studies.

Data Source (Location)	Density (km^2/bear)	Remarks
Fuller and Keith (in prep.) (AOSERP study area)	2-4	- determined by comparing home range sizes of 4 cubless females with other studies
Kemp (1972) (Cold Lake, Alberta)	2.59	- 4-year mean of an unhunted population
Nagy and Russell (1978) (Swan Hills, Alberta)	56-80	- a hunted population sympatric with a grizzly bear population
Young (1978) (AOSERP study area)	3.57-5.26	- based on a comparison of densities within specific vegetation types near Cold Lake and relative proportions of equivalent habitat in the AOSERP study area - range assumes either total avoidance or use of muskeg
Beecham (1976) [in Modafferi (1978)] (Idaho)	2.07, unhunted population 2.33, hunted population	
Bray (1967) [in Piekielek and Burton (1975)] (Yellowstone National Park, Montana)	13.47	- unhunted population sympatric with a grizzly bear population
Erickson and Petrides (1964) (Michigan)	3.81	- hunted population
Jonkel and Cowan (1971) (Montana)	2.07-4.40	- the change in density was believed to reflect increased hunting pressure
Lindzey and Meslow (1977b) (Washington)	0.67-0.89	- lightly hunted island population
McCaffrey et al. (1976) (New York)	15.80-18.40	- 2 heavily hunted areas, northern and southern Catskills, examined
McIlroy (1970) (Alaska)	0.32, lightly hunted 1.85-6.67, heavily hunted	- coastal population
Modafferi (1978) (Alaska)	3.02	- coastal population, hunted
Pelton (1976) (Tennessee)	2.59	
Piekielek and Burton (1975) (California)	1.30-2.59	- hunted population
Poelker and Hartwell (1973) (Washington)	1.81-2.59	- mainland population, hunted
Shoesmith (1977) (Manitoba parks)	8.63	- parks maintain the highest densities in the province
Spencer (1966) (Maine)	14.40	- hunted population

Table 5. Summary of information on age and sex structure, age of maturity, and factors influencing natality and mortality in black bears from selected North American studies.

Data Source (Location)	Sex Ratio (male:female) Category	Ratio	Age Structure Category	Structure	Age of Maturity	Factors Influencing Natality[a]	Factors Influencing Mortality Category	Rate	Remarks
Kemp (1972) (Cold Lake, Alberta)	adult, 1968-69 adult, 1970	50:50 65:35		73:27[b]			annual rates: cub yearling 2-year old 3-year old plus	 26.7% 36.7% 37.5% 12.5%	- unhunted population
Nagy and Russell (1978) Swan Hills, Alberta)		74:26	(n=44)	50:30:20[c]	youngest female in estrous 3.5 years; youngest female breeding 5.5 years; adult at 4 years	2.2 cubs/female (n=5)			- 75% of captured bears were less than 5 years old - hunted population
Ruff (1978) (Cold Lake, Alberta)	all ages, all years all ages, pre post recovery cub/yearling pre post recovery subadult pre post recovery adult pre post recovery	62:38 58:42 68:32 62:38 57:43 63:37 50:50 72:28 80:20 70:30 69:31 53:47 54:46	preremoval post-removal recovery	55:21:24[c] 34:49:17[c] 55:26:19[c]	adult at 4 years		annual average, 1974-77 females males males and females cumulative, 1974-77: males females	 27% 28% 28% 62% 60%	- adult males removed in 1971, 1972 - average population size: preremoval, 1968-71: 80 bears postremoval, 1972-75: 141 bears recovery, 1976-77 111 bears - essentially hunted - difference in sex ratios from 50:50 may be apparent rather than real due to high mobility of males, especially subadults
Beeman (1975) (Tennessee)				68:18:14[d]		2.1 cubs/female 17.4% of females were with cubs	annual rate:	21.7%	- unhunted population
British Columbia Dep. of Recreation and Conservation (1974, 1975)	1973 (n=454) 1974 (n=310)	77.5:22.5 78.4:21.6	1973 (n=488) 1974 (n=332)	93:7[e] 93.4:6.6[e]					- hunter kill data - sex ratios refer to non-juveniles
Erickson (1964a, b) Erickson and Nellor (1964) Erickson and Petrides (1964) (Michigan)	hunter reports, sex unconfirmed: cubs (n=44) yearlings (n=29) hunter reports, sex confirmed: captured bears: all traps culvert traps steel traps	 64:36 45:55 48:52 59:41 71:29 44:56	all bears wild bears	54:46[b] 41:59[b]	both males and females at 3.5 years; however most males were immature at 3 years	2.15 cubs/female (n=20 observations) 2.05 cubs/female (hunter kill data) mean ovulation rate 2.4 ova/female	annual rates: minimum cub yearling older	 19% 26% 4% 21%	- 84% of the mortality is due to hunting - culvert traps select for males and older bears - in hunter reports, the proportion of males reported increases with the time between kill and report of kill
Eveland (1973) (Pennsylvania)	(n=41 capture) (n=56 harvest, no cubs)	73:27 76:24	capture, n=40 harvest, no cubs, n=56	25:48:28[c] 43:30:28[f] 39:34:27[c] 50:23:27[f]	adult at 3 years				- hunted population
Harger (1970) (Michigan)		70:30							- capture of nuisance bears hunted population
Hatler (1967) (Alaska)	hunter reports (n=57) (n=16)	 66.7:33.3 56:44				1.73 cubs/female (n=30) 1.96 cubs/female (n=23, central Alaska)			- hunted population

