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Towards Acceptable Change: A Thresholds Approach to Manage Cumulative Effects of Land Use Change in the Southern Foothills of Alberta

By

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Abstract

In September 2005, a group of landowners, industry, environmental groups and local governments launched an ALCES (A Landscape Cumulative Effects Simulator) project to assess the cumulative impact of future land use in southwest Alberta, called the Southern Foothills Study (SFS). ALCES is a computer model that allows resource managers to quantify and track cumulative changes to natural landscape types in response to ecological processes and human land use practices. The project was created in response to local concerns over the potential impact of growing land use development and the desire for a stakeholder-driven land use planning process. At the outset of the project, three components of environmental and socio-economic value were identified by the Southern Foothills Study members: fescue grassland, grizzly bears, and water. This research builds upon the work of the Southern Foothills Study to look at how thresholds can be used to help manage the cumulative effects of land use activity on the valued ecosystem components. A threshold is the point at which an indicator changes from an acceptable to unacceptable condition, defined from an ecological and/or social perspective. Candidate thresholds for the valued components were identified through a literature review and interviews with key informants. In a workshop with member of the Southern Foothills Study, the candidate thresholds were evaluated from a social perspective. Alternative scenarios of development were developed to explore the implications of setting thresholds on land use development and activity. Recommendations for thresholds-based management of cumulative effects are provided, considering regulatory and land management processes in Alberta.

Key words: thresholds, cumulative effects assessment, regional planning, scenario analysis, Southern Foothills of Alberta

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1. Introduction, Methods and Context

1.1. Introduction

In September 2005, a group of landowners, industry representatives, environmental groups and local governments launched an ALCES (A Landscape Cumulative Effects Simulator; Stelfox 2006a) project to assess the cumulative impact of future land use in southwest Alberta, called the Southern Foothills Study (SFS). ALCES is a STELLA-based computer model that allows resource managers to quantify and track cumulative changes to natural landscape types in response to ecological processes and human land use practices (Schneider et al. 2003). The project was created in response to local concerns over the potential impact of growing land use development and the desire for a stakeholder-driven land use planning process. At the outset of the project, three components of environmental and socio-economic value were identified by the Southern Foothills Study members: native fescue grassland, grizzly bears, and water.

The Alberta Government's provincial land use planning approach, integrated resource management, has been characterized by administrative fragmentation resulting in poor integration. The lack of clearly defined land-use and resource management objectives, coupled with urban and industrial expansion, has led to increasing land-use conflicts. Individual resource development projects continue to be approved in the absence of comprehensive land use planning, frustrating landowners (Kennett and Wenig 2005).

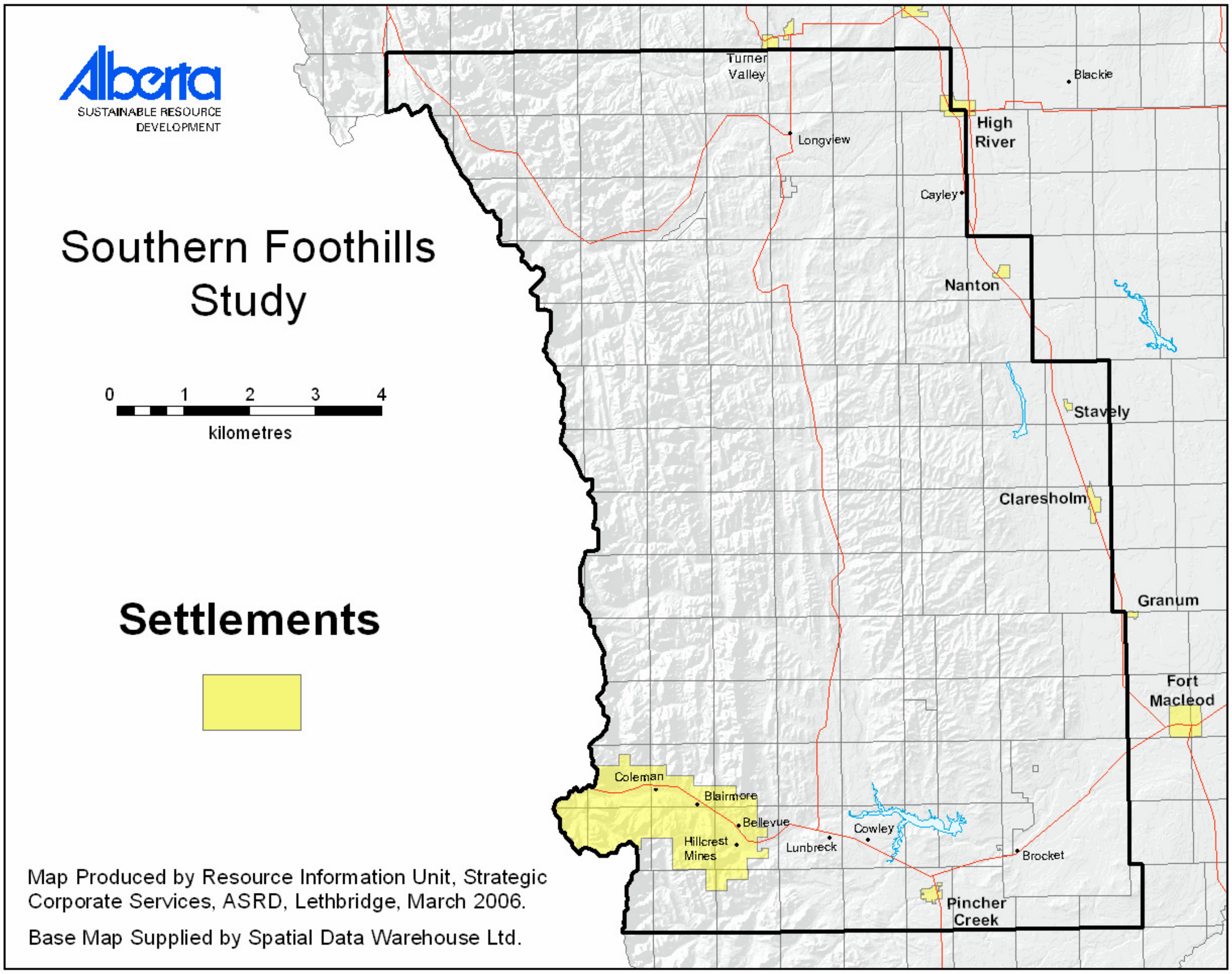
Environmental impact assessments (EIA) for individual development proposals may predict small changes to the environment, yet these projects, combined and compounded over time can have large disturbances to land, soil, water, wildlife and vegetation. Cumulative effects are "changes to the environment that are caused by an action in combination with other past, present, and future human actions" (Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999:3). Individual project assessments have not been effective in identifying and managing cumulative effects. Cumulative effects management requires new approaches that take a regional focus and address the impact of multiple land use activities, across different spatial and temporal scales.

This research builds upon the work of the Southern Foothills Study to look at how thresholds might help to manage cumulative effects on the key ecosystem components: water, grizzly bears and native fescue grassland. A threshold “is a technically or socially-based standard that identifies the point at which an indicator changes to an unacceptable condition” (Salmo Consulting Inc. 2006). Thresholds may be based on measurable land use, population or habitat indicators, and can be defined from an ecological and social perspective (Salmo Consulting Inc. and Diversified Environmental Services 2003).

1.2. Study Area

The Southern Foothills, shown in Figure 1.1, (also called the study area) is 1,217,700 ha in southwest Alberta extending to the north near Turner Valley, to just south of Pincher Creek, east to Highway 2 and west to the British Columbia border (Southern Foothills Study 2007). The Southern Foothills are located in the Parkland, Mixedgrass and Rocky Mountain Natural Regions (Alberta Sustainable Resource Development 2005). The vegetation transitions from grassland in the Foothills Fescue and Mixedgrass Subregions, to the forests and shrublands of the Foothills Parkland, Montane, Alpine and Sub-Alpine Subregions (Bradley, Quinn, and Duke 2002).

Figure 1.1 Southern Foothills Study Area



The study area has had a relatively short history of non-indigenous human settlement, beginning in the 1880s. Today the area is widely used for a variety of resource activities: coal mining, oil and gas exploration and development, industrial forestry, and agriculture (grazing of domestic livestock and cropland). The area is also used for recreational activities, including hunting, fishing, camping, horseback riding and use of off-highway vehicles (Sawyer et al. 1997).

1.3. Purpose and Research Questions

The purpose of this research is to understand how thresholds can be used as a tool to help manage cumulative effects of land use change. Through a case study approach in the Southern Foothills, the research will be guided by the following research questions:

1) How can thresholds be used as a tool to help manage regional cumulative effects?

2) What is an effective process for defining ecological, land use and management thresholds?

3) What are the implementation issues for thresholds-based management given Alberta's regional land use planning process?

1.4. Scope and Limitations

This research is exploratory in nature. It is intended to determine what information and methods could be used in a process to define thresholds. The research does not definitively determine acceptable change on the landscape.

ALCES is a strategic landscape tool which looks broadly at the impacts of land use over the whole landscape. At the scale of the SFS study area, the ALCES model does not address site-specific environmental information. More research would need to be conducted to set thresholds at a smaller sub-regional scale.

ALCES is a spatially-stratified model. The amount of land taken up by natural landscape and footprint types are calculated using a geographic information system (GIS) and input into the model as numbers. Users can direct footprint types to grow into certain landscape types, but the model does not differentiate where in the study area this is occurring. This is a limitation to the model as users have to take ALCES outputs and infer where the change is occurring based on the actual spatial location of features on the landscape. This also permits discussion to remain strategic in nature, necessary for policy level decisions about landscape change. ALCES outputs can be presented in map format using a geographic information system but should be shown as simple symbols and patterns on the landscape. Otherwise, viewers may wrongly interpret that ALCES is predicting exactly where development will occur.

1.5. Methodology

1.5.1. Literature Review

A literature review was conducted to understand how thresholds could be applied to cumulative effects assessment and regional land use planning. A review was conducted of scientific studies on the three ecosystem components (water, fescue grassland and grizzly bears) in relevant ecosystems in Alberta, British Columbia and the northwestern United States. Sources of information included:

- On-line journal databases;
- Websites for regulatory agencies and land use planning processes;
- Studies and reports from scientific research programs such as the Eastern Slopes Grizzly Bear Project and Foothills Model Forest.

The literature review helped to identify examples of thresholds-based management in other jurisdictions, potential thresholds, and approaches and issues to thresholds implementation.

1.5.2. Southern Foothills Study Advisory Group and Public Meetings

The Southern Foothills Study Advisory Group met several times over the course of this research. The author attended these meetings to learn about the concerns of the group and to gain an understanding of the ALCES model. A series of seven public meetings were held in Southern Alberta to present the results of the Southern Foothills Study in the fall of 2006.[1] The author attended the public meetings as a participant-observer, to learn about the cumulative effects study, and the public's response to it. The author's presence was announced at the beginning of the meetings as consistent with University of Calgary Ethics Board requirements.

1.5.3. Key Informant Interviews

Interviews were conducted with selected individuals to determine potential thresholds for the three ecosystem components and to understand the application of thresholds in land use planning processes in other jurisdictions. Interviewees were selected based on their knowledge of thresholds-based management of cumulative effects or one of the three ecosystem components: grizzly bears, fescue grassland and water quality. The interviews were between 30 minutes and one hour. Interviews were held with twenty individuals (see *Appendix B* for a list of interviewees) and the interview questions were semi-structured. Prepared questions were used to guide the interview, but the discussion deviated from the questions depending upon the interviewee's particular knowledge or experience. Ethics approval from the University of Calgary's Ethics Board was obtained to conduct the key informant interview, and the research conducted with Southern Foothills Study members, described in the following section.

[1] Public meetings were held in: Cowley, Black Diamond, Nanton, Claresholm, Pincher Creek, Chain Lakes, Calgary and High River.

1.5.4. Workshop, Survey and Follow-Up Interviews

There were five components to the research with members of the Southern Foothills Study Advisory Group: a workshop with small group discussions; plenary discussions; an individual survey; a pre-workshop survey; and a post-workshop interview. Prior to the workshop, members were asked to complete a pre-workshop survey that was used to inform the selection of indicators and the development of workshop materials. Twenty members of the Southern Foothills Study (SFS) Advisory Group participated in a day-long workshop. The workshop activities were pre- tested with a group of ten graduate students from the University of Calgary.

During the workshop, group discussions were held to evaluate the candidate thresholds as determined through the literature review and interviews with key informants (see Chapter 3). Alternative land use scenarios were then presented to show the implications of setting thresholds. A survey, completed individually, was used to understand participants' opinion on thresholds-based cumulative effects management, and desired future landscape conditions (See *Appendix E* for survey). The results of the survey were analyzed to understand participants' opinion on alternative scenarios and potential thresholds. Participant responses were also grouped according to type of representative: landowner and local organization; environmental organization; resource company; and government (municipal, provincial and federal). A semi-structured follow-up interview was held with 17 of the 20 participants[2] for 20 to 30 minutes to discuss and clarify their survey answers and opinion on land management.

1.6. Master Degree Project Organization

1.6.1. Chapter Two: Thresholds-Based Management of Cumulative Effects: Theory and Practice

Chapter Two provides a review of thresholds-based management of cumulative effects in theory and in practice in other jurisdictions in North America. The review explores the application of thresholds and similar concepts such carrying capacity, limits of acceptable change and management targets.

[2] Post- workshop interviews were conducted with eighteen of the twenty participants. Interviews could not be arranges with two of the participants.

1.6.2. Chapter Three: Identification of Candidate Thresholds for the Southern Foothills: Literature Review and Interviews

Chapter Three identifies indicators and candidate thresholds for the three ecosystem components as determined through a literature review and interviews with key informants. The candidate thresholds were tracked in ALCES to determine when and to what degree they were exceeded within the Southern Foothills Study's "Business-As-Usual" Scenario of future development.

1.6.3. Chapter Four: Addressing the Social Acceptance of Thresholds in the Southern Foothills

Chapter Four presents the results of the five components to the social evaluation of thresholds: a workshop with small group discussions; plenary discussions; an individual survey; a pre-workshop survey; and a post-workshop interview. Recommendations for an effective process to determine thresholds are provided. Issues addressed include stakeholder engagement, scenario analysis, and the integration of social values.

1.6.4. Chapter Five: Implementation of Thresholds-Based Management of Cumulative Effects: Recommendations and Conclusions

In Chapter Five, the implementation issues associated with thresholds-based management of cumulative effects are outlined. Recommendations for thresholds implementation as part of land use planning in the Southern Foothills are provided considering the current and proposed regulatory and land management processes in Alberta. The recommendations are informed by a literature review, case studies presented in Chapter Two, interviews with experts on thresholds-based management of cumulative effects and the author's professional experience.

