Thresholds for Addressing Cumulative Effects on Terrestrial and Avian Wildlife in the Yukon

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EXECUTIVE SUMMARY

The definition, concept and practical application of terrestrial and avian wildlife thresholds are discussed for the purposes of regional land use planning and assessment of cumulative effects. Three major types of thresholds are identified: ecological (including habitat availability and population thresholds), land and resource use, and social.

Specific ecological and land and resource use thresholds suggested in the literature or as applied in the Yukon and elsewhere are discussed in detail for three terrestrial species (grizzly bear, woodland caribou and moose); and, for two bird classifications (landbirds and waterbirds). Administrative opportunities for developing and applying the thresholds are proposed. Candidate thresholds are recommended based on information availability and suitability. All thresholds and approaches for determining each type of threshold are summarized.[1]

Terrestrial Wildlife

Considerable opportunity exists in the Yukon for developing thresholds for large terrestrial wildlife. Recommended thresholds for grizzly bear include minimum habitat effectiveness, maximum human-caused mortality, maximum road density, and minimum core security areas. Recommended thresholds for caribou include minimum calf/cow ratio, minimum habitat availability or effectiveness, and maximum energetics loss. Recommended thresholds for moose include minimum calf/cow ratio or population size, ratio, and minimum habitat availability or effectiveness.

Avian Wildlife

There are currently no readily implementable thresholds for landbird or waterbird species. The development of appropriate thresholds will require more detailed information on land and resource use and on species-specific responses to disturbance.

[1] Tables 6-1 and 6-2; see the table on next page for a review of types of thresholds.

Summary of Thresholds

Type	Thresholds
Ecological	
Habitat Availability	• minimum patch size • minimum corridor width • maximum gap distance between patches • core security areas • carrying capacity • maximum tolerable energy expenditure • maximum disturbance factors and zones of influence • maximum surface water level drawdown
Populations	• minimum desired population size • minimum viable population size (MVP) • optimum calf/cow ratio • optimum natural mortality/natality rates
Land and Resource Use	
Physical Works and Associated Activities	• maximum road density for specific traffic levels • maximum zone-of-influence for specific disturbances (e.g., noise from aircraft) • exposure rate
Human Activity	• maximum level of visitation • maximum hunting mortality rate • maximum defense-of-life-and-property (DLP) mortality rate • maximum acceptable extent of development that cause sensory disturbances (e.g., to light, dust, sound, smell and vibration)
Social	
Aesthetic	• maximum tolerable extent of perceived visual change
Perceived Acceptable Limits	• maximum perceived acceptable changes to habitat, species distribution or level of human disturbance

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Kirk Strom .... Grizzly Bear Technical Advice

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ABBREVIATIONS

AAH	Allowable Annual Harvest
AXYS	AXYS Environmental Consulting Ltd.
BBS	Breeding Bird Survey
BBVS	Banff-Bow Valley Study
BMU	Bear Management Units
CCR	Calf/Cow Ratio
CEA	Cumulative Effects Assessments
CEAA	Canadian Environmental Assessment Act
CEM	Cumulative Effects Model
CMT	Caribou Management Team
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWS	Canadian Wildlife Service
DAP	Development Assessment Process
DF	Disturbance Factor
DIAND	Department of Indian Affairs and Northern Development
DLP	Defense-of-Life-and-Property
DU	Ducks Unlimited
ELC	Ecological Land Classification
ER	Exposure Rate
GIS	Geographic Information System
HEP	Habitat Evaluation Procedure
HSI	Habitat Suitability Index
HU	Habitat Unit
LAC	Limits of Acceptable Change
MASH	Minimum Amount of Suitable Habitat
MVP	Minimum Viable Population
NAWMP	North American Waterfowl Management Plan
OU	Operating Unit
RoW	Right-of-Way
RSA	Regional Study Area
TEK	Traditional Ecological Knowledge
UFA	Umbrella Final Agreement
VEC	Valued Ecosystem Component
WMZ	Wildlife Management Zone
YRR	Yukon Renewable Resources
YTG	Yukon Territorial Government
ZOI	Zone of Influence

1.0 Introduction

1.1 Background

The Department of Indian Affairs and Northern Development (DIAND) is responsible for administering projects and lands under federal jurisdiction in the Yukon. This responsibility includes the review, under the *Canadian Environmental Assessment Act* (CEAA), of applications for project approvals and related permits and licenses. The Department also has a role in directing overall land use management and promoting sustainable development in the Yukon.

The CEAA requires the consideration of cumulative effects for screenings, comprehensive studies, and panel reviews for individual project applications. During review of these applications, DIAND must consider the significance of cumulative effects as part of its determination on project approval.

Resource thresholds provide regional objectives for the maintenance and management of resources. They provide both project proponents and regulators with a basis for evaluating the significance of project-specific effects or regional cumulative effects on the resource in question, as is required for Cumulative Effects Assessments (CEAs). The availability of thresholds, against which to compare the project effects, can considerably improve DIAND's ability to make a better informed decision in satisfaction of both its statutory and land use management responsibilities. However, no direct use of thresholds for wildlife has yet been identified and applied by the Yukon Territorial Government (YTG) or by DIAND (R. Horner, pers. comm.; P. Henry, pers. comm.; L. Mychasiw, pers. comm.; B. McLean, pers. comm.) for environmental assessments, forestry planning or wildlife management.

AXYS Environmental Consulting Ltd. (AXYS) has been retained by DIAND to develop a report on thresholds that could be used to evaluate the significance of land use effects on wildlife. The objectives of this report are to:

- define and describe various general types of thresholds;
- identify specific thresholds for the three wildlife species selected by DIAND (i.e., grizzly bear, woodland caribou and moose and birds); and
- identify opportunities for the development and use of these thresholds in the Yukon.

1.2 Cumulative Effects Issues in the Yukon

Current activities in the Yukon include timber harvesting, mining exploration and operations, oil and gas exploration and operations, associated vehicle and aircraft use, recreational activities, and traditional (i.e., First Nations) use. Cumulative effects from these activities on major wildlife species are of particular concern to DIAND, and include direct habitat loss, reduced habitat effectiveness, habitat fragmentation, decreased reproductive success, increased access potential, and increased wildlife mortality.

Although activity in many sectors has decreased (permit applications have recently decreased by half from an average of 500 per year; J. Hough, pers. comm.), certain geographic areas remain a focus of development, particularly the southern-half of the Yukon (i.e., south of Dawson along the 64^{th} parallel to the territorial border with British Columbia). In this region, the Watson Lake/Liard region is especially active with logging and mining exploration. Throughout the Yukon, the numerous and relatively small projects (e.g., placer mines, small cutblocks, access roads) are of a greater concern than the few single major projects (there is currently only one new Level 2 assessment for DIAND, the Silvertip mine in B.C. between Watson and Teslin).

1.3 Report Structure

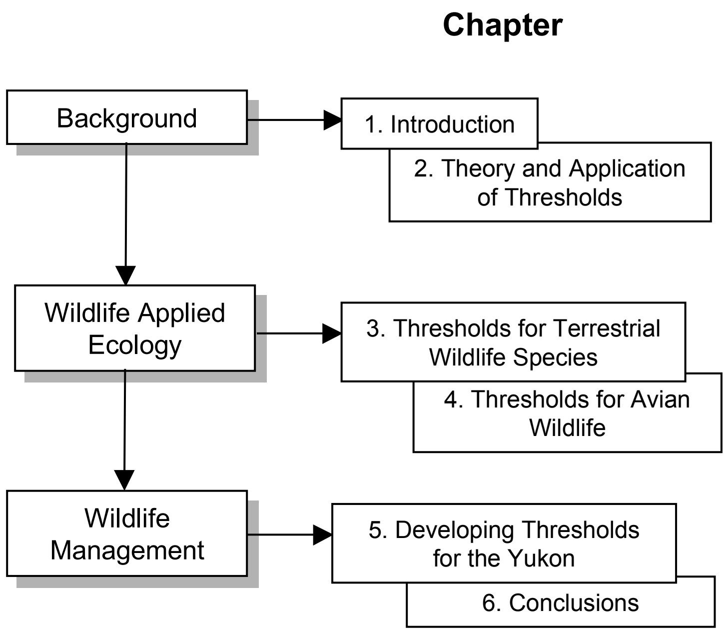
The report is organized into seven chapters as follows:

1. **Introduction:** Describes the purpose of the report and provides an overview of cumulative effects concerns in the Yukon.
2. **Theory and Application of Thresholds:** Provides an introduction to cumulative effects and cumulative effects assessment, defines thresholds and discusses the use of thresholds, and defines three basic types of thresholds.
3. T**hresholds for Selected Terrestrial Wildlife Species:** Examines thresholds for grizzly bear, caribou and moose.
4. **Thresholds for Avian Wildlife:** Examines thresholds for landbirds and waterbirds.
5. **Developing Thresholds for the Yukon:** Discusses opportunities to implement thresholds.
6. **Conclusions:** Summarizes the wildlife thresholds and provides detailed and concise summary tables of all thresholds.
7. **Bibliography**

To place this material into context for various readers (e.g., biologists, resource managers), the report can be used as follows (see Figure 1-1):

- Read Chapters 1 and 2 to obtain background material to assist the reader in understanding the basics.
- Read Chapters 3 and 4 for technical details on species biology, applied ecology, and assessment techniques.
- Read Chapters 5 and 6 to obtain information and recommendations for the purposes of resource management.

Figure 1-1 Report Chapter Structure and Content



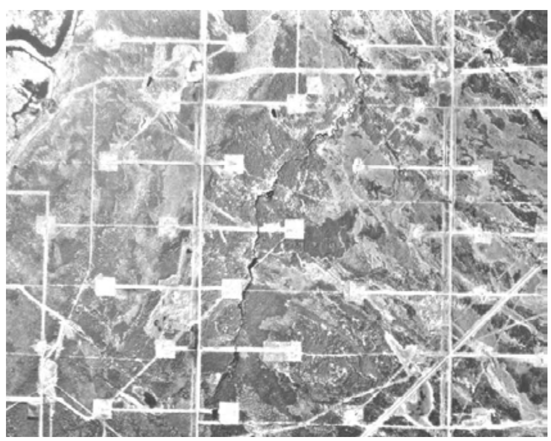
2.0 Theory And Application Of Thresholds

2.1 The Meaning and the Assessment of Cumulative Effects

Cumulative effects are changes to the environment that are caused by an action in combination with other past, present and future human actions (Hegmann *et al.* 1999, p. 3). A Cumulative Effects Assessment (CEA) is an assessment of those effects, typically under some form of regulatory requirement for specific project applications.

Cumulative effects occur when an action, whether it is an activity (such as an aircraft overflight) or a project (such as a mine), affects an environmental component that is also affected by other actions. In this way, the environmental component (e.g., a trout, a moose, or a rare plant) experiences effects from various sources at different times and different places. The total or "cumulative" effect is therefore greater than the effect from any one action alone.

Figure 2-1 An Example of "Nibbling" Cumulative Effects (gas wells)



These effects happen because a physical constituent is transported over long distances (e.g., sediment in streams, stack emissions); or, land, wetlands and open water bodies are progressively reduced in size and quality for wildlife and plant species (the "nibbling" effect). These situations are aggravated by too many actions occurring within too short a period of time (i.e., spatial and temporal "crowding") and by the increased incentive to conduct further actions as more and more actions occur (i.e., the spin-off or "induced" effect).

In summary, the following three conditions must be true for there to be a cumulative effect attributable to a single project under review:

1. The project will have a measurable effect on the resource in question.

2. The project effect acts in a cumulative fashion with those of other land use pressures.

3. The project effect, in combination with other land use effects, measurably changes the state of the resource.

The steps and methods to complete a CEA are identical to those already long adopted for EIAs. What is new in CEAs is the mandatory consideration of the contribution of other actions to effects; and, that those actions must also be in the future to the extent reasonable and possible.[2]

Cumulative effects are of concern because eventually the environmental component may be severely affected. An assessment of cumulative effects attempts to determine if that condition has already been reached, or if it may yet be reached within the reasonably foreseeable future. As to what is meant by "severely affected" will depend on the environmental component in question; but typically, it reflects a point at which the component no longer exists or is sufficiently impaired that it can no longer exist in some desired earlier state.

Land use managers, such as various levels of government, need to know if a resource has or will be so affected. For project specific assessments, they need to know both the incremental contribution of that project and the overall contribution of all projects to effects on any given environmental component. For regional land use planning, they want to know how much development will be too much. In both cases, a point of comparison is required to assist in making land use decisions, against which the merits of further development may be judged. For project CEAs to be meaningful, and for regional land use planning to be viable, it is critical that such points are available.

2.2 Definition of Thresholds

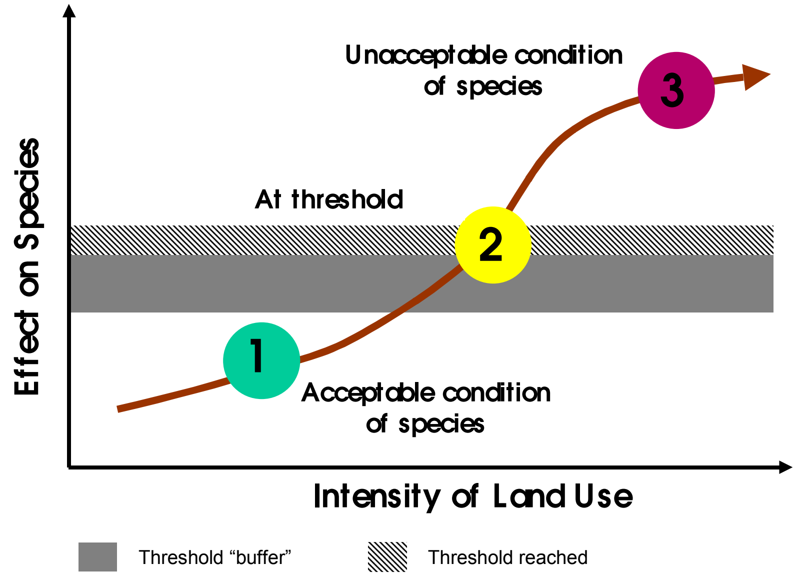
A threshold can be defined as a point at which a resource undergoes an unacceptable change or reaches an unacceptable level, either from an ecological or social perspective. Within the context of assessing environmental and social impacts from land use developments, a threshold is considered to be the limit to which an important resource can tolerate land use effects before experiencing an unacceptable adverse effect (Hegmann *et al.* 1999).[3] Thresholds are usually (and most usefully) expressed numerically, although thresholds can be expressed as a subjective desired state.

Figure 2-2 illustrates the basic concepts of thresholds. As land use pressures increase, the adverse effects on a species also increase. At relatively undisturbed conditions, the condition of the species may be acceptable (Point 1) by whatever species management criteria being used. Eventually, some condition is reached at which a threshold is reached (Point 2), after which the threshold has been exceeded (Point 3) and the condition of the species becomes unacceptable.

[2] See Hegmann *et al.* 1999 for a complete description of CEA approaches.
[3] Such a resource is any part of the natural environment or human community that is considered important, on the basis of cultural values or scientific concern, by project proponents, public, scientists or government involved in the assessment process.

In practice, thresholds are not a single point (or "line") but a continuum (the grey shaded area) in which concerns are first raised before a critical condition is reached (the cross-hatched shading). In this way, a management "buffer" is provided to ensure that action is taken before the worst-case conditions arise and become much more difficult or impossible to rectify.

Figure 2-2 Understanding Thresholds



2.3 Evolution of Thresholds and Cumulative Effects

Despite the importance of thresholds in CEAs, relatively little has been published in the research literature providing specific details on types and practical implementation of thresholds. Instead, the development of thresholds has largely been moved forward by use management initiatives in certain environmentally sensitive geographic areas for specific species, especially national parks, and through their identification and use in various project assessments. For example, respectively, grizzly bear studies in Banff and Yellowstone National Parks, and heavy oil project assessments in Alberta's Athabasca Oil Sands.

The Athabasca Cumulative Effects Assessment Framework (Golder 1999), a document establishing a consistent approach to projects CEAs in the region, defines thresholds as "Objective criteria beyond which is deemed to be an unacceptable level of impairment of an environmental resource or that the accumulated stress on the system (over space and time) will cause the system to fundamentally change." The Framework admits that thresholds should be conservative to reflect ecological uncertainty, and that ultimately qualitative conclusions can usually only be made as to the population level effect on the viability of a species. This conclusion suggests quite a different approach than that advocated in the U.S. for the quantitative determination of "maximum acceptable limits of impact on target resources" in the assessment of effects due to hydroelectric projects (Bain *et al.* 1986).

The evolution of thresholds has also been realized in the development of regional land use plans. Again using the oil sands example, the Integrated Resource Plan (IRP) for the region provides management goals such as maintaining black bear populations within the current range distribution and the current fall population of 300, and encouraging greater harvests to increase recreational benefits. In addressing the role of IRPs in Alberta, Dias and Cherney (1994) viewed such plans as providing a framework in which thresholds could be developed and used through an ecosystem based planning approach that "could provide a more explicit context for considering cumulative effects by establishing ecological thresholds based on social, economic and ecological values" (p. 303). Also, these thresholds "would state the socially acceptable limits of change that will be permitted for a VEC. Developing ecological thresholds would involve tough trade-offs based on ecological, social and economic values. Once established, they would provide an explicit yardstick by which proponents, the public and decision-makers could assess proposed developments and evaluate the potential impact on a regional scale" (pp. 311-312).

2.4 Thresholds and Resource Management

Thresholds enable both project proponents and regulators to evaluate the acceptability of project-specific and cumulative effects on a resource. If project effects, either independently or in combination with other land use pressures, force a wildlife resource into an unacceptable condition or level, then the project effects may be deemed as significant. If the incremental effects of the project do not force the resource into an unacceptable condition or level, then project effects are typically viewed as being insignificant. The use of thresholds reflect an intent by regulatory agencies to allow changes to resource values, either through land use or through direct effects on the land use, up to a point before the administrative authority takes measures to cease or modify projects and activities under their jurisdiction. According to Zeimer (1994), "Often the reason to identify thresholds is a desire to allow some management action to proceed unhindered until the magnitude of effect reaches a point at which regulation becomes necessary" (p. 319).

Thresholds used in these ways contribute to fulfilling the regulatory authority's role in ensuring responsible and sustainable land and water management. In the case of Yukon DIAND, for example, thresholds may be used by assessment officers in their review of permit and license applications and in their determination of significance before approval may be granted.

2.4.1 Levels of Effect's Significance

Table 2-1 provides an example of an approach where the significance of effects on a wildlife species is ranked according to a series of criteria. The ranking used represents a type of threshold; the values can be modified as necessary to better reflect specific environmental conditions and disturbances.

Table 2-1 Evaluating Significance for Effects on Biological Species in Assessments

Effects Issues to be Considered	Significance Rankings			Ranking of Significance
	Low (L)	Moderate (M)	High (H)	
1. Fraction of population exposed to reduced reproductive capacity and/or survivorship as a result of project-specific or cumulative effects; or, fraction of available habitat reduced by project-specific or cumulative effects.	<1%	1-10%	>10%	L if Low. If M or H, go to question 2.
2. Potential recovery of the population or habitat with mitigation.	Complete	Partial	None	L if Low. If M or H, go to question 3.
3. Recovery time to acceptable conditions.	< 1 year or 1 generation	1-10 yrs or 1 generation	>10 yrs or > 1 generation	L, M or H

Source: AXYS 1997

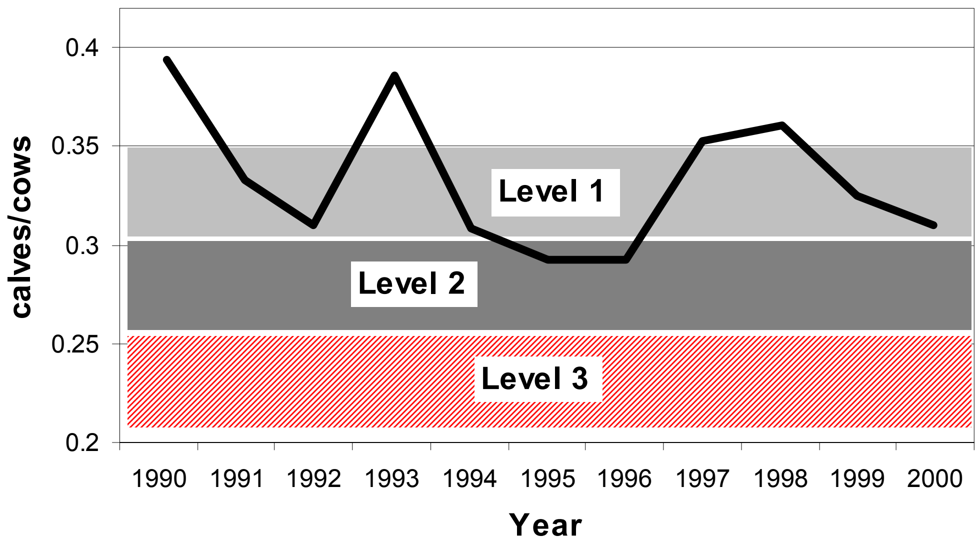
2.4.2 Levels of Management Response

Based on the approach that a threshold is best represented by a range of a measurable values, a management response may be required if the measured value decreases below a given value, and immediately required if the value decreases considerably below a lower value in the threshold's range. This represents a risk-based approach to thresholds based on current understanding and prediction of population-level responses to human and natural disturbances.

Figure 2-3 illustrates this approach, using caribou calf/cow ratios (CCR) over a ten year period as an example, in which three "management response" levels are identified. The levels are defined as follows:

- Level 1: Caution required in the management of new developments or increased land use pressures (i.e., .3<CCR<.35).
- Level 2: No further development allowed until additional mitigation and regional land use measures are implemented (i.e., .25<CCR<.3).
- Level 3: Species recovery program mandatory (i.e., CCR<.25).

Figure 2-3 Example of Possible Management Response Levels for a Wildlife Threshold



In Alberta, the *Regional Sustainable Development Strategy for the Athabasca Oil Sands* (Alberta Environment 1999), intended to promote sustainable development in this heavily industrialized region, proposes the implementation of a "Tiered Management Approach". This approach defines three levels or tiers of management response based on the state of a resource relative to a threshold. In this way, action can be initiated in proportion to the known or suspected severity of an effect on an environmental component. The three levels are (p. 18):

1. ***Cautionary***: Additional or more intensive monitoring is required to ensure the amount of stress on an ecosystem does not exceed the target level. This is the minimum response for an issue that has arisen but not enough information is yet known regarding the effects.

2. ***Target***: The management objective for the amount of stress on an ecosystem. Any stress beyond this point triggers stakeholder consultation. Any stress below this point implies some form of issue resolution is required.

3. ***Critical Load***: The continuous maximum amount of stress that an ecosystem can support without resulting in long-term environmental damage.

Table 2-2 defines the management actions for each level.

Table 2-2 Alberta Oilsands Tiered Management Approach

	Cautionary	Target	Critical Load
Key Response	**Continuous Improvement**	**Issue Resolution Management**	**Response Management**
Management Actions	• best management practices • adherence to provincial and national guidelines for leak detection and repair • routine environmental and activity monitoring	• expanded environmental monitoring and applied research initiated to support issue resolution • stakeholder consultation—issue resolution strategy • voluntary implementation of issue resolution strategy by regulators and affected stakeholders • best available demonstrated technology abatement equipment in new, expanding and retrofitted facilities	• stakeholder-derived response strategy • mandated implementation of response strategy by regulators through the approvals process • best available technology in new, expanding and retrofitted facilities • economic instruments; activity restrictions

Source: AE 1999, p. 19

2.5 The Practical Application of Thresholds

Practical application, however, of thresholds for biological organisms suggest that the “point” in the “*point* at which a resource undergoes an unacceptable change” may more reasonably not be a single fixed value, but instead be represented as a range. This better reflects natural variability (e.g., in population sizes), within which the lows experienced may not necessarily be the single threshold value (e.g., trigger a population collapse). Furthermore, the acceptable maximum and minimum of such a range may be based on a longer period of time rather than a single year as a “moving average”, such as the last 10 years of a population size. Therefore, for example, a threshold for a species’ natality rate of calves/cows or cubs/sows may exist somewhere between two numbers.

Furthermore, there can be more than one threshold for a species. For example, if a population is to be managed as a “source population” for a region, then that population’s viability/survivorship (i.e., “functional plateau”) must be higher than a population that is not viewed as a source population.