continued...

Table 5. Concluded.

Data Source (Location)	Sex Ratio (male:female) Category	Ratio	Age Structure Category	Structure	Age of Maturity	Factors Influencing Natality[h]	Factors Influencing Mortality Category	Rate	Remarks
Jonkel and Cowan (1971) (Montana)	cubs, adults have an even sex ratio but 1.5-2.5 year old males are twice as numerous as the same age females	53:47		41:30:29[c]	youngest female in estrous 4.5 years; first litter at 6.5 years; adult at 4 years	1.7 cubs/female (n=38 study area), 1.6 cubs/female (n=204, entire state) 15.6% of females were with cubs (range 0-40%) mean ovulation rate 1.8 ova/female	annual rates: 0.5-1.5 years 5 years or more (excluding handling and trapping deaths)	 5-13% 14%	- once separated from the mother, cub and yearling mortality increases - low reproduction in years of huckleberry scarcity
Juniper (1978) (Quebec)		66.7:33.3							- n=21 hunter kills and 9 nuisance bears examined by the author
Lindzey (1976) (Washington)					76.6% of the females mature at 3.5 years	reproduction rates: 3 year old females 0.87 4 year old females 0.234 5 year old females 1.07	annual rates: 3 year old females 4 year old females 5 year old females all females males and females	 21.0% 14.1% 18.9% 18.2% 20.2%	- island population subject to bow hunting
McCaffrey et al. (1976) (New York)	northern southern	51:49 60:40	northern southern	23:43:34[c] 39:27:34[f] 10:21:69[c] 17:14:69[f]	not stated				- northern and southern Catskills - hunted population - hunter kill data
McIlroy (1970) (coastal Alaska)	(n=136)	85:15		90:10[g]		1.85 cubs/female (n=14)			- hunter kill data
Modafferi (1978) (Alaska)	(n=13 captured bears)	10:90	(kill data)	56:44[g]					
Piekielek and Burton (1975) (California)	(n=88, kill data) (n=39, capture)	58:42 64:36	(n=43, capture)	32:11[b]		36% of females were with cubs (n=11), 1.67 cubs/female (n=6)	annual (hunter caused)	9-12%	- hunted population
Poelker and Hartwell (1973) (Washington)	(kill data) (control captures) (n=39, capture-relocate)	59:41 56:44 48:52			youngest breeding female 3.4 years; 1 of 2 females 4.4 years had placental scars	lactation rate 19% estrous rate 31% mean ovulation rate 1.9 ova/female	natural mortality unknown annual rates: man-caused estimate of total	 17% 15-18%	- the control program is biased toward captures of males - best estimate of sex ratio thought to be obtained from marked-unmarked ratio (48:52)
Raybourne (1976) (Virginia)					minimum breeding age 2.5 years; well established at 3.5 years		minimum one year rate	24%	
Rogers (1976) (Minnesota)					captive females mature at 2.5 years; females with access to garbage at 4.4 years; females without access to garbage at 5.6 years	females 5.5 years old or more were with cubs 33% after years of scarce food, 44% after years of moderate abundance; 59% after years of exceptional abundance	mortality prior to weaning, increases with increasing litter size cub and yearling mortality from natural causes mortality of bears 2.5 years or more, human related	20% 90% 90%	- females did not produce cubs unless they gained sufficient weight in the autumn - early mortality appears to be nutrition-related
Shoesmith (1977) (Manitoba)		82:18 approx.							- hunter kill data - range given at 4-5 males to one female
Spencer (1966) (Maine)	(trapped or hunter killed)	57.5:42.5				2.4 cubs/female (observation)			- hunted population