1.7. Southern Foothills Study: Land Use Change

The Southern Alberta Land Trust Society (SALTS) coordinates the Southern Foothills Study (SFS). Initiated in 2005, the Study members include representatives from: landowner and local organizations; environmental organizations; resource companies; and municipal, provincial and federal government departments (see *Appendix A* for list of members and supporters). The results of the SFS were presented in October and November 2006 at a series of public meetings held in seven communities in Southern Alberta. Over six hundred people attended the meetings. An hour-long presentation by Dr. Brad Stelfox on the results of the Southern Foothills Study was followed by question and answer period. The SFS showed that by year 2055 projected changes in landscape and land uses will result in declining water quality, loss of wildlife habitat, and an increase in human population.

Meeting attendees were asked to complete a survey on the presentation, land management practices, cumulative effects, and their degree of concern about the degradation of ecosystem components and land uses like recreation and ranching. Of the 600 people who attended the public meetings, 344 surveys were returned (Southern Foothills Study 2007). Praxis, a Calgary-based company was hired to aid in the analysis of the survey and to conduct a random-sample telephone survey of urban and rural respondents using similar questions. The phone survey was conducted with 800 residents within the study area as well as residents of the nearest major cities, Calgary and Lethbridge (Ibid).

The ALCES Group, a consulting company, developed scenarios that depict the landscape for pre-development, present (2005) and future (2055). Much of the data were obtained with permission from the Alberta Government from a similar study conducted in Southern Alberta, called the Southern Alberta Sustainability Strategy (now called Southern Alberta Landscape Study (SALS)). SALS used the ALCES model to quantify landscape change and has not yet been released to the public (Alberta Government 2004).

The SFS scenario of the future, projects land use change from 2005 to 2055. The scenario of the future was called "Business-As-Usual" because the assumptions in the model represent the expected growth in each sector based on current policies and practices. The assumptions were developed through consultation with key informants from each land use sector. The assumptions were generally made to represent low land use growth rates and rapid reclamation rates of land use footprint disturbances. These decisions increase the confidence rate in the scenarios although likely underestimate the potential impact if the land uses are developed at higher growth rates.

ALCES is a STELLA-based computer model that uses stock and flow algorithms. ALCES can calculate the impact of natural disturbances (e.g., fire, non-native plant invasion, and insects) and human land uses on natural landscape types and indicators of ecological health (e.g., water quality, wildlife habitat). ALCES is a means to understand and project cumulative effects of multiple land uses on environmental, social and economic variables. The natural landscape and footprint categories for the Southern Foothills Study are presented in table and graph format below (Figure 1.2, Table 1.1, and Table 1.2). The ALCES results for each of the three valued components (water, fescue grassland and grizzly bears) are presented in Chapter Three.

Figure 1.2 Current Natural Landscape and Footprint Types, Percentage of the Landscape, 2005

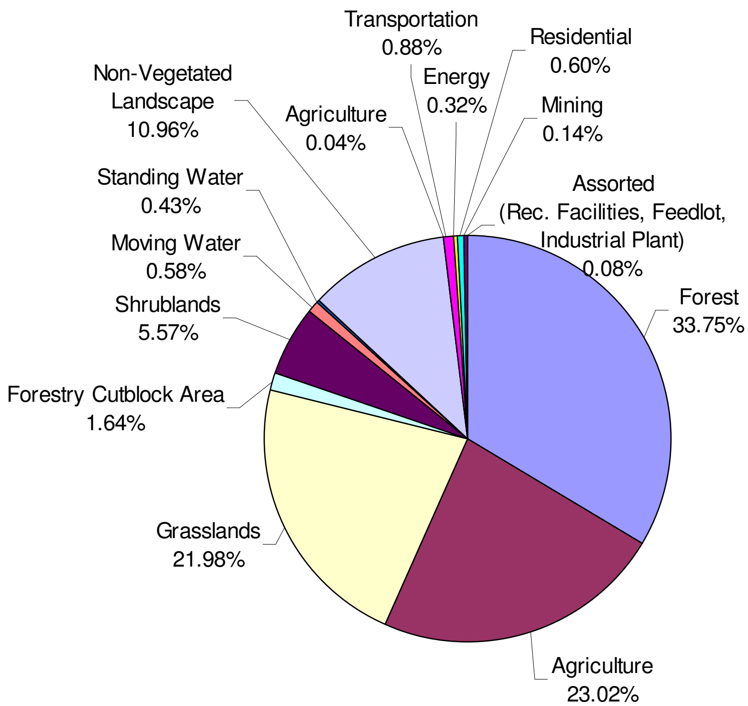


Table 1.1 SFS Business-As-Usual by Footprint Type (2005 to 2055)

Footprint Type	2005 Ha	2055 Ha
Major Road	962	1,803
Minor Road & Trail	7,335	13,238
Wind Turbines	138	371
In-block Road	650	1,876
Electricity Transmission Line	1,600	4,632
Gravel Mine	928	2,379
Coal Mine	768	1,018
Canal	404	404
Agricultural Residences	4,000	4,420
Rural Residences	1,000	4,384
Town/ City	2,301	10,335
Recreational Facilities	874	3,832
Industrial Plant	136	744
Seismic Line	3,465	2,284
Well site	279	2,597
Pipeline	802	6,081

Feedlot	100	211
Cutblock Area	20,000	22,900
Total	45,742	83,509

Table 1.2 Southern Foothills Study Business-As-Usual Scenario Land Use Change

Land Use/ Landscape	2005	2055	Percent Change
Assorted (Rec. Facilities, Feedlot, Industrial Plant)	0.08%	0.37%	339.02
Energy	0.32%	0.89%	180.36
Residential	0.60%	1.56%	158.32
Transportation	0.88%	1.78%	102.87
Mining	0.14%	0.28%	97.72
Forestry Cutblock Area	1.64%	1.84%	11.97
Agriculture	23.03%	23.90%	3.77
Natural Landscape Types	73.30%	69.39%	-5.34%
Total	100.00%	100.00%	

The land uses that are projected to change the most in the SFS Business-As-Usual Scenario are recreational facilities, energy, residential and the transportation sector, as shown in Table 1.2.

1.7.1. Human Population, Rural Residential and Recreation

The human population in the study area is expected to grow at a rate of 3% from 40,000 to 175,356, an increase of 338% by 2055. This population growth will take place within the present communities of the Southern Foothills and through the development of rural residential acreages. The number of rural residential acreages is projected to grow from 500 to 2190, occupying 4,384 ha of land in the study area.

The populations in the major cities of Lethbridge and Calgary, although outside the study area are also projected to grow and they will influence the growth of recreational land uses, such as golf courses, off road vehicle trails, and resort developments within the study area. The number of tourism activity days is expected to increase by 60% to 38 million by 2055.

1.7.2. Agriculture

Much of the landscape change from pre-settlement to today is a result of agricultural practices. The total cropland in the study area peaked in 1985 and has been declining since. Although new cropland is still created by converting native landscape types, a greater amount of cropland is converted for other uses, such as urban expansion, rural residential acreages and hydrocarbon development.

The agricultural sector can be divided into cultivated cropland and rangeland. The area of cultivated cropland and tame grassland may increase from 283,000 ha to 293,000 ha from 2005 to 2055. The total tonnes of crops produced per year are projected to increase from 814,000 tonnes to 848,000 tonnes. The number of cattle in the study area on rangeland and in feedlots may rise from 205,000 to 321,000 by 2055. The hectares of land taken by feedlots are projected to double.

1.7.3. Forestry

There are two forest management systems in the Southern Foothills. The northern part of the study area is within the Spray Lakes Forest Management Agreement (FMA) and the southern part is managed through the C5 Forest Management Unit (FMU). The total hectares of forestry cutblocks in the study area is expected to increase slightly by 2055, from 20,000 ha to 22,900 ha. This is due to the fact that the reforestation rate is projected to be close to the deforestation rate. Approximately 1,000 ha of forest are expected to be logged each year.

1.7.4. Energy and Mining

The Southern Foothills are underlain by the Western Sedimentary Basin, containing deposits of conventional oil and gas, and unconventional tight gas shales and coalbed methane. The SFS projections for hydrocarbon production are provided in Table 1.3. Energy footprints represented in ALCES are seismic lines, well sites, roads, and pipelines. Roads are calculated in the transportation section. Seismic lines are projected to increase from 5,490 km in 2005 to 10,456 km in 2055. The wind energy industry is concentrated in the southern portion of the study area near Pincher Creek. The hectares of land occupied by wind turbines are expected to increase from 138 ha in 2005 to 371 ha in 2055.

Table 1.3 Total Cumulative Projected Hydrocarbon Production (m^3) in the Southern Foothills (2005- 2055)

Hydrocarbon	2005 m^3	2055 m^3
Oil	25,308	77,200
Natural Gas	307,433,739	888,805,500
Coalbed Methane	0	4,051,619,700

Gravel mining occurs throughout the study area. It is expected to increase in area by 2055. Uranium and magnetite mining may be a future land use, although is not yet incorporated into the Southern Foothills Study.

1.7.5. Transportation and Electricity Transmission

All land uses require roads. There are approximately 6,500 km of major, minor and in-block[3] roads in the study area. This is projected to increase to 14,000 km by 2055. Electricity transmission lines are projected to increase from 533 km in 2005 to 2,050 km in 2055.

[3] In-block roads provide temporary access and are reclaimed once the forest block has been harvested.

2. Thresholds-Based Management of Cumulative Effects: Theory and Practice

2.1. Introduction

Land use planners are increasingly realizing that conventional approaches to managing renewable and non-renewable resources are ineffective. The extraction of resources such as oil and gas and timber results in land disturbance that has negative and often irreversible effects on wildlife populations, the persistence of native plant species, water quality and quantity, and community resilience. One approach to managing cumulative social and environmental effects is to apply thresholds or limits to human land disturbance, based on a blend of ecological science and public values.

The use of thresholds in landscape management can help ensure that human activities do not cause irreversible or undesirable environmental or social consequences. To select thresholds, stakeholders and planners must first identify the conditions and components of the landscape that are desirable and of highest priority.

This chapter describes how thresholds have been applied to manage cumulative effects in various jurisdictions through project-level cumulative effects assessments and regional land use planning processes. Interviews were conducted with key informants to understand how thresholds have been defined or applied in the Northwest Territories (N.W.T.) and British Columbia (B.C.).

The first section explains cumulative effects and cumulative effects assessments. The second section focuses on defining thresholds and threshold frameworks to manage landscape change. Finally, four examples of thresholds-based management in other jurisdictions are provided. The conclusion summarizes the key lessons for thresholds-based management of cumulative effects considering social and ecological factors.

2.2. Cumulative Effects Defined

Cumulative effects are the result of multiple human actions over time and space. The persistent addition of infrastructure or activity in an area can have a compounding or additive and/or synergistic effect. For example, when people extract resources or build a community, there is increased activity and disturbance in an area. Each individual action, such as the first road, can seem insignificant but when combined with other actions in the area can have serious consequences.

Cumulative effects are "changes to the environment that are caused by an action in combination with other past, present, and future human actions" (Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999:3). This definition summarizes the main concepts of cumulative effects: they are a result of several human actions over a defined period of time.

In the literature on cumulative effects, there are many explanations of the types or categories of cumulative effects. The types are defined either from the perspective of the processes of human action or the response of the ecosystem.

From the perspective of human action, Contant and Wiggins (1991) defined cumulative effects as actions producing impacts that are either additive or synergistic. An additive effect occurs when small additions are made that all add up to a sum. Additive effects usually result in a linear response, like when phosphorus runs off the land to a waterbody. A synergistic effect occurs when the combined effect is unexpected, often greater than the sum. The synergistic effect is also called interactive, whereby the "total effect of an interaction between two or more agents is greater than the sum of the effects of the individual agents" (Peterson et al. 1987:7). An example of this is biomagnification of chemicals in the food chain.

Peterson *et al*. (1987) and Sonntag *et al*. (1987) expanded the explanation of cumulative effects to include 4 types that together form a hierarchy from lower to higher magnitude of cumulative effects. These four types are not mutually exclusive. For example, additive effects may become amplifying. These categories are useful here as they refer specifically to thresholds.

Linear Additive Effects: incremental actions that accumulate and have a steady linear effect on a system. For example – drainage of chemicals to a river from a number of sources.

Amplifying or Exponential Effects: incremental effects that have a bigger effect than the one before. For example - carbon dioxide emissions into the global atmosphere - the effects become gradually more detectable.

Discontinuous Effects: incremental effects that cause the exceedance of a threshold. The system or components of it change drastically. For example - the eutrophication of a lake - once sufficient phosphates have accumulated in a lake anaerobic activity is triggered.

Structural Surprises: changes to a system due to numerous and varying actions. It is difficult to tell which factor had the biggest effect. This can be a result of not only ecological, but also social and economic forces. For example - the collapse of the Atlantic fishery (environmental change, seals, overfishing, foreign fleet etc.).

Cumulative effects can also be classified according to the response of the ecosystem, as shown in Table 2.1.

Table 2.1 Typology of Cumulative Effects

Type of Effect	Description	Example
Time crowding	Frequent and repetitive impacts on a single environmental medium	Fish harvesting exceeds stock regeneration time
Space crowding	High density of impacts on a single environmental medium	Multiple inputs of effluent into a lake
Compounding effects	Synergistic effects arising from multiple sources on a single environmental medium	Emissions to the atmosphere
Time lags	Long delays in experiencing impacts	Carcinogenic effects
Space lags; Extended boundaries	Impacts resulting some distance from source	Long-range transport of atmospheric pollutants (LRTAP)
Triggers and thresholds	Disruptions to ecological processes that fundamentally change system behaviour	Climate change
Indirect effects	Secondary impacts resulting from a primary activity	Road developments opening frontier areas
Patchiness effects; Incremental changes; Nibbling	Fragmentation of ecosystems	New road through a forest

Source: (Sonntag et al. 1987; Peterson et al. 1987).

Identifying cumulative effects on a valued ecosystem component can be very complicated as the effects can come from multiple sources and can be direct or indirect. The most challenging cumulative effects to predict are those that are synergistic and unexpected, and those for which there are time or space lags, making it difficult to pinpoint the source. Cumulative effects can be assessed when a new project is proposed, or through regional planning. In the first case, the goal is to identify the contribution of a project to the cumulative effects. In regional planning, the cumulative effects of a particular land use sector or a variety of land uses can be assessed over a wider area and longer time period.