The development of thresholds for addressing cumulative effects for migrating species poses a unique challenge both from a scientific and administrative point of view. Administrative implementation of management strategies to control cumulative effects should ideally involve cross-boundary cooperation to ensure that environmental stressors remain within acceptable limits throughout the species' range. However, the effective integration of multiple-jurisdiction management initiatives across a broad, diverse landscape to control cumulative effects is difficult, if not impossible to achieve (although, for example, the North American Waterfowl Management Plan is a serious attempt at such a strategy). As a result, resource management agencies must develop resource objectives and thresholds for migratory species at a more regional scale to best address the seasonal and habitat-specific pressures facing the species in the management jurisdiction. While this may only represent a "piece of the puzzle", it is one that can be reasonably implemented and that will contribute, at least in some way, to sustainable management of the species.

Management objectives and thresholds that pertain to the protection of habitat are often the most practical vehicle for managing cumulative effects on species. In developing such thresholds, an understanding of the following factors is required (Hill *et al.* 1997) within any management area:

- nature and intensity of land use disturbances;
- proximity of critical habitats to sources of disturbance;
- proximity of alternative habitats;
- species-specific seasonal variation in sensitivity to disturbance; and
- presence or absence of species of particular management concern (e.g., listed species).

2.6 Types of Thresholds

Thresholds may take many forms. The most commonly used and readily available are those associated with quality parameters for air and water (e.g., SO_2 levels in air; Total Suspended Solids in water) and for dosage levels affecting human and animal health (e.g., exposure risk levels based on daily intake of contaminants).

Thresholds for wildlife are not as common, and for most species are not available in a form that can be readily applied in assessments or land use planning. Some thresholds that have been developed include:

- number of animals in a specific geographic area (e.g., 200 moose within a certain watershed or game management unit);
- species population indices (e.g., minimum calf/cow ratio);
- maximum human-caused mortality rate (e.g., hunting quotas);

- maximum exposure to a contaminant (e.g., ingestion by wildlife of contaminated vegetation);4
- minimum habitat availability;
- maximum level of land use activity or development within a specific geographic area (e.g., cleared area, length of access, access density) the corollary being minimum habitat effectiveness;
- maximum level of human presence (e.g., maximum allowable visitation levels on a park trail (in persons/month);
- limit to overall landscape change as subjectively expressed by residents and recreational land users (e.g., maintaining integrity of a viewshed); and
- limit to overall landscape change as expressed by First Nations based on traditional ecological knowledge (TEK) relative to a desired historical baseline (e.g., continued loss of land base resulting in decreased trapping opportunity and success).

These thresholds can be organized into three broad types:

1. Ecological (includes two sub-types: habitat availability and population);
2. Land and resource use; and
3. Social.

2.6.1 Ecological Thresholds

Ecological thresholds represent points at which a resource may no longer be sustainable. Project-related and cumulative effects on a wildlife resource may cause the species in question to approach a threshold either through influences on habitat availability or population recruitment/survival. The following discussion on ecological thresholds has therefore been subdivided into these two categories.

2.6.1.1 Habitat Availability Thresholds

Habitat availability is primarily a measure of the ability of the land base to provide food and cover for wildlife (i.e., habitat suitability and capability). However, animals may be unwilling to utilize suitable habitat in close proximity to land use activities to the same degree as comparable undisturbed habitat. Consequently, the willingness of animals to utilize habitat must also be factored into habitat availability (i.e., habitat effectiveness). For example, if female caribou cannot achieve appropriate security within calving grounds, then calving success and resulting recruitment to the herd may be affected. Similarly, security from disturbance effects of human activities is critical in allowing

[4] This Report does not discuss thresholds related to chemical/pollutant effects.

grizzly bears to effectively access and utilize key feeding habitats such as salmon streams and berry patches. This physiological and behavioural response[5] is also influenced by the size, shape and distances between patches of potentially suitable habitat (i.e., degree of landscape "patchiness").

Certain levels of habitat availability are required to maintain sustainable populations of wildlife within a given land base. Where the habitat requirements of a species are relatively well understood, threshold levels of habitat availability can be established for management or regulatory purposes. These thresholds may reflect absolute quantities of habitat, habitat patch size, connectivity and distribution, or measures of habitat effectiveness (i.e., useable habitat as a percentage of total habitat), depending on the species involved.

To assist in the evaluation of project or cumulative effects on habitat availability, the response of the species in question to disturbances associated with land use activities must be considered and quantified. These responses reflect a threshold of tolerance of an individual animal, which must then be translated into a practical thresholds that can be used for assessment and management purposes for populations.[6] Typically, this quantification is expressed through the use of two parameters (see Table 2-3 for an example): i) the distance from a land use activity within which the species is measurably affected, referred to as the "Zone of Influence" (ZOI); and, ii) an index of the severity of disturbance referred to as the "Disturbance Factor" (DF) within the ZOI. The DF is an index ranging in value from 0 (i.e., no disturbance and no effect on a specific species) to 1 (i.e., high disturbance and probable exclusion of species in question). The values are determined based on review of available literature; in some cases numerical values are inferred due to lack of quantitative information. Figure 2-4 illustrates a comparison for grizzly bear habitat between an undisturbed region and the same region disturbed by various roads, trails and facilities.

2.6.1.2 Population Thresholds

The long-term survival (viability) of populations is dependent on a balance between the rate of animals removed from a population (through emigration and mortality) and the rate of animals added to a population (through immigration and births).[7] Project-related effects or cumulative effects that alter these parameters have the potential to influence the long-term sustainability of a wildlife population.

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[5] See Appendix A for more detailed information on response mechanisms.

[6] This raises two important points. Firstly, a *major* assumption in current environmental assessment practice is that analysis based on effects on individuals may be used to presume effects on populations. This assumption is often realized through the analysis and interpretation of changes to wildlife habitat as an indirect or "surrogate" indicator of changes to wildlife. Secondly, although species response to human activities can be used as a basis for the separation of a species from a disturbance (e.g., no logging within 150 m of a waterbody supporting breeding birds), the establishment of such specific resource management "buffers" do not in themselves constitute a "threshold" for the purposes of this report. Instead, these distances contribute to the development of the types of regional-level thresholds described and advocated herein. This is not to say that, on an interim basis (e.g., failing the regulatory authority to implement thresholds or the lack of supportive scientific information), such buffers would not be a useful and pragmatic wildlife management technique until regional management thresholds can be confidently established.

[7] This is commonly expressed in ecology as N=B-D+I-E; where N is the population size, B is births, D is deaths, I is immigration and E is emigration.

Land use activities can potentially influence animal populations through direct animal mortalities (e.g., elimination of nuisance animals, vehicle/animal collisions, defence-of-life-and-property). For intensively managed species, acceptable levels of human induced mortalities may be available for use as management or regulatory thresholds. With such thresholds, some potential incremental increases in mortalities from a project may be accommodated by the species and may be considered acceptable by regulatory authorities if such increases do not result in the cumulative mortality rate to reach or exceed the threshold.

Table 2-3 Examples of Wildlife Zone of Influence and Disturbance Coefficients for Some Wildlife Species in Kluane National Park

Species		Aircraft	Trails	Roads	Settlements[3]
Grizzly bear	ZOI[1]	1	0.1	3	3
	DC[2]	H	L	H	M
Dall sheep	ZOI	0.5	0.1*	0.2	NA
	DC	M	L	L	NA
Mountain goat	ZOI	1	0.2	0.4	NA
	DC	H	H	H	NA
Moose	ZOI	0.2	0.1*	.1	.5
	DC	M	L	L	M
Golden eagle	ZOI	0.5	0.3	0.5*	NA
	DC	M	L	L	NA

Source: Hegmann 1995
*inferred (no direct quantitative evidence from literature)
1. ZOI in km.
2. DC rankings: L = low, M = moderate, H = high, NA = not applicable (i.e. activity not expected to occur).
3. “Settlements” includes any point sources of human disturbance

Land use activities can also potentially influence animal populations through more subtle energetic costs to animals constantly exposed to such activities. When confronted with a disturbance, animals have the option of either moving to avoid the disturbance (displacement outside the ZOI) or existing within the ZOI. Within the ZOI, activity budgets may be affected, with the potential for reduced foraging efficiency and altered energetic costs. As with habitat availability calculations, the extent of the ZOI and the relative severity of disturbance within the ZOI must be factored into any evaluation of potential energetic costs. Either option represents an incremental energetic cost to the animal that would have been absent in undisturbed terrain. It has been suggested that such costs, if sufficiently high, may influence the reproductive performance and even survivorship of an animal, although there remains considerable difficulty in establishing a cause and effect relationship at an individual or population level based on the knowledge obtained in the general literature. Contributing to this difficulty is the variation observed in response by different groups of the same species to largely the same disturbances in similar conditions.

Population level thresholds are also implied in the International Union for the Conservation of Nature (IUCN) *Categories of Endangerment for Species at Risk*.[8] The

[8] These may be adopted by Canada in pending federal and territorial legislation addressing Species at Risk.

categories classify a species into one of eight rankings based on the degree of risk to the species survival in the wild. Five criteria are used to evaluate which category is warranted. These criteria include numerical values for percentage population decline and period of time in which this decline occurs. For example, for Criterion A, a species is classified as *Critically Endangered* if there is a population decline of 80%, as *Endangered* if there is a population decline of 50%, and as *Vulnerable* if there is a population decline of 20%. For all of these, this decline has occurred or may occur within 10 years or three generations (whichever is longest). In practice, such declines must be recognized as temporary if part of a cyclic population change (e.g., the ten year lynx and hare cycle in the Yukon).

2.6.2 Land and Resource Use Thresholds

Land use plans provide regional objectives for the type and extent of land use activities within a given geographic area. Such plans should ideally provide the following types of baseline, planning and regulatory information:

- an understanding of regional issues of concern;
- spatial and temporal boundaries for planning purposes;
- environmental baseline and land use information for the planning area;
- definition and delineation of land use zones, each with various levels of restrictions on developments and environmental protection measures; and occasionally,
- recommendations for periodic monitoring of environmental conditions to evaluate planning effectiveness and the need for planning modifications.

Typically, the guidelines and objectives presented under the land use zonations can be used as regulatory and decision-making thresholds, against which the appropriateness of proposed projects may be judged. For example, road and associated public access development is a component of land use development that is becoming increasingly detrimental to wildlife in many areas through: 1) direct loss of habitat along cleared rights-of-way; 2) decreased habitat effectiveness adjacent to the road due to motorized traffic; and 3) the potential for increased hunting opportunity and harvest success (representing an indirect or induced effect). These effects have been well documented for various species and road conditions (e.g., Jakimchuk 1980, Bjorge 1982, Indian and Northern Affairs Canada 1983, Singer and Beattie 1985, Thiel 1985, Elison *et al.* 1986, Shideler *et al.* 1986, Mychasiw and Hoefs 1988, Cameron *et al.* 1992, Nellemann and Cameron 1996, Jalkotzy *et al.* 1997). Consequently, regional access management has become a common component of land use plans, with clear objectives on the location, abundance and operational conditions of the roads. The acceptability of proposed projects can be evaluated based on the incremental contribution of access of these projects within a regional context.

Figure 2-4 Comparison of Grizzly Habitat in Disturbed and Undisturbed Regions

back of figure

Resource use plans are frequently a component of land use plans. They can identify baseline conditions for key wildlife resources in the area, identify issues associated with the interaction of land use activities and wildlife, and then set objectives for desirable wildlife levels, uses and protection. These objectives often identify numbers of animals to be sustained within the planning area. The acceptability of proposed projects with the potential for influencing animals numbers can therefore be evaluated by regulators, based on whether the project jeopardizes the ability to comply with regional objectives for the wildlife of concern.

2.6.3 Social Thresholds

Ecological or land and resource use thresholds, or the information required to support such thresholds, may not be available or are not available with an acceptable degree of confidence. In such cases, if decision makers wish to continue to use thresholds as a criteria in their review of applications and land use, there remains the need for a mechanism to derive thresholds in the absence of adequate scientific based information and traditional knowledge.

Such thresholds are referred to as “social” thresholds, reflecting the largely subjective derivation of the threshold. Social thresholds can at first appear in any quantitative (e.g., ecological or land use) or qualitative form (e.g., representing “limits of acceptable change”). However, *qualitative* thresholds need to be translated into a “working” definition that can be practically implemented. That being the case, the challenge is not defining *types* of social thresholds, but in defining how to *derive* the threshold. An ideal process to achieve this objective should:

- allow the incorporation of all best available information and professional judgement;
- ensure that the stakeholders involved consent to the threshold; and
- test the validity of the threshold by utilizing an adaptive approach in which the first threshold is later possibly modified based on further information, such as monitoring or the review of new research.

These attributes suggest an approach to developing and implementing thresholds as follows:

1. Through a central co-ordinating group (e.g., a federal or territorial department), review available literature about the species regarding its response to effects of concern and its current and predicted distribution and occurrence in the region of interest.

2. Convene a workshop of technical specialists to recommend options for thresholds, using the provided information. Record all decisions, assumptions and data uncertainties.

3. Convene a workshop of affected and interested stakeholders who, along with the specialists, modify the suggested threshold options (in recognition of the scientific

uncertainty) based on views of the participants. Clear resource management objectives are required against which the threshold should apply.

4. Implement the thresholds as a factor in the application and land use decision making process.

5. Establish a monitoring program to determine if the threshold appears to be effective in achieving the resource management objectives.

6. If the threshold does not appear to be effective, re-convene the workshop participants to modify the threshold.

A critical and unique aspect of the above process is interpreting "views of the participants" in step 3, which implies the translation of opinion into a threshold that can be practically implemented in a decision making process. This involves balancing human concerns about wildlife in the midst of a variety of societal values (Manfredo *et al.* 1995); and, in understanding the four components of an individual's perception: 1) *attitudes*, which are an evaluation or feeling about something; 2) *values* which measure how important something is; 3) *norms or standards* which individuals use for evaluating activities (example as good or bad); and, 4) *motivation* which is why people behave the way they do.

Any consensus building process as used in many public participation forums is required to ensure the equal consideration of all views followed by a common decision. Examples of approaches to accomplish this objective include the round-table used by the Banff Bow Valley Task Report (Banff Bow Valley Study 1996) and Limits of Acceptable Change Process (LAC) (Stankey *et al.* 1985; Merigliano *et al.* 1997) to evaluate experiential values in wilderness recreational settings.[9]

Of particular relevance in the north are the means of communicating concerns as expressed by Aboriginal peoples. Comments made during public hearings, for example, often rely on a general observation about a perceived diminished or lost wildlife population in comparison to some reference time in the past within or before the observers generation. These observations reflect a long-term historical trend in a population, and a perceived cause-effect relationship in instances when a human disturbance occurred during that time. This information therefore represents a valuable input into the threshold decision making process.

As social thresholds, once derived, should be no different from ecological or land use thresholds, the remainder of this report will not explicitly refer to social thresholds.

[9] The LAC does not provide thresholds. It is one means of interpreting subjective views.

3.0 Thresholds For Selected Terrestrial Wildlife

This section discusses the use of thresholds for regulating cumulative land use pressures on grizzly bear, woodland caribou and moose. Where possible, actual threshold values used in the Yukon or other jurisdictions for these species have been discussed. However, in the absence of such values, the discussion has focused on the types of measurable parameters that could be used for evaluating project-related and cumulative effects on these species.

3.1 Grizzly Bear

Consideration and adoption of thresholds in species population management often reflect knowledge about the state of human impacts to the species and its habitats. For example, approaches in the management of grizzly bears in more heavily human populated and impacted southerly ecosystems in Canada and United States have evolved towards consideration of often complex suites of issues that affect both populations and habitats. In the Yukon, human-related impacts to ecosystem functions and health are far less than that experienced in the southern ecosystems. Consequently, population and harvest controls have been predominant in species' management while thresholds related to habitat availability and disturbance have been slower to evolve.

Grizzly bears can be an effective indicator of cumulative effects at a landscape scale because of the match between habitat requirements of the species (up to 1682 km^2 home ranges for males in the Yukon [Yukon Territory Government (YTG) 1997]) and the scale at which the environmental effects of development accumulate within the landscape. Effective use of grizzly bear as an indicator necessitates setting thresholds beyond which environmental effects will be detrimental to either the individual or the population.

3.1.1 Habitat Availability Thresholds

A suite of methods for determining habitat related thresholds for cumulative effects is found, for example, in the *Ecological Outlooks Project* prepared for the Banff-Bow Valley Study (Gibeau *et al.* 1996). This includes a habitat effectiveness model that follows the cumulative effects model (CEM) for grizzly bears developed by the U.S. Forest Service (U.S. Department of Agriculture Forest Service 1990). In addition to the habitat effectiveness model, the *Project* used core area analysis to identify areas secure from human disturbance for foraging use by female bears (Mattson 1993). The third tool used in the *Project* was the linkage zone prediction model. This allowed land managers to identify areas that facilitate movement between habitat fragmented by human disturbance. It is assumed that human disturbance in areas of high human development influences grizzly bear distribution. The model showed areas of high to low danger of human disturbance, with areas of low danger as potential linkage zones.

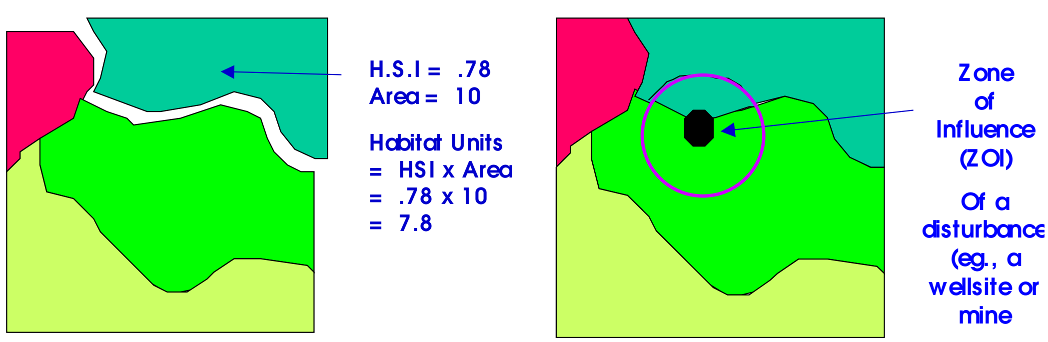
Despite the relatively advanced nature of the CEM, after a review of the application of the model for Yellowstone National Park's grizzly bear population, a key developer of the approach concluded that a "conservative approach to management of [bear] habitat and mortality" is warranted because of a high risk to the long-term viability of the park's bear population (partly due to increased access, visitor use and direct mortalities along the park periphery) (Mattson 1993). Mattson recommended "no increase in mortality risk" be allowed, and defined a practical working threshold such "that the situation should be no worse than at present and improved by any means possible."

The tools discussed below should be used as part of a suite of approaches for grizzly bear management. Each is applicable at different scales and for different purposes; use of one tool to the exclusion of the others risks ignoring cumulative effects at other scales and effects acting on grizzly bears in different ways. These approaches vary in their ease of implementation, data and monitoring requirements, and in their reliance on modeling and Geographic Information System (GIS) techniques. The use of habitat effectiveness models, core security area analysis, and linkage zone analysis has relatively high data and technology requirements. Development of these tools requires an integrated land use, habitat database and GIS capability.

3.1.1.1 Habitat Effectiveness

The habitat effectiveness model begins with subjective delineation of bear management units (BMU) at a 1:50,000 scale based on topography, human use, and known bear use. The habitat component of the model is based on habitat suitability ratings of ecological land classification (ELC) polygons within each BMU. Each polygon is assigned an index (ranging from 0 to 1) reflecting its monthly importance to grizzly bears (see Figure 3-1 for an example). The result of this evaluation is an assessment of potential habitat quality for each BMU for each season. The disturbance component of the model considers four factors: whether human activity is vehicular or non-mechanized (foot or horse); whether activity occurs at a point or along a linear feature; whether activity is high or low in intensity, and; whether there is associated cover. Based on this stratification, each activity group is assigned a DC and ZOI based on values developed for the Yellowstone ecosystem or as modified and adopted elsewhere.

Figure 3-1 Example of Habitat Assessment Analysis



Note: Shaded areas are "polygons" in a GIS representing patches of contiguous vegetation, soils and terrain features as interpreted by an ELC.

Disturbance coefficients multiplied by habitat values within the ZOI generated "realized" habitat values, which are interpreted as the ability of the habitat influenced by human activity to support bears. The comparison of potential and realized habitat is habitat effectiveness, or the percentage of habitat left after accounting for human disturbance. This model does not predict the number of bears that would be supported by an area. Yellowstone National Park identified a habitat effectiveness value of 80% as a threshold below which grizzly bear use of an area declines. Banff National Park has adopted a threshold which requires 80% of all BMUs to have 80% or greater habitat effectiveness (Parks Canada 1997). BMUs that will not reach 80% contain human use levels that preclude habitat effectiveness of greater than 80%.

Data from a number of intensive grizzly bear studies have been used to develop ZOIs and DCs for the grizzly bear models. Some of the more relevant information has been summarized below:

- On a seasonally closed road, the mean distance that bears were found from roads increased from 655 m to 1222 m when a closed road was opened (Kasworm and Manley 1990).

- Grizzly bears appeared to avoid habitat up to 274 m from trails (Kasworm and Manley 1990). Generally, trails were found to displace grizzly bears less than roads.

- In northwestern Montana grizzly bears avoided roadside buffer areas with increasing traffic on these roads and with increasing road densities (Mace *et al.* 1996). Bears in that study did use important habitat adjacent to low to moderately used roads. In particular, all bears studied avoided buffers of roads with >60 vehicles/day, most avoided buffers of roads experiencing >10 vehicles/day, with some selection or no response to roads experiencing less than or equal to 10 vehicles/day.

- Female grizzly bears, while willing to cross certain two-lane highways, were unwilling to cross the more heavily used Trans-Canada highway in the Bow River valley (Gibeau and Heuer 1996).

- In another study in Montana, areas within 500 m of roads were used significantly less than expected in the spring and fall (Aune *et al.* 1986). For bears not thought to be habituated to roads, avoidance of areas was noted within 500 m of roads for spring, summer, and fall, and avoidance of areas up to 1000 m was noted in the fall.

- Similarly, in Yellowstone National Park, grizzly bears avoided habitat within 500 m of roads in spring and summer and within 3 km in the fall (Mattson *et al.* 1987).

Using such information, the CEM (cumulative effects model) quantifies ZOI and DC for 12 different categories of disturbances, based on a linear, dispersed or point source pattern, motorized or non-motorized, intensity of use, periodicity of use, and for cover and non-cover terrain conditions. Table 3-1 summarizes this information (from Weaver *et al.* 1986). The numbers and approach have been subsequently modified to reflect different conditions, such as in the Canadian Rockies, in which DCs were defined within a constant 500-m ZOI.

Table 3-1 ZOI and DC for Grizzly Bear as used in the CEM

Activity	Cover		Non-cover	
	ZOI (km)	DC	ZOI (km)	DC
Motorized				
linear, high use	.8	.7	3.2	.6
linear, low use	.8	.9	3.2	.8
point, diurnal high intensity	1.6	.5	3.2	.4
point, diurnal low intensity	1.6	.7	3.2	.6
point, 24-hour	1.6	.2	3.2	.1
Motorized, dispersed	na	.5	na	.4
Non-motorized				
linear, high use	.2	.8	.8	.7
linear, low use	0	1	.8	.9
point, diurnal	.5	.8	.8	.5
point, 24-hr	.5	.5	.8	.3
dispersed, high use	na	.8	na	.7
dispersed, low use	na	1	na	.9

Source: Gibeau *et al.* 1996

3.1.1.2 Connectivity

The linkage zone prediction model (adopted in Canada from the U.S. Fish and Wildlife Service in Gibeau *et al.* 1996) predicts areas in the landscape that provide varying degrees of danger to grizzly bears. This tool differs from habitat effectiveness modeling in that it is used to analyze and map areas in a landscape that could act as potential wildlife movement corridors connecting habitat separated by human activity. The degree of danger an area represents to bears is based on four criteria: access route density, type and density of human use, presence/absence of hiding cover, and occurrence of riparian areas. Four categories of access route density were defined based on Servheen and Sandstrom (1993): 0 mi/mi^2, 0-1 mi/mi^2, 1-2 mi/mi^2, and >2 mi/mi^2. Human use points or lines with less than 100 people/month were buffered with a 120 m ZOI, while areas above 100 people/month were buffered with a 240 m ZOI. The presence or absence of hiding cover and riparian areas was determined from the existing ecological land classification. The output of the model produced a map of areas of high potential for wildlife use and travel to which particular management attention should be paid. This model has been used in Banff and Jasper National Parks to draw management attention to wildlife movement “pinch-points” and areas reflecting the last available movement corridors in highly developed areas.