[a] n = sample size.
[b] 2 years old or more: cubs and yearlings.
[c] 4 years old or more: 2 and 3 years old: cubs and yearlings
[d] adults (undefined): subadults (undefined): cubs and yearlings
[e] adult (undefined): juvenile (undefined)
[f] 3 years old or more: 2 years old: cubs and yearlings
[g] 5 years old or more: 1 to 4 years old.
[h] Litter size (number of cubs per female) based on the total number of cubs divided by the number of females with cubs.

females reached sexual maturity varied from 2.5 to 5.5 years (Table 5). Captive females, those with access to garbage, and those in areas of abundant natural food were productive at a younger age and at shorter intervals than other females (Jonkel and Cowan 1971; Rogers 1976). The proportion of females with cubs each year varied from 0-40 percent in Montana (Jonkel and Cowan 1971). Values from most other studies fell within this range (Table 5). The exception was Rogers (1976) who found 33-59 percent of females had cubs depending on the abundance of food.

The only information on natality available for Alberta was a 2.2 cub average litter size for Swan Hills (Nagy and Russell 1978) with females first breeding at 5.5 years of age. Both Nagy and Russell (1978) and Ruff (1978) considered black bears to be adult at 4 years but did not define the criterion by which this was decided. There was no information on natality available for the AOSERP study area.

4.2.2 Mortality

Estimates of mortality in black bear populations ranged from 15 to 28 percent for both sexes (Table 5). Some studies estimated only hunter-caused mortality (9 to 17 percent). Estimates of cub and/or yearling mortality ranged from 4 to 26 percent. Data from two studies suggested that mortality was not sex-related; both Lindzey (1976) and Ruff (1978) found the mortality rate of females was only 1 to 1.3 percent lower than that of males. Erickson (1964a) found that 84 percent of mortality was hunter-caused. Rogers (1976) suggested that 90 percent of the mortality of bears 2.5 years of age or more was due to hunting but that 90 percent of cub and yearling mortality was due to natural causes.

The only Alberta population data available showed a high mortality rate (28 percent) in an essentially unhunted population (Ruff 1978). There was no mortality information available for the AOSERP study area.

4.3 AGE AND SEX STRUCTURE

4.3.1 Age Structure

There was little consistency shown in North American studies grouping black bears into age classes. Problems arose as a result of the variability in the age at which bears were considered adult and to neglegence in defining terms. Some authors did not state what age classes were included in the terms adult and subadult, at what age adulthood was reached, and/or the criterion used to determine adulthood. Added to this confusion was the use of hunter-kill data versus capture data. Kill data tended to be biased towards older animals, particularly males, due to both hunter choice and availability of animals (Hatler 1972). Capture method can bias the sample obtained in trapping studies (Erickson and Petrides 1964; Poelker and Hartwell 1973). Given these conditions, there was some difficulty in comparing studies. The comparison in Table 5 was based on the authors' stated division between adult and subadult bears or, if the age at which bears were adult was not defined, bears four years old or more were considered to comprise the adult class.

Six of the studies listed in Table 5 give age structures based on the following structure--adult (or four years or more): subadult (or two or three years old):cub/yearling. Three of these had similar age structures for captured bears in hunted populations (41:30:29, 43:30:28, and 50:30:20 in Jonkel and Cowan 1971, Eveland 1973, and Nagy and Russell 1978, respectively). There was more diversity in the age structures of captured bears in unhunted populations (68:18:14 and 55:21:24 in Beeman 1975, and Ruff 1978, respectively) but the proportion of adults was generally higher than in the previous three studies. Data from hunter surveys had the greatest diversity and generally the smallest proportion of adults (50:23:27 in Eveland 1973 and 23:43:34 and 10:21:69, both in McCaffrey et al. 1976).