2.3. Project-Specific Cumulative Effects Assessments

Cumulative effects assessment (CEA) practices grew from recognition of the deficiencies of environmental impact assessments (EIA) in addressing long-term impact of environmental degradation. Interest in wider goals such as the maintenance of biodiversity and sustainable development required revising the impact assessment legislation and policy (Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999).

In the 1970s and 1980s, the federal government established guidelines for assessment practice such as the Canadian Environmental Assessment and Review Process. The Canadian Environmental Assessment Research Council initiated research on cumulative effects assessment and their associated technical and methodological challenges. In the 1980s a number of project assessments incorporated cumulative effects (such as the Northern Saskatchewan Uranium Mines and Alberta-Pacific Pulp Mill) and in the 1990s regional planning initiatives demonstrated use of CEAs (such as the Hudson Bay Programme, Northern Rivers Basin Study, Oak Ridges Moraine Area Planning Study) (Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999). In 1995, the federal government passed the Canadian Environmental Assessment Act replacing previous legislation. Subsequently, provincial legislation was likewise amended to include cumulative effects (e.g., the Alberta *Environmental Protection and Enhancement Act* and the British Columbia *Environment Assessment Act).*

Many practitioners argue that cumulative effects assessments (CEAs) are EIAs done correctly (Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999; Duinker and Greig 2006). In a CEA, the study area is enlarged, and past, present and future actions are assessed to determine their effect on components of an ecosystem. In all other ways, a CEA follows the same format as an EIA. The Assessment Framework for EIA and specific tasks for a CEA are listed in Table 2.2 (recreated from Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999: 9).

Table 2.2 Impact Assessment Framework

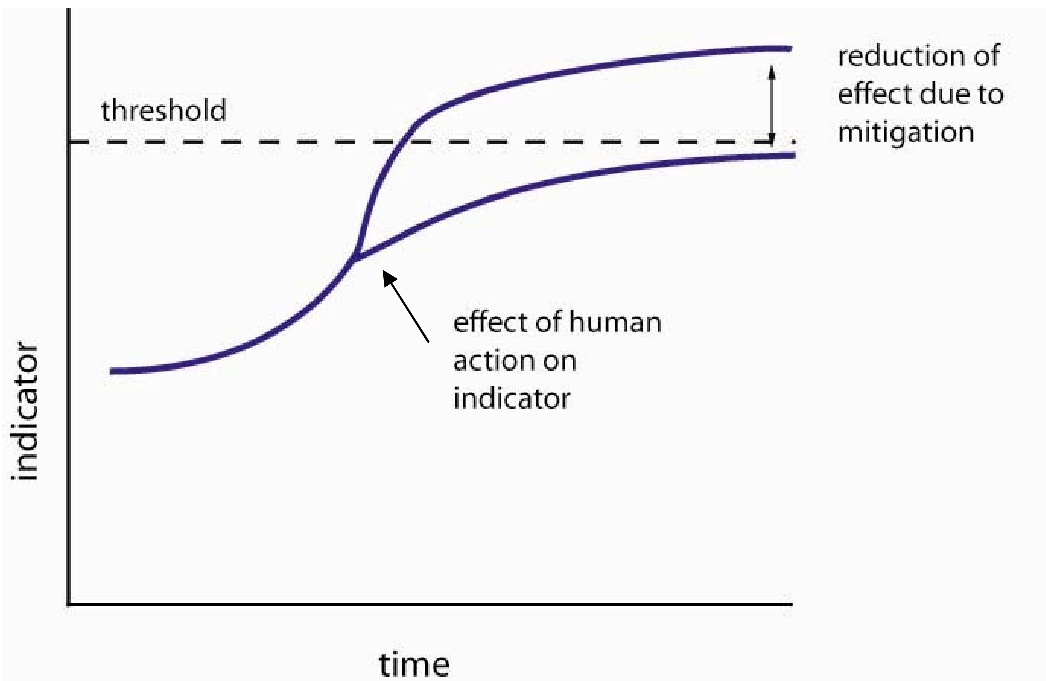
Basic EIA Steps	**Tasks for a CEA**
Scoping	Identify regional issues of concern Select Appropriate regional Valued Ecosystem Components (VECs) Identify spatial and temporal boundaries Identify other actions that may affect the VECs Identify potential impacts due to actions and possible effects
Analysis of Effects	Complete the collection of regional baseline data Assess effects of proposed action on selected VECs Assess effects of all selected actions on selected VECs
Identification of Mitigation	Recommend mitigation measures
Evaluation of Significance	Evaluate the significance of residual effects Compare results against thresholds or land use objectives and trends
Follow Up	Recommend regional monitoring and effects management

A critical part of a CEA is determining the significance of a detected impact on a Valued Ecosystem Component (VEC) (Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999). A VEC is an environmental variable that is of value to the public or identified for special protection or management. To identify cumulative effects requires distinguishing the variables that interact with the VEC and the degree of effect upon it. The impact must be shown to adversely affect the component beyond an acceptable point (Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999). The point at which the effect has significance can be determined through evidence that a threshold has been exceeded.

Thresholds provide a basis from which to evaluate cumulative effects (more explanation of thresholds in next section). If the presence of a threshold can be determined, it acts as a measure against which planners and regulators can judge incremental projects. If the project exceeds a threshold, the project may be denied or the proponent may be required to develop some form of mitigation. Figure 2.1 illustrates the potential effect of mitigation in relation to a threshold.

A rationale for identifying and implementing thresholds is that development can continue unhindered until a threshold is approached. This provides certainty and clarity to operators in the area as to the limits to development.

Figure 2.1 Potential Effects of Mitigation in Relation to a Threshold



Source: (Recreated from Hegmann 2003).

Thresholds are critical to determining if the cumulative effects on a VEC are significant. However, thresholds have not been identified for most VECs. The project-level CEA then assumes that there is no threshold. In the absence of the identification and monitoring of ecological thresholds, cumulative effects may only be managed once the public becomes concerned due to visible or perceived changes to the environment (Duinker and Greig 2006; Kennett 1999).

Duinker and Greig (2006) argue that project-level CEAs are not effective, and that fundamental changes are required. The project-centered approach does not encourage a proponent to assess the impacts of multiple projects on a VEC. The proponent's goal is to get project-approval, first and foremost (Duinker and Greig 2006). The CEA is usually limited to a particular study area and time frame, which may not be wide enough in scope to assess all past, present and future impacts on a VEC. Moreover, there is also frustration over project-based CEAs when the proponent may not be able to get detailed or proprietary information about other developments in the area (Quinn et al. 2004). As a result of these problems, project-level CEAs have been limited in their ability to assess cumulative effects, and manage those effects into the future.

The alternative to project-specific cumulative effects assessments is regional cumulative effects assessments (also called strategic assessments) and regional planning conducted by government agencies. Regional assessments can address cumulative effects over a larger area, over a longer period of time, and consider the effects on valued ecosystem components as a result of a variety of land uses. Pro-active regional planning initiatives can also define desired ecological and social objectives for the area and set thresholds (Kennett 1998). Regional planning processes can be integrated with and provide guidance to individual project-level cumulative effects assessments.

2.4. Thresholds to Manage Cumulative Effects

To properly assess and manage cumulative effects, the desired state of the landscape or ecosystem must be identified. The significance of the cumulative effect needs to be based on a clear definition of what is acceptable and what is not. The line between the two can be defined by a threshold that is based on science and/or social values.

The term threshold was first used in the field of ecology to refer to an abrupt change in the state of matter or in a system caused by a small change in spatial pattern (Turner and Gardner 1991). It is also referred to as the amount or intensity of a "stimulus that is required to produce a response in an organism or an ecosystem" (Peterson et al. 1987:8). A threshold in this context is a point indicating when abrupt change will occur. Andrén (1994) popularized the term in the field of conservation biology. His research sought to identify a threshold for the proportion of suitable habitat on a landscape to avoid negative cumulative effects on birds and mammals due to habitat fragmentation. Since then, thresholds have been increasingly explored and applied by resource managers who see the potential to set limits to manage the ecosystem or a particular component (Luck 2005). Thresholds are also being used in the field of impact assessment to determine the point at which a project has significant environmental or social impact on an indicator. Other terms for ecological thresholds are: conservation threshold, threshold of conservation concern, environmental threshold, and landscape threshold (The Environmental Law Institute 2003; Radford, Bennett, and Cheers 2005; Tahoe Regional Planning Agency 2002). The concept of threshold has been expanded in recent decades in the field of regional planning and resource management to embrace the concept of goals, targets, standards or guidelines, carrying capacity, or limits of acceptable change (explained below) (Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999).

There are many definitions of thresholds, as shown in Table 2.3. The definition by Ziemer (1994) below, limits a threshold to a scientific standard. Yet, this definition ignores inherent social or political decisions in setting thresholds. Indeed, the rationale for the decision to use a threshold to manage cumulative effects may be rooted in science but it will be influenced by the values of individuals, an organization, government or industry. A more complete definition is found in the Dehcho Land Use Plan in which acceptability is defined from "an ecological or social perspective," or both [added]. The definition by Salmo Consulting (2006) is the broadest and makes clear that both science and social science can provide input to defining thresholds.

Table 2.3 Definitions of Thresholds

Source	Definition of Threshold
(AXYS Environmental Consulting Ltd. 2001)	A limit to which an important resource can tolerate land use effects before experiencing an unacceptable adverse effect.
(Dehcho Land Use Planning Committee 2006)	A threshold is defined as a point at which an indicator changes to an unacceptable condition, with acceptability defined either from an ecological or social perspective.
(Ziemer 1994 rephrased in Antoniuk and Ainslie 2003)	A threshold is an objective, science-based standard used to evaluate the acceptability of project-specific and cumulative effects.
(Salmo Consulting Inc. 2006)	Technically or socially-based standards that identify the point at which an indicator changes to an unacceptable condition.
(Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999)	A limit of tolerance of a Valued Ecosystem Component (VEC) to an effect, that if exceeded results in an adverse response by that VEC.

(Tahoe Regional Planning Agency 1980)	“Environmental threshold carrying capacity” means an environmental standard necessary to maintain a significant scenic, recreational, educational, scientific or natural value of the region or to maintain public health and safety within the region.
(Huggett 2005; Radford and Bennett 2004)	Ecological thresholds are points or zones at which relatively rapid change occurs from one ecological condition to another.

Science can provide a foundation for decision on appropriate thresholds to manage landscape change. However, ultimately any land use decision is value-laden: “much of the controversy surrounding resource management questions is not from a lack of science, or disagreements over the state of nature, but instead involve basic disputes over human values” (Szaro et al. 2005:9-10). Thresholds may be based on science but when they are applied to manage cumulative effects, they will be reflective of human values and in the end, are social and political decisions.

2.4.1. Range of Natural Variability

Thresholds may not exist as fixed points, but may be found within ranges of natural variability. In understanding natural variability, the underlying assumption is that “using natural disturbance patterns to guide management patterns is one of the best possible means of achieving ecological sustainability in the absence of information on alternatives” (Antoniuk and Ainslie 2003:5). By understanding natural disturbance patterns, such as climate change, fires, weather patterns, flooding, erosion, natural succession and random events, the natural variability of environmental conditions can be determined. If it is not possible to restore an indicator within the range of natural variability, the maximum deviation from the range of variability may need to be determined.

2.4.2. Carrying Capacity

Carrying capacity is a term often equated with a threshold, as it represents a limit that an ecosystem can take prior to impeding its function. It refers to “the level of population or development that can be sustained in an area without adversely affecting that area beyond and acceptable level” (Randolf 2004:604). Usually this term is used to refer to an acceptable population level in an area. The acceptability of the population number is variable depending upon two things: the effect the population has on the ecosystem, and the technology/innovation available to reduce the effect. The concept of carrying capacity works well when calculating the rangeland capacity of animal per unit of land, but is difficult to calculate when dealing with multifaceted human impacts that differ in type, timing, intensity and duration. Like a threshold approach, the carrying capacity can be based on ecological factors but is ultimately determined by social values and through political negotiation.

2.4.3. Outcome or Input-Based Thresholds

Thresholds can be based on a social or ecological condition (outcome) or activity intensity (input). Outcome-based thresholds are desirable as outcomes are what management is concerned with (Antoniuk and Ainslie 2003). Outcome-based thresholds may be based on several inputs. A threshold based on an input indicator may be used when the outcome indicator cannot be easily measured. Input thresholds may be based on, for example, the maximum level of land use activity, or human disturbance rate (e.g., number of people on a trail per day). Outcome thresholds may be based on the minimum amount of habitat within an area, or the percentage of non-native species present (Antoniuk and Ainslie 2003).

2.4.4. Recognizing Uncertainty

In setting thresholds, planners must make clear their information gaps, lack of knowledge or scientific agreement, and variations in the natural systems. This leads to an understanding of their level of confidence and conversely, their uncertainty with the threshold defined (Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 1999).

The precautionary principle may be applied by defining conservative thresholds to reflect ecological uncertainty (AXYS Environmental Consulting Ltd. 2001). The precautionary principle, as defined 1992 United Nations Conference on Environment and Development, is "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (Rio Declaration on Environment and Development, Principle #15 1992).

2.4.5. Scale

Thresholds exist at varying spatial and temporal scales. Scale refers to the "spatial or temporal dimension in which an organism or pattern or process is recognizable" (Farina 1998:36). The scale depends on the organism or component of the ecosystem of concern. A species may experience the environment at a range of scales; a population may be affected by habitat fragmentation at the landscape scale, and an individual affected by structural elements within a vegetation type (Farina 1998; Lindenmayer and Luck 2005). A species may also have seasonal variations in behaviour and have dramatic population changes over several years. The selection of scale should take into account the biological attributes of a species, such as dispersal movements and population density. For components like water or grassland, the scale should reflect whether or not cumulative effects of land use activity on ecological and social processes and patterns are detectable. Today, through the use of remote sensing and geographic information systems, large landscape and regional scales can be examined. At the landscape scale attributes like natural disturbance regimes, soil types, vegetation types and land uses can be measured. Together they form an overall mosaic, the pattern of which can be used to detect changes in ecosystem components. The indicator selected to represent the valued component must also reflect the scale at which the cumulative effects of landscape change may be detected.

2.5. Types of Indicators and Thresholds

The Organization for Economic Co-operation and Development (OECD) defines an indicator as "a parameter, or a value derived from parameters, which points to, provides information about or describes the state of a phenomenon, environment or area with a significance extending beyond that directly associated with a parameter value"(OECD 2006). An indicator is a characteristic of a social or ecological component that is of value to the public. Indicators are used to measure the state of an ecosystem or component of the ecosystem.