The Bow Corridor Ecosystem Advisory Group (1997) identified thresholds for wildlife movement corridors in the Bow Valley, Alberta. Primary wildlife corridors are defined as areas of land connecting large, contiguous habitat and being used by wary wildlife species. These corridors also provide connectivity between distant populations. Vegetation in these areas meets cover requirements for a variety of species and may also provide forage habitat. These primary corridors are to have a minimum width of 350 m and may be wider or narrower depending on topography, cover, and corridor length. A secondary corridor is defined as that appropriate for smaller species, or those species more tolerant of human activity or development, such as elk. Secondary corridors also provide linkage to larger patches of habitat. As for primary corridors, secondary corridor dimensions may vary with topography, cover, and corridor length.

3.1.2 Population Thresholds

Grizzly bears have low reproductive rates and as a result can sustain only low rates of human caused mortality and are slow to recover from over-harvest (YTG 1997). In addition, increases in mortality have not been linked with compensatory increases in cub production or survivorship, or in subadult survivorship (Miller 1990, Weaver *et al.* 1996). Thus, removals from the population through natural causes, management actions, hunting, or through land use activities (e.g., highway mortalities) are an important component of managing grizzly bear populations.

As in other jurisdictions, Yukon uses total known mortalities of grizzly for managing this species. Currently, YTG has adopted and uses an annual allowable number of human-caused grizzly kills of 6% of the estimated population. This is based on estimates adopted by other North American biologists, recognizing the low reproductive capacity and low recruitment rates in most populations (J. Hechtel, pers. comm.; Horesji 1996). Within this 6%, one third may be females. On a sex-specific basis, it has been estimated that a human-caused mortality rate of 2 females/year/100 females would be sustainable if each female is removed from separate 1000 km^2 areas. If only males are killed, it has been estimated that a human-caused mortality rate of 6 males/year/100 males would be sustainable (YTG 1997).

Such management thresholds can be used to assess the potential impacts of a proposed project on bears in an area. If the project has the potential to result in bear mortalities and if these mortalities can be accommodated within the designated 6% threshold, then the project may be viewed as acceptable. Alternatively, if the incremental mortalities from the project, in combination with existing and future mortality sources, result in an exceedance of the threshold, then the project could not be accommodated from the perspective of bear management, unless other sources of mortality (e.g., legal harvests) are reduced.

If such thresholds are to be used for impact assessment and land use decision-making purposes, it is important to consider the dependence of these thresholds on accurate population and density estimates, as well as mortality estimates. In the Yukon, population estimates are derived for ecoregions based on limited studies that have generated area-specific population estimates based on extrapolation of estimates from other areas (J. Hechtel, pers. comm.). From a mortality perspective, deaths from defense-of-life-and-property (e.g., for bears foraging in garbage) are considered unacceptably high in the Yukon (J. Hough, pers. comm.) but are often difficult to quantify. Difficulties in estimating non-harvest mortalities and low recruitment rates require conservative thresholds for total mortality (Nagy 1990, Miller 1990, YTG 1997). Nagy (1990) recommends a maximum known human-caused mortality rate of 4% with a sex ratio of three males to one female for the northern Yukon. Population management should also include criteria for habitat effectiveness with clear thresholds such as road densities (to be discussed later) (Horesji 1996).

Demographic parameters pertaining to females grizzly bear have also been used for population management and may have some application for cumulative effects assessment. For example, Weaver *et al.* (1996) cite adult female grizzly survivorship of higher than 0.92 as characteristic of estimated stable or increasing Rocky Mountain populations. Assuming that such survivorship data were available for a particular region, this value could be used to assess the potential sensitivity of an area to project development and associated impacts. Sex ratios in harvest statistics are frequently used as an indirect method of estimating female mortality rates in a population. However, Miller (1990) warns against setting objectives for grizzly bear harvest based on the sex or age ratios in harvest statistics since the sex ratio in grizzly bear harvests is a function of a number of factors and is not constant. For example, males and females may be differentially vulnerable to human-caused mortality. Additionally, natural mortality rates may differ by sex and age and the proportion of total mortality may not be represented by harvest statistics. As a result, Miller recommends setting harvest guidelines in terms of the total number of adult females that may be harvested, and the same approach is likely appropriate for establishing acceptable thresholds for total human-caused mortalities.

3.1.3 Land and Resource Use Thresholds

3.1.3.1 Road Densities

Roads are thought to present the most important threat to grizzly bear habitat both through the resultant avoidance of habitat and associated mortality related to hunting (USFWS 1993). Therefore, road densities have been suggested in a number of studies as a practical threshold for the purposes of establishing management objectives for grizzly bear (i.e., based on relatively readily available data on access routes). The ecological effects of roads on a landscape are generally measured by open road densities (Forman and Hersperger 1996).

Road density standards have become an important component of grizzly bear management plans (Mattson 1993). Indeed, long-term access management plans are required to maintain viable grizzly bear populations (McLellan 1989). To use road densities for management and planning purposes, information on the nature, location and use patterns of the roads is required. Road use information (i.e., levels of use) may be available from government transportation, planning, and recreation departments, as well as through local knowledge and primary research. Road densities can be calculated with the aid of a GIS to spatially display density distribution.

The allowable level of road density may vary with the land-use objectives of an area. Mace *et al.* (1996) found that areas with less than 6 km/km^2 were used by grizzlies while areas with higher densities were not. The U.S. Fish and Wildlife Service (1993) cite allowable open road densities in grizzly bear recovery areas of between 0.47 km/km^2 to 0.62 km/km^2 while Craighead *et al.* (1995) promote more conservative open road densities of $<0.16\ km/km^2$.

Mattson (1993) outlines five points to consider when setting road density standards or thresholds:

1. Road density standards should vary among ecosystems as a function of bear range sizes and local human attitudes, with lower allowable densities where ranges are larger and/or human attitudes more negative.

2. Road density standards should reflect mortality risk (largely due to induced hunting as opposed to vehicle collisions) more than habitat alienation; and if behavioral data are used as a basis for road density standards, then the spatially explicit effects of habituation and/or intra-specific spacing on mortality risk should be accounted for.

3. Road densities should be calculated so as to account for the effects of variable cover and road closures.

4. Trails should be incorporated into road density calculations on the basis of pro-rated equivalencies.

5. Studies of the relationships between road densities and bear behavior or demography should ideally encompass an area equivalent to approximately 10 female home ranges, including areas not impacted by roads, and should include enough data to allow spatially explicit structured analysis of life expectancy and population growth rate.

For the Yellowstone ecosystem, Mattson recommended average open road densities of not greater than 0.16 km/km^2 for a home range with allowable increased densities of less than 0.4 km/km^2 over some part of the home range. Mattson recommends standardizing actual road length with conversion factors for other variables such as presence of associated hiding cover, level of use, and presence of motorized use versus non-motorized (foot) use:

> *For example, with 100% cover and closure of all roads to motorized traffic, a total density standard of 0.8 mi/mi^2 could be met with as many as 2.67 mi/mi^2 of existing closed roads and trails. At the other extreme, if 25% cover and open roads were maintained at maximum allowable densities (e.g. 0.6 mi/mi^2), total density of linear features would have to be approximately 0.87 mi/mi^2 to meet density standards.* (p. 13)

The Interagency Grizzly Bear Committee (1994) outlines a methodology to establish thresholds for road densities in grizzly bear recovery zones. While actual thresholds are not suggested, a four-step methodology for developing thresholds is defined:

1. Delineate BMUs, with each being the approximate size of an adult female grizzly bear home range.

2. Develop road density maps for each seasonal use period if possible, and categorize roads as: open, restricted, open motorized trail or restricted motorized trail. These maps are then used to calculate and categorize road/trail densities.

3. Identify core areas. These are areas which: 1) have no motorized use during the non-denning period; 2) have no road/trails with high intensity, non-motorized use; and, 3) are a minimum of 0.3 miles (500 m) from any open road or motorized trail. Additionally, if information is available, core areas should contain representative

habitat (for all seasonal habitat needs) of the BMU. Core areas should also remain in place for at least 10 years to allow for female replacement.

4. Define acceptable levels of motorized access. While specific thresholds are not provided, parameters for consideration are suggested and include total motorized access route density, open road and open motorized trail density, and the proportion of the analysis area in the core area.

It is important to remember that many of these models and thresholds were developed in other regions (e.g., originally in the Yellowstone area and subsequently in the Montana Flathead and Alberta's Eastern Slopes) and as a result, coefficients and assumptions may need to be adjusted to potentially different situations in the Yukon. Horejsi (1996) makes a number of recommendations on road densities for the Yukon. These recommendations are based on the requirement of the area of interest remaining 60% roadless (i.e., having 60% of the area greater than 1 km from a road). First, any potential roaded area should remain roadless for 11 to 20 year periods (to allow resident females to adjust to different land-uses and to produce a replacement female). Second, a threshold road density of 0.4 km/km^2 should be established. The planning area should be divided into Operating Units (OU) equal in size to the home range of an adult female (250 km^2). Within each OU, not more than 10% may have a road density that exceeds 1.25 km/km^2; an additional 10% may sustain road densities of less than 0.62 km/km^2, and; up to 30% of the OU may have a road density up to 0.3 km/km^2. Horejsi recommends including seismic roads in road density calculations unless these features contain no mechanized use and vegetation is in an advanced degree of recovery from disturbance. Horejsi does not propose any associated minimum size threshold for a roadless area, which is an important consideration in other studies (Mattson 1993; Gibeau *et al.* 1996).

3.1.3.2 Core Security Area

Human access is recognized as one of the most important factors when considering grizzly bear security (Gibeau *et al.* 1996). As a result, it is recognized that preservation of areas where grizzly bears will be secure from human encounters is important (Mattson 1993). Core security area analysis[10] was conducted for the *Ecological Outlooks Project* using similar methods as that done by the Interagency Grizzly Bear Committee (1994). A core security area is an zone roughly equal in size to the area required for 24 to 48 hour foraging period of a female grizzly. Zones of Influence for human use points or lines were set at 500 m on either side of a feature. A minimum size threshold for core security areas of 10.1 km^2 was adopted for the analysis of Banff National Park, as has been done by the U.S. Forest Service for the Flathead National Forest. Gibeau *et al.* (1996) do not provide a threshold value for the area of landbase that should be secure. Jasper National Park has, however, adopted a threshold of 60 to 67% of each BMU as secure habitat (H. Purves, pers. comm.).

[10] Core security area is closely linked with habitat availability in the context of the thresholds classification used in this Report. Core security area is a combination of land use thresholds and habitat availability thresholds. Access proliferation results in habitat fragmentation. Habitat fragmentation can be measured either with or without the direct indication of roads. Core security measurement however is solely based on access measurements, the result being the identification of habitat patches (i.e., fragmented habitat). For this reason, core security is classified as a land/resource use threshold as opposed to a habitat availability threshold.

Mattson (1993) discusses core security areas and defines them as the average daily foraging radius of a female grizzly bear (in Yellowstone) with a 2 to 4 km buffer. This is calculated as an area with a minimum diameter of 6 km and approximate area of 28 km^2. To allow undisturbed and barrier free movement, these security areas have approximately twice the radius of an average 24 to 48 hour feeding session (an area of 10 km^2 with a radius of 1.8 km). For a grizzly bear life range of 884 km^2, approximately 57% of the area would be in security areas. Security areas should ideally be contiguous and part of a network as opposed to being scattered and isolated. With respect to levels of use in these areas, Mattson recommends limited dispersed use by hunters, no open roads, and low densities of closed roads or trails. For a BMU, standardized road density is not greater than 1.38 times the open road density or 0.36 mi/mi^2.

3.1.3.3 Human Visitation

Thresholds have been developed based on maximum tolerable levels of non-motorized human visitation in protected areas. In Banff National Park, increased human use was identified as contributing to a significant effect on the park's grizzly bears (BBVS 1996). These thresholds of use were then recommended to assist in future park management efforts in the park's backcountry.

A GIS was used to map levels of human use in the park on a 6-point scale, ranging from 10 persons per month to 1 million persons per month (each increment represented an increase in use by a factor of 10). As expected, backcountry trails experienced the least amount of use, while popular tourist areas, highways and townsites received the highest level of use. A limit of 100 persons per month would not exceed a threshold of tolerance for the bears during the summer (this can be compared to a winter threshold of 1000 person per month for wolves based on observed responses of wolves to human disturbances and activities).

3.2 Woodland Caribou

3.2.1 Habitat Availability Thresholds

Currently, habitat availability does not appear to be a limiting factor to woodland caribou in the Yukon, as caribou densities are well below habitat carrying capacity (YRRCMT 1996). However, a primary habitat management practice for woodland caribou is the identification, demarcation and protection of core habitat areas. Current management practice in the Yukon is to restrict all development and disturbances within the core winter areas of each herd. While it is recognized that many other features of caribou habitat are important, such as movement corridors from summer range to winter range, efforts to map those areas have been unsuccessful (R. Florkiewicz, pers. comm.).

In the southern Yukon, degradation of lichen and lichen-producing resources are a concern, leading to a "zero" tolerance (i.e., a threshold of zero loss) for loss of lichen-producing habitat (R. Florkiewicz, pers. comm.). The potential for disturbance to caribou during seasons other than winter are also recognized as having potential for causing deleterious effects on populations. However, due to a general lack of knowledge about the effects involved, no mechanism for managing these disturbances in the southern Yukon has yet been developed, and no explicit habitat thresholds have been established.

In other management jurisdictions in Canada, habitat availability has been used as a measurable parameter for assessing impacts to barren-ground caribou from project developments[11]. In the Northwest Territories, summer foraging habitat availability was modeled for the proposed Diavik diamond mine (AXYS *et al.* 1998) for different development scenarios. Habitat Suitability Index (HSI) modelling was used to evaluate the potential of identifiable land/vegetation cover types to support caribou during the summer period, based on known or assumed relationships between elements of habitat structure and the provision of life requisites. Habitat Suitability Index values were calculated on a scale of 0 (no habitat value) to 1 (optimal habitat value) for each cover type, based on the presence of important forage species and on the proximity to concealment cover for predators. The area of each cover type was multiplied by its HSI value to determine the number of foraging Habitat Units (HUs) for caribou.

Habitats were grouped into three equal suitability classes to illustrate the distribution of foraging habitat under baseline conditions:

- **High** (HSI > .30): heath tundra, tall shrub, heath boulder.
- **Moderate** (.26< HSI ≤ 30): sedge meadow, tussock hummock, eskers, bedrock.
- **Low** (HSI ≤ .26): heath bedrock, boulder, birch seep.

To assess habitat loss from project development, the project footprint and ZOI were superimposed onto the habitat map, and HSI values were modified within affected areas based on assigned Disturbance Coefficients (see Table 3-2). To adjust these values, the ZOIs and DCs were developed from knowledge of caribou responses to activities, and the nature of activities associated with the mine. As is typical for the quantification of complex species responses, the values are associated with some uncertainty and therefore should be conservatively applied.

[11] Although barren-ground caribou and their environment differ from woodland caribou, this discussion based on barren-ground caribou assumes that the fundamental concepts (not necessarily the values) may be adopted in the Yukon.

Table 3-2 Caribou ZOI and DCs Used for Assessing Cumulative Habitat Loss from the Diavik Diamond Mine and other Land Uses

Disturbance Source	Zone of Influence	Disturbance Coefficient[1]
Exploration camp	3 km	0.1 (very low)
Mine footprint	N/A	1.0 (very high)
Mine Zone of Influence	3 km	0.1 (very low)
Outfitting base camp	2 km	0.1 (very low)
Hunting corridor	2 km	0.1 (very low)
Wildlife research station	3 km	0.1 (very low)
Road camp	3 km	0.1 (very low)
All weather road	1 km	0.1 (very low)
Airstrip[2]	7 km/1 km	0.3 (low)

Source: AXYS *et al.* 1998, Table 6.3.1-1
Notes:
1. Assumed proportional reduction in HSI value for caribou (between 0 and 1), represented by both a numerical and descriptive ranking.
2. 7 km off end, 0.5 either side of airstrip

In summary, assessing cumulative changes in habitat availability involved the following steps in the Diavik assessment:

1. Map seasonal habitat suitability (HSI values) for vegetation and land cover classes in the Regional Study Area (RSA).

2. Calculate summer habitat availability in the RSA under baseline conditions.

3. Superimpose land uses on the RSA.

4. Calculate reductions in habitat effectiveness within footprints and ZOIs, and recalculate habitat availability within the RSA.

5. Calculate net change in habitat availability for various assessment periods.

No thresholds of required habitat availability were provided by resource management agencies to evaluate cumulative effects significance for this study. Instead, the incremental loss of habitat resulting from the project and other land use activities was evaluated within the context of habitat availability within a designated regional study area[12.]

There are no standard habitat evaluation systems for caribou in Yukon, or established thresholds for habitat availability to assist with land use planning. However, discrete critical (core) winter ranges of caribou herds have been mapped, with efforts to expand accuracy of mapping to all herds (R. Florkiewicz, pers. comm.). Distribution of that information is currently limited to discussion with regional biologists and viewing maps available in regional offices (R. Florkiewicz, pers. comm.). For caribou, mapping must

[12] Such an analysis may also be used to provide a qualitative review of the effected habitat connectivity, especially between large areas of high habitat suitability.

include lichen producing habitats. This may be obtained from remote sensing such as satellite imagery for landscape-scale planning. Smaller scale mapping is required where site-specific features such as road crossing corridors are important (e.g., Carcross Herd, R. Farnell, pers. comm.).

Based on this existing information, it would appear that a framework is in place for developing lichen-based habitat classification system for evaluating winter habitat for caribou. If models could be developed for calculating and mapping HSI values for identifiable cover types, then land use activities with associated ZOIs and DCs could be superimposed onto the land base to evaluate current ecological integrity for caribou. Thresholds could then be developed for caribou ranges of interest to assist with land use planning and impact assessment. Such thresholds could be based on habitat effectiveness objectives (i.e., ratio of realized habitat to potential habitat, expressed as a percent for a designated area), or total habitat availability objectives (i.e., total habitat units for a designated area).

3.2.2 Population Thresholds

Mortality of caribou through natural predation and hunting is the primary management concern of the Yukon Renewable Resources Caribou Management Team (CMT). As stated in their *Woodland Caribou Management Guidelines*: "Yukon woodland caribou occur at densities well below habitat carrying capacity and are held there by predation and human harvest" (YRRCMT 1996). They state that, particularly for small herds, predators can play a significant role in caribou abundance. Due to the greater potential effects of annual mortality on long-term survival of small herds, hunting has either been suspended (Carcross/Squanga Herds) or stricter controls through permit hunts on several small herds (including the Klaza Herd) have been imposed. Interestingly, since moose are considered an important alternative prey to caribou for wolves, predation mortality of caribou can be directly affected by the number of moose in an area. Additional mortality through the high rate of road kill (5/year) on the Carcross herd is of concern to the Department of Renewable Resources (R. Farnell, pers. comm.).

Project developments in caribou range can influence population parameters through three processes:

- direct animal mortalities (e.g., highway mortalities);
- increased energetic costs to the animal; and
- increased exposure to predators/hunters.

Given the vulnerability of caribou to factors influencing the productive capacity of the population, protection strategies and thresholds linked to population parameters can have a vital role in land use planning in caribou areas.

3.2.2.1 Use of Population Parameters

Where a large proportion of a population has the potential for exposure to intensive land use activities, thresholds related to population parameters such as calf/cow ratios can be established to monitor herd health trends by management agencies. Such thresholds also provide regulators with a parameter for evaluating the ability of a population to accommodate land use activities. For example, in the southern Yukon, an assumption made by the YTG Caribou Management Team is that populations with 30 to 35 calves/100 cows is generally stable to increasing. A series of years with less than 30 calves/100 cows indicates low recruitment and a population that is probably declining. If a proposed development has the potential to seriously interact with a population exhibiting below-threshold cow/calf ratios, the potential effects of the project on the caribou may be viewed as being unacceptable, unless other factors influencing herd demographics are controlled.

While development pressures such as urban expansion, forest clearing and agriculture are increasing in the southern Yukon, the *Woodland Caribou Management Guidelines* do not specifically identify cumulative effects thresholds. However, the YTG is actively studying and managing woodland caribou populations on a herd-by-herd basis for the 23 herds in the southern Yukon (R. Farnell and R. Florkiewicz, pers. comm.). Management and study emphasis is placed on those herds perceived as being threatened, such as the Aishihik herd (Farnell *et al.* 1996), and has included:

1. radio collar studies, to delineate herd ranges;
2. population trends, measured by annual sample counts during the fall breeding season when the sex and age composition is evident;
3. population change, determined by census surveys every 4 to 5 years; and
4. habitat assessments, to determine range productivity and identify critical areas.

These assessments have led to management action that included establishing a wolf control program for some herds and closing the hunting season on other herds with the objective of decreasing overall caribou mortality (YRR 1998). Such techniques could also be used to enable caribou populations to better accommodate certain levels of development and disturbance, should it be in the public interest for such developments to proceed.

3.2.2.2 Use of Energetics Modeling

Land use activities can also potentially influence caribou populations through more subtle energetic costs to animals constantly exposed to such activities. When confronted with a disturbance, animals have the option of either moving to avoid the disturbance (displacement outside the ZOI) or existing within the ZOI. Within the ZOI, activity budgets may be affected, with the potential for reduced foraging efficiency and altered energetic costs. As with habitat availability calculations, the extent of the ZOI and the relative severity of disturbance within the ZOI must be factored into any evaluation of potential energetic costs. Either option represents an incremental energetic cost to the animal that would have been absent in undisturbed terrain.

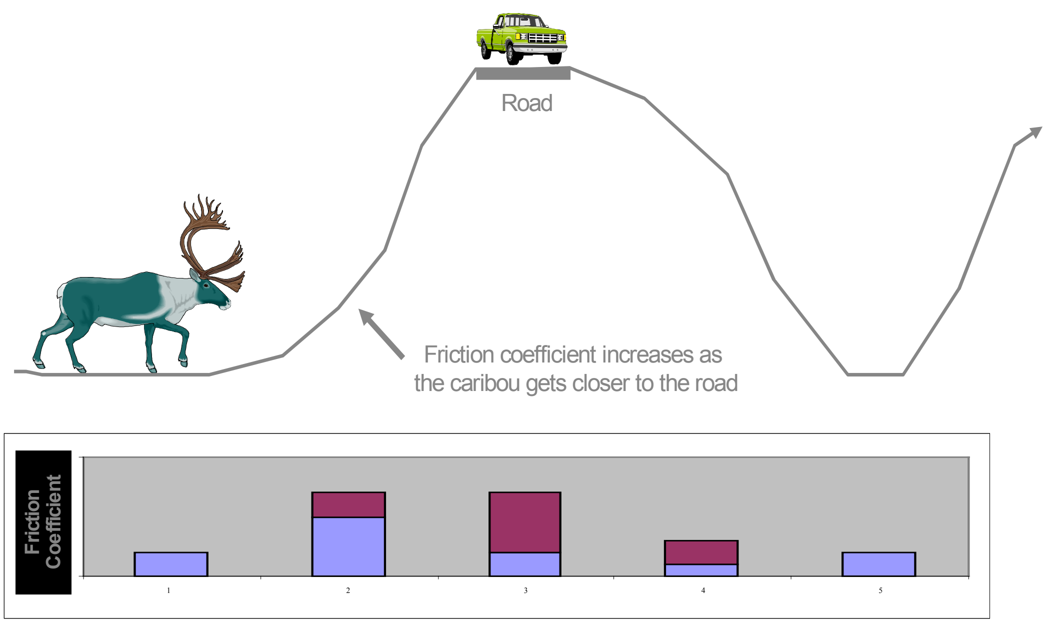
While few energetic thresholds have been completed for the management or protection of caribou herds, a number of modeling techniques have been developed to assess the potential energetic effects of land use activities on caribou. Recent initiatives include the development of an energetics model for the Yukon Porcupine herd (by the Canadian Wildlife Service), and have the use of an energetic model for the Diavik diamond mine CEA.