The Alberta black bear populations had similar age structures despite the fact that one was hunted and thought to be expanding in size (Nagy and Russell 1978) and the other was unhunted and considered stable (Ruff 1978). The differences in age structures (a greater proportion of subadults and a lesser proportion of adults) reflected the expansion of the Swan Hills population studied by Nagy and Russell (1978). There was no studies documenting age structure for bear populations in the AOSERP study area.

4.3.2 Sex Structure

In addition to the biases noted at the beginning of Section 4.3.1, Erickson (1964a) found that the proportion of males reported killed by hunters increased with the time elapsed between the kill and its report. Males made up 56 to 84 percent of the hunter-killed bears in North American studies (Table 5). The single value below this range was 45 percent for yearling males (Erickson and Petrides 1964). The values most frequently reported were between 55 and 60 percent and 75 and 80 percent. Bears killed by hunters but with sex confirmed by the author or another reliable source were 48 and 66.7 percent male (Erickson 1964a and Juniper 1978, respectively).

The proportion of captured bears which were males ranged from 10 to 74 percent (Table 5); the most frequently reported values were between 55 and 60 percent.

A hunted population in the Swan Hills area had a sex ratio of 74 males to 26 females (Nagy and Russell 1978). An unhunted population near Cold Lake had a premanipulative sex ratio of 58 males to 42 females (Ruff 1978). After all adult males were removed, the proportion of males increased to 68 percent due to an influx of subadults. There were no studies documenting sex structure for bear populations in the AOSERP study area.

4.4 FACTORS INFLUENCING POPULATION REGULATION

4.4.1 Extrinsic Factors

4.4.1.1 Food supply. Food supply can be affected by the alteration of habitat that occurs with clear-cutting and fire. In Washington, the regrowth of vegetation that followed logging provided a rich food source; however, use of the resource increased if patches of mature forest cover were left (Lindzey and Meslow 1977a). Reseeding of cutlines increased the food supply and, hence, bear numbers near Swan Hills (Nagy and Russell 1978).

Survival and reproduction of black bears can be influenced by the amount of food available. Subadults were often in poor condition when they emerged from dens; spring food supply was poor (Jonkel and Cowan 1971). Cub weight was dependent on the amount of food available to both the nursing sow and the self-reliant cub; Rogers (1976) found that light-weight cubs suffered higher mortality than heavy cubs. The rate of physical and sexual maturation was affected by nutrition (Jonkel and Cowan 1971; Rogers 1976). Well-fed captive females and females with access to dump food produced cubs at an earlier age than wild females without access to dump food (Rogers 1976). Variations in the weight of females prior to denning (Rogers 1976) and food availability (Jonkel and Cowan 1971) caused fluctuations in the pregnancy rate.

4.4.1.2 Other factors. Jonkel and Cowan (1971) hypothesized that the consumption of hormone-like substances in plants might also be involved in population fluctuations, but that the ultimate limits were set by the climate and topography and the way these affect vegetation cover and food supply in any particular area.

4.4.2 Intrinsic Factors

4.4.2.1 Intraspecific interactions. Kemp (1976) has shown that agonistic behaviour of adults had a self-regulatory effect on a black bear population near Cold Lake, Alberta. After adult males were removed, the size of the population and the number of subadults increased for a number of years, then decreased toward the stable, preremoval size. Rogers (1976) supported this view but felt that the territoriality of a male served to eliminate non-resident bears from his area and that of the females with whom he had mated. This would tend to increase the food supply for the pregnant female and, later, cubs. It would also reduce intraspecific predation on his offspring by transient subadults.

4.4.2.2 Interspecific interactions. Where black and grizzly bears are sympatric the possibility for interspecific competition exists. Nagy and Russell (1978) hypothesized that, in Swan Hills, Alberta, the black bear could be eliminated by direct predation or displacement by the larger, more aggressive grizzly and by available space. Density of black bears would be dependent on that of the grizzly and the frequency of inter- and intraspecific encounters. According to this theory the increase in black bears near Swan Hills was facilitated by the low and declining number of grizzlies.

4.4.2.3 Genetic control. It has been suggested that genetic control of the population size acts by affecting increment (litter size) (Jonkel and Cowan 1971; Nagy and Russell 1978), individual size variation (Jonkel and Cowan 1971), and colour phase. Rogers (1976) found that brown phase females had larger litters and that cub survival decreased with increasing litter size.

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