There is a wealth of literature on the characteristics of a good indicator (National Round Table on the Environment and the Economy 2003; Noss 1990; Segnestam 2002). Some of these characteristics include: easy to measure and monitor; provides information about the condition of an ecological or social value; sensitive enough to provide an early warning of change; applicable to broad landscape and long time frames; and able to differentiate between natural and human-induced changes (National Round Table on the Environment and the Economy 2003; Noss 1990).

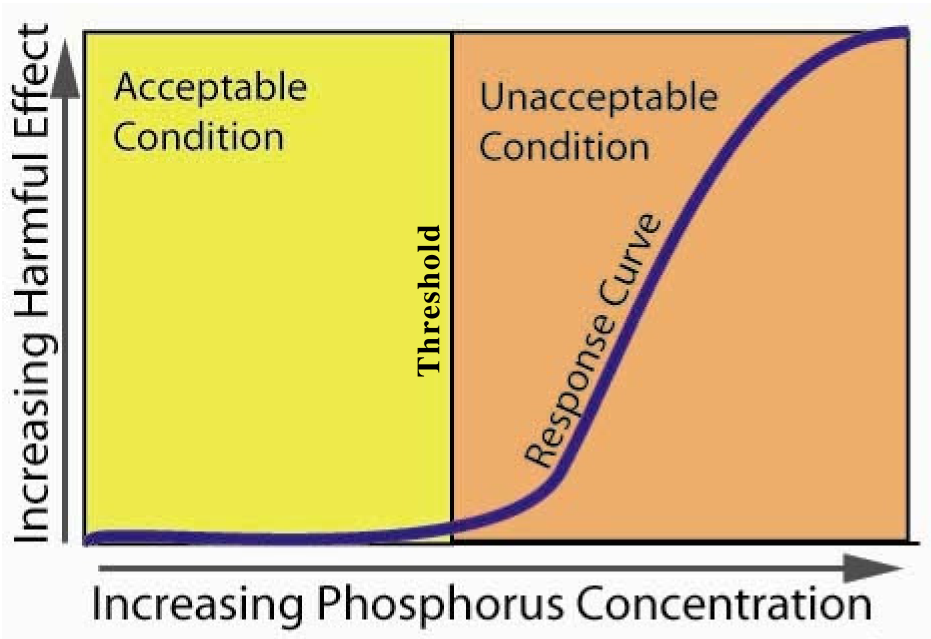
In land use planning, a suite of indicators is generally felt to be better for measuring the changing state of an ecosystem as a whole that one indicator alone. The suite should give a good picture of the overall system or a variety of environmental dimensions.

Indicators can be classified into four categories: physical and chemical, ecological, land and resource use, and social (Antoniuk and Ainslie 2003). Physical and chemical indicators and thresholds are most often used as guidelines to ensure the protection air and water quality. Ecological indicators measure biodiversity, animal populations, habitat quality and abundance (e.g., minimum core area/ habitat availability). Land use indicators measure human footprint of disturbance and human level of activity (e.g., total cleared area/ road density/ stream crossing density). Social indicators and thresholds measure components of society (e.g., suicide rates, average annual income). Social components, indicators and thresholds are outside the scope of the study, and so are left out of the discussion below.

2.5.1. Physical and Chemical Indicators and Thresholds

There are many physical or chemical indicators and thresholds that are developed and implemented by governments to protect human and wildlife populations. The most common examples are air and water quality guidelines. A water quality guideline can be based on the levels of nitrogen, phosphorus or sedimentation, for example. The guideline may refer to the point at which the water is no longer potable or the level of quality that will support a fish population. The threshold may be set based on a dose-response curve identified, as illustrated in Figure 2.2 (i.e., the response of an indicator to changes in chemical or physical variables)

Figure 2.2 Theoretical Dose-Response Curve with Threshold



Source: (Recreated from Salmo Consulting Inc. et al. 2004: 36).

2.5.2. Ecological Indicators and Thresholds

Ecological indicators measure habitat conditions, biodiversity, the abundance of a particular species, communities and guilds, and risk of species loss (Antoniuk and Ainslie 2003). In comparison to physical or chemical indicators, there is less research on how to determine or implement thresholds for ecological indicators.

Habitat conditions can be explained in terms of habitat availability and effectiveness. The survival of a species has been shown to be directly correlated with the amount of habitat available and the quality of it. The degree of disturbance or amount of linear disturbance can be shown to decrease the quality of habitat (in terms of availability or effectiveness) for certain species (Antoniuk and Ainslie 2003).

Habitat availability is the amount of usable habitat available to a particular species. It can be measure by the amount of each vegetation type and the suitability of that type to support a species. Habitat availability thresholds are generally points at which rapid changes in the size of habitat patches can occur and are measured by percent of habitat available in a given area (e.g., >30% habitat availability) (Salmo Consulting Inc. and Diversified Environmental Services 2003).

Habitat availability models (also called suitability models) can be used in an area to predict the habitat loss associated with a proposed development and compare that to the potential loss of species. Assessments of particular species using suitability models may include the quality of the habitat, the seasonal and life characteristics of that species (Salmo Consulting Inc. and Diversified Environmental Services 2003).

Habitat effectiveness measures the quality of habitat for a particular species. It considers the effect of human disturbances and activities on species' use of habitat. Habitat effectiveness is calculated using a number of factors:

1) Quality of habitat types ranked according to their effectiveness for the species under evaluation.

2) Types of human disturbances grouped according to how they influence the species. Zones of influence (ZOI) can be measured around certain disturbances, indicating how effective the habitat is around the disturbance.

3) Human disturbance and the associated zones of influence (ZOIs) overlaid on the habitat map to determine the suitability of habitat on the landscape (Antoniuk and Ainslie 2003).

Other habitat condition indicators and thresholds include patch and corridor size, core area, edge effects, the latter two of which are described in the land use indicators section below.

Population thresholds can be set for particular species, such as a minimum viable population. These thresholds may be based on conservation genetics to avoid inbreeding effects. They are difficult to determine for many animals given the natural variability of populations. If a threshold can be determined, expertise must exist for its measurement and monitoring.

2.5.3. Land and Resource Use Indicators and Thresholds

Land use indicators are used to measure human disturbances. There are a suite of landscape ecology metrics that can be used to evaluate the impact of human disturbance. Indicators can include access density (total length of roads, pipelines, seismic lines in an area), area of cleared/disturbed land, core area, edge area (specified area around linear disturbance), road density, stream crossing index (# of crossings in an area) and riparian area cleared (Antoniuk and Ainslie 2003). Land and resource use indicators measure the impact of humans, rather than the wildlife or ecosystem component itself.

Core area and edge area are ecological indicators that quantify the amount of area that is affected by human disturbance. The impact of edge and core area availability depends on the impact of a human disturbance on a particular species. Core area indicators are often defined as the area more than a certain distance (e.g., 100 m) from an edge (Salmo Consulting Inc. and Diversified Environmental Services 2003). Some species have shown an avoidance of edge and require large habitats without fragmentation to subsist. Similarly, patch sizes can be used as indicators of habitat fragmentation. The width of a habitat corridor can be important too, for a small width may inhibit wildlife movement.

Fragmentation of a landscape by linear features (roads, pipelines, utility corridor rights of way) can lead to the rapid loss of species as the edges create barriers to species movement and dispersal. Fragmentation is measured by the spatial pattern of the landscape and indicated by access density, road density, stream crossing index, and edge area.

Human activity can also inhibit wildlife use or movement in an area. Indicators for this may be the number of trails in an area or the number of people using an area during a specific time.

2.6. Frameworks for Determining Thresholds

Objective science-based thresholds for all indicators do not exist and in some cases, the line between acceptable and unacceptable conditions is not clear. Land and resource managers have developed decision-making frameworks to address these gaps. Described here are the two Frameworks: 1) Limits of Acceptable Change, and 2) Tiered Thresholds.

2.6.1. Limits of Acceptable Change

In resource and land management, the Limits of Acceptable Change (LAC) framework refers to social or value-based decisions regarding desired landscape conditions and the actions to protect those conditions. LAC is a methodology based on the concept of thresholds. LAC was first defined by Stankey in 1985 and has most often been used to manage recreational carrying capacity in wilderness settings (Cole and Stankey 1998).

There are nine steps in the LAC process, which can be summarized as: stakeholders narrate the conditions of a resource, the key components of that story become the indicators of acceptable change, and standards are set around the indicators. A bundle of indicators is used to monitor the quality of the environmental or social system. The standards are absolute limits that define the maximum deviation from complete protection (Cole and Stankey 1998). Standards ensure the minimally acceptable condition. The standards are developed through compromises between stakeholders. In comparison to an environmental assessment, which focuses on a component of the ecosystem, LAC focuses on the human actions that management seeks to control rather than a charismatic species or environmental component (Macleod Institute 2002).

Although LAC was developed for wilderness settings, it can be used as a collaborative planning framework for other land use management situations. While the original LAC process focused on the conflict between two goals (e.g., tourism versus protection of wilderness), other land management process may have conflicts between three or more goals. These goals may need to be prioritized with the guidance of existing legislation (e.g., Species at Risk Act) and policies. Conflicts may be more intense in these situations, either hampering or extending the time frame of collaborative processes like LAC. Conflict may exist over the amount of activity and whether a land use is acceptable at all (Brunson 1998).

Outside wilderness settings, the LAC process can involve comparing the current situation with alternative scenarios and deciding which scenarios are the most favourable (Brunson 1998). The desired future condition must include all land uses that are deemed acceptable. The maximum amount of change as well as the minimum amount of change may both need to be defined (Ibid). In areas with multiple land uses we must ask the question "how much is too much", as well as the question "how little is too little?" The LAC standards may represent defined rates of change rather than a static end (and unnatural) state. Once the conditions are defined qualitatively by stakeholders, planners may have to define the standards quantitatively (Ibid).

2.6.2. Tiered Thresholds

The tiered thresholds approach involves defining different levels of thresholds with associated management actions. The approach has been used by the Clean Air Strategic Alliance (CASA) in Alberta to measure acidic air pollutants by assigning management responses to particular levels of pollutants (Clean Air Strategic Alliance and Alberta Environment 1999). The thresholds were developed based on scientific assessments of acid deposition and determined through CASA's unique multistakeholder process. CASA, formed in 1994, has representation from government, industry and non-governmental organizations. Section 14 of the Alberta Environmental

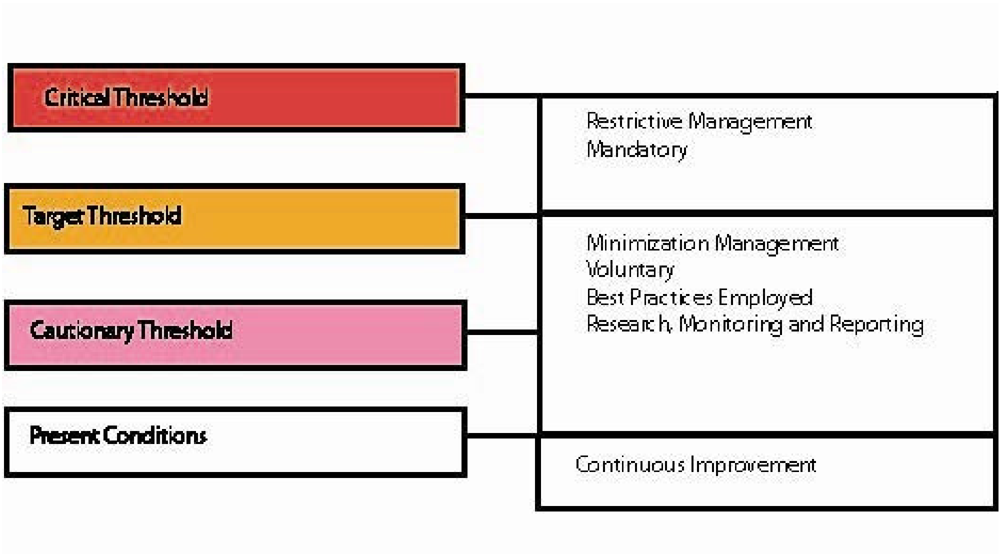
Protection and Enhancement Act (1995) requires the identification of environmental objectives for air quality for all of Alberta. This legislation provides the legal backbone for CASA work.

A subgroup of CASA conducted a review to determine the maximum critical load of acid deposition per hectare in Alberta (Clean Air Strategic Alliance and Alberta Environment 1999). The review determined an approach to managing acid emission in Alberta with three threshold levels: cautionary (or monitoring), target, and critical. The critical threshold is the maximum amount that can be sustained by the system or species without irreversible harm. CASA defined critical as 95% protection of sensitive, moderately-sensitive and low sensitive soils. The percentage was determined to be acceptable to the stakeholders. When the critical threshold is reached, mandatory and restrictive measures are put in place to ensure that the threshold is not exceeded and reduced to the target level.

The target threshold reflects a politically or socially desirable level. It is well below the critical threshold to ensure a margin of safety and precaution. The target level is negotiated by stakeholders and often represents the current situation. In the CASA example, the target was set at 90% of the critical load (Clean Air Strategic Alliance and Alberta Environment 1999). At the target level, some management activities can be brought in such as voluntary use of best practices. The target level meets the requirement of the Alberta Environmental Protection and Enhancement Act (AEPEA) to set ambient environmental quality objectives in consultation with the public.

At the cautionary level, continuous monitoring is required. Local data are used to confirm the appropriateness of critical and target thresholds. No other management action is required other than following the regulatory guidelines. Figure 2.3 illustrates the threshold levels and associated management actions.

Figure 2.3 Tiered Threshold Approach and Associate Management Actions



Source: (Recreated from Clean Air Strategic Alliance and Alberta Environment 1999: 31).

The tiered threshold approach has since been suggested for thresholds-based management in other jurisdictions, beyond air quality (AXYS Environmental Consulting Ltd. 2003; Salmo Consulting Inc. et al. 2004). The main benefit of a tiered threshold framework is that it provides a clear link between threshold levels and management actions. Uncertainty around thresholds is explicit and flexibility can be provided for different management actions. The action required is in response to the severity of the cumulative effect.

2.7. Regional Planning and Cumulative Effects Management

Regional approaches are better suited than project level ones for the management of cumulative effects that are caused by multiple stressors at a variety of spatial and temporal scales. Information from the regional context is necessary to assess the combined effects of all land use activities, in order to determine if individual projects are acceptable. Regional planning and cumulative effects management in Western Canada demonstrate an approach that links regional management objectives or goals, with thresholds that are applied at the local or operational scale (AXYS Environmental Consulting Ltd. 2001, 2001, 2003; Macleod Institute 2002; Salmo Consulting Inc. and Diversified Environmental Services 2003).