Friction Modeling

As part of the wildlife impact assessment for the proposed Diavik Diamond Mine, "friction modeling" was used to assess the potential effects of the project and other surrounding land use activities on caribou movement costs during spring and fall migration (see Figure 3-2). Based on predicted and established relationships between caribou movements and such factors as slope, aspect, vegetation cover, and waterbodies, the modeling assigned friction coefficients to the land base within a regional study area under predevelopment conditions. Using randomly selected starting points at the edge of the study area, the model was then run to predict the pathway of least resistance and associated energetic costs for caribou moving through the study area under pre-development conditions. Existing and proposed land use developments with assigned ZOIs with increased friction coefficients were then superimposed on the land base, and the model was re-run to determine potential increases in energetic costs from the avoidance of or interaction with land use activities. The significance of project-related and cumulative increases in energetic costs was then evaluated within the context of total energetic costs incurred moving through the study area.

Friction modeling was originally developed in Banff National Park to predict paths of least resistance for large carnivores moving through the Bow Valley Corridor (Paquet *et al.* 1996). Model output was used to assist in developing future land use planning initiatives to improve habitat connectivity and ecological integrity for large carnivores in the Park. Given the mountainous nature of much of the woodland caribou terrain, this modeling technique could be adapted to identify important movement corridors for caribou, and the nature and extent of development that could be accommodated within such corridors. Development thresholds could then be established, based on required corridor distributions and configurations.

Figure 3-2 Friction Modeling for Caribou



Models Associated with Body Condition

The Canadian Wildlife Service (CWS) in Whitehorse has recently developed an energetics model for the Porcupine caribou herd that predicts body fat content of adult, lactating female caribou at the time of the fall rut. Information required to run the model includes starting female body weight on the calving grounds, seasonal diet, forage availability, typical activity budgets for females (under normal and high insect-harassment periods), and levels of insect harassment during the summer period (based on weather data) (D. Russell, pers. comm.). A probability curve also developed by CWS relates body fat content at the time of the rut with the likelihood for conception, enabling herd productivity to be estimated for a particular year.

To supplement the impact assessment information provided by the friction modeling runs for the Diavik Diamond Mine, the CWS model was adapted for use on the Bathurst caribou herd to predict the potential effects of the mine on herd productivity. Additional information required for these runs included the proportion of herd exposed to Diavik's ZOI, the duration of exposure to the ZOI during the summer and fall periods, and the predicted activity budgets of caribou under the influence of the ZOI. Much of this information was developed from three years of baseline information on caribou collected for Diavik. Although no thresholds on acceptable conception rates were available to enable the significance of project-related effects to be evaluated, the magnitude of predicted incremental change within the context of natural variability was calculated as a means of evaluating the significance of project effects.

This model offers a possible strategy for developing thresholds for management and impact assessment purposes. Assuming that models can be developed that accurately predict body condition under natural conditions, existing and proposed land use activities could be superimposed onto the landscape with associated ZOIs to determine the potential effects of cumulative activities on herd productivity. A threshold of acceptable conception rates could then be established to evaluate the acceptability of potential project effects. However, the data requirements to develop the bioenergetic data base needed for a woodland caribou model would be large, and the model difficult to implement quickly for the woodland caribou situation. In addition, detailed herd distribution and habitat use data would be required to estimate the exposure of animals to proposed land use developments.

In northern Alberta, an alternative approach for estimating the energetic implications of land use developments on woodland caribou was developed in response to increasing oil and gas activities in woodland caribou range. Bradshaw (1994) studied the increased physical stress and energy expenditure caused by the combined impact of energy exploration, traffic and physical barriers on woodland caribou in this area. His modeling approach considered: 1) the normal winter energetic budget of woodland caribou in northeastern Alberta; 2) the degree to which multiple perturbations can affect winter energy loss; and, 3) the history and disturbance of winter petroleum exploration in northeastern Alberta.

Based on his work, Bradshaw concluded that woodland caribou are more susceptible to site-specific disturbances, as they are much more sedentary than barren-ground caribou which exhibit very large seasonal movements. He proposed an "Exposure Rate" (ER) threshold for woodland caribou of 23 perturbation encounters/winter or .0375 encounters/km^2/winter (i.e., 23 encounters expressed as a function of mean winter home range area). Beyond this value, it was concluded that mean winter weight loss would exceed that which occurs in the absence of disturbance. Bradshaw further concluded that "it is essential that land use planning focus on methods of reducing the numbers of exploration programmes in different areas of high industrial use."

This work provides a more practical approach to the development of thresholds for caribou management and protection in Yukon. Much of Bradshaw's information on overwintering bioenergetics for woodland caribou and the effects of perturbations on energetic costs was developed from existing information sources, rather than field research, and could be adapted to the Yukon setting. New information required for the work predominantly pertained to the nature and distribution of exploration activities planned for the assessment area. Detailed herd distribution and habitat use data was also required to estimate the exposure of animals to proposed developments. Based on the availability of herd data for woodland caribou in Yukon and the ability to track development proposals through permit applications, it would appear that these latter two data sets could be developed for use in the Yukon setting.

3.2.3 Land and Resource Use Thresholds

3.2.3.1 Territorial Management Guidelines

Land and resource use thresholds often take the form of protection or mitigation requirements, rather than broad regional objectives. For example, DIAND's *Timber Harvesting Planning and Operating Ground Rules* (DIAND 1998) include harvesting design thresholds within caribou management zones pertaining to the retention of high quality winter habitat in key habitat and migration corridors, and the configuration of cutblocks (i.e., cutblocks should be <200 m wide and <20 ha in area).

Similarly, the *Woodland Caribou Management Guidelines* lists 36 management principles, guidelines and assumptions intended to provide a framework for consistent responses by Yukon Renewable Resources to management plans, programs and regulation proposals. These items include generalized facts known about the entire population such as descriptions of herd sizes (see Appendix B) and general migratory behaviour, to generalized assumptions of adult mortality rates, stable male/female ratios within herds, and habitat use. While woodland caribou are managed on a herd-by-herd basis (R. Florkiewicz, pers. comm.), this document is used as a general guideline for the management of woodland caribou throughout the Yukon. Caribou management therefore focuses on harvest control and protection of key habitat by implementation of project-specific mitigation measures and land use and access control.

In support of these initiatives, the Territorial government conducts four primary woodland caribou assessment programs (YRRCMT 1996):

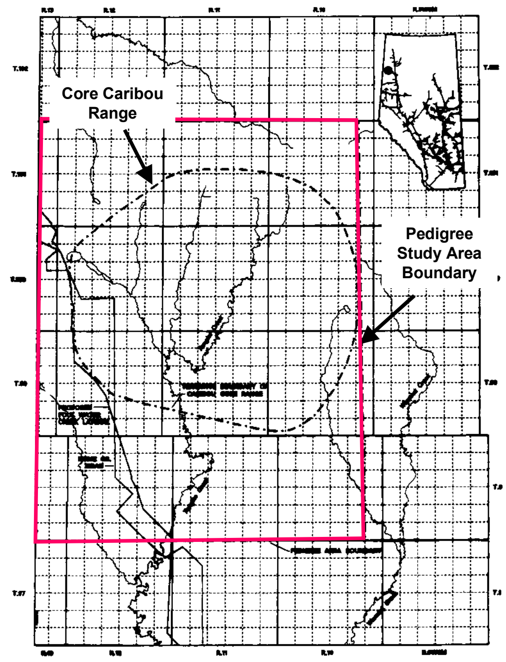
1. radio collar studies, to delineate herd ranges;
2. population trends, measured by annual sample counts during the fall breeding season when the sex and age composition is evident;
3. population change, determined by census surveys every 4 to 5 years; and
4. habitat assessments, to determine range productivity and identify critical areas.

3.2.3.2 Access and Exploration Controls

Thresholds based on maximum levels of activity in a given area may be used to restrict the level of development in that area. This approach was adopted for a Caribou Protection Plan in the Pedigree region of northwestern Alberta (Pedigree Caribou Standing Committee 1991). The following discussion is based on this Plan.

The purpose of the Plan, a joint industry-government initiative, was to develop and implement land use guidelines governing oil and gas operations in key caribou winter range in the Pedigree region. A study area boundary of approximately 1,200 km^2 was established (about 12 townships), surrounding a core caribou range of approximately half that size (Figure 3-3). The types of effects caused by industrial activity included access development, habitat alteration, predation pressures and sensory disturbance. Linear corridors with the potential to support road or off-road vehicles (e.g., ATVs) include seismic lines, pipelines and resource access roads (e.g., to wellsites, pipelines and timber harvest cutblocks).

Figure 3-3 Pedigree Caribou Study Area



Source: Pedigree Caribou Standing Committee 1991.

The plan made use of a variety of land use thresholds as follows:

Maximum Simultaneous Activity Levels per Township

- A maximum of 30 km of linear corridors will be active in any township (i.e., 100 km^2) within the Pedigree area at any given point in time from December 1 to April 30. This active corridor density (i.e. 1 km/3.3 km^2 or 0.33 km/km^2) was adopted based on an assumed ZOI of 1 km on either side of the corridors, resulting in a maximum of 60% of any township being within a potential ZOI at any given time. An active corridor is defined as any seismic line, utility line or access road supporting equipment of vehicle travel during exploration, construction or operational phases of development.

Maximum Activity Levels per Township per Winter

- A maximum 300 km new linear corridors will be approved in any township during a single winter. Such approvals will be granted on a first-come-first-served basis until the limit is reached. Emergency maintenance requirements will not be affected by this restriction.

Absolute Maximum Development per Township

- Cumulative areas of disturbance (i.e., clearing) from all components of oil and gas activities will be monitored after each season of operation to determine the total level of habitat alteration within the Pedigree area. Once 5% of the area of any township has been altered from clearing, all future activities will be restricted to existing cleared corridors.

It should be recognized that this plan was developed for a specific geographic setting with specific land use pressures. Due to a decline in exploration pressures in the area, it was not in place for a long enough period of time to enable an evaluation of the thresholds to be undertaken. Consequently, the thresholds developed for this plan would have to be reviewed and likely modified for other settings. However, it provides an example of preliminary land use thresholds developed for the protection of woodland caribou. The basic framework of the approach could have applicability in the Yukon, particularly considering the level of herd-specific information available.

3.3 Moose

3.3.1 Habitat Availability Thresholds

Although moose is one of the most heavily studied wildlife species in North America, little has been developed on habitat-related thresholds for the management and protection of this species. However, the moose has relatively well understood habitat requirements because of its dependency on browse for much of the year and, as a result, has been the object of considerable habitat suitability modeling over much of North America. Habitat supply information for coarse regional planning can usually be generated for moose from remotely-sensed data sources (e.g., air photos, satellite imagery), coupled with a habitat classification, evaluation and mapping system. As a result, net changes in seasonal habitat availability can be quantified for various land use development scenarios without extensive data requirements. Similar to the caribou discussion, assessing project-specific or cumulative changes in habitat availability within an area of interest would involve the following steps:

1. Rate and map seasonal habitat suitability values for habitat classes in the area of interest.

2. Calculate seasonal habitat availability in the area under baseline conditions.

3. Superimpose existing and proposed land uses on the area.

4. Calculate reductions in habitat effectiveness within footprints and ZOIs, and recalculate habitat availability within the area.

5. Calculate net change in habitat availability for various assessment periods.

Appropriate ZOIs and DCs would have to be developed for moose for this process. In general, moose tolerate human presence to a greater degree than many ungulate species. Nevertheless, there is evidence of reduced habitat use by moose around well-traveled roads and other facilities, relative to that in comparable undisturbed habitats (Skinner

1996). Based on a literature review and expert consultation, Norecol, Dames and Moore Inc. (1998) suggested that habitats be de-rated in areas surrounding industrial facilities and regularly used roads or highways. Van Egmond and Giles (1996) reduced habitat values for moose within 1 km of land use activities for impact studies in northeastern Alberta, while studies in northeastern B.C. reduced habitat values within 500 m of disturbances (AXYS 1999).

3.3.2 Population Thresholds

There are an estimated 60,000 to 65,000 moose in the Yukon, and total numbers are believed to be stable to slowly increasing (YRR 1998). Moose populations in the southern Yukon are at naturally low densities and range from 150 to 250 moose/1000 km^2 (YRRMMT 1996). Most moose habitat in the Yukon is relatively undisturbed by human activity, but many productive habitats are in demand for human uses. Although hunting pressure is high in some areas, the total reported moose harvest is well within the estimated sustainable harvest of 2000 to 2500 moose/yr (YRR 1998).

No population or bioenergetic-based thresholds currently in use for moose management or protection related to land use developments were identified. However, current population monitoring in the Yukon may provide information to assist in the development of such thresholds. High priority areas for monitoring moose populations were established in the mid-1980s, all close to Yukon communities (YRRMMT 1996). Assessment of moose populations is based on periodic surveys, and YTG has surveyed approximately 15% of the Yukon. Moose populations at moderate risk are to be surveyed every 5 to 10 years, while those at high risk should be surveyed every 3 to 5 years. Similar to the caribou discussion, cow/calf ratios or other population parameters may become available for assessing the relative health of regional herds, and such parameters could be used parameter for evaluating the ability of a herd or population to accommodate land use activities.

3.3.3 Land and Resource Use Thresholds

DIAND's *Timber Harvesting Planning and Operating Ground Rules* (1998) contains harvesting design thresholds within moose management zones. This includes maximum edge to edge distance of cutblocks of <400 m, all points within cutblocks within 200 m of thermal/hiding cover, and patches no less than 3 to 5 ha in area.

The *Moose Management Guidelines* (YRRMMT 1996) lists 68 management principles, guidelines and assumptions intended to provide a framework for consistent Departmental responses to management plans, programs and regulation proposals. These include generalized facts known about the entire moose population such as population size, to generalized assumptions of adult mortality rates, stable male/female ratios, habitat use, and effects of natural predation. This document is used as a general guideline for management of moose throughout the Yukon. To that end, management focuses on harvest control and protection of key habitat, through mitigation of land use and access control (YRRMMT 1996).

The following strategies have been identified in the *Guidelines* as important for moose management:

- The control of human activities including hunting and disturbance is the most important and practical moose management technique.
- The likelihood of successful reproduction can decline if the proportion of bulls drops below 30 bulls/100 cows (i.e., too few males to breed with the females).
- It is critical that access be regulated. For direct new access such as roads, effective mechanisms to control the harvest by all users, including First Nations, are required.

Allowable Annual Harvest (AAH) rates for Yukon moose can range from 2 to 5%. Harvest rates over 5% can be considered under the following circumstances:

- high density or rapidly growing populations;
- experimental management programs; and
- for a moose population that is regularly surveyed and is stable or increasing.

4.0 Thresholds For Avian Wildlife

There are 276 species of birds documented in the Yukon. Of these, 145 are seasonal breeders (i.e., they migrate out of the Yukon for the winter), while 41 are resident year-round (Appendix C).

4.1 Landbirds

Landbirds include raptors, upland gamebirds, herons, and songbirds. There are 163 species of landbirds in the Yukon, accounting for 59% of the species known to occur in the region (Yukon Bird Club 1998). The landbird group includes most of the resident species that breed and overwinter within the Yukon, and also a number of species that are either short or long distant (Neotropical) migrants that breed in the Yukon, and overwinter as far south as Mexico or Central and South America. These migrant species are subject to a broad, global scale of cumulative effects, rather than being limited to the cumulative effects within the Yukon alone. Also, the migration routes of most landbirds are not as well understood as they are for waterbirds (Section 4.2). Neotropical migrants appear to be more "sensitive" to landscape changes than do temperate migrants or resident birds (Flather and Sauer 1996). However, for the purposes of this document, the grouping of birds to landbirds and waterbirds will be sufficient to summarize current knowledge of cumulative effects thresholds on bird populations.

Population declines have been noted for forest breeding Nearctic-Neotropical migrant landbirds over the past four decades (reviewed in Askins *et al.* 1990). The most probable links to those declines include spreading urbanization, increased habitat loss and forest fragmentation (Villard *et al.* 1999) and associated increase in nest parasitism and depredation (Temple and Wilcox 1986; Donovan *et al.* 1995; Hahn and Hatfield 1995; King *et al.* 1996), and the loss of wintering habitat in Mexico and Central and South America (Warkentin and Hernández 1996). A review of long-term breeding bird population data suggested that depredation on the breeding ground in North America plays a larger role in migratory songbird decline than does deforestation on the wintering grounds in the tropics (Böhning-Gaese *et al.* 1993).

The Yukon Territory Department of Renewable Resources is currently developing a list of priority management species that includes all Yukon vertebrate wildlife. The list of species is being developed in a fashion similar to British Columbia's Red and Blue List ranking system (Harper *et al.* 1994; W. Nixon, pers. comm.). Management of bird species and their habitats requires basic knowledge of life history characteristics for bird species inhabiting the Yukon. However, knowledge of basic life history and dispersal characteristics for the majority of landbird species found in the Yukon is lacking. For instance, good demographic information is not yet available for most species on their breeding grounds, migration routes, or winter grounds (Sherry and Holmes 1995). Information is also lacking on species-specific dispersal distances, how mortality varies throughout the annual cycle for any single Neotropical migrant bird species, or where individuals from particular breeding populations overwinter (Sherry and Holmes 1995). While there is no doubt that there are cumulative effects related to human disturbance on bird populations, the unknowns of basic life history characteristics and dispersal patterns make it difficult to identify limiting factors for bird populations, and even more difficult to approach population tolerance thresholds. While quantification of these variables remain elusive, critical thresholds certainly must exist (Mönkkönen and Reunanen 1999).

Landbirds can be an effective indicator of cumulative effects at a landscape scale because of their diversity of habitat uses, the high species diversity present in the Yukon, the relative ease of locating and counting birds, and increasing public awareness of bird conservation and the effects of disturbance and habitat loss for a variety of species world-wide. The following sections summarize the current knowledge of cumulative effects thresholds for landbirds, with a focus on providing definitions and potential applications for the Yukon.

4.1.1 Habitat Availability Thresholds

Human effects on habitat that have been identified as important to landbird populations across North America include habitat loss and fragmentation (Groombridge 1992, in Fahrig 1997). Habitat fragmentation typically refers to the creation of habitat gaps and habitat edges, and the associated loss of habitat connectivity. These processes have undoubtedly contributed to decreases in the number of some forest species, and may also account for temporal variation in species richness due to local extinction and turnover at the landscape scale (Boulinier *et al.* 1998). Habitat loss and fragmentation can result from any land use activity involving the clearing/modification of native (and sometimes non-native) vegetation communities, but have predominantly occurred from large scale land use activities such as agriculture, forestry and urbanization. These processes may also result from natural processes such as forest fires.

Due to the relative sparse development within the Yukon, habitat availability generally does not appear to be a limiting factor to most landbird populations. However, there are a few areas where particular habitat types may be threatened. Some of the most important migrant songbird habitat in the Yukon is located in the southeast and includes the La Biche, Beaver, and Liard River Valleys and higher elevation subalpine habitats of the Kotaneelee Range (M. Gill, pers. comm.; Eckert *et al.* 1997; Eckert 1998). The availability of riparian spruce habitat, particularly in the southeast, has been identified as a management concern because of increasing logging interests in the area (M. Gill, pers. comm.). Such forests provide particularly unique habitat components for birds, including large nesting trees for bald eagle and osprey (D. Mossop, pers. comm.), and snags and other wildlife trees important for cavity nesters (Mossop 1997). Minimum acceptable thresholds for the amount of this habitat to be retained have not been established (M. Gill, pers. comm. and C. Eckert, pers. comm.).

4.1.1.1 Habitat Loss and Fragmentation Thresholds

Habitat loss and fragmentation occur simultaneously across a landscape and can potentially affect the stability of populations. Those effects may occur across a landscape through isolation of sub-populations and by reducing the amounts of suitable habitats capable of meeting basic living requirements (Lande 1987; Hanski *et al.* 1996; Villard *et al.* 1999). In highly fragmented forests, it is still unclear whether some bird populations have been reduced because of fragmentation effects (i.e., smaller patch sizes, loss of connectivity), or because of overall habitat loss (Villard *et al.* 1999). Several modeling exercises suggest that the effects of habitat loss far outweigh the effects of habitat fragmentation (Fahrig 1997).

Habitat availability can be reduced through direct removal of the habitat (e.g., forest harvesting, draining of wetlands, road construction), or by fragmentation of habitat into smaller and smaller patches until those patches become so ineffective that birds are no longer able to use them to meet their living requirements. Habitat can be fragmented by the parceling of the landscape into patches through a pattern of habitat removal across a landscape, or by sensory disturbances in adjoining areas where birds use of existing habitat patches would be limited due to recurring disturbances (Gutzwiller *et al.* 1998). However, there was little evidence in the literature to suggest the existence of discrete thresholds where bird species respond significantly to landscape fragmentation characteristics.

Results of a forest fragmentation and habitat loss modeling exercise suggested that when breeding habitat covers a minimum 20% of a landscape (discussed below), population survival is ensured regardless of the level of fragmentation across a landscape (Fahrig 1997, Andrén 1994 in Villard *et al.* 1999). Similar results of a 20% threshold were found for northern spotted owl abundance in Pacific Northwest forests (Lamberson *et al.* 1992). The nature of the 20% threshold appears to be the reduced juvenile bird dispersal, resulting in a failure to colonize new territories due to a shortage of habitat. In this study, the actual habitat availability threshold varied depending on the initial number of owl pairs, the density of suitable habitat, and dispersal strategies (Lamberson *et al.* 1992).

There are many interpretations of what defines a “landscape” (McGarigal and Marks 1995), and a full discussion of that topic is beyond the scope of this report. Landscapes generally occupy some spatial scale between an organism’s home range and its regional distribution. For Neotropical migratory birds, landscape sizes used for an evaluation of habitat availability would occupy spatial scales that are intermediate between a species’ territory or home range (e.g., 1–100 ha), and the species’ distribution over larger areas (e.g., 1–1000 km^2) (Freemark *et al.* 1995), perhaps such as a watershed. Landscape sizes that have been used to assess the amount of remaining habitat have ranged from 1,000 ha (Lamberson *et al.* 1992; Rosenberg *et al.* 1999), 100 km^2 (10,000 ha) of mixed agricultural/forest landscapes (Villard *et al.* 1999), to 1,200 km^2 (120,000 ha) with a resolution of 200 m x 200 m (Flather and Sauer 1996; Boulinier *et al.* 1998) based on the habitat represented by a breeding bird survey route. Another study of the effects of forest fragmentation on bird densities in northern boreal forest used data that was collected over a 100,000 km^2 area over a period of several decades (Helle and Järvinen 1986).

Landscape scale assessments have also included measures of the minimum amount of suitable habitat (MASH), defined as the minimum density of habitat patches necessary for the long-term persistence of interacting local populations (Hanski *et al.* 1996). Those assessments were made using a modeling approach of landscapes in Finland. Mönkkönen and Reunanen (1999) caution against the use of generalized landscape thresholds in that generalizations across large geographic regions can not be produced. Instead, regional, site, and population-specific thresholds must be developed and be based on empirical observations.

Habitat structural thresholds theoretically exist where habitat destruction and fragmentation can occur until structural properties of the habitat patches themselves change in a non-linear fashion once a certain threshold of habitat removal is reached

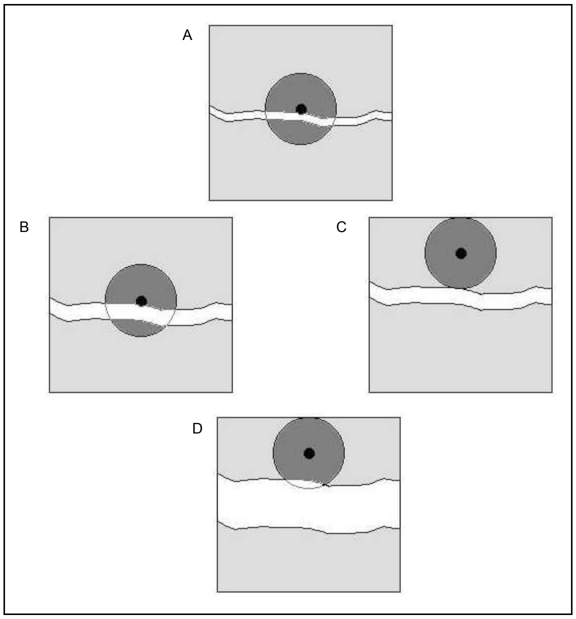
(Bascompte and Solé 1996). However, no discrete thresholds of that type have been defined, and if they were, they would be dependant on specific vegetation, topographic, and other site-specific features. Overall, we currently lack a common parameter for measuring habitat fragmentation across a landscape (Villard *et al.* 1993; McGarigal and Marks 1995; Hessburg *et al.* 1999). Methods of assessing landscape spatial patterns suggested by the latter two documents may provide guidance for future assessments. However, considerable effort remains in understanding the effects of habitat loss and fragmentation on landbird habitat or on populations at the landscape scale (Mönkkönen and Reunanen 1999).