Regional objectives set through land use planning are a necessary pre-condition to the definition of thresholds. The objectives make clear the issues, species or components of the ecosystem that are a priority. The objectives can also define future social or environmental conditions that are desirable. The thresholds are then defined to meet the identified objectives. The following examples of thresholds-based management are provided to understand how thresholds have been defined, applied and implemented in other jurisdictions.

2.7.1. Northeast B.C.: Muskwa-Kechika Management Area

Thresholds for land disturbance have been applied in the Muskwa-Kechika Management Area (MKMA) in northeastern British Columbia (B.C.) through pre-tenure planning for mineral rights and a Cumulative Effects Assessment and Management Framework (CEAMF).

Both the pre-tenure planning process and CEAMF in the Muskwa-Kechika area are part of the province-wide community-based process for land management. In 1995, the Land and Resource Management Planning process created multistakeholder forums with mandates to develop regional land use plans, and set conservation and resource use objectives. The Government's Integrated Land Management Bureau coordinates the work of numerous government ministries to manage crown land and natural resources. The Bureau is responsible for finalizing land and resource management plans for all areas of the Province. Land use zones have been defined in northeastern B.C. reflecting the priority use for each area. There are zones for agriculture; general resource use; intensive resource development; special management with limits to protect sensitive values; and wildlands where ecological conservation is intended to coexist with oil and gas development (R. McManus Consulting Ltd. and Salmo Consulting Inc. 2004).

Pre-tenure plans exist for special management areas with oil and gas potential in the eastern parts of the MKMA within Western Sedimentary Basin. Five of seven pre-tenure plans, legislated through the *Muskwa-Kechika Management Area Act*, have been completed within the MKMA. The pre-tenure plans are intended to guide the environmentally and socially- responsible development of oil and gas resources. Prior to issuing mineral rights, a pre-tenure plan includes an environmental assessment to identify the potential impact of the development, and to set limits on development to maintain the ecological integrity of the boreal forest.

The pre-tenure plans are driven by a results-oriented process in which key indicators are monitored to meet a management objective. The objectives are broad statements about the future condition of an ecosystem component, measured by the indicator. For example, if an objective is to restore disturbed areas to pre-development conditions, the indicators could be the proportion of area restored and the amount of non-native species present.

Thresholds, called management targets in this case, are applied to the indicators. These targets are numerical limits or development requirements that may be reviewed given new information and monitoring. Thresholds for key indicator species can be measured by the number of hectares disturbed within a particular habitat class (Government of British Columbia 2004). The developers within an area must work together to minimize their land disturbance and keep below the thresholds.

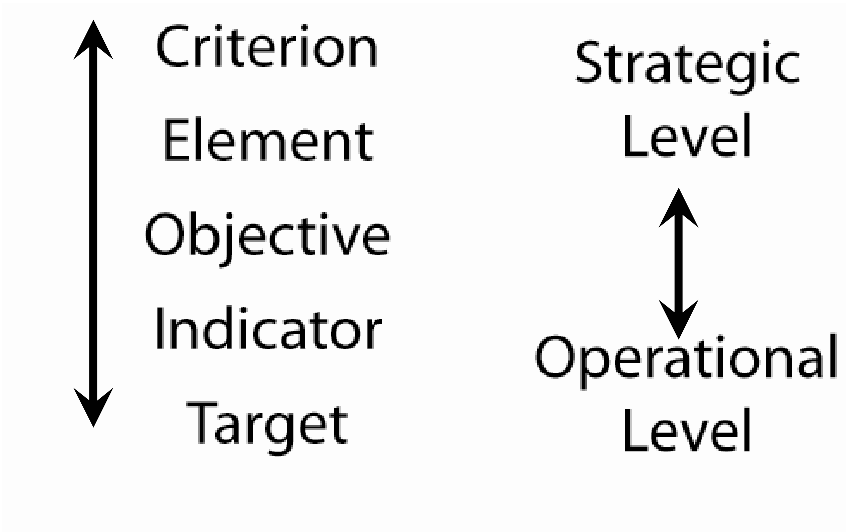
The process to implement thresholds in northeastern B.C. follows these steps:

1. Develop explicit definitions of acceptable change.
2. Adopt candidate thresholds as a foundation for future discussion.
3. Evaluate the ecological and economic implications of thresholds implementation.
4. Develop standardized analysis, reporting and review methods.
5. Provide required land use data in a consistent and readily available format.
6. Implement a pilot study to validate thresholds and optimize analysis, reporting and review methods.
7. Continue monitoring to refine thresholds and management actions (Salmo Consulting Inc. and Diversified Environmental Services 2003).

The threshold levels in the pre-tenure plans are far from being reached. Oil and gas development is still a relatively new industry in British Columbia, and the success of thresholds-based management has yet to be determined.

The components of the Results-Based Framework for pre-tenure plans range from strategic level criteria to operational level targets, as illustrated in Figure 2.4.

Figure 2.4 Components of a Results- Based Management Framework



Source: (Recreated from Government of British Columbia 2004).

In the MKMA, an example of a criterion is the conservation of biological diversity. The elements of this criterion are:

- Conservation of ecosystem diversity;
- Conservation of species diversity;
- Areas of special biological significance;
- Restoration of ecosystems.

The objectives, indicators, targets and outputs for the elements "Conservation of Ecosystem Diversity," and "Conservation of Species Diversity" are presented in Table 2.4 as examples.

Table 2.4 Results-Based Framework from Pre-Tenure Plan, Selected Elements, Objectives, Indicators, Targets and Outputs

Element	Objective	Indicator	Target	Output
Conservation of Ecosystem Diversity	The structure and function, and distribution of ecosystems remain within a natural range.	Disturbance (ha) to site series and associated structural stage within the project area(s).	Site series remains intact after development and restoration (measured as hectares of disturbance).	Overview assessment Restoration plan Operations and indicators monitoring

Element	Objective	Indicator	Target	Output
Conservation of Species Diversity	Habitat elements for each focal species are sustained in winter habitat capability classes that range from 1-6 within each biophysical zone.	For each focal species, the amount (% and ha) of disturbance by habitat capability class.	For the plains bison, moose and elk focal species, 97% of the winter habitat remains undisturbed in moderately high and high capability habitat. For the Stone's sheep and mountain goat focal species, 98% of the winter habitat remains undisturbed in moderately high to high capability habitat. For each focal species, 95% of winter habitat remains undisturbed in moderate to nil capability habitat.	Overview assessment Site-level habitat assessment Operations and indicators monitoring Restoration plan

Source: (Government of British Columbia 2004).

Successful completion of land use plans and pre-tenure plans in British Columbia are a result of a number of factors that can provide lessons to other jurisdictions. There is strong government commitment to the land use planning process and integration with wider, more strategic provincial goals and legislation (R. McManus Consulting Ltd. and Salmo Consulting Inc. 2004).

2.7.2. Beaufort Delta Cumulative Effects Study

The Beaufort Delta (4,100,000 ha) is located in northern Yukon and Northwest Territories and is home to Inuvialuit and Gwich'in peoples. The goals of the study were to identify a suite of Valued Ecosystem Components and potential thresholds or limits of acceptable change to manage the cumulative effects of human land use. The Beaufort Delta Cumulative Effects Study was supported by the Environmental Studies Research Funds, a research program directed by a joint government/industry/public management board administered through the National Energy Board (Environmental Studies Research Funds 2007).

Two approaches were used in the project: research and workshop. The workshop helped to educate regional planning agencies, regulators, co-management boards and other key audiences and to provide an initial review of the valued components, indicators and candidate thresholds. The research was conducted by a number of consultants and advisors who are known experts in cumulative effects management or thresholds management.

The thresholds are intended to be used at both the project and regional level, to evaluate the acceptability of incremental cumulative effects and changes. In selecting the indicators, researchers based their decisions on current policy or legislative documents such as the Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan, to ensure that the indicators reflect local issues and concerns. A geographic information system (GIS) model with information about the current landscape was used to confirm current conditions and the measurability of indicators.

A workshop was held in October 2005, to review the selected valued components, indicators and candidate thresholds developed by the researchers (Dillon Consulting Ltd. and Salmo Consulting Inc. 2005). Participants expressed general support for the indicators and the thresholds approach. Participants felt that the regional vision should be to improve social conditions rather than to worsen the situation and that both the positive and negative effect of land use change should be considered. A tiered thresholds approach was preferred to be linked with the land use zones in regional planning documents. The eight valued ecosystem components (VECs) were selected based on:

- How well they are understood by regional planners and regulators;
- How representative they are of regional environmental and social conditions;
- Where they can be described by one of more indicators;
- Whether they allow analysis of key cumulative effects pathways;
- How well they can be evaluated at multiple scales (regional, local);
- Whether they are compatible with the existing Cumulative Impact Monitoring Program (CIMP).

Table 2.5 shows some of the valued ecosystem components, indicators and candidate thresholds selected for the Beaufort Delta. Indicators were identified to measure the health and sustainability of the VECs. The indicators selected were to be: easily understood by decision-makers; currently being monitored; applicable at both the regional and project levels; applicable over long time frames and a broad geographic area. The suite of indicators was also selected to reflect project incremental effects and natural variations. Issue, species- specific and generalized indicators were all selected to understand the changes in environmental and social conditions of the region as well as measure project-specific impact (Dillon Consulting Ltd. and Salmo Consulting Inc. 2005).

Table 2.5 Selected Candidate Indicators and Thresholds for the Beaufort Cumulative Effects Study

Valued Ecosystem Component	Indicator	Candidate Threshold
Land	Sensitive environmental features (ha and % of area disturbed in unique vegetation communities, rare plants, mineral licks, dens, nests, nesting colonies; Pingo Canadian Landmark).	Target: no disturbance or activity within 250 m. Critical: no net loss (taking into account mitigation or compensation). Cautionary/Restrictive Critical: Consider for management units (e.g., ICCP). Category E lands or GLUP Heritage Conservation Zones) where environmental values are the primary management objective.
Freshwater	Total aquatic and riparian area disturbed (ha and % of area disturbed by stream crossings, bank and bed alterations, and riparian clearing/disturbance).	Critical: no net loss (taking into account mitigation, enhancement or compensation). Cautionary/Restrictive: stream crossing density less than 0.25 crossings/ km^2.

The next steps in this project are to review the suite of candidate VECs, indicators and thresholds with the regulators and decision-makers and further refine them to ensure they are acceptable (Dillon Consulting Ltd. and Salmo Consulting Inc. 2005). Wider consultation must occur to ensure general agreement. A cumulative effects model could also be used to further understand the implications of thresholds on land use change. In addition, a standard method of measuring the indicators must be defined as well as clear guidelines on policy or regulatory action should the thresholds be approached or exceeded (Dillon Consulting Ltd. and Salmo Consulting Inc. 2005).

2.7.3. Dehcho Land Use Plan

Dehcho Territory is in central and southern Northwest Territories. The Dehcho Land Use Planning Committee was established in May 2001 with the signing of the Dehcho First Nations Interim Measures Agreement. The final Draft Dehcho Land Use Plan was completed in June 2006 (Dehcho Land Use Planning Committee 2006). The Plan will become legally binding upon the completion of the Dehcho Final Agreement, being negotiated by the Federal Government and Dehcho First Nations. Until then, the Draft Plan will be implemented through the Mackenzie Valley Resource Management Act.

The Plan is intended to guide decision-making and regulation of land use proposals. The vision and goals of the plan are met through land use zoning, indicating what land uses are appropriate and where.

In 2004, the Dehcho Land Use Planning Committee contracted Salmo Consulting to suggest cumulative effects indicators and thresholds. The thresholds and indicators in the final Draft Land Use Plan are based on this report, although significantly modified based on input from government, industry and local stakeholders.

In the Final Draft Plan, thresholds to manage cumulative effects have been set for the General Use and Special Management Zones. See Table 2.6 for the cumulative effect indicators and thresholds. Existing land uses are not subject to thresholds but their impacts are added to the calculation of cumulative effects for future land uses. Other limits include restrictions on activity during key wildlife breeding, calving or migration periods, and minimum altitude levels for aircraft flying over critical habitat (Dehcho Land Use Planning Committee 2006).

Table 2.6 Guidelines for Cumulative Effects Indicators and Thresholds

Indicator	Critical Threshold	Species
Corridor or Road Density	1.8 km/km^2 Corridor Density (includes cutlines, winter roads, all-weather roads, transmission and utility corridors)	Woodland Caribou
	0.6 km/km^2 Road Density (includes winter and allweather roads)	Grizzly Bear
Habitat Availability	<10% of land disturbed	N/A
Minimum Patch Size and Core Area	Critical: >65% medium core areas (> 515 Ha)	Woodland Caribou
	Critical: >65% large core areas (> 1000 Ha)	Grizzly Bears
Stream Crossing Density	<0.5 crossings/km^2	Fish

Source: (Dehcho Land Use Planning Committee 2006a: 39).

Once thresholds have been reached, operators in the area will be required to find ways to reduce their disturbance by using best practices such as overlapping infrastructure right of ways or low impact seismic exploration. Operators may also be required to accelerate reclamation in disturbed areas or offset disturbance by reclaiming other areas of similar ecological value (Dehcho Land Use Planning Committee 2006).

Extensive external consultation was held throughout the planning process, involving industry, government and the general public. As a result of the consultation, the application of thresholds in the plan changed significantly, as is evident from the changes to each version: from the first in June 2005, second in November 2005 and the final in June 2006 (Wiebe pers. comm.).

The first plan version included thresholds for caribou moose, grizzly bears, marten and fish. In the final version, only grizzly bears and boreal woodland caribou were included, as they represent the species of most value to local people and are the most threatened and sensitive wildlife species (Wiebe pers. comm.). The first draft plan also included tiered thresholds: critical, target, and cautionary as recommended in the Salmo report. These were taken out of the November 2005 and final version in June 2006, leaving in only the critical thresholds (as in Table 2.6). This was done to avoid confusion on the assessment, management and implementation of thresholds (Wiebe pers. comm.). Not all agreed with this change. In letter to the Dehcho Land Use Planning Committee, Environment Canada and Canadian Parks and Wilderness Society suggested that the tiered thresholds approach be reinstated (Dehcho Land Use Planning Committee 2006).

The final Draft Plan lists thresholds as guidelines rather than regulatory conditions for project approval as in early versions of the plan (Dehcho Land Use Planning Committee 2006). The final Draft Plan requires responsible authorities to consider the results of cumulative effects assessments in decision making on land and water uses and to develop habitat monitoring and assessment programs to monitor the success of thresholds. The plan also requires that within four years, the thresholds must also be reviewed for their economic and operational impact on industry, impact on project approvals, and economic costs to the region from rejected projects (Dehcho Land Use Planning Committee 2006).

The Canadian Association of Petroleum Producers (CAPP) submission on the 2005 Draft Land Use Plan highlights the debate over the use of thresholds. In the submission it is written,

> CAPP recognizes that the conditions of the Plan are to be reviewed through adaptive management, however we feel that the initial conditions put in place are overly burdensome and place uncompetitive conditions on activity in the Dehcho. Ultimately, the Dehcho region could be deprived of the benefits from responsible development (Canadian Association of Petroleum Producers 2006).

CAPP objected specifically to the thresholds identified in the Plan, which it argued are based on little scientific certainty, do not reflect the reality that oil and gas development occurs in concentrations, and would restrict the ability of operators to complete life cycle of development from seismic exploration to production. CAPP writes, "The Plan, as drafted, fails to appropriately promote the economic well-being generated from responsible development of the region through its excessive restrictions on industry" (Canadian Association of Petroleum Producers 2006). CAPP argued that if road density thresholds were based on calculation per ¼ oil and gas grid (approximately 52 square kilometres), that development of the petroleum resources would be virtually impossible (Canadian Association of Petroleum Producers 2006). Thresholds based on linear disturbances (such as roads, pipelines and seismic lines), CAPP argued, were not acceptable because they have different effects based on their size, access and human use (Canadian Association of Petroleum Producers 2006). Later in August 2006 after the final version was released, CAPP wrote that it would not support the Plan as it would limit development activity on over 60% of the region (Canadian Association of Petroleum Producers 2006).

2.7.4. Lake Tahoe Basin

Lake Tahoe is the second-deepest lake in the world, surrounded by mountains and identified as a prime recreational area in the 1950s. In 1969, the states of California and Nevada, which surround the lake, formed the Tahoe Regional Planning Agency (TRPA). In 1980, growing conflict over developments around the lake led to a new structure for the TRPA and the requirement to establish thresholds based on the region's carrying capacity. The process to determine thresholds is to:

- Identify environmental components;
- Identify variables affecting the components;
- Determine which measures would be appropriate as indicators;
- Determine an acceptable threshold level for each appropriate indicator;
- Evaluate mechanisms to achieve each threshold to see if it is meaningful and possible (Randolf 2004:610).

Nine thresholds were adopted by TRPA in 1982 for air quality, water quality, soil conservation, vegetation, fisheries, wildlife, scenic resources, noise, and recreation. See Table 2.7 for a sample of the thresholds selected for Lake Tahoe.

Table 2.7 Threshold Standards for Lake Tahoe, Selected Examples

Threshold Category	Indicator	Threshold Standard
Wildlife	The minimum number of population sites and disturbance zones maintained as determined by inspection by qualified experts.	Provide a minimum number of population sites and disturbance zones for TRPA listed species. Perching trees and nesting sites shall not be physically disturbed, nor shall the habitat within disturbance zone be manipulated in any manner, unless needed to enhance habitat quality. Numbers vary by species.
Vegetation	For species richness and relative abundance, the area of plant associations as determined by the Forest Service vegetation inventory. For pattern, the size and location of forest openings as described in federal forest management plans (acres).	Species Richness: Maintain the existing species richness of the Region by providing for the perpetuation of the following plant associations: Yellow pine forest; Red fir forest; Subalpine forest; Shrub Association; Sagebrush Scrub association; Deciduous riparian; Meadow associations (wet and dry meadow); Wetland associations (marsh vegetation); and Cushion plant association (alpine scrub). Relative Abundance: Of the total amount of undisturbed vegetation: Maintain at least four percent meadow and wetland vegetation. Maintain at least four percent deciduous riparian vegetation. Maintain no more than 25 percent dominant shrub vegetation. Pattern: Provide for the proper juxtaposition of vegetation communities and age classes by: 1. Limiting acreage size of new forest openings to no more than eight acres; and 2. Adjacent openings shall not be of the same relative age class or successional stage to avoid uniformity in stand composition and age.

Source: (Recreated from Tahoe Regional Planning Agency 2002).

Once the thresholds were identified, a plan was to be developed to meet the thresholds and evaluate five alternate planning strategies (Tahoe Regional Planning Agency 2006). In 1984 the Tahoe Regional Plan was created. A wide variety of strategies were identified to achieve the thresholds. The region was divided into five land use designations: conservation, recreation, residential commercial, public service and tourist. A management strategy was also devised that stipulated the level of mitigation or regulation required for each land use designation.

The thresholds determined are both quantifiable and qualitative. They are either a number standard, or where the indicator could not be quantified, they are management standards prescribing a quality or policy statement and associated course of action. For example, the annual mean phytoplankton primary productivity was set at 52 $gmC/m^2/yr$; and for undeveloped areas, the policy was "Preserve existing naturally functioning [stream environment zones] lands in their natural hydrologic condition, restore all disturbed [stream environment zones] lands in undeveloped, unsubdivided lands…" (Tahoe Regional Planning Agency 2007). In 1997, the Environmental Improvement Program, a public/private partnership, was created to coordinate numerous projects to meet the goals and thresholds in the Plan (Tahoe Regional Planning Agency 1997).

Thresholds are evaluated every five years. In the 2006 threshold evaluation, out of the thirty-six indicators selected to track the progress of nine threshold categories, nine attained the standard, twenty-three did not, and the remaining four are undetermined. Thirty-three of the thresholds were recommended for amendment or review as part of TRPA's strategy of adaptive management (Tahoe Regional Planning Agency 2007).

2.8. Conclusion

Identification of thresholds can help determine the significance of cumulative effects and meet land and resource management objectives. Thresholds may be based on measurable land use, ecological, or population indicators, and identify the point at which indicator changes become unacceptable.

Thresholds can be used to help to achieve society's objectives for a landscape. They can help to clarify the scale, timing and amount of development that is acceptable. This however, is dependent on the development of a vision for the future.

Thresholds were first used in the field of ecology to refer to dramatic changes in the state of an ecosystem or species. The term has since been expanded to refer to a scientifically and socially-based standard. As resource management is ultimately influenced by human values, so too must the determination of thresholds be based on values. This is done through the selection of VECs, and by setting a particular threshold.

The regional planning initiatives mentioned above can provide lessons for defining and implementing thresholds. As recommended in the Beaufort Cumulative Effects Study, modeling can be used to understand the range of possible futures and the potential impacts to valued components. Alternative development scenarios can be run to determine the potential effects of different management actions (Cornish 2004). The likelihood that thresholds will be violated can be assessed as well as the implications of setting thresholds to other economic, social and environmental components.

The Lake Tahoe example highlights why monitoring must be interlinked with thresholds-based management. Monitoring, as part of adaptive management, helps to determine if management objectives are being met. As a result, thresholds must be based on indicators that are easily measured and monitored.

Successful implementation of thresholds occurs where there exists a strong regional planning process, and supporting legislation and policy. Thresholds-based cumulative effects management is best applied through regional planning. The thresholds can then provide guidance to decision making at the local and project levels.

The use of the term threshold is not entirely consistent in the literature or the case studies reviewed. The term ‘management target’ was used in the Muskwa-Kechika to make it more palatable with industry and the public (Sawchuk pers. comm.). The term threshold can have a negative connotation when it is thought of as a barrier to economic development.

Three of the four case studies provided are in areas with little or no development. The establishment of thresholds in these places may be easier given that hard choices have not yet been made on whether or not to restrict development. The test of thresholds-based management will come when the thresholds are being approached and land managers must begin to create new regulations or limit development to avoid exceeding the threshold.

Resource managers and planners must be cautious when applying thresholds to different ecosystems as there are few principles for defining and applying thresholds (Groffman et al. 2006). The definition of a threshold may incorporate social values or be strictly science-based.

The assumptions and decision-making processes involved in defining thresholds must be clearly identified.

3. Identification of Candidate Thresholds for the Southern Foothills: Literature Review and Interviews

Candidate thresholds for the Southern Foothills Study's three key valued components (Sections 3.1, 3.2 and 3.3; water, grizzly bears and fescue grassland, respectively) are identified in this chapter. Potential indicators of the cumulative effects of land use change on each component are also identified. The present and projected future state of the components in Alberta and the Southern Foothills are presented from the literature and from the Southern Foothills Study Business-As-Usual Scenario. Past and present management strategies particular to each component are reviewed. The candidate thresholds selected by the author reflect ecological science and expert opinion as presented in the literature review and through key informant interviews. Key informants were selected based on their knowledge of land use impacts on the valued components (*Appendix A* for list). The candidate thresholds provided a starting point for discussion at the workshop with members of the Southern Foothills Study. In the following chapter, the results of a workshop to evaluate the social acceptability of the indicators and thresholds are presented. When more information specific to the unique geography of the Southern Foothills becomes available, these candidate threshold values may need to be re-evaluated.

3.1. Thresholds for Watershed Protection

Water is a highly valued natural resource in the Southern Foothills of Alberta. The foothills and mountains have been called the "rain towers" of Alberta as they are a source of water supply for all Prairie Provinces (Vaux Jr. and Sandford 2006; Stelfox 2006). Both Alberta government policy and landowners in the Southern Foothills view watershed protection as a key principle for land management (Stelfox 2006; Alberta Government 1977).

This section describes the cumulative impact to water in the study area, followed by an explanation of water management in Alberta. A literature review and interviews were conducted to identify indicators and potential thresholds for watershed and watershed-related factors such as aquatic resources, and riparian health. Candidate thresholds are identified and the extent to which they are exceeded in 2055 according to the Southern Foothills Study is evaluated.

3.1.1. Cumulative Land Use Impact on Water Resources in the Study Area

The study area includes portions of the Oldman River and the Bow River catchments, sub-basins within the South Saskatchewan River Basin. Water resources and aquatic habitats in the Southern Foothills are affected by the conversion of land to agricultural cropland, cattle grazing practices, forest harvesting, recreational use and the expansion of rural acreages and energy developments. Some of the major land use impacts on water resources are:

- Land conversion for cropland – Land cultivation requires the exposure of soil, which can erode, runoff and deposit sediment into lakes and rivers. In addition, the application of fertilizers and pesticides can directly affect water quality.
- Cattle manure and urine deposits – Runoff of nutrients from feedlots, cropland or rangelands can result in higher levels of phosphorus and nitrogen, coliform counts and decline in oxygen levels in water bodies.
- Degradation of riparian areas – Land use activities that cause physical damage to stream banks and riparian areas can accelerate erosion and sedimentation and decrease the ability of riparian vegetation to filter nutrient runoff (Adams pers. comm.).
- Disturbance or clearing of vegetation - Water flowing over unvegetated lands to rivers and streams will travel much quicker than over vegetated lands. The greater the speed of water flowing overland, the less nutrients and sediments are filtered prior to entering water bodies, and the less water that is trapped underground.
- Soil compaction and the building of impermeable surfaces – Water flowing over compacted or impermeable surfaces are less likely to infiltrate the soil. Water infiltration is critical to soil moisture levels, and to ground water sources that restore stream base flow (Fitch and Adams 1998).

A watershed study in the Southern Foothills concluded,

> "At present nearly a third of the watersheds have a very high potential for damage from the combined effects of peak flow and surface erosion; nearly two-thirds have a moderate potential for such damage. At present there remain only two of 90 watersheds in the study

> area that have little or no development and therefore low potential for watershed damage"(Sawyer et al. 1997:4).

All watersheds had elevated levels of peak flow and surface erosion degrading stream channels and riparian and aquatic habitat (Sawyer and Mayhood 1998; Sawyer et al. 1997).

3.1.1.1. Water Quantity and Demand

Vaux Jr. and Sandford (2006) expect a crisis in water availability in the near future in Southern Alberta. The average stream flow in the Oldman River has declined over the last 50 years likely due to the reductions in snow pack at higher elevations, as result of climate change (Byrne et al. 2006). Water scarcity is increasing in Southern Alberta due to several factors:

- "Heavy reliance on water by the agricultural sector;
- A rapidly growing population;
- Increased water demands from cities and industry;
- Reduced flows in important watercourses;
- Unpredictable climate variability" (Vaux Jr. and Sandford 2006:12).

The uncertainty of climate change, although not specifically addressed in this paper, adds emphasis to the use of the precautionary approach to water management. Climate change is a wild card in water management (Vaux Jr. and Sandford 2006). It is difficult to predict the magnitude of impacts from climate change. It will likely alter traditional patterns of precipitation and lead to greater evaporation loss and drought periods.

The cumulative effects model ALCES (A Landscape Cumulative Effects Simulator) developed for the Southern Foothills projects the cumulative impact on water resources in response to ecological processes and land use practices.