4.1.1.2 Forest Gap Thresholds

The placement of openings within forest cover may influence ways in which bird territories are established. Some forest species may include some forest openings within their territories to a certain maximum proportion that is dependent on conditions of the opening and the condition of the existing forest. If gaps force individuals to shift their territories to more consistent forest cover, there is the potential for negative population effects resulting from the creation of increasingly overlapping territories (Hagan *et al.* 1996, Rail *et al.* 1997) (Figure 4-1). At the individual level, there might be species-specific threshold responses to habitat openings. For instance, Swainson's thrush did not appear to shift their territories in response to openings created by recreational trails, unpaved roads, and powerline rights-of-ways through mature balsam fir/spruce forest in eastern Québec until the openings became >25 m wide; golden-crowned kinglets to openings 40 m wide; black-throated green warblers to openings 35–40 m wide (Rail *et al.* 1997), and 65–70 m wide for white throated sparrows, a forest generalist (Rail *et al.* 1997). These movement thresholds may have impacts at the population level once openings become so dispersed across the landscape that due to a lack of recolonization following local extinction, maintenance of a stable population can not be ensured (Villard *et al.* 1999). However, a landscape evaluation to determine thresholds of forest opening sizes and dispersal of those openings has not been conducted.

Birds respond to forest gaps in a variety of ways that are dependent upon species behaviour, habitat preference, and the width of the forest gap (Rail *et al.* 1997) (Figure 4-1). Desrochers and Hannon (1997) and Rail *et al.* (1997) have studied the phenomena of bird response to habitat gaps created by forest harvesting. Generally, habitat generalists (e.g., dark-eyed junco) were more likely to cross treeless gaps than were forest specialists (e.g., golden-crowned kinglet), but again, actual threshold distances were not quantified because the study also included varying spatial patterns of habitat openings that were difficult to quantify. A general conclusion of the Desrochers and Hannon (1997) study in northern Alberta was that birds were twice as likely to travel through 50 m of woodland than through 50 m of open ground, and that many birds will choose forested crossings even if they are up to three times longer than crossing through an opening. In a related study in fragmented boreal forest of northern Alberta, a study of bird movements through forest corridors connecting larger patches of habitat mention the possibility of there being threshold distances above which birds would not travel (Machtans *et al.* 1996). However, discrete threshold distances were not quantified in that study.

Figure 4-1 Forest Gaps and Bird Territories



A theoretical bird territory (circle) placed along a forest gap (white area). In (A) birds may use two forests (shaded area) separated by a narrow gap (e.g., 3 m wide) as if it were contiguous habitat. As the gap width increases (e.g., >20 m), preference of birds for woodland may become apparent (C), until finally, the gap width exceeds some threshold that regardless of habitat preference, the opening exceeds the average territory width (D), until birds are forced to use the treeless edge of only one side of the gap as a territory boundary (Source: Rail *et al.* 1997).

Patch sizes less than 5 ha are typically excluded from bird surveys and analysis because they are too small to conduct an effective bird survey, and they are too heavily influenced from surrounding landscapes to determine actual uses of the small patches (AXYS, pers. obs.; Villard *et al.* 1999). A study of female ovenbird breeding success in mature hardwood forest patches of different sizes (4.5–25.9 ha patches) surrounded by agriculture in eastern Québec found that pairing success was reduced because dispersal and habitat selection were altered (Villard *et al.* 1993). However, the size threshold at which patches became ineffective was unknown. Future modeling habitat availability may be approached using breeding habitat area requirements such as area occupied by a breeding male, or dispersal distances of juveniles (White *et al.* 1997).

4.1.1.3 Forest Edge and Habitat Effectiveness

Clearing required for roads, pipelines and other linear developments can result in the introduction of forest edge into large areas of interior forest. Expanding urbanization and other developments can change habitat effectiveness beyond the interface between the development and the habitat edge (Friesen *et al.* 1995; Friesen 1998) (Table 4-1). Road and other right-of-way densities are typically high in areas that have been logged or intensively developed for oil and gas, and the effects on wildlife due to road construction often overshadow the effects of timber management (Reid 1993). Increase in the amount of forest edge/clearing interface and increased patch fragmentation have resulted in increased nest depredation and nest parasitism rates within remaining forest habitat, thus lowering the local productivity of birds using the remaining habitat (Roth and Johnson 1993; Seitz and Zegers 1993; Yahner *et al.* 1993; Camp and Best 1994; Hagan *et al.* 1996; King *et al.* 1996; Darveau *et al.* 1997; Suarez *et al.* 1997; Keyser *et al.* 1998; King *et al.* 1998; Villard *et al.* 1999). Nest depredation and parasitism rates along abrupt habitat edges such as those created by agriculture and roads were found to be nearly twice as high as along more gradual edges where vegetation succession was allowed to occur in hardwood forests in southern Illinois (Suarez *et al.* 1997). The study also suggested that edge habitats may be colonized by younger birds or birds in poor reproductive condition, indicating poorer habitat quality (Van Horne 1983).

Human intrusion can have effects on habitat effectiveness by restricting access to various resources, and affecting reproductive success by disturbing breeding behaviour or causing nest abandonment (Hill *et al.* 1997; Gutzwiller *et al.* 1998). Human intrusion near nest sites is perhaps the most disturbing variable to nest success of many raptor species, particularly golden eagle (D. Mossop, pers. comm.). Repeated human intrusion (e.g., hikers along a trail adjacent to breeding habitat) may not have been a major factor affecting bird behaviour in mixed conifer forests of Wyoming (Riffell *et al.* 1996). Human intrusion is, however, the major problem for nesting raptors (D. Mossop, pers. comm.), and overwintering raptors at roost sites (Holmes *et al.* 1993). Most of the research on disturbance thresholds has been conducted on raptors; an example of some of that research and the derived disturbance thresholds on bald eagles is presented in Table 4-2.

4.1.1.4 Temporal Structural Change

Human impacts on long-term habitat structural changes occur primarily through harvest rotational practices in managed forests. In the absence of forest outside of a timber harvest landbase, old-growth characteristics can potentially be eliminated across entire landscapes. Typical harvest rotation ages for forest stands in the southern Yukon is 80 years for pine, 100 years for spruce, and 120 years for spruce/fir stands (DIAND 1998). Harvesting stands at these ages may limit habitat forest age thresholds of several bird species, most importantly for primary cavity excavating species. For instance, in western Newfoundland, a minimum forest age of between 60-80 years was found to be required in balsam fir forests before black-backed woodpeckers would use this habitat type. Similar types of thresholds have been found for the northern spotted owl in the Pacific Northwest (Forsman *et al.* 1977; Miller *et al.* 1997), and for a number of songbirds that can be found in southeast Yukon (Enns and Siddle 1996).

4.1.2 Population and Demographic Thresholds

Direct mortality due to hunting is limited to some upland gamebirds and waterfowl, while most migratory songbirds and raptors are protected from hunting under the North American Migratory Bird Act. The mortality for the current upland gamebird hunt in the Yukon probably is not having an effect on gamebird populations (D. Mossop, pers. comm.).

The southeast Yukon is the northern range limit for a number of migratory songbirds, many of which have similar status to songbirds found in northeast British Columbia (Enns and Siddle 1996) which are also at the extent of their distribution. Birds existing at the geographic margins of their breeding range, as is the case for many landbirds in the Yukon, may be subject to increased variation in many demographic factors including

Table 4-1 Examples of Zones of Influence for Some Landbird Species Found in the Yukon

Species	Disturbance Type	Disturbance Effect	ZOI (m)	Habitat Type, Location, Comments	Source
Ovenbird	Increased edge created by small forest clearcuts (2.1–5 ha)	Decreased nest success due to increased depredation	200	Hardwood forest, New Hampshire. Small-scale clearcutting in extensively forested landscapes can elevate nest predation rates and may decrease ovenbird productivity within a 200-m zone adjacent to clearcuts. Making clearcuts as close to circular as possible can minimize effect of edge.	King *et al.* 1996
American kestrel	Combined walking and vehicle disturbance	Flushing bird from winter foraging/roost area	75	Grassland/agricultural area, Colorado	Holmes *et al.* 1993
Merlin			125		Holmes *et al.* 1993
Prairie falcon			160		Holmes *et al.* 1993
Rough-legged hawk			210		Holmes *et al.* 1993
Ferruginous hawk			140		Holmes *et al.* 1993
Golden eagle			300		Holmes *et al.* 1993

Table 4-2 Examples of Spatial Buffers and Temporal Restrictions for Bald Eagles

Location	Spatial (m)	Temporal	Reason for closure	Source
Montana	400	01 Feb–15 Aug	Reduce human disturbance.	D. Flath, Montana Fish, Wildlife and Parks, Bozeman, pers. comm., cited in Richardson and Miller 1997
	800	01 Feb–01 Aug	Reduce effects of noise.	Call 1979, cited in Richardson and Miller 1997
North-central Minnesota	500	Not discussed	Reduce human disturbance. Buffer based on flushing distance of disturbed eagles.	Fraser 1985
	250	Prior to egg laying through incubation	Reduce effects of human activity.	Grier *et al.* 1983, cited in Richardson and Miller 1997
Colorado	800	15 Nov–31 July	No explanation provided, but associated with foraging eagles	Colorado Division of Wildlife 1995, cited in Richardson and Miller 1997
Oregon	800	1 Jan–31Aug	To reduce human disturbance. Based on breeding phenology. This restriction relaxed around unoccupied or failed nests.	Anthony and Isaacs 1989
Oregon	400	Year-round	To reduce effects of habitat removal. Based on patch stability (3-tree lengths plus a 200 m buffer).	Anthony and Isaacs 1989
British Columbia	200	Nesting season	To reduce human disturbance. A no activity buffer. No foundation for buffer width was provided. Further suggested that 2–2.5 h of forest be left unlogged around known nest trees.	Davies 1985

(Mönkkönen and Reunanen 1999). Fluctuating population numbers may also be a factor of migratory birds failing to return to the northern extent of their breeding territory if there is suitable habitat available further south along the migration route (as has been suggested for birds returning to wintering grounds in Costa Rica (Warkentin and Hernández 1996). However, for some species, peripheral bird populations, such as many of the wood warblers found in southeast Yukon, may be genetically distinct from those found in the core of the range. These genetically distinct populations contribute to the genetic variation of the metapopulation, which is important for surviving long-term environmental changes such as habitat loss or alteration and global warming (Newton 1998; Fraser *et al.* 1999). Overall, changes in habitat and associated effects on bird densities in southeast Yukon can have far-reaching and long-term effects on entire populations for some species of landbirds.

Researchers are still at the stage of assessing large populations across the landscape, and there are currently no good estimations of absolute populations of birds in the landscape. Minimum viable population studies (Hanski *et al.* 1996) have based their assessments of populations on the amount of available habitat as a surrogate to actual landbird numbers. Bird population monitoring efforts and sources of survey data in the Yukon are presented in Appendix D.

4.1.3 Land and Resource Use Thresholds

Broad-scale land and resource thresholds have not been considered for birds as they have for more prominent species as grizzly bear and caribou. DIAND's *Timber Harvesting Planning and Operating Ground Rules* (1998) approaches some of the land and resources use thresholds by concentrating on site-specific features of harvest areas and through nest site protection. Some of the landbird concerns that are addressed in that document include the following management guidelines:

Cavity Tree and Snag Retention

1. Wherever possible, cavity tree requirements should be included in individual trees, clumps, and islands within the cutblock. Minimum size for a clump is a radius of one tree length.

2. Cavity trees should be 7 m high and have a 30 cm diameter.

3. Dead standing and/or live potential snag trees should be left in the cutblock, (approximately 8 trees/ha) wherever this does not jeopardize worker safety.

Nest Sites

1. Avoid harvesting and disturbing nest sties such as those of hawks and owls.

2. Leave a patch of trees 100 m or more in diameter to conceal the nest and provide perching sites.

3. Operating windows may be necessary to reduce disturbance effects on birds of prey during the nesting period.

4.2 Waterbirds

Of the 276 bird species documented in the Yukon, 108 (39%) are waterbirds (Yukon Bird Club 1998). For the purposes of this document, "waterbirds" include swans, geese, ducks, loons, grebes, rails, seabirds and shorebirds. The majority of Yukon waterbirds are migratory, breeding in the Yukon but overwintering as far south as Mexico, and Central and South America. The Yukon has the only nesting surfbirds in Canada, and healthy numbers of breeding trumpeter swans, a species listed as vulnerable by COSEWIC (Committee on the Status of Endangered Wildlife in Canada)(Mike Gill, pers. comm.).

Banding studies have shown that Yukon waterbirds are associated with all four North American flyways. Both the Pacific and Central Flyways converge in the Yukon, resulting in a diversity of migration patterns among Yukon waterbirds. Within the Yukon, the Pacific Flyway extends outward from the Tintina Trench, an extension of the Rocky Mountain trench, and includes the area west of Whitehorse. The Central Flyway occurs in the area east of Teslin (T. Powell, pers. comm.). The major migration routes include the Pacific Coast route, the Pacific Oceanic route, the Mackenzie Valley-Great Lakes-Mississippi Valley route and tributaries, and the Great Plains-Rocky Mountain routes.

At present, there are no imminent threats to waterbird populations in the Yukon, with the possible exception being loss of wetland habitat due to residential development in the southern Yukon (J. Hawkings, pers. comm.). Spring staging areas that can include large open water areas are often close to human development (e.g., Marsh Lake south of Whitehorse), thus the birds staging there may be subjected to increasing human disturbance. However, limited information on the seasonal distribution and abundance of waterfowl in the Yukon limits the ability of biologists to make conclusions on threats to waterbirds (J. Hawkings, pers. comm.).

Other human activities that have been identified as potentially disruptive to waterbird habitat in the Yukon include mining and processing, oil and gas development, recreational activities, and hydroelectric development. In 1996 the Yukon *State of the Environment Report* estimated that 13% of the Yukon consisted of natural areas (e.g., limited evidence of development impacts) and 7% was developed or occurred near developed areas. The developed areas were associated with roads in central and southern Yukon, most of which have been developed since 1945 (Yukon Department of Renewable Resources and Environment Canada 1996). The report also stated that there has been little loss of important wetlands and that four wetland areas have protected status as a result of land claims settlements since 1984. Some of the smaller wetlands, mainly in southern Yukon, are threatened by residential or agricultural development (Yukon Department of Renewable Resources and Environment Canada 1996).

The Canadian Wildlife Service manages migratory waterbirds in the Yukon. Because of the large-scale migration patterns of many waterbird species, cross-boundary initiatives are required to address the conservation of individual species. The North American Waterfowl Management Plan (NAWMP), which was introduced in 1986 provides a framework for prioritizing conservation at a scale which can take into consideration the entire range of migrating species (Hyslop 1986). A major goal of the NAWMP is to achieve and maintain a continental breeding population of 62 million ducks, and a fall flight of 100 million geese and 152,000 swans. This goal will influence an estimated 4.5 million hectares of habitat in Canada and the U.S. over the first 15 years of the program (Hyslop 1986).

Ducks Unlimited Canada (DU) developed a Continental Conservation Plan in 1994 to guide habitat programs continent-wide. The Plan contains a detailed analysis of the status of North American waterfowl species and their habitats, and provides recommendations regarding where and on what DU should focus its efforts. At present, DU has determined that the Yukon and Northwest Territories is an extremely important region for waterbirds, particularly for geese, but that the "low human population has resulted in minimum disturbance to waterbird habitat" (Ducks Unlimited Canada 1999).

4.2.1 Habitat Availability Thresholds

While more is known about basic life history and dispersal characteristics of Yukon waterbirds than for most landbirds information on the distribution and other life history characteristics of most waterbird species in the Yukon is still incomplete. As a result, very little information is available on the effects of habitat loss or degradation to waterbirds in the Yukon.

Given the lack of information that is required to develop specific thresholds for land and resource use, the approach currently being adopted involves identifying key habitat types and areas of regional or global significance within the Yukon that comprise critical staging, resting, or breeding areas for waterbirds. Key habitat types for Yukon waterbirds include shallow bays, lake margins, meltwater ponds and shoreline leads, all of which provide important foraging and resting areas for both migrant and resident waterbird species. The availability of high-quality food sources and the habitats that support them is critical for waterbird populations, as food supply is widely recognized as a major determinant of habitat quality and bird behaviour (Newton 1998). Therefore, protection of habitat that supports important forage species is critical, particularly during staging. For example, troughs, thermokarst pits, and water tracks have microreliefs conducive to saturated soils that are dominated by cotton-grass, an important food plant for snow geese during autumn staging (Hupp and Robertson 1998). An example which illustrates the importance of winter food supply is the case of the trumpeter swan in Montana and Idaho, where the population increased from 30 to 600 birds between 1936 and the mid 1950s as a result of an increase in winter food availability (Cade and Temple 1995).

Areas of regional or global significance for waterbirds in the Yukon include wetlands that have been identified as key spring staging areas. These include: McLintock Bay on Marsh Lake, Teslin Lake Outlet/Johnson Crossing, Kluane Lake Outlet to the Kluane River and Tagish Narrows outlet to the Six Mile River. Old Crow Flats is an important moulting, breeding and staging ground, where waterbirds can be more concentrated than at any other location in the north. Duck densities on the Flats have been estimated at 80 ducks/km^2, which is two to three times higher than recorded by any of the eleven Alaskan waterbird breeding grounds surveyed annually by the U.S. Fish and Wildlife Service (Eamer *et al.* 1996). Other areas of lesser significance during spring staging include Six Mile Lake on the Dezadeash River, Quiet Lake at the outlet to the Big Salmon River and the outlet at Little Atlin Lake (T. Powell, pers. comm.). In addition, the Nisutlin River delta has been identified as a critical waterbird staging area of national importance that supports abundant resident waterbirds. The Nisutlin is particularly critical staging habitat during the fall migration, probably because water levels are raised during the fall at McLintock Bay for hydroelectric supply to Whitehorse (T. Powell, pers. comm.).

Currently, habitat availability does not appear to be a limiting factor to waterbirds in the Yukon, (D. Mossop, pers. comm). However, habitat management practices for waterbirds in the Yukon involve the identification and protection of key wetlands for waterbird staging. In the southern Yukon, where the most development has occurred, fifty wetlands have been identified as key habitat areas for waterbirds, and of these five are considered to be critical habitats (T. Powell, pers. comm.). Currently, there are annual surveys of migrating waterbirds being conducted at 150 small wetlands in the southern Yukon. However, the baseline census data generated by these surveys does not lend itself to the development of thresholds for cumulative effects assessment.

The drawdown of lake levels for hydroelectric power alters the timing of high water, which in turn alters waterbird habitat. The resulting impact to waterbirds is that the best food resources are too deep to be reached by surface-feeding ducks, geese, and swans, thereby compromising habitat effectiveness for waterbirds (T. Powell, pers. comm.). Experimental drawdowns could be conducted to determine the maximum drawdown level that does not negatively influence waterbird foraging. In addition, data on the critical dates for spring staging could be used to establish temporal thresholds for drawdown. These could be estimated simply by using existing survey data to determine the interval within which there would be significant impacts to waterbirds.

Assessing the cumulative effects of habitat fragmentation on waterbirds is a challenge for managers given the migratory nature of the majority of Yukon waterbird species. Many large wetlands and shoreline areas in North America have been fragmented and isolated, reducing both the quality and quantity of available habitat for waterbirds (Brown and Dinsmore 1986).

4.2.1.1 Habitat Effectiveness

Human activities can influence waterbirds by altering their behaviour, by increasing health/mortality risks, or by causing an overall reduction in habitat effectiveness. Direct responses to human intrusion-related disturbance that have been reported in the scientific literature include temporary or permanent displacement from feeding, resting or nesting sites (Belanger and Bedard 1989; Conomy *et al.* 1998; Madsen *et al.* 1998); decreased feeding/foraging time (Owens 1977; Belanger and Bedard 1990; Skagen *et al.* 1991); nest abandonment (Choate 1967; Morse *et al.* 1969); and increased alertness and alarm behaviour (Conomy *et al.* 1998). Indirect responses to disturbances which were less easily observed and quantified included increased health/mortality risks, increased energy expenditure and depleted energy (fat) reserves (Davis and Wisely 1974).

The information that is available on disturbance effects on waterbirds is limited primarily to observational studies of bird responses to human disturbance, however much of that information is anecdotal and does not lend itself to quantifiable measures. A review of bird disturbance literature conducted by Hill *et al.* (1997) found that 54% of the 153 studies were based on simple observations, usually without any testing of hypotheses. The majority of studies which have attempted to quantify disturbance effects have been conducted at the local population scale and results cannot be generalized to regional or flyway population scales. There have been few efforts to interpret the mechanisms of disturbance to population or flyway levels (Hill *et al.* 1997). Examples taken from the literature of zones of influence for waterbird species found in the Yukon are presented in

Table 4-3. Thresholds related to human disturbance for waterbird species found in the Yukon are provided in Table 4-4.

4.2.2 Population and Demographic Thresholds

Managing for cumulative effects on waterbird populations poses a unique challenge as waterbirds are vulnerable to loss of en-route habitats through developments (particularly along coasts and major rivers) and, as birds are forced to concentrate in these settings, they further become vulnerable to overhunting. Although hunting has been a major source of disturbance for waterbirds in some parts of Canada in the past (e.g., overhunting trumpeter swan at the turn of the century), and is currently a threat in some parts of Europe (Madsen *et al.* 1998), it is not presently considered a threat to populations in the Yukon (J. Hawkings, pers. comm.; D. Mossop, pers. comm.). Hunting of waterbirds accounted for only 1,000–2,000 ducks and approximately 500 geese during the 1998 hunting season, not including native harvest which is estimated to be significantly lower (J. Hawkings, pers. comm.).

Management of waterfowl is still at the stage of assessing large populations of waterbirds across the landscape, and there are currently few estimations of absolute populations for waterbird species. Population thresholds may exist for species in the Yukon that are considered at risk globally. For example, trumpeter swan, which is listed as “vulnerable” by COSEWIC, is found in large numbers during the spring at McClintock Bay. At a given time, one can see over 1,000 trumpeter swans, which is greater than six percent of the world population of 16,000. It is possible that 6,000 or more trumpeter swans (more than a third of the world population) visit the Yukon annually. Loss of critical staging habitat within the Yukon may influence trumpeter swan populations, however there is no data available on habitat availability/population number associations.

Waterbird population monitoring efforts and sources of survey data in the Yukon are presented in Appendix D.

4.2.3 Land and Resource Use Thresholds

Land and resource thresholds have not been considered for waterbirds as they have for more prominent species such as grizzly bear and caribou. Because of the paucity of available information for determining land and resource use thresholds for waterbird disturbances, a framework for assessing the relative effects of different disturbance types may be the most useful tool until more concrete thresholds are available. Hill *et al.* (1997) identified four general categories of disturbance type and described the associated gradients of responses for waterbirds (Figure 4-2).

Although Figure 4-2 provides a generalized approach to estimating disturbance responses of waterbirds, it is important to consider factors that may influence the response (e.g., timing; intensity and duration of disturbance), availability of alternative habitat, bird size, flock size, species-specific responses to disturbance and habituation.