Figure 3.1 Water Demand Within Study Area

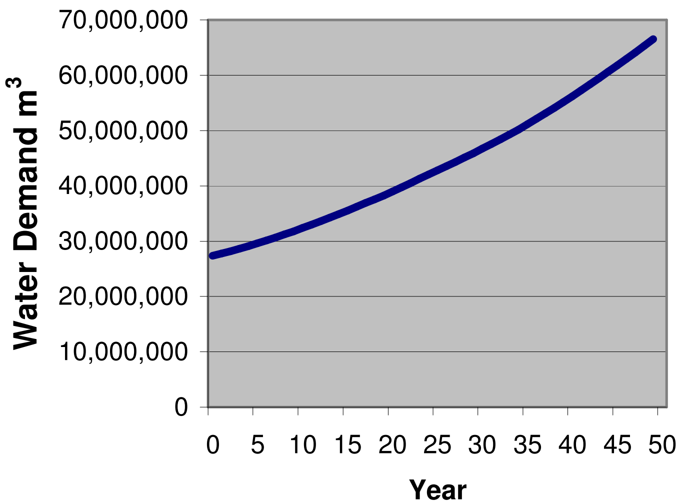
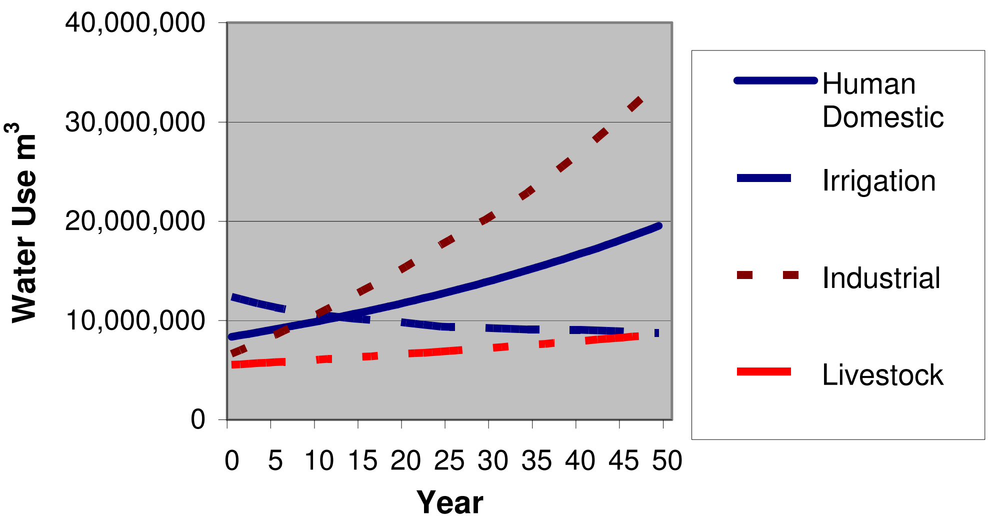


Figure 3.2 Water Use Demand By Land Use



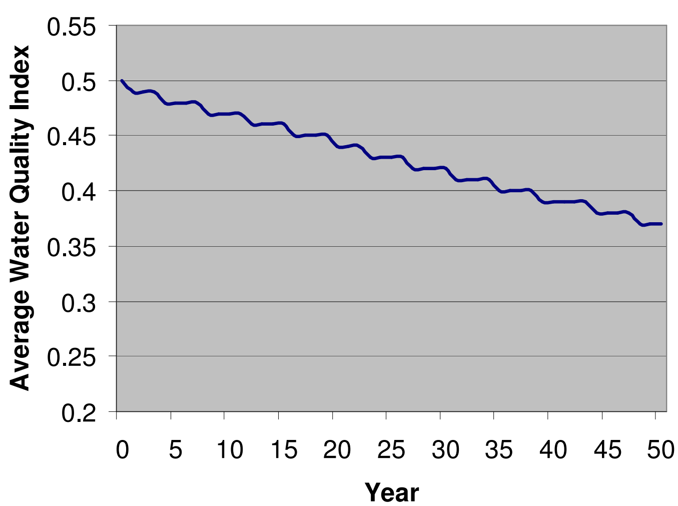
Water demand is forecasted to grow by 142% by 2055, shown in Figure 3.1. The change in water use of each land use sector is indicative of the growth of that sector in the future (Figure 3.2). Industrial water use (mining, oil and gas etc.) is expected to grow the most by 412%, followed by a growth in domestic human water use at 134%. Water use by livestock operations is forecasted increase by 54% and irrigation water use decline by 29%, due to the expected decline in that sector's operations in the future. Despite the projected growth in water use in the region, the amount of water used is dwarfed by demand for water downstream (Stelfox, pers. comm.).

3.1.1.1.1. Water Quality

A water quality index unique to the ALCES model was developed for the Southern Foothills Study. The model measures the change in phosphorus, nitrogen and sedimentation from runoff associated with particular land use activities. Figure 3.3 shows the projected changes to the water quality index as modeled to year 2055.

Excessive amounts of phosphorus can accelerate eutrophication by stimulating algae and plant growth (Environment Canada 2005). Where nitrogen is in excess, it can cause plant growth or algae blooms that lower the oxygen levels in the water and produce toxins harmful to aquatic organisms. Nitrate can cause lower reproductive success, slower maturation or even death to aquatic organisms (Environment Canada 2005). Land use disturbance can accelerate erosion and lead to elevated amounts of sediment in water bodies that can be damaging to water quality and aquatic habitat (Anderson 1996). Fish can experience stress when sediment levels rise; the stress may change their behaviour and ability to spawn (Ibid). Other measures of water quality not included in the ALCES index include bacteria, metals, temperature, dissolved oxygen, radioactive contaminants and more.

Figure 3.3 Average Water Quality Index



As shown in Figure 3.3, the average water quality index (phosphorus, sedimentation and nitrogen combined) is expected to decline 26% by 2055 (Stelfox 2006). The value of 1.0 in the index represents the average range of natural variability.

3.1.1.1.2. *Fish Habitat and Species*

Disturbance of the forest and grassland from land use activities and development has effects on fish and fish habitat including:

- Blockages to fish migration and movement due to dams, roads and irrigation diversions;
- Changes in water quality and quantity due to accelerated runoff from unvegetated lands, sedimentation, increases in water temperature and discharges from coal mining and urban development;
- Changes in the timing and duration of hydrological peak flow upsetting stream channel balance;
- Reduced natural woody debris input to stream channels causing changes to stream channels and reductions in fish habitat (Anderson 1996; Fitch 1997).

There are over 20 species of fish found in the study area, 7 of which are native (Sawyer et al. 1997). Of the native species, two are listed nationally and provincially as species at risk: the bull trout (*Salvelinus confluentus)* and westslope cutthroat trout (*Oncorhynchus clarkii lewisi)* (Alberta Fish and Wildlife Division 2006; Government of Canada 2005). Both fish populations have been declining due to over harvesting, competition from non-native species and habitat change from human activities (Fitch 1997; Mayhood 1998). Although in reduced concentrations, these fish species are still found in the Southern Foothills of Alberta in the parkland and prairie regions (Alberta Fish and Wildlife Division and Alberta Conservation Association 2003). Controls on fish harvesting and habitat protection, such as setting limits on acceptable habitat change are critical to the species' recovery (Alberta Fish and Wildlife Division and Alberta Conservation Association 2003; Fitch 1997).

3.1.2. Water Management in Alberta

The Alberta Government's policy on provincial water resources are outlined in the Water for Life Strategy. Established in 2003, the Strategy's goals are to ensure:

- A safe, secure drinking water supply;
- Healthy aquatic ecosystems; and
- Reliable, quality water supplies for a sustainable economy (Alberta Government 2003).

The Strategy sets a 30% target for the improvement of the efficiency and productivity of water resources by 2015 (Alberta Government 2003). It sets out three types of partnerships to implement the Water for Life Strategy: The Provincial Water Council; Watershed Planning and Advisory Councils (WPACs); and Watershed Stewardship Groups (WSGs).

The South Saskatchewan River Basin Water Management Plan, approved in August 2006, recognizes that much of the watershed has reached or exceeded its allocation limit (Alberta Environment 2006). Over 20,000 water licenses have been issued in the South Saskatchewan River Basin since the 1890s (Oldman Watershed Council 2006). As part of the plan, Alberta Environment will no longer accept new surface water license applications for the Bow, Oldman, and South Saskatchewan sub-basins (including groundwater in alluvial aquifers hydraulically connected to the surface waters). The Plan sets a water conservation objective for sub-basins in the South Saskatchewan River Basin at “45% of the natural rate of flow, or the existing instream objective plus 10%, whichever is greater at any point in time” (Alberta Environment 2006:8).

Alberta has an obligation to pass 50% of the water from the South Saskatchewan River Basin to the Province of Saskatchewan as per the cross-provincial *Master Agreement on Apportionment* (1969) (Alberta Environment 2006). This has not been a problem in the past as historically around 75% of water flows into Saskatchewan but this amount is predicted to decrease dramatically in the future (Ibid).

The Watershed Planning and Advisory Councils for the Oldman and Bow River Basins are tasked with developing watershed management plans. The Bow River Basin Council is currently developing Phase 1 of the plan, focused on water quality. Outcomes and objectives will be set for areas where water resources in the Basin are considered the most stressed (Sokiak pers. comm.). The water quality objectives will include “thresholds (i.e., values not to be exceeded), targets (i.e., values to strive for longer-term) and associated timelines for implementing management actions and monitoring and evaluation” (Bow River Basin Council 2006:2). The objectives will be used to measure changes to water quality and to guide the management of water quality in the Basin Ibid).

There are no prescribed watershed assessment procedures in Alberta to evaluate the cumulative impact of all activities on a landscape (Hills pers. comm.). Watersheds assessments can measure the direct and indirect effects on flow rates and patterns, sediment yields, stream habitat, and fish of clearings and road and trail networks for land use activities (Trombulak and Frissell 2000; Sawyer et al. 1997; British Columbia Ministry of Forests 1995).

3.1.3. Watershed Indicators and Potential Thresholds

Indicators of water resources and aquatic habitat can be divided into three categories: physical and chemical; ecological; and land use. This division of indicators into categories has been applied in other studies on thresholds-based management of cumulative effects (Salmo Consulting Inc. et al. 2004; Salmo Consulting Inc. and Diversified Environmental Services 2003).

3.1.3.1. Physical and Chemical Indicators

3.1.3.1.1. Water Quality

Water quantity and quality are interlinked. Reduced water quantity means that there is less water to dilute pollutants (Fitch pers. comm.). The level of contamination is also affected by seasonal variation in water flows (Byrne et al. 2006). Declining water quality increases water treatment costs and has negative impacts on aquatic ecosystems.

The Canadian and Alberta Water Quality Guidelines suggest standards or thresholds for the physical and chemical properties of water in order to protect water quality for human use and aquatic habitat (Alberta Environment 1999; CCME 1999).

Two interviewees argued that the Canadian and Alberta Water Quality Guidelines may not be rigorous enough for the Southern Foothills because the area contains the headwaters for many water bodies downstream (Fitch and Hills pers. comm.). These interviewees believe the water quality in the study area must be held to a higher standard to ensure water quality standards are met downstream and that aquatic environments are protected. Guidelines should be developed on a sliding scale, with the highest water quality requirement near the headwaters (Fitch pers. comm.).

3.1.3.1.2. Water Quality Index

A threshold can be set for an acceptable percentage of change in water quality. For example, Salmo Consulting and Axys (2004) recommended thresholds for change to the water quality index for the Dehcho region in the Northwest Territories. The target threshold was 10% change and the critical threshold was 20% change from baseline conditions. The threshold was derived from research on ecological risk assessment in North America (Salmo Consulting Inc. et al. 2004). A 10% change in total suspended solids was identified as a limit for the protection of water quality and a change of over 20% is more likely to be detected by field measurement and statistical tests (Salmo Consulting Inc. et al. 2004).

3.1.3.2. Ecological Indicators

3.1.3.2.1. Aquatic Habitat

The Federal Department of Fisheries and Oceans has a principle of no net loss of productive capacity of fish habitat assessed on a project-by project basis (DFO 1986). This means disturbance of fish habitat will be avoided as much as possible and where impacted, an equivalent amount of habitat must be restored in another area. Productive capacity is defined as "the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend" (DFO 1986:27). The principle can apply to the stock of a species or the area of habitat. It can also apply to physical disturbances or detrimental water quality changes in aquatic habitats (DFO 1986).

3.1.3.2.2. Riparian Health and Buffers

Riparian areas are transition zones between aquatic and terrestrial areas adjacent to rivers, streams and lakes. Riparian areas naturally improve water quality by intercepting and filtering nutrients and particulates from uplands before they reach the water (Naiman, Decamps, and McClain 2005). Riparian areas remove and regulate sediment, nutrients, pesticides and herbicides from runoff; stable stream banks; reduce the magnitude of floods; and provide forage and wildlife and fish habitat (Fitch and Ambrose 2003). Human activities can degrade riparian areas through erosion, sedimentation, pollution, and increase levels of light and temperature (Fitch and Adams 1998).

The capacity of riparian areas to retain nutrients depends on the water table depth, water resistance time and the degree of contact between the soil and groundwater. If the groundwater passes below the roots of the riparian vegetation, nutrients may pass by unhindered (Naiman, Decamps, and McClain 2005).

To minimize impact on riparian areas, protected areas or buffers can be established around aquatic areas. Table 3.1 below lists potential thresholds for riparian buffers and health. The desired buffer width may vary depending upon the ecological objective. If the objective is to protect wildlife habitat and species diversity, then the buffer may be greater than if the objective is water quality (The Environmental Law Institute 2003).

Table 3.1 Summary of Thresholds and Standards for Riparian Buffers and Health

Threshold/Standard	**Location**	**Source**
Riparian Buffer		
Minimum of 25 metres to manage pollutant and nutrient runoff Minimum of 30 metres to aid in temperature and microclimate regulation and sediment removal Minimum 50 metres to ensure bank stabilization Minimum of 100 metres to provide wildlife habitat	Recommended buffer widths based on particular ecological objectives determined through a review by the Environmental Law Institute	(The Environmental Law Institute 2003)
Minimum of 200 metres for larger rivers, like the Crowsnest and Oldman	Recommended by Lorne Fitch for Southern Foothills, Alberta	(Fitch 2007 pers. comm.)
100 metres	Recommended setback from high water mark or water bodies on native prairie landscape	(Native Prairie Guidelines Working Group 2002)
Minimum buffer width should include the high water mark	This would take into account the vegetation that is affected by “elevated water tables, or flooding and by the ability of soils to hold water”	(Naiman, Decamps, and Pollock 1993)
Minimized development of roads within 500 m of stream and stream crossing	Recommended for the protection of bull trout habitat by the British Columbia Interior Watershed Assessment Procedure	(British Columbia Ministry of Forests and British Columbia Ministry of Environment 1999)
Riparian Health		
Less than 5% of bare ground or vegetation loss	Range health assessment guidelines for Alberta	(Fitch and Adams 1998)

Buffers can be set at uniform or variable widths. Uniform buffers are easier to enforce, and require less time and resources to manage (The Environmental Law Institute 2003). Yet, uniform buffers may not be wide enough to take into account meander rates or the high water mark (Fitch pers. comm.). Variable buffer widths may be set based on a detailed site assessment of each riparian area, taking into account the adjacent land uses, vegetation, topography, soils, and hydrology.

The quality of the riparian area is at least as important as whether or not there is a buffer in place. Degraded riparian areas will not perform as nutrient and sediment traps to protect stream and lake water quality. Riparian health assessments, as conducted through the Cows and Fish Program[4], have been developed to understand the condition of riparian areas and the impact of different land management actions (Fitch and Adams 1998). Assessments of riparian health include: the extent that is covered by vegetation; the percentage of non-native species and deep-rooted vegetation; the amount of bare ground, woody debris and soil compaction; and how much of it has been altered by human activity (Fitch and Ambrose 2003). The amount of bare ground that is human or cattle-caused is evidence of riparian health degradation (Fitch and Ambrose 2003).

3.1.3.3. Land and Resource Use Indicators

3.1.3.3.1. Vegetation Cover

3.1.3.3.1.1. Forestry- Equivalent Clearcut Area

The reduction of forest area has been directly related to an increase in water yield and runoff and a decline in water infiltration (Bosch and Hewlett 1982). Vegetation cover allows precipitation to flow at a meted rate off the land and infiltrate the soil, restoring groundwater sources. When the vegetation is removed, soil stability is reduced. Water flowing over the land will speed up, accelerating sediment and nutrient runoff to bodies of water.