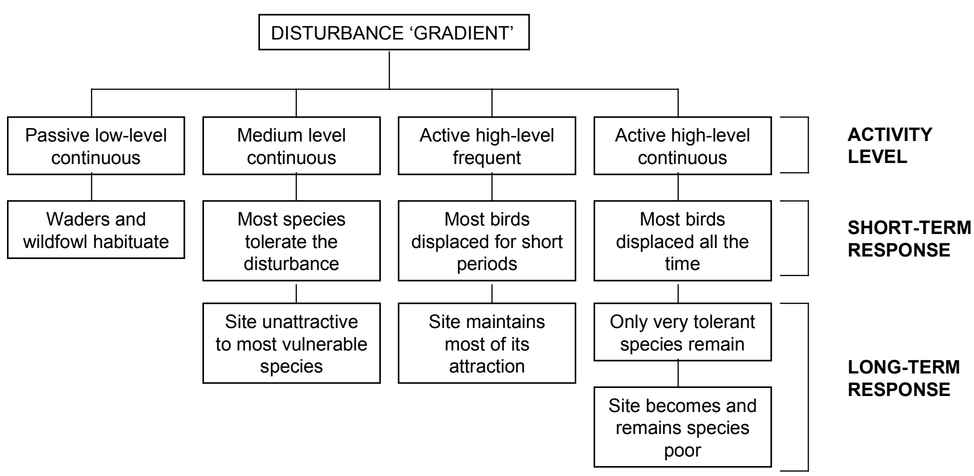
Table 4-3 Examples of Zones of Influence for Waterbird Species Found in the Yukon

Species	Disturbance Type	Disturbance Effect	ZOI	Habitat Type and Location	Comments/Buffer	Source
Brant	Vehicle traffic	Took flight	200 feet	Teshekpuk Lake, Alaska		U.S. Bureau of Land Management 1997
Brant and Canada goose	Low-level flying	Took flight	Altitude of 610 m; lateral distance of <1.6 km	Izembek Lagoon, Alaska	Response to disturbance occurred up to 1,219 m altitude and 4.8 km lateral distance.	Ward *et al.* 1999
Ring-billed gull	Walking ATV Automobile	Took flight	34 m 32 m 22 m	North and central Florida, U.S.	Recommended buffer: 91 m Recommended buffer: 101 m Recommended buffer: 84 m	Rodgers and Smith 1997
Willet	Walking ATV Automobile	Took flight	21 m 19 m 24 m	North and central Florida, U.S.	Recommended buffer: 74 m Recommended buffer: 73 m Recommended buffer: 77 m	Rodgers and Smith 1997
Sanderling	Walking ATV	Took flight	14 m 15 m	North and central Florida, U.S.	Recommended buffer: 67 m Recommended buffer: 69 m	Rodgers and Smith 1997
Double-crested cormorant	Walking	Took flight	31 m	North and central Florida, U.S.	Recommended buffer: 102 m	Rodgers and Smith 1997
Great blue heron	Walking	Took flight	31 m	North and central Florida, U.S.	Recommended buffer: 100 m	Rodgers and Smith 1997
Ruddy turnstone	ATV	Took flight	15 m	North and central Florida, U.S.	Recommended buffer: 72 m	Rodgers and Smith 1997

Table 4-4 Thresholds Related to Human Disturbance for Waterbird Species Found in the Yukon

Species	Disturbance	Disturbance effect	Habitat Type and Location	Comments/ Source
American wigeon	Hunting	When 3–4 punts were present, >50% of birds departed; when >4 punts were present almost all birds departed.	Experimental wetland refuges in Denmark.	Shooting from mobile and stationary punts was identified as the most disturbing human activity over fishing, sailing, and windsurfing (Madsen *et al.* 1998)
Snow goose	Low-level flying	>2 hours of disturbance resulted in a 50% drop in the mean number of geese the next day.	Montmagny bird sanctuary, Québec, Canada.	Transportation-related disturbance, particularly low-flying aircraft, accounted for 45% of all disturbance (Belanger and Bedard 1989)
Brant	People approaching on foot wearing bright red jackets.	Foraging time was reduced by 11.7% on weekends and 4.9% on weekdays.	Leigh Marsh, Essex, England.	Owens 1977

Figure 4-2 Classification of Disturbances to Waterbirds



Source: Modified from Hill *et al.* 1997

Timing of disturbance: Waterbirds are most vulnerable to disturbance during the staging, nesting, brooding and moulting seasons (Eberhardt *et al.* 1989). Therefore timing of the disturbance may be as or more important than the intensity or duration of the disturbance. Moulting geese are flightless and more sensitive to disturbance than during other periods of their life. A recent study to determine the acceptable effects of disturbance on geese at Teshekpuk Lake, Alaska documented that during moulting and staging (June 1–September 30), brant and other geese are disturbed by even low levels of human activity (U.S. Bureau of Land Management 1999). As a result of that study, some time-specific protective measures include restricting ground level activity to October 1–April 30 and avoiding flying over the area, or maintaining a minimum altitude of 5,000 ft above ground level from May 1–September 30. Belanger and Bedard (1989) found that when disturbance resulting from transport-related activities (in particular low-flying aircraft) exceeded 2 hours, a 50% drop in snow geese occurred the following day.

Availability of alternative habitat: Cumulative effects of disturbances may be minimized if alternative habitat areas are available. An example of the importance of alternative habitat is the Nisutlin River Delta. The Nisutlin is critical waterbird staging habitat during the fall migration, probably because water levels are raised during the fall at McLintock Bay for hydroelectric supply to Whitehorse. The artificially-raised water levels make aquatic plants inaccessible to foraging waterfowl (T. Powell, pers. comm.). Since the Nisutlin is only 80 km from McLintock Bay, it appears to serve as suitable alternative habitat.

Bird and flock size: In general, larger birds that are higher on a food chain tend to be more vulnerable to disturbance than small birds (Hill *et al.* 1997). In addition, large flocks are more susceptible to disturbance than small flocks (Dahlgren and Korschgen 1992; Hill *et al.* 1997). However, quantification of these thresholds has not been conducted.

Species-specific responses to disturbance: Responses to disturbance may vary by species. For example, a study relating the effects of recreational activities to waterbird disturbance found that green-winged teal, northern shoveler, and common goldeneye were most susceptible, whereas mute swan, tufted duck, common pochard and mallard were more tolerant (Tuite *et al.* 1984). Another study noted interspecific differences to human disturbance which showed that wigeon were most vulnerable whereas mute swans and coots were less vulnerable (Madsen *et al.* 1998).

Response to disturbance may also vary within a single species. For example, wood duck recovery studies showed that northern populations which migrated the longest distances suffered greater mortality than southern populations due to exposure to a succession of opening dates for hunting as they moved southward in their migration (Newton 1998). Similarly, white-fronted geese with broods were found to hide in response to aircraft disturbance, while non-breeding geese flushed at greater distances (Bromley *et al.* 1995).

In a screening for a proposed hiking trail in La Mauricie National Park, a user visitation threshold was established for nesting loon (Hegmann *et al.* 1999). Based on field observation, a limit of 15 persons/ha/yr was suggested, beyond which a decrease in reproductive success could possibly occur.

Habituation: Repeated exposure to a specific disturbance may result in habituation, thereby reducing the negative effect on an individual bird or flock. This is exemplified by a recent study which concluded that black ducks could become habituated to continued exposure to aircraft noise in 2–17 days, whereas wood ducks did not become habituated (Conomy *et al.* 1998).

5.0 Developing Thresholds For The Yukon

5.1 Administrative Mechanisms for Addressing Cumulative Effects Thresholds

Regulatory opportunities for addressing cumulative effects, and the identification and implementation of thresholds, can be found in various existing and evolving land use planning and regulatory forums. Table 5-1 provides a summary of these options with examples. The following discussion reviews the most promising options.

Table 5-1 Existing Opportunities to Facilitate Review of Cumulative Effects in the Yukon

Initiative	Examples
Territorial Permitting Processes	• DIAND *Land Use Guidelines* (e.g., Access Roads and Trails, Mineral Exploration) • DIAND *Timber Harvest Planning and Operating Ground Rules* • License and Permit Review (e.g., Level 1 and 2) under *Canadian Environmental Assessment Act* (CEAA) • Project Inter-agency Referral Process • Regional Environmental Review Committee • Yukon Water Board
Evolving Assessment and Regional Planning Process	• Development Assessment Process (DAP) • Habitat Protection Guidelines for Forestry • Regional Development Offices (under DAP) • Renewable Resource Councils (under UFA)
Coordinating Groups	• Alsek Renewable Resource Committee • Federal Territorial Advisory Committee • Fish and Wildlife Management Board • Forest Land Use Advisory Committee • Heritage Resources Board • Land Use Advisory Committee • Ross River Wildlife Planning Team • Tribal Councils • Wildlife Management Advisory Council • Yukon Land Use Planning Council
Regional Planning Approaches	• Forestry Management Plans • Greater Kluane Regional Land Use Plan • Regional Land Use Planning Commissions • Strategic Forestry Baseline Assessment • Wildlife Management Plans (for specific species) • Yukon North Slope Wildlife and Conservation Plan • Yukon Placer Authorization • Yukon Protected Areas Strategy
Land databases	• DIAND Land Interest Management System (LIMS) • YTG Renewable Resources Biophysical Inventory and "Corporate" GIS

5.1.1 Permit and License Reviews and Application of Local Mitigation Measures

The most effective means of addressing cumulative effects in a screening level review process (i.e., as is first conducted for permit and license applications) is ensuring that local effects are minimized through the use of effective mitigation measures. In this process, thresholds may be applied to reduce the likelihood of local effects becoming cumulatively significant. A process for doing this has already been proposed (AXYS 1997).

5.1.2 Regional Land Use Planning

Regional Land Use Planning is the most effective precursor to addressing cumulative effects. Although no plans yet exist in the Yukon that provide this function, there is considerable potential for this under the conditions of the Umbrella Final Agreement (UFA), providing the terms of First Nation's Land Claims, and the pending introduction of the Development Assessment Process (DAP) that will effectively supplant CEAA. These provide ideal mechanisms for implementing thresholds to address land use effects.

Lessons can also be learned from the extensive land use planning process and regional monitoring initiatives in other northern Canadian jurisdictions; namely, Nunavut and the western NWT (including the Gwich'in and Sahtu Settlement Areas and the Inuvialiut Settlement Region). Thresholds could be designed for various wildlife species within various ecological areas (e.g., watersheds) and administrative regions (e.g., forest management areas, game management zones, DIAND districts, regions under UFA, Development Offices under the DAP).

5.1.3 Resource Management Plans

Management plans have been created in the Yukon for timber harvesting and wildlife, such as the habitat protection guidelines within DIAND's *Timber Harvesting Planning and Operating Ground Rules* (1998). These plans provide sector-specific and species-specific guidance or conditions to proponents of proposed projects. Incorporation of thresholds within these plans provides an opportunity to broadly address effects on wildlife in the Yukon at the level of individual projects.

5.1.4 Protected Areas

Protected area strategies typically provide a vehicle for the development and implementation of thresholds, as such strategies place restrictions on land use activities. The recent *Yukon Protected Areas Strategy* (Yukon Government 1998) defines three levels of protection: 1) *Goal 1 areas* that are representative core protected areas within each of the 23 ecoregions that contribute to the protection of biodiversity and ecological integrity; 2) *Goal 2 areas* that are special places (e.g., areas with special wildlife and habitat values such as calving areas, migration routes), with varying levels of protection through management plans that include potential for certain resource development; and, 3) *Managed Lands* that are managed through existing processes.

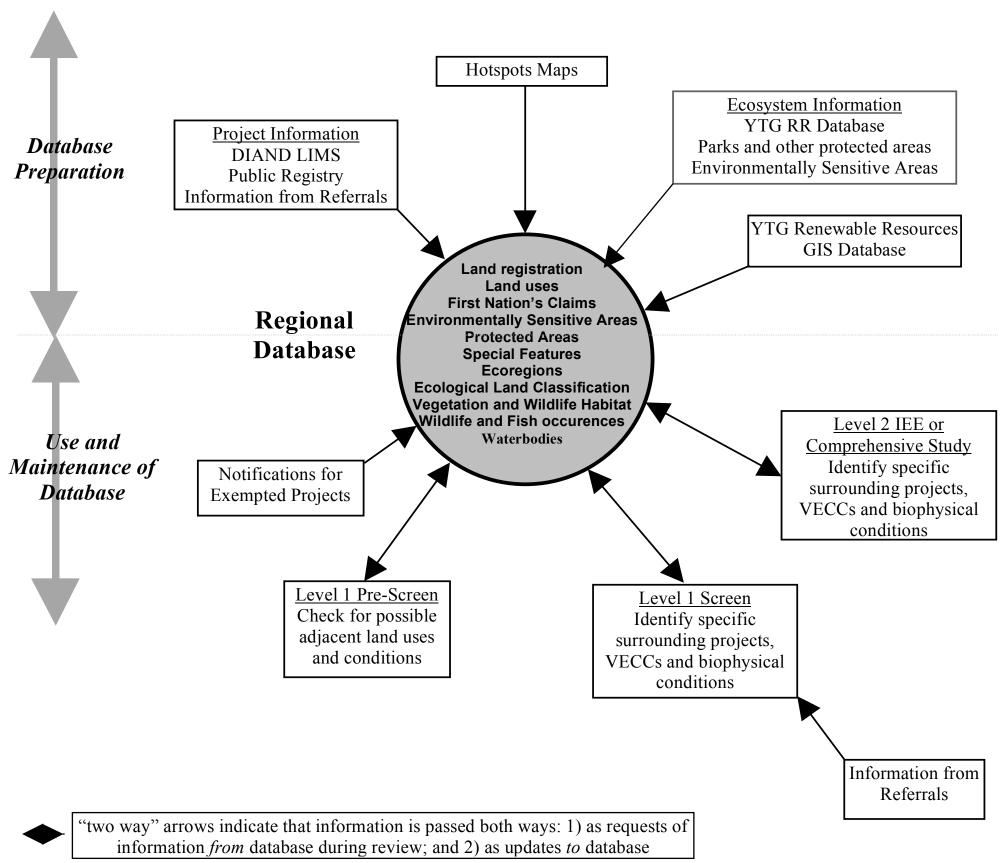
5.1.5 Public and First Nations Consultation

Devolution of federal responsibility and the emergence of regional-based administrative bodies will contribute to more local decision making that can better reflect regional issues and interests. The application of social thresholds will be facilitated by this new process. Also, the incorporation of TEK will be enhanced due to the increased involvement of First Nations in the control of their lands.

5.1.6 Environmental and Land Use Databases

A land and environmental database is an essential element of a process that can successfully address project-specific cumulative effects and regional land use planning. Although both YTG and DIAND currently have mapping programs, neither yet are advanced enough to provide detailed and spatially referenced data (e.g., as in a GIS) on wildlife or land use parameters (e.g., all active and past permits and licenses). An exception is the "Wildlife Key Area" database as part of Forest Management Planning, which identifies winter areas, migration corridors and breeding areas. Figure 5-1 illustrates an ideal scenario in which a centralized database would "serve" various assessment needs in the Yukon.

Figure 5-1 Implementation and Information Flow of Hypothetical Regional Database



5.2 Recommended Process to Implement Thresholds in the Yukon

The completion of this report represents the first step in a process that can lead to the implementation of thresholds that are acceptable to Yukoners and are effective in addressing cumulative effects concerns. The following outlines a four phase approach proposed towards this goal.

Phase 1: ***Develop Background Report***: Discuss thresholds that could be used to evaluate the significance of land use effects on wildlife (this phase is represented by this report).

Phase 2: ***Development and Refinement of Threshold Values***: To identify and refine thresholds for cumulative effects in the southern Yukon, a series of technical workshops and public consultation sessions would be held involving representatives of territorial and federal government agencies, local communities (including First Nations), industry and other stakeholders (see section below for details).

Phase 3: ***Implementation of Thresholds Using a Case Study***: A specific geographic region of concern because of land use pressures would be selected. In a workshop forum, the recommended thresholds would be evaluated for their ability to be implemented and monitored within the land use setting. Candidate areas include the Upper Liard and Dawson regions.

Phase 4: ***Adaptive Monitoring of Thresholds***: Assuming that the thresholds are accepted during the workshop in Phase 3, the thresholds would be employed on a trial basis in the case study area, and monitored. This phase would involve an adaptive monitoring approach whereby cumulative effects would be monitored relative to the proposed thresholds. Monitoring could involve expert opinion on trends, as well as quantitative measurements and modeling. On the basis of this input, modifications to thresholds values and/or the monitoring approaches would be recommended. This phase would involve periodic consultative workshops with government agencies, community representatives, industry and other relevant stakeholders.

5.2.1 Approach to Phase 2

The Phase 2 workshop is an exercise in gathering information and ideas regarding the implementation of thresholds in the Yukon. A series of workshops (after a pilot in Whitehorse) would be conducted from which the results would be evaluated and future steps determined based on discussions regarding the most efficient and practical subsequent approach.

A two-day format is suggested. Participants would ultimately be at DIAND’s discretion; however, it is recommended that participation from non-governmental groups be included as much as possible (e.g., local communities, First Nations, industry, other stakeholders). Options include:

1. Full participation both days by both government and non-government.

2. Participation both days by DIAND only.

3. Participation in Day 1 by DIAND only (or with selected representatives from other agencies and departments), and full participation on Day 2.

Day 1 would establish a mutual understanding of threshold implementation in plenary, and Day 2 would develop these ideas into specific tasks through the use of break-out groups.

The following is a suggested workshop format (this can be used to form an agenda). Times are provided only as examples.

DAY 1

1. Provide an overview of the joint DIAND/DOE initiative (30 min presentation and discussion).

2. Provide background information on CEAs and thresholds (30 min presentation and discussion).

3. Review highlights from the existing threshold's report, particularly recommendations for certain types of thresholds and constraints and opportunities for their implementation (1 hr presentation and discussion).

4. Discuss opportunities for implementing thresholds in existing (e.g., CEAA) and future regulatory process (e.g., DAP) in the Yukon, including available baseline information (e.g., wildlife populations, wildlife habitat, human disturbances) and administrative mechanisms (e.g., permitting and licensing) (3 hr plenary discussion). This and other similar sessions rely extensively on the knowledge of the participants (e.g., DIAND Level 1 screeners, resource users).

5. Summarize results of discussion and plan break-out groups for Day 2, focussed on those results (1 hr plenary discussion).

DAY 2

1. (Morning): Break-out groups on topics selected from Day 1. Examples include:

   - ***Information Sources***: Availability and limitations of mapped information (e.g., habitat, land use) and development of required data sets (e.g., wildlife surveys).

   - ***Wildlife Species***: Species' specific discussions of available information and practical (i.e., measurable and implementable in current process) thresholds.

   - ***Co-operative Regional Land Use Planning***: Inter-agency and industry co-ordination of land use planning (e.g., for specific resource groups such as commercial timber harvesters).

   - ***Public and First Nation's Facilitation***: Process to consult public and First Nations groups and implement their views within existing and pending assessment process and land use administration; and, incorporation of Traditional Ecological Knowledge.

- ***Permit and License Screening***: Use of existing permit and license application process to collect information and apply thresholds in approval decision making.

- ***Thresholds in Protected Areas***: Application of thresholds in protected areas.

2. (Afternoon): Plenary review of results of break-out group discussions and formation of goals and objectives for follow-up to a Phase 3.

5.3 A Management Framework

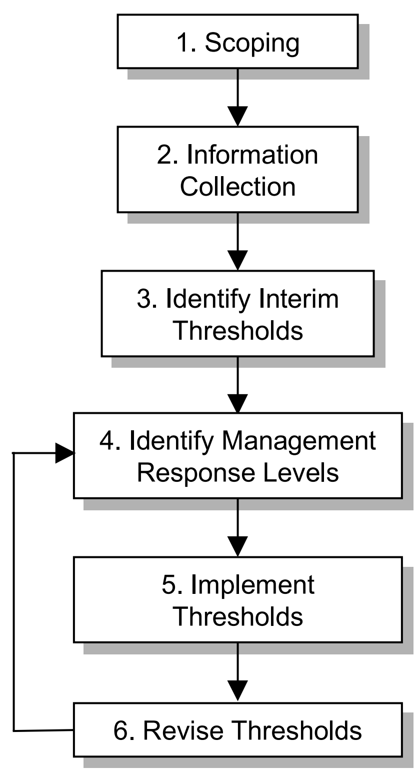
Table 5-2 summarizes a six-step framework for the implementation of thresholds (summarized in Figure 5-2).

Table 5-2 Threshold Implementation Steps and Management Actions

Step	Actions
1. Scoping	• Identify geographic region of concern. • Identify issues of concern. • Identify activities of concern (past, present and future). • Identify effects caused by activities. • Identify management species affected by activities. • Identify target management species.
2. Information Collection	• Collect map based descriptions of activities (i.e., land use), species habitat and habitat use. • Collect available information on habitat requirements, occurrence and range, known responses to activities, and known thresholds to activities.
3. Identify Interim Thresholds	• Select most practical and implementable thresholds based on available information for target management species and activities. Ecological thresholds are preferred, as they best reflect actual animal responses. Land use thresholds are next preferred, as they allow management through quantifiable thresholds but are based on more readily obtained information. Social thresholds are least preferred as the basis of the thresholds are not as clear and consistent. 1. ***Ecological*** (Habitat Availability, Habitat Effectiveness, Mortality rate, Calf-cow ratios, Energetic costs): choose if have adequate information describing the species, the species can be monitored, and existing and future information can be modelled to identify the threshold relative to the management response levels. 2. ***Land Use*** (Access Corridor Density, Availability of Core Security Areas): choose if land use information readily available, land use pressures changing rapidly and an immediate management response is required, or if species specific information does not allow the derivation of an ecological threshold.

	3. ***Social***: Choose if inadequate information available for target species and land use.
4. Identify Management Response Levels	• Given the thresholds identified in Step 3, define the management responses to be implemented before the threshold is reached, when reached, and if exceeded.
5. Implement Thresholds	• In the geographic region identified in Step 1, introduce the thresholds into the project review and/or land use planning process as one of the attributes contributing to decisions on acceptability of future activities. For ecological thresholds, monitor species occurrence and habitat use and establish a means to map land use changes and incorporate into wildlife models. For land use thresholds, map activities and maintain a cumulative total of land use activities relevant to the chosen threshold. • Identify responsible authorities to periodically review threshold information and initiate management action as required.
6. Revise Thresholds	• Upon implementing thresholds for a pre-determined period of time, re-evaluate the threshold based on new information and discussion regarding suitability of using the threshold in the project review or land use planning process.

Figure 5-2 Threshold Implementation Steps



6.0 Conclusions

6.1 General Conclusions

Thresholds for the management of cumulative effects on wildlife can be categorized as ecological, land and resource use, and social. Among these categories, there are a number of measurable parameters or indices that can be used for the actual development of thresholds. Thresholds for birds are not yet available for practical implementation.

The following general conclusions have been developed:

- The most information and the most advanced analytical tools for identifying and applying thresholds for the management of cumulative effects are available for grizzly bear. However, recent advances in caribou biology and assessment are improving.

- Habitat-based thresholds are commonly expressed by habitat effectiveness, which represents a ratio of realized to potential habitat values.

- Population-based parameters such as calf/cow ratios and mortality rates can be used to assess the potential sensitivity of a population to cumulative effects, and to establish thresholds for the management of cumulative effects. Such thresholds rely on an accurate picture of population dynamics, and a knowledge of land use effects on population dynamics.

- Land use thresholds have less comprehensive data base requirements than ecological thresholds and, hence, are generally more practical to implement. Road and utility corridor density is a measurable, effective parameter that can be used to develop thresholds for the management of cumulative effects. In more controlled environments (e.g., National Parks), activity level thresholds may also be used to manage cumulative effects.

- Social thresholds for wildlife generally represent regional objectives for the abundance, distribution and availability of wildlife for the use of the general public or specific stakeholders. Such thresholds are developed through multi-stakeholder consultative processes, and are generally implemented and achieved through the development of ecological and land use planning thresholds discussed above.

- The process of selecting thresholds will be considerably influenced by the availability of the data base required, and the associated ability to determine if a threshold is being exceeded for a given species.

6.2 Candidate Wildlife Thresholds in the Yukon

This section discusses those thresholds that may have the greatest likelihood of success of being implemented in the Yukon. The discussion identifies: information that is currently available in the Yukon in support of developing thresholds, thresholds or management practices related to thresholds already used in the Yukon, thresholds that have been suggested or implemented outside the Yukon; and, finally recommends which thresholds are the best candidates for continuation or development in the Yukon.

Quantification of some of these thresholds was provided in Chapters 3 and 4. The nature of the derivation of these numbers (e.g., environmental setting, types of impacts) must first be reviewed to determine if any modifications are warranted to reflect other geographic locations before a published threshold number can be confidently adopted.

6.2.1 Grizzly Bear

Population estimates of grizzly bears are available for the Yukon's ecoregions; however, there is considerable uncertainty associated with the numbers. Some of the 22 ecoregions are very large in size, and habitat mapping is not yet available on this regional basis. However, land use information is available, albeit not yet in an electronic spatial database (i.e., GIS) that would facilitate habitat modeling.

A population threshold (direct-mortality) of 6% yearly is currently applied for human-caused kills. Other potential thresholds include habitat effectiveness, connectivity, road densities, core security areas, and human visitation.

The practice of regional land use planning and CEA in the Yukon could be improved with the adoption of one or more of the following thresholds for grizzly bear:

1. ***Minimum habitat effectiveness***: Habitat effectiveness modeling can be conducted for selected ecoregions. Due to the data-intensive ELC mapping requirements, a single ecoregion under existing or increasing land use pressures (e.g., the Liard River ecoregion) could be mapped first.

2. ***Maximum human-caused mortality***: This threshold can be applied in regions where there is a high certainty that population numbers and mortalities are accurate. This threshold can be used in other regions as survey data become available.

3. ***Maximum road density***: Use of this threshold requires less intensive data gathering than for habitat effectiveness, as rights-of way locations (e.g., roads, trails, powerlines, pipelines, seismic lines) are usually readily available from various map sources and easily entered into a GIS. As access increases in a region, the degree to which that region's access may be approaching or exceeding a threshold may then be monitored.

4. ***Minimum core security areas***: This threshold can be readily used based on the same data as used for road density thresholds. Areas already below the core-security threshold can be readily identified, and areas undergoing rapid change can be monitored and an "early-warning" provided to allow time for management action before the threshold is exceeded.

6.2.2 Caribou

Population estimates and trends for 23 herds in the Yukon are known and regularly updated. Habitat availability is generally not yet a concern; habitat mapping is limited to critical winter range and lichen producing areas.

Existing thresholds include minimum calf/cow ratio, habitat effectiveness (no loss of lichen producing areas), and hunting bag limits in wildlife management zones (or suspension of hunting). Management practices related to thresholds include restrictions of developments in core-habitat areas during critical times of the year and minimum cutblock width and area.

Other potential thresholds include minimum population size, maximum access density, and maximum exposure rate to disturbances.

The practice of regional land use planning and CEA in the Yukon could be improved with the adoption of one or more of the following thresholds for caribou:

1. ***Minimum calf/cow ratio or population size***: Population parameters appear to be available for many of the herds in the Yukon, and can be used to evaluate the capability of the herds to accommodate new land use perturbations.

2. ***Minimum habitat availability or effectiveness***: The dependency of caribou on lichen-producing habitats for much of the year and the ability to detect such habitats from remotely-sensed data sources makes this species a good candidate for habitat supply modeling. Such modeling can be conducted for selected ecoregions. Due to the relatively intensive habitat mapping requirements, a single ecoregion under existing or increasing land use pressures (e.g., the Liard River or Aishihik ecoregions) could be mapped first as a pilot study.

3. ***Maximum energetics loss***: Energetics modeling is a potential tool to track cumulative stresses and provide information to assist in the development of integrated land use decisions necessary for ensuring the sustainability of a herd. Further research and monitoring may be required (see Appendix B).

6.2.3 Moose

The Yukon has a large territorial population at low densities. Hunting pressures are considered sustainable in most regions. Periodic surveys are made throughout the territory but especially in regions where populations are considered low. Critical winter habitat is being mapped.

Existing thresholds include maximum annual allowable harvest rates, minimum bull/cow ratio, and maximum size of cutblocks (a form of habitat availability). Hunting closures occur when moose densities drop below a minimum. No other practical types of thresholds for land use management have been identified for moose as applied outside the Yukon.

The practice of regional land use planning and CEA in the Yukon could be improved with the adoption of one or more of the following thresholds for moose:

1. ***Minimum calf/cow ratio or population size***: Population parameters appear to be available for many of the herds in the Yukon, and can be used to evaluate the capability of the herds to accommodate new land use perturbations.

2. ***Minimum habitat availability or effectiveness***: The dependency of moose on early successional habitats or browse-dominated habitats (e.g., subalpine Salix communities) for much of the year and the ability to detect such habitats from remotely-sensed data sources makes this species a good candidate for habitat supply modeling. Such modeling can be conducted for selected ecoregions. Due to the relatively intensive habitat mapping requirements, a single ecoregion under existing or increasing land use pressures (e.g., the Liard River or Aishihik ecoregions) could be mapped first as a pilot study.

6.2.4 Landbirds

Population estimates and trends are not available for the majority of landbirds in the Yukon. The effects of disturbance cannot be generalized for the large number of landbird species that occur in the Yukon. Determining land and resource use thresholds is further complicated by the migratory nature of Yukon landbirds. The wide-ranging and diverse habitats used by landbirds during their annual cycle makes it difficult, both from an ecological and logistical perspective, to assemble adequate data for threshold determination. As a result, few measures of land and resource use thresholds exist for the Yukon or elsewhere.

Habitat availability is generally not a concern, but old-growth riparian spruce habitats in the southeast corner of the Yukon are threatened by forest clearing. That particular forest type provides habitat for a number of landbirds that are at the northern extent of their breeding range, and represents the only habitat in the Yukon where those particular species can be found. There are efforts to protect that habitat type, but there is no information available as to the minimum amount that must be retained to sustain the current diversity of landbirds using that habitat type.

There are some site-specific management procedures suggested by DIAND in the *Timber Harvest Planning and Operating Ground Rules*, but those are guidelines are probably not appropriate for determining cumulative effects thresholds of developments across a landscape.

As discussed above, the effects of habitat loss probably outweigh the effects of habitat fragmentation or loss of connectivity. Villard *et al.* (1999) suggest that a conservation strategy of maintaining habitat “connectivity” [e.g., as is currently pursued through the British Columbia Forest Practices Code (B.C. Ministry of Environment and B.C. Forest Service 1999)] may be a minor solution to addressing the real issue of minimum area habitat thresholds. Mönkkönen and Reunanen (1999), from their work on long-term disturbances of boreal forest biota in Finland, suggest that the aim of management should be to identify and protect the habitat requirements of more sensitive species at smaller, regional levels of management, rather than attempting to develop globally encompassing management guidelines.

6.2.5 Waterbirds

Information on basic life history characteristics, demographics, and dispersal patterns for waterbird species is lacking for the Yukon. Although some detailed information is available for particular species (e.g., trumpeter swan), the effects of disturbance cannot be generalized for the large number of species that occur in the Yukon. The determination of land and resource use thresholds is further complicated by the migratory nature of Yukon waterbirds. The wide-ranging and diverse habitats used by waterbirds during their annual cycle makes it difficult, both from an ecological and logistical perspective, to assemble adequate data for threshold determination. This uncertainty is acknowledged in a recent report from the Yukon Canadian Wildlife Service which states that: “It is a bit unclear as to what is the minimum that would be required to protect the habitat used by these birds and protect them from “significant” disturbance to their daily feeding and resting routine. Waterfowl are quite adaptable, but nobody can predict just how much change they will tolerate” (J. Hawkings, pers. comm). With basic information still lacking, it is difficult to develop specific land and resource use thresholds. As a result, few measures of land and resource use thresholds exist for the Yukon or elsewhere. Thresholds of human intrusion include zones of influence which have been estimated by monitoring waterbird responses to various forms of human disturbance, but little else has been quantified in terms of disturbance thresholds.

At present, there are no threats to waterbird populations in the Yukon, either from hunting or from habitat disturbance. The practice of regional land use planning and CEA in the Yukon could be improved by monitoring current land use activities (e.g., development of wetlands, reservoir drawdown, hunting) and identifying potential thresholds associated with these activities for waterbirds in general, or for species considered to be specifically vulnerable to disturbance.

6.3 Summary Tables for Wildlife Thresholds

A summary of all potential thresholds is provided in Table 6-1.Table 6-2 reviews the types of thresholds available for wildlife that are currently practical for use in the Yukon, and the general approaches and data requirements associated with them.

Table 6-1 Potential Thresholds, Methods and Options for Administrative Implementation

Type	Thresholds	Measurable Parameters	Methods	Administrative Implementation
Ecological				
Habitat Availability	• minimum patch size • minimum corridor width • maximum gap distance between patches • core security areas • carrying capacity • maximum tolerable energy expenditure • maximum disturbance factors and zones of influence • maximum surface water level drawdown	• maximum acceptable probability of species using a disturbed area (%) • maximum alteration of seasonal movements (km) • maximum reduction or total loss of high quality habitat in a given area (ha) • minimum size of a contiguous habitat patch (ha) • maximum width of cleared areas (m) • *x* km^2 of contiguous habitat to provide minimum daily/seasonal life requirements • maximum number of individuals displaced (#)	• energetics models (e.g., friction model)habitat evaluation procedure (HEP) • landscape level spatial analysis of habitat patches, gaps and corridors	• co-management boards • government guidelines, policy, legislation • approval conditions (e.g., permits, licenses) • regional land use plans • timber harvesting plans • protected areas planning • industry-government agreements
Populations	• minimum desired population size • minimum viable population size (MVP) • optimum calf/cow ratio • optimum natural mortality/natality rates	• population/flock size (#) • *x* calves/ y cows, where x is a minimum acceptable • *x* individuals lost/year	• population surveys • carrying capacity analysis	• co-management boards • government guidelines, policy, legislation • regional land use plans • timber harvesting plans • protected areas planning • industry-government agreements • hunting regulations

Land and Resource Use				
Physical Works and Associated Activities	• maximum road density for specific traffic levels • maximum zone-of-influence for specific disturbances (e.g., noise from aircraft) • exposure rate	• *x* encounter events • *x* km/km^2 of road-vehicle accessible right-of-ways (RoWs) • *y* km/km^2 of off-road vehicle RoWs • *z* km/km^2 of all RoWs accessible by mechanized vehicles and/or foot traffic • *x* m from road resulting in y % reduction of habitat use by a specific species within that distance • *y* km from aircraft overflight at which species flees from disturbance	• defining maximum density of roaded access in any given planning area • defining minimum core security area in any given planning area	• co-management boards • government guidelines, policy, legislation • regional land use plans • timber harvesting plans • protected areas planning • industry-government agreements
Human Activity	• maximum level of visitation • maximum hunting mortality rate • maximum defense-of-life-and-property (DLP) mortality rate • maximum acceptable extent of development that cause sensory disturbances (e.g., to light, dust, sound, smell and vibration)	• maximum number of front-country or backcountry visitors in a given area • maximum % of harvest kills to total population (x kills/ y population) • maximum acceptable % of DLP kills to total population (x kills/ y population)	• population surveys • carrying capacity analysis	• co-management boards • government guidelines, policy, legislation • approval conditions (e.g., permits, licenses) • regional land use plans • timber harvesting plans • protected areas planning • industry-government agreements • hunting regulations

Social				
Aesthetic	• maximum tolerable extent of perceived visual change	• maximum loss of forest/wetland cover due to timber harvesting as seen from an adjacent viewpoint • maximum extent of visible linear developments • no development in a given area	• public consultation • any other tools described above	• co-management boards • government guidelines, policy, legislation • approval conditions (e.g., permits, licenses) • regional land use plans • timber harvesting plans • industry-government agreements • protected areas planning
Perceived Acceptable Limits	• maximum perceived acceptable changes to habitat, species distribution or level of human disturbance	• no development in a given area • delay of development in a given area (e.g., until monitoring completed) • conditional approval of development in a given area	• public consultation • any other tools described above	• co-management boards • government guidelines, policy, legislation • approval conditions (e.g., permits, licenses) • regional land use plans • timber harvesting plans • protected areas planning • industry-government agreements • hunting regulations

Table 6-2 Typical Approaches for Assessing Acceptability of Land Use Activities in the Yukon

Measurable Parameter	Data Requirements	Approach[1]
Ecological Thresholds		
Habitat Availability	• digital data base (if possible) of biophysical components of the land base of interest • food and cover requirements of species • species-specific habitat usage information • habitat classification and mapping system • knowledge of the effects of land use disturbance on habitat use for species of interest	1. rate and map seasonal habitat suitability (HSI) values for habitat classes in the area of interest; or, if HSI analysis not possible, calculate habitat loss for each type of habitat classified (e.g. wetland, upland forest) 2. calculate seasonal habitat availability in the area under baseline conditions 3. superimpose existing and proposed land uses on the area 4. calculate reductions in habitat values within footprints and ZOIs, and recalculate habitat availability within the area; and/or calculate reductions in available habitat based on minimum patch size estimate, and recalculate habitat availability within the area 5. calculate net change in habitat availability for various assessment periods 6. review net change within the context of established thresholds on a species by species basis
Habitat Effectiveness	• digital data base (if possible) of biophysical components of the land base of interest • food and cover requirements of species • habitat classification and mapping system • patch size requirements for species of interest • knowledge of the effects of land use disturbance on habitat use and/or the number and size of patches in the landscape • knowledge of species-specific requirements for minimum patch size (i.e., for usage and breeding success)	1. rate and map seasonal habitat suitability (HSI) values for habitat classes in the area of interest; and/or, estimate the minimum patch size threshold for target species 2. calculate seasonal habitat availability in the area under baseline conditions 3. superimpose existing and proposed land uses on the area. 4. calculate reductions in habitat values within footprints and ZOIs, and recalculate habitat availability within the area. 5. calculate habitat effectiveness (i.e. ratio of realized to potential habitat availability) 6. review habitat effectiveness within the context of established threshold

Mortality Rate	• population size in region of interest • approximate rates of mortality from natural and human-related causes • probability of mortalities from various land use activities	1. review population size and known mortality sources for area in question 2. estimate potential mortality rate from land use activities 3. review potential incremental increase in mortality from the land use activities 4. review potential increase in mortality within the context of established threshold
Calf/Cow Ratios	• periodic aerial surveys to establish on-going trends in calf production and recruitment • knowledge of the potential effects of land use disturbance on calf production and survival	1. identify any apparent trends in calf/cow ratios likely related to land use activity 2. use calf/cow ratios to evaluate the ability of a herd/population to accommodate new land use development
Energetic Costs	• habitat use patterns of species within area of interest • typical activity budgets and bioenergetic demands of species under undisturbed conditions • effects of land use disturbance on normal activity patterns and energetic budgets	1. determine and map seasonal distribution of species within area of interest 2. superimpose land use activities (existing and proposed, with associated ZOIs) on area of interest 3. estimate exposure rate of animals to land use disturbance, based on availability of disturbed and undisturbed habitat 4. review implication of increased exposure rate from new development within the context of established threshold

Land Use		
Access Corridor Density	• habitat use patterns of species within area of interest • knowledge of effects of access corridors on species in question • human use levels in area of interest	1. determine and map seasonal distribution of species within area of interest 2. superimpose access corridors (existing and proposed, with associated ZOIs) on area of interest 3. estimate levels of human use along the corridors 4. determine existing corridor density 5. review implication of increased corridor density from new development within the context of established threshold
Availability of Core Security Areas	• habitat use patterns of species within area of interest • knowledge of effects of access corridors on species in question • habitat security requirements of species in question	1. determine and map seasonal distribution of species within area of interest 2. superimpose access corridors (existing and proposed, with associated ZOIs) on area of interest 3. determine existing availability of core security areas 4. review implication of reduced core security areas from new development within the context of established threshold

1. Assuming that thresholds have been established.

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APPENDICES

Appendix A: Wildlife Physiological and Behavioural Response Mechanisms

An animal, in response to a disturbance, may move away from the disturbance (i.e. displacement), may alter its behavior (e.g. habituation or attraction leading to a direct conflict with humans, or avoidance leading to inefficient use or alienation of habitat), or it may experience a detrimental physiological response (e.g. increased heart rate). The implications of this to wildlife includes less energy for maintenance, growth and reproduction needs; death or illness, trampling, and abortions; and reduction in range and access to resources (e.g. food, escape terrain, cover) and increased predation. Most field research on wildlife response has assessed the degree of immediate response to a specific disturbance (e.g. aircraft, motorized vehicles, industrial facilities); often such studies are very specific to a certain species, environment, disturbance type and pattern of human activity.

Any of these responses may ultimately lead to reduced natality or increased mortality. Direct mortality results from management efforts to ensure human safety. The degree to which this occurs may depend on the habituation of the animal (or avoidance or attraction) to the disturbance.

The degree to which a response ultimately translates into adverse effects on a larger population (if at all) has not been precisely determined for any species. Such an effect would appear as reduced reproductive fitness and habitat utilization, perhaps reducing the population size and the health or reproductive capability of individuals to levels below those needed to maintain a viable population. There remains considerable difficulty in establishing a cause and effect relationship at an individual or population level based on the knowledge obtained in the general literature and the habitat and wildlife data available. Contributing to this difficulty is the variation observed in response by different groups of the same species to largely the same disturbances in similar conditions.

Physiological and behavioural responses are most commonly expressed in assessments through the quantification of the distances from specific disturbances in which an effect is considered unacceptable (e.g., panic flight or significantly reduced use of habitat within that distance); and, a measure of the degree of adverse response within that distance. These factors, referred to as the Zone of Influence (ZOI) and Disturbance Coefficients (DC) respectively, provide a crude but measurable representation of complex response mechanisms.

Appendix B: Information on Yukon Woodland Caribou

Herds

Woodland caribou are distributed across the Yukon in 23 herds whose populations range from about 100 to 10,000 individuals (see Table B1). The total Yukon population at the end of 1998 was estimated at 30,000 animals (YRR 1998). Because of varying survival rates and other demographic characteristics, this number fluctuates through time as caribou herds do not remain at a fixed size. For the purposes of this report, all of the ranges of the herds, or portions of the ranges, can be found south of Dawson City.

Table B-1 Yukon Woodland Caribou Herds

Herd	Population estimate	Year estimated	Status[1]	Comments
Aishikik	750	1994	>	wolf control program began '93
Atlin	500–1000	1995	?	managed mainly by BC
Bonnet Plume	5000	1982	?	increased mineral exploration '95
Carcross/ Squanga	450	1995	?	
Chisana	700	1995	<	
Ethel Lake	300	1995	~	
Finlayson	4000	1997	~/ <	
Hart River	1200	1978	?	lightly hunted due to inaccessibility
Ibex	425	1998	>	growing at 13%/yr since '90
Klaza	450	1995	~	
Kluane	180	1996	>	
La Biche	400	1993	?	
Little Rancheria	700	1988	~	
Mayo	unknown		?	anecdotal information only
Mentasta	700	1995	<	ranges mostly in Alaska
Moose Lake	200	1991	~	
Nahanni	2000	1995	?	
Pelly Herds	1000		?	
Redstone	5000–10000	1982	?	
Smith River	200		?	
Tatchun	300	1995	~	
Tay River	4000	1991	~	
Wolf Lake	1200	1998	~	

Source: YRRCMT 1996

1. Status: < = decreasing, ~ = stable, > = increasing, ? = unknown

Hunting

The Yukon is divided into 11 Wildlife Management Zones (WMZ). Each WMZ contains Subzones with distinct geographic boundaries (see Table B2). Barren-ground caribou are found in Zones 1 and 2, while woodland caribou are not found in Zone 1 (northern Yukon, north of Peel River). Zone 2 contains the two most northern woodland caribou herds: the Hart River and Bonnet Plume Herds (YRRCMT 1996).

Hunting “Bag” limits are established and most hunting regulations are established at the Subzone level (YRR 1998). Bag Limits (the number of animals that can be harvested by one hunter in a season) are Yukon-wide; i.e., a limit that applies in one management subzone where a hunter is licensed applies to the entire Yukon for that hunter for that species. The Yukon Government bases bag limits on each herd based solely on the harvestable yield of caribou herds, dictated by the size and trend of each caribou herd (YRRCMT 1996).

Additional restrictions to hunting within management Subzones includes no hunting zones within certain distances of major transportation corridors. This includes a 1 km wide no hunting zone on either side of the Dempster Highway, and a ban on using all terrain vehicles within an eight kilometre zone of the Dempster Highway (YRRCMT 1996). Various other no-hunting zones exist within different Management Zones and Subzones.

As of the 1998–1999 hunting season, all female caribou are protected, except in Zones 1 and 2. The hunting season on woodland caribou herds includes closures in some Zones, between August 1 to October 10, August 1 to October 31, and August 1 to January 31 for male caribou in some Subzones of Zone 2. Harvest in some areas is further restricted to Permit hunting only for male caribou. In 1996, non-native hunters reported 373 harvested caribou (both woodland and barren ground), and non-resident hunters took 189 caribou (YRR 1998). Yukon First Nation members with a final agreement have the right to hunt for food (includes any sex of any species at any time) inside the Traditional Territory of their own First Nation. Beneficiaries of a Yukon First Nation without a final agreement may hunt outside the Traditional Territory of First Nations with final agreements, and may also take any sex of any species at any time (YRR 1998). As an aid to assessing caribou mortality due to hunting, all licensed hunters are required to report the results of their big game hunts to the Department of Renewable Resources.

Harvest by First Nations are generally not reported. The change of management control of woodland caribou herd management through settlement of Land Claims with various First Nations is of concern to wildlife biologists (R. Florkiewicz, pers. comm.); however, many First Nations are cooperating with the YTG biologists.

Table B-2 Bag Limits for Caribou and Moose (1998/99) in the Yukon

Zone	Subzone	Female caribou	Male caribou	Male moose	Notes
1	1-01	Closed	Closed	Closed	Barren-ground caribou
	1-04, 1-05, 1-12 to 1-72	Two caribou may be taken if at least one is taken from Zone 1 or 2	Two caribou may be taken if at least one is taken from Zone 1 or 2	One	Barren-ground caribou
2	All subzones			One	
	2-24, 2-25, 2-29, 2-46 to 2-63	Closed	One		Barren-ground caribou
	2-01 to 2-23, 2-26 to 2-28, 2-30 to 2-45, 2-64 to 2-93	Two caribou may be taken if at least one is taken from Zone 1 or 2	Two caribou may be taken if at least one is taken from Zone 1 or 2		Barren-ground caribou
3	All subzones	Closed	Closed	One	
4	All subzones	Closed			
	4-03, 4-51		Closed	Closed	
	4-01, 4-02, 4-04 to 4-50, 4-52		One	One	
5	5-14 south, 5-15, 5-18 to 5-20, 5-22 to 5-24, 5-26 to 5-42, 5-45 to 5-47			Closed	
	5-01 to 5-14 north, 5-16, 5-17, 5-21, 5-25, 5-43, 5-44, 5-48 to 5-51			One	
	All subzones	Closed			
	5-01 to 5-03, 5-06, 5-07, 5-09 to 5-14, 5-18 to 5-21, 5-27 to 5-51		Closed		
	5-04, 5-05, 5-15 to 5-17, 5-22 to 5-26		One		Permit required in subzones 5-22 to 5-26
6	All subzones	Closed	Closed	Closed	Kluane Wildlife Sanctuary, closed to all hunting.

7	All subzones	Closed	Closed	One	Permit hunt only for moose.
8	All subzones	Closed		One	
	8-01 to 8-11, 8-18 to 8-25		One		
	8-12 to 8-17, 8-26, 8-27		Closed		
9	All subzones	Closed	Closed	One	Permit hunt for moose for three different seasons
10	All subzones	Closed	One	One	Permit hunt only for male caribou in 10-05 to 10-09, 10-17 to 10-19
11	All subzones	Closed	One	One	Permit hunt only for male caribou in 11-02 to 11-18, 11-20 to 11-23

Source: YRR 1998.

Appendix C: Bird Species Documented in the Yukon

Bird Species	Freq.[1]	Dist.[2]
LOONS		
Red-throated Loon	B	
Pacific Loon	B	
Common Loon	B	
Yellow-billed Loon		
GREBES		
Pied-billed Grebe	caB	
Horned Grebe	B	
Eared Grebe	ac	
Red-necked Grebe	B	
“Western” Grebe	ca	
CORMORANTS		
Double-crested Cormorant	caB	
HERONS		
Great Blue Heron		S
VULTURES		
Black Vulture	ac	
Turkey Vulture	ac	
SWANS, GEESE AND DUCKS		
Tundra Swan	B	
Trumpeter Swan	B	
Greater White-fronted Goose	B	
Snow Goose	B	
Brant	B	
Canada Goose	B	
Wood Duck	ac	
Gadwall	B	S
Eurasian Wigeon		S
American Wigeon	B	
Mallard	wB	
Blue-winged Teal	B	
Cinnamon Teal		S
Northern Shoveler	B	
Northern Pintail	B	
Green-winged Teal	B	
Canvasback	B	
Redhead	B	
Ring-necked Duck	B	
Greater Scaup	B	
Lesser Scaup	B	
King Eider	B	N
Common Eider	B	N
Harlequin Duck	B	
Surf Scoter	B	
White-winged Scoter	B	
Black Scoter	ca	
Oldsquaw	B	
Bufflehead	B	
Common Goldeneye	wB	
Barrow’s Goldeneye	B	
Hooded Merganser	ca	
Red-breasted Merganser	B	
Common Merganser	wB	
Ruddy Duck	B	S
DIURNAL BIRDS OF PREY		
Osprey	B	S
Bald Eagle	wB	
Northern Harrier	B	
Sharp-shinned Hawk	B	
Northern Goshawk	wB	
Broad-winged Hawk	ac	
Swainson’s Hawk		
Red-tailed Hawk	B	
Rough-legged Hawk	B	
Golden Eagle	B	
American Kestrel	B	
Merlin	B	
Peregrine Falcon	B	
Gyrfalcon	wB	
GROUSE AND PTARMIGAN		
Ruffed Grouse	wB	
Spruce Grouse	wB	
Blue Grouse	wB	
Willow Ptarmigan	wB	
Rock Ptarmigan	wB	
White-tailed Ptarmigan	wB	
Sharp-tailed Grouse	wB	
RAILS		
Sora	B	S
American Coot	B	S
CRANES		

Bird Species	Freq.[1]	Dist.[2]
Sandhill Crane	B	
Common Crane	ac	
PLOVERS, SANDPIPERS and ALLIES		
Black-bellied Plover		
American Golden-Plover	B	
Semipalmated Plover	B	
Snowy Plover	ac	
Killdeer	B	
Greater Yellowlegs		S
Lesser Yellowlegs	B	
Wood Sandpiper	ac	
Solitary Sandpiper	B	
Willet	ac	
Wandering Tattler	B	
Spotted Sandpiper	B	
Upland Sandpiper	B	
Whimbrel	B	
Hudsonian Godwit		
Bar-tailed Godwit	ca	
Marbled Godwit	ac	
Ruddy Turnstone	B	N
Black Turnstone	ac	
Surfbird	B	
Red Knot	ac	
Sanderling		
Semipalmated Sandpiper	B	
Western Sandpiper		
Little Stint	ac	
Least Sandpiper	B	
White-rumped Sandpiper		
Baird's Sandpiper	B	
Pectoral Sandpiper	B	
Sharp-tailed Sandpiper		S
Dunlin	ca	
Stilt Sandpiper	B	
Buff-breasted Sandpiper	B	N
Short-billed Dowitcher	B	S
Long-billed Dowitcher	B	
Common Snipe	B	
Wilson's Phalarope	B	S
Red-necked Phalarope	B	
Red Phalarope	B	N

Bird Species	Freq.[1]	Dist.[2]
SKUAS, GULLS AND TERNS		
Pomarine Jaeger		N
Parasitic Jaeger	B	N
Long-tailed Jaeger	B	
Franklin's Gull	ca	
Little Gull	ac	
Bonaparte's Gull	B	
Mew Gull	B	
Ring-billed Gull	ca	
California Gull	ca	
Herring Gull	B	
Thayer's Gull		S
Iceland Gull	ca	
Lesser Black-backed Gull	ac	
Slaty-backed Gull	ca	
Glaucous-winged Gull		S
Glaucous Gull	B	
Sabine's Gull	ca	
Black-legged Kittiwake	ac	
Red-legged Kittiwake	ac	
Ross's Gull	ac	
Caspian Tern	ca	
Arctic Tern	B	
Black Tern	B	SE
MURRES		
Thick-billed Murre	ac	
Black Guillemot	B	N
Ancient Murrelet	ac	
PIGEONS and DOVES		
Rock Dove (I)	wB	S
Mourning Dove		
OWLS		
Great Horned Owl	wB	
Snowy Owl	B	N
Northern Hawk Owl	wB	
Great Gray Owl	wB	
Short-eared Owl	B	
Boreal Owl	wB	
Northern Saw-whet Owl	ac	
GOATSUCKERS		
Common Nighthawk	B	
HUMMINGBIRDS		
Rufous Hummingbird		S

Bird Species	Freq.[1]	Dist.[2]
KINGFISHERS		
Belted Kingfisher	B	
WOODPECKERS		
Yellow-bellied Sapsucker	B	
Red-breasted Sapsucker	ca	
Downy Woodpecker	wB	S
Hairy Woodpecker	wB	
Three-toed Woodpecker	wB	
Black-backed Woodpecker	wB	S
Northern Flicker	B	
Pileated Woodpecker	B	SE
TYRANT FLYCATCHERS		
Olive-sided Flycatcher	B	
Western Wood-Pewee	B	
Yellow-bellied Flycatcher		S
Alder Flycatcher	B	
Least Flycatcher	B	S
Hammond's Flycatcher	B	
Dusky Flycatcher		S
Eastern Phoebe	B	SE-LB
Say's Phoebe	B	
Western Kingbird	ac	
Eastern Kingbird		SE
SHRIKES		
Northern Shrike	wB	
VIREOS		
Blue-headed Vireo		SE
Warbling Vireo	B	S
Philadelphia Vireo		SE-LB
Red-eyed Vireo		SE-LB
JAYS, MAGPIES AND CROWS		
Gray Jay	wB	
Steller's Jay	ca	
Clark's Nutcracker	ca	
Black-billed Magpie	wB	S
American Crow	ca	
Common Raven	wB	
LARKS		
Horned Lark	B	

Bird Species	Freq.[1]	Dist.[2]
SWALLOWS		
Purple Martin	ac	
Tree Swallow	B	
Violet-green Swallow	B	
Northern Rough-winged Swallow		S
Bank Swallow	B	
Cliff Swallow	B	
Barn Swallow	B	
CHICKADEES		
Black-capped Chickadee	wB	
Mountain Chickadee	wB	S
Boreal Chickadee	wB	
Gray-headed Chickadee	ca	
NUTHATCHES		
Red-breasted Nuthatch	wB	S
CREEPERS		
Brown Creeper	ca	
WRENS		
Winter Wren		SE
Marsh Wren	ca	
DIPPERS		
American Dipper	wB	
KINGLETS		
Golden-crowned Kinglet		S
Ruby-crowned Kinglet	B	
THRUSHES		
Bluethroat		N
Northern Wheatear	B	
Mountain Bluebird	B	
Townsend's Solitaire	B	
Gray-cheeked Thrush	B	
Swainson's Thrush	B	
Hermit Thrush	B	
American Robin	wB	
Varied Thrush	B	
STARLINGS		
European Starling (I)	B	S

Bird Species	Freq.[1]	Dist.[2]
PIPITS		
Yellow Wagtail	B	N
Red-throated Pipit	ac	
American Pipit	B	
WAXWINGS		
Bohemian Waxwing	wB	
Cedar Waxwing	B	SE
WOOD WARBLERS		
Tennessee Warbler	B	
Orange-crowned Warbler	B	
Nashville Warbler	ac	
Yellow Warbler	B	
Magnolia Warbler	B	SE
Cape May Warbler		SE
Yellow-rumped Warbler	B	
Townsend's Warbler	B	
Palm Warbler	ca	
Bay-breasted Warbler	B	SE-LB
Blackpoll Warbler	B	
Black-and-white Warbler	B	SE-LB
American Redstart	B	S
Ovenbird	B	SE-LB
Northern Waterthrush	B	
Mourning Warbler		SE-LB
MacGillivray's Warbler	B	S
Common Yellowthroat	B	
Wilson's Warbler	B	
Canada Warbler		SE-LB
TANAGERS		
Western Tanager	B	SE
SPARROWS		
American Tree Sparrow	B	
Chipping Sparrow	B	
Clay-colored Sparrow	ca	
Brewer's Sparrow	B	S
Lark Sparrow	ca	
Savannah Sparrow	B	
Le Conte's Sparrow		SE
Fox Sparrow	B	
Song Sparrow	caB	
Lincoln's Sparrow	B	
Swamp Sparrow	B	SE
White-throated Sparrow	B	SE
White-crowned Sparrow	B	

Bird Species	Freq.[1]	Dist.[2]
Golden-crowned Sparrow	B	
Dark-eyed Junco	wB	
Lapland Longspur	B	
Smith's Longspur	B	
Snow Bunting	wB	
CARDINALS		
Rose-breasted Grosbeak		SE-LB
Lazuli Bunting	ac	
BLACKBIRDS		
Red-winged Blackbird	B	
meadowlark sp.	caB	
Yellow-headed Blackbird	ac	
Rusty Blackbird	B	
Brewer's Blackbird	ca	
Common Grackle	ac	
Brown-headed Cowbird	B	S
Baltimore Oriole	ac	
FINCHES		
Brambling	ca	
Gray-crowned Rosy Finch		
Pine Grosbeak	wB	
Purple Finch	B	
House Finch	ca	
Red Crossbill	wB	S
White-winged Crossbill	wB	
Common Redpoll	wB	
Hoary Redpoll	wB	
Pine Siskin	B	
American Goldfinch	ac	
Evening Grosbeak	w	S
OLD WORLD SPARROWS		
House Sparrow (I)	ac	

Source: Cameron Eckert, Yukon Bird Club 1998**.** Updated to October 1999.

Notes: [1]Frequency and Breeding Codes: B = Confirmed Breeding; ca = casual (at least two records, but not seen each year; ac = Accidental (recorded only once); w = winter (observed annually in winter).

[2]Distribution Codes: N = North Coast, including the northern foothills of the British and Richardson Mountains, the Coastal Plain and the Beaufort Sea. S = Southern Yukon south of 63° N (includes Pelly Crossing but not Stewart Crossing). SE = Southeast Yukon — southern Yukon east of 131° W (Swift River). *Species noted as SE-LB are found primarily along the La Biche and Beaver Rivers in the extreme southeast Yukon.*

Appendix D: Bird Population Monitoring Programs in the Yukon

LANDBIRDS

One of the inherent difficulties in surveying natural populations is surveying large areas in a limited amount of time. There are few monitoring programs in the Yukon that are collecting long term population trend data for landbirds. The Canadian Wildlife Service is conducting site-specific surveys that are currently focused on landbird inventories in southeast Yukon (M. Gill, pers. comm.; C. Eckert, pers. comm.). Those inventories may provide baseline data to assess the impacts on specific populations, but they will be unsuitable as baseline data for entire Yukon. Larger scale inventories that are conducted in the Yukon include the North American Breeding Bird Survey (BBS). However, a continental review of tanager (*Piranga* spp.) distribution relative to various forest disturbances and varying levels of forest fragmentation revealed that single-species or local studies cannot be extrapolated to other species or regions (Rosenberg *et al.* 1999), thus signifying the importance of landscape–scale evaluations of bird populations. A description of the objectives and methods of the BBS surveys is presented below.

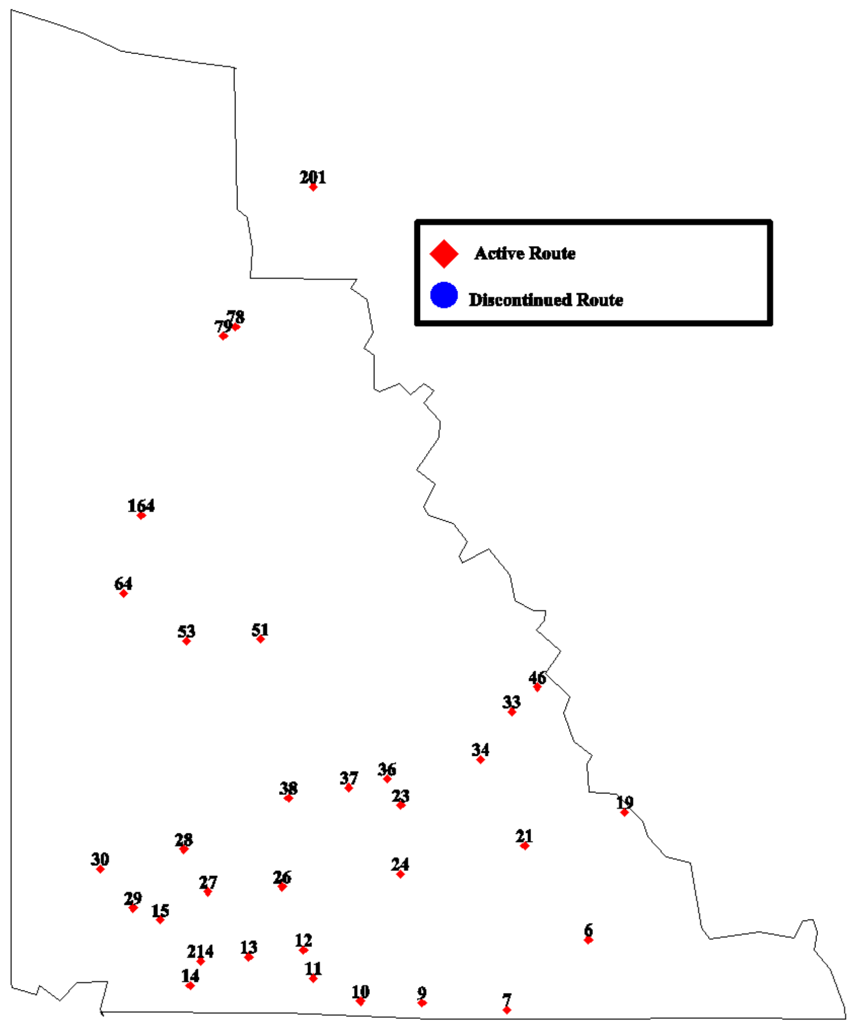
Breeding Bird Survey (BBS)

Purpose
The BBS is designed to detect and measure long-term changes in breeding bird populations.

Description
A standardized roadside survey run mainly by volunteers. Observers count all birds seen or heard at 50 3-min stops located 0.8 km apart along a 40-km route. All birds located within a specified radius around each station are recorded, and abundances are calculated in counts per 40-km route. Routes are run once a year, usually in June. Each route takes 4 to 5 hours starting 1/2 hour before sunrise. There are currently 32 designated routes in the Yukon (see map below), and population trends have been calculated for a few species from a few of the most consistently run routes. Further discussion of the validity and use of BBS data is beyond the scope of this report.

Availability of Data
Raw data are available on request from Canadian Wildlife Service for Canadian routes. Long-term trends and annual changes are calculated each year by Canadian Wildlife Service and published periodically. An annual newsletter discussing results is sent to all participants. The Yukon Coordinator of the BBS is Wendy Nixon, Canadian Wildlife Service, 91782 Alaska Hwy, Whitehorse, YK Y1A 5X7. Telephone: 867-667-3929. Fax: 867-667-7962. Email: wendy.nixon@ec.gc.ca.

Figure D-1 A Schematic Diagram Identifying Breeding Bird Survey Routes in the Yukon.



Source: USGS Patuxent Wildlife Research Centre and Canadian Wildlife Service 1999.

Table D-1 Bird Species for which BBS Trend Data are Available in the Yukon

Species	1964 – 1998			1974 – 1998			1984 – 1998			1994 – 1998		
	Trend[1]	*P*[2]	N[3]	Trend	*P*	N	Trend	*P*	N	Trend	*P*	N
Lesser Yellowlegs	1.8		17	1.8		17	0.7		17			
Common Snipe	1.5		16	1.5		16	6.1		16			
Northern Flicker	0.9		15	0.9		15	0.5		15			
Olive-sided Flycatcher	-7.9		17	-7.9		17	-7.2		17			
Gray Jay	-3.2		19	-3.2		19	-1.3		19	-7.6		16
Common Raven	6.1		15	6.1		15	5.4		15			
Boreal Chickadee	0.6		16	0.6		16	10.2		16			
Ruby-crowned Kinglet	16.7	*	18	16.7	*	18	19.1	*	18			
Swainson's Thrush	0.1		19	0.1		19	1.3		19	-3.8		16
American Robin	1		17	1.0		17	-1.9		17	-8.2		15
Varied Thrush	11.3		18	11.3		18	4.1		17			
Bohemian Waxwing	-7.9		15	-7.9		15	-5.7		15			
Orange-crowned Warbler	25.5	*	16	25.5	*	16	20.1		16			
Yellow-rumped Warbler	5.8	*	19	5.8	*	19	5.9	n	19	0		16
Northern Waterthrush	13.6	*	15	13.6	*	15						
Wilson's Warbler	11.4		18	11.4		18	14		18			
Chipping Sparrow	0.9		17	0.9		17	1.2		17			
White-crowned Sparrow	-1		18	-1.0		18	0.3		18	0.3		15
Dark-eyed Junco	-0.2		19	-0.2		19	-0.6		19	-11.4	*	16
White-winged Crossbill	10		16	10		16	9.9		16			

Notes:
Source: Environment Canada, B. McBride, National Wildlife Research Centre [CWS] unpubl. data.
[1] Trend is the mean annual percent change in population.
[2] *P* is the statistical significance * indicates $P < 0.05$; n indicates $0.05 < P < 0.15$
[3] N is the total number of routes used to calculate the trend.

WATERBIRDS

There are several waterbird monitoring programs in the Yukon, a selection of which are described below:

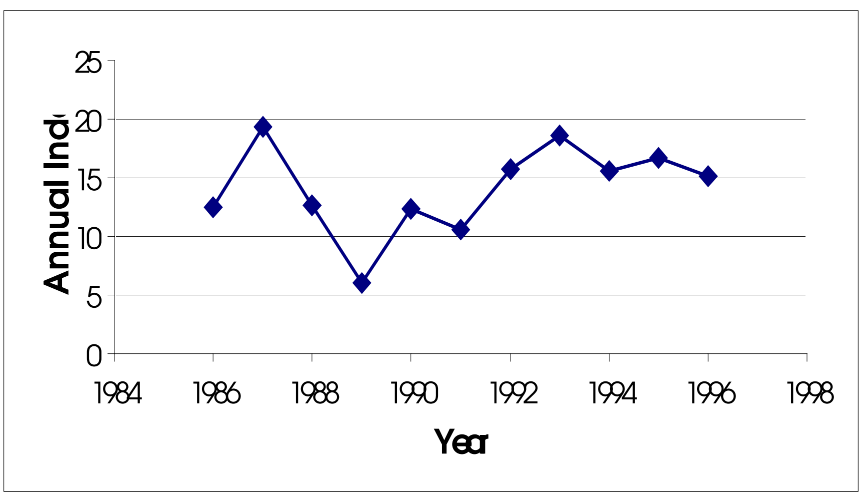
Breeding Bird Survey (BBS)

Purpose
See LandBirds section.

Description
See LandBirds section. The Canadian Bird Trends Database provides information on Canadian bird species including: population trends, range distribution, and national conservation designations (Environment Canada 1998). Population trends are derived from Canadian Breeding Bird Survey (BBS) data and are updated on an annual basis. BBS Trend Data was available for only two species of waterbird from the Yukon: the common snipe and lesser yellowlegs. The figure below shows the trend in annual indices of population change for Yukon wetland bird species based on Breeding Bird Survey data from 1986 through 1996. The trend, which is equivalent to the mean annual percent change in bird population, was 3.7 for the Yukon. Seventeen routes were used to calculate the trend, the lowest number of routes used for this calculation of all Canadian provinces.

Availability of Data
See LandBirds section.

Figure D-2 Annual Indices of Population Change for Wetland Species in the Yukon (1986–1996) as Assessed by the Breeding Bird Survey



Source: Canadian Wildlife Service (NWRC) 1998.

Old Crow Flats Waterfowl Breeding Population Survey

Purpose
To conduct annual counts to document changes in waterfowl breeding populations.

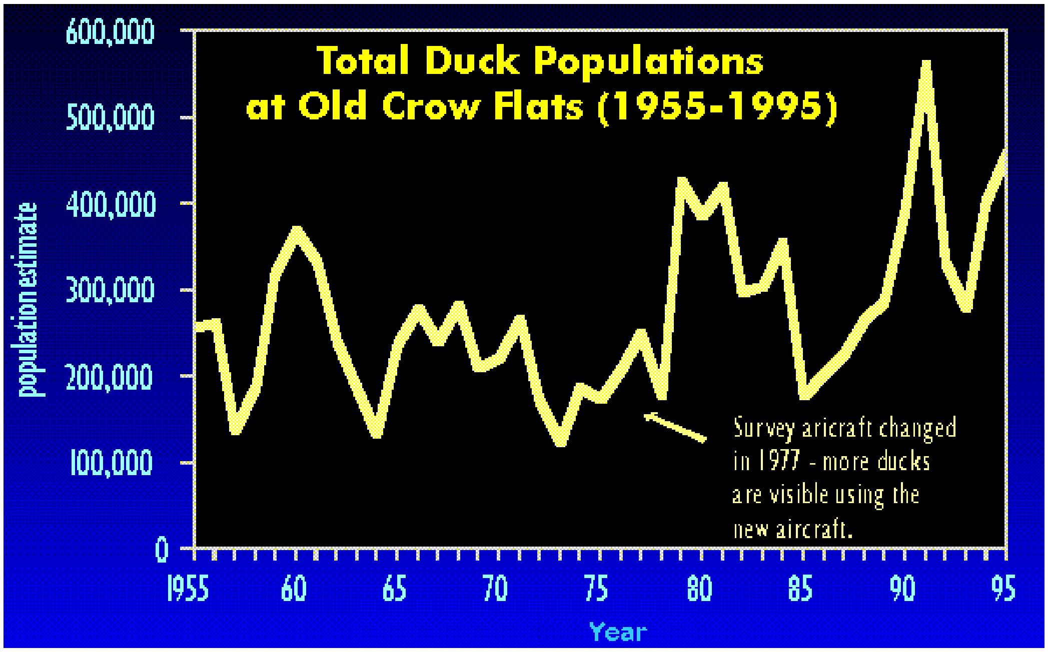
Description
Old Crow Flats is located 73 km north of the Arctic Circle and 110 km south of the Beaufort Sea. It represents one of the Yukon's most valuable wetlands and provides breeding, moulting and staging habitat for fall waterfowl migration. Old Crow Flats is recognized as an Ecological Site by the International Biological Programme (IBP) and was designated as a wetland of international importance under the Ramsar Convention in 1982. The U.S. Fish and Wildlife Service in Alaska conducts annual counts of the waterfowl breeding population. The results show that total numbers of waterfowl have remained much the same, or slightly increased during this time. However, there have been dramatic changes in some species, such as ring-necked duck, northern shoveler, and tundra swan. The causes of these changes have not been well studied, but a change in environmental conditions at Old Crow Flats is one of the possibilities. More than 100 bird species have been recorded on the Flats, including at least 21 species of waterfowl. The area serves as an important breeding and moulting ground for approximately 500,000 waterfowl. Aerial surveys indicated that waterfowl breeding populations over the past 30 years have included:

- 20,000-80,000 white-winged and surf scotes
- 50,000-100,000 greater and lesser scaups
- 20,000-100,000 American wigeons
- 10,000-100,000 northern pintail ducks
- 5,000-40,000 canvasback ducks
- 10,000-30,000 oldsquaw ducks

The Flats also support tundra swans, white-fronted geese, three species of loons, and a variety of other waterbirds. Some birds breed and moult on the Flats, while others such as Barrow's goldeneye do not breed there but come in midsummer from further south to undergo their annual moult. The figure below shows total duck populations at Old Crow Flats between 1955 and1995.

Availability of Data
Information is available at: http://www.taiga.net/wetlands/oldcrow/monitor.html or by contacting Chuck Young at the U.S. Fish and Wildlife Service, Region 7 Office, 1011 E. Tudor Rd. Anchorage AK 99503.Telephone: 907-786-3909.

Figure D-3 Total Duck Populations at Old Crow Flats, Yukon (1955-1995)



Source: Eamer et al. 1996

South Yukon Waterfowl Breeding Population Survey

Purpose

The goal of this survey is to estimate the numbers of waterfowl breeding in a large number (approximately 150) of wetlands adjacent to the road system each spring. When combined with the results of surveys from other parts of North America, they help assess the trend in continental populations of waterfowl.

Description

The South Yukon Waterfowl Breeding Population Survey was initiated in 1991 in response to the Yukon Waterfowl Management Plan (Yukon Waterfowl Technical Committee, 1991) which identified the lack of information on the trends in Yukon waterfowl populations as a problem which should be addressed. Both the Crow Flats and South Yukon surveys showed increases in waterfowl numbers in 1998 compared to 1997, in particular the dabbling ducks (Blue-winged and green-winged teal, northern shoveler) as well as ring-necked duck and Canvasback. The figure above shows the increase in total duck populations at Old Crow Flats over the last four decades.

Availability of Data

Data is available at: http://www.taiga.net/wetlands/syukonsurvey. Further information on the survey can be obtained by contacting Jim Hawkings at the Canadian Wildlife Service in Whitehorse (867-667-3927 or jim.hawkings@ec.gc.ca) or Dave Mossop at Yukon College (867-668-8736).