[4] The Cows and Fish Program began in 1992 as a partnership between government ministries, non-governmental organizations, and agricultural associations to improve riparian management on rangeland Active on eleven ranches in the study area, local landowners educate one other about successful riparian protection and grazing strategies. Partners: Alberta Beef Producers; Trout Unlimited Canada; the Canadian Cattlemen's Association; Alberta Sustainable Resource Development; Alberta Environment; Alberta Agriculture, Food and Rural Development; Prairie Farm Rehabilitation Administration; Fisheries and Oceans Canada; and Alberta Conservation Association.

Water runoff from cleared areas will fluctuate depending upon annual precipitation and is likely to be greater in drier climates, where vegetation is slower to regrow (Bosch and Hewlett 1982). The amount of soil compaction and method of logging will also affect water yield and infiltration.

The British Columbia Interior Watershed Assessment Procedure (IWAP) has been applied to measure the type and extent of the cumulative impact from land use change in the Southern Foothills of Alberta (Sawyer and Mayhood 1998; Sawyer et al. 1997; British Columbia Ministry of Forests 1995). The British Columbia IWAP was originally applied to watersheds where the equivalent clearcut area reaches 30% of the watershed (British Columbia Ministry of Forests 1995). This is meant to represent the point at which cumulative effects of landscape change are likely felt.

Valdal (2006) studied the impact of forest operations on westslope cutthroat trout in British Columbia and determined that the IWAP 30% threshold was too lenient to detect significant landscape scale impacts of forestry-related roads and land disturbance on aquatic habitat. From a review of catchment studies, Bosch and Hewlett concluded that even if less than 20% of the forest is cleared stream flow changes are detectable (Bosch and Hewlett 1982). In 1999, The British Columbia IWAP threshold for cumulative watershed effects was changed to 20% (B.C. Ministry of Forests 1999).

3.1.3.3.1.2. Rangelands- Soil Exposure

Range health assessment guidelines were developed by the Division of Public Lands and Forest under the Alberta Sustainable Resource Development in 2003 and revised in 2005 (Adams et al. 2005). Rangelands include any native or non-native vegetation that has the potential to be grazed. These include grassland, forestland, shrubland, pasture land and riparian areas. The assessment is meant to be a tool for livestock producers, energy companies, resource managers, and protected area managers to detect changes in the condition of range health.

Soil stability is one of the key indicators of range health. Soil stability depends on the climate, topography and plant cover. Evidence of accelerated erosion, the amount of vegetation cover and the amount of bare soil on a site are measures of soil stability. Vegetation cover increases water infiltration and limits soil erosion (Adams et al. 2005). Soil loss due to disturbances and erosion can degrade the soil fertility, resulting in drier, less productive landscapes (Adams et al. 2005).

In a range health assessment, a lower score is given to a site that shows signs of soil movement or altered flow patterns that are human or cattle-caused. A soil exposure score is given to different vegetation types based on the percent of bare soil. The bare soil thresholds range from 1-10%. The assessment can be conducted at a variety of scales: plant community, field or pasture, management unit or polygon (Adams et al. 2005). Whether or not these thresholds are appropriate at the landscape level must be determined in consultation with a hydrologist (Adams pers. comm.).

3.1.3.3.2. Road Densities

Roads are the largest source of sediment in the foothills of Alberta (Anderson and Anderson 1987) and are required for most human activity and development (Mayhood pers. comm.). Controlling the amount of roads built in an area can directly limit the amount of sedimentation and indirectly limit the impact of associated land uses (Mayhood pers. comm.). Road density is measured in kilometres per square kilometre (km/km^2). Refinements to the indicator include: Road density at higher elevations; roads on erodible soil; roads less than 100 m from a stream; roads on erodible soil less than 100m from a stream; and roads on unstable slopes (British Columbia Ministry of Forests 1995).

Sawyer et al (1997) conducted a watershed assessment in southwest Alberta and found that that nearly 88 percent of the watersheds in the study area have high potential for erosion damage due to the amount of roads on erodible soil. Similarly, Valdal (2006) found that forestry activities on erodible soils had a disproportionately large impact on the persistence of westslope cutthroat trout in the Upper Kootenay River Watershed of British Columbia.

Potential thresholds or standards for road density that indicate the level of cumulative impact to watershed and aquatic habitat are listed in Table 3.2.

Table 3.2 Summary of Thresholds and Standards for Road Density

Threshold/Standard	**Location**	**Source**
Watershed Road Density (indicator of cumulative risk of peak flow and erosion)		
Cautionary- 0.3, 0.6, 0.9 km/km^2 Target- 0.6, 0.9,1.7	Recommended for watersheds designated as Special, General and Enhanced Resource Development Areas in	(Salmo Consulting Inc. and Diversified Environmental Services 2003)

km/km^2 Critical- 0.9, 1.7, 2.4 km/km^2	northeast B.C. (between 50-500 km^2)	
Low- <0.9 km/km2 Medium- 0.9-1.8 km/km^2 High- > 1.8 km/km^2	Peak flow hazard levels used in watershed assessment procedures for British Columbia	(British Columbia Ministry of Forests 1995; Low-Medium-High level set in Antoniuk and Ainslie 2003)
Low- <0.9 km/km^2 Medium- 0.9-1.72 km/km^2 High- > 1.72 km/km^2	Surface erosion hazard levels used in watershed assessment procedures for British Columbia	(British Columbia Ministry of Forests 1995; Low-Medium-High level set in Antoniuk and Ainslie 2003)
Road Density at high elevations above the H60 line (H_{60} is the upper 60% of a watershed based on an area-elevation curve)		
Low <0.3 km/km^2 Medium 0.3-0.6 km/km^2 High > 0.6 km/km^2	Peak flow hazard levels used in watershed assessment procedures for British Columbia	(British Columbia Ministry of Forests 1995; Low-Medium-High level set in Antoniuk and Ainslie 2003)
Roads on Erodible Soil		
Low < 0.15 km/km^2 Medium 0.15-0.34 km/km^2 High > 0.34 km/km^2	Peak flow hazard levels used in watershed assessment procedures for British Columbia	(British Columbia Ministry of Forests 1995; Low-Medium-High level set in Antoniuk and Ainslie 2003)
Road Density for persistence of sensitive fish species (including bull trout)		
Cautionary- 0.2, 0.4, 0.6 km/km^2 Target- 0.3, 0.6, 1.0 km/km^2 Critical- 0.4, 0.9, 1.2 km/km^2	Recommended for landscape designated as Special, General and Enhanced Resource Development Areas in northeast B.C. (minimum of 450 km^2)	(Salmo Consulting Inc. and Diversified Environmental Services 2003)
<0.28 km/km^2	Average road density for the persistence of bull trout populations	(U.S. Fish and Wildlife Service 1998)
>0.87 km/km^2	Average road density where bull trout populations are depressed	(U.S. Fish and Wildlife Service 1998)
1.55 km/km^2	Maximum road density in areas 7 times more likely to have persistent bull trout	(Rieman, Lee and Thurow 1997)

	populations in the Columbia River and Klamath River Basin	

The table above summarizes published road density thresholds that have been applied or recommended to protect watersheds or fish habitat in North America. The thresholds recommended for northeast British Columbia depend on level of development permitted in management zones. The British Columbia Interior Watershed Assessment Procedures can be used to detect the level of cumulative impact (low, medium, high) based on the total road density in a watershed. Tiered thresholds are also commonly used to link observed road densities with associated management actions. Tiered thresholds require regulators to take precautionary actions prior to reaching critical thresholds.

3.1.3.3.3. Stream Crossings

The number of times linear disturbances (roads, pipelines, seismic lines and utility corridors) cross streams in an area (called stream crossings) is an indicator of soil erosion, water temperature change, fishing pressure and barriers to fish passage (Antoniuk and Ainslie 2003). Stream crossings are measured by the number of linear disturbances per kilometre of stream or watershed area. In Alberta, roads crossing streams were found to account for as much as 90% of the sedimentation in watercourses (Anderson and Anderson 1987). Published thresholds for the density of stream crossings are listed in Table 3.3. Stream crossing densities are calculated with the use of geographic information systems (GIS).

Stream crossing as an indicator of aquatic health is fraught with difficulties as not all crossings are the same (Fitch pers. comm.). Stream crossings may or may not have an impact on sedimentation, fish habitat and movement depending upon how they are constructed and maintained.

Table 3.3 Summary of Thresholds and Standards for Density of Stream Crossings

Threshold/Standard	**Location**	**Source**
Cautionary Target- $<0.5/km^2$ Target- $<0.32/km^2$	Recommended for the subwatershed level in the Dehcho Territory of the Northwest	(Salmo Consulting et al. 2004)

	Territories	
More than $0.6/km^2$	Considered significant and triggers the B.C. Watershed Assessment Procedure in places where bull trout spawn	(British Columbia Ministry of Forest and British Columbia Ministry of Environment 1999)
Low < $0.24/km^2$ Medium $0.24-0.5/km^2$ High > $0.5/km^2$	Surface erosion hazard levels used in watershed assessment procedures for British Columbia	(British Columbia Ministry of Forests 1995; Low-Medium-High levels set by Antoniuk and Ainslie 2003)

3.1.4. Candidate Thresholds for the Southern Foothills

Depending upon the management objective, several thresholds may be required to protect watersheds and watershed-related factors such as water quality and aquatic habitat. Following are candidate thresholds based on the indicators of water quality standards and index, road density, and total landscape disturbance. Thresholds for other indicators (e.g., stream crossings and riparian buffers) are not recommended at this time until more information is available to evaluate these indicators within the study area.

Water Quality

Recommended thresholds: Standards as set in the Canadian and Alberta Water Quality Guidelines and percent change in the ALCES water quality index

The current water quality guidelines and standards should be met throughout the study area. Water quality standards in exceedance of the Canadian and Alberta Water Quality Guidelines may be appropriate for the study area, although it is beyond the scope this paper to determine exact numbers.

The percent change to the ALCES water quality index can be used an indicator of stakeholders' willingness to accept change to water quality in exchange for land use activity. This threshold would need to be determined in consultation with stakeholders.

Road Density

Recommended threshold: 0.9 km/km^2

A road density threshold of 0.9 km/km^2 is recommended to protect watershed health and aquatic habitat in the Southern Foothills. The literature reviewed here suggests that a road density threshold between 0.28 km/km^2 and 1.55 km/km^2 should be set to protect fish populations. The selected road density threshold is the average road density present where bull trout populations have begun to decline in the United States. The road density threshold of 0.9 km/km^2 is also considered to be a low risk for negative impact on the watershed indicators of peak flow and surface erosion (British Columbia Ministry of Forests 1995).

Figure 3.4 Total Road Density and Candidate Threshold

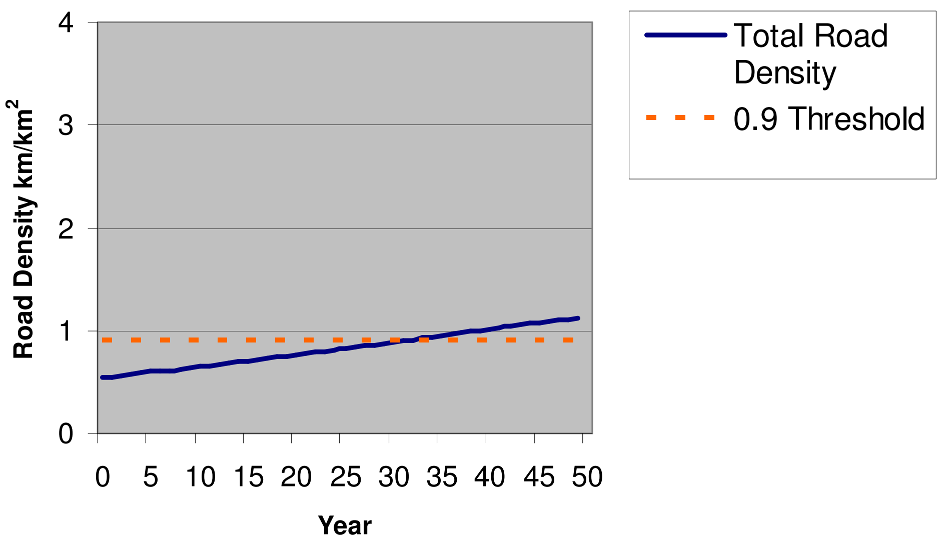


Figure 3.4 shows the road density in the study area rises from 0.54 km/km^2 to 1.12 km/km^2 in the Business-As-Usual Scenario. The 0.9 km/km^2 threshold was exceeded in year 32 or 2037.

Total Landscape Disturbed (anthropogenic, cropland included)

Recommended threshold: 20-30% Total Landscape Disturbed

A 20-30% threshold for total landscape disturbed for overall watershed protection is recommended. Total landscape disturbed refers to the amount of land for which land is cleared of vegetation at any one time. As recommended for the Interior Watershed Assessment Procedures in British Columbia, the amount of vegetated land in a watershed is an indicator of soil erosion, peak flow and sedimentation. The cumulative impacts of land uses on watersheds are expected to be detected when there is between 20-30% equivalent clearcut area (British Columbia Ministry of Forests 1995; B.C. Ministry of Forests 1999). The exact threshold number between 20-30% will have to be set based on further research or determined through discussions with stakeholders about social acceptability.

The total landscape disturbed in the study area in 2005 and projected for 2055 are shown in Table 3.4.

Table 3.4 Total Landscape Disturbed in Hectares and Percentage of Landscape

	2005	**2055**
All Footprint (Ha)	328,414	376,608
% of Landscape Disturbed	**26.70%**	**30.61%**

Agricultural cropland is included as landscape disturbance in Table 3.4 because of the common practice of tilling, where the vegetation is removed and soil disturbed annual, increasing sedimentation and runoff rates.

Thresholds Not Specified at this Time

A stream crossing threshold is not recommended at this time until more research is conducted on the impact of stream crossings within the Southern Foothills. There is significant variation in the impact of stream crossings depending upon how they were constructed and maintained so this indicator cannot be reliably used.

A uniform riparian buffer standard has merit despite the considerable debate in the literature on the value and application of uniform buffer widths. Ideally, riparian buffers should be developed based on the unique site characteristics such as amount of surrounding land use activity, riparian area health, and topography. Yet, for the ease of administration and implementation, a uniform buffer should be set, although the exact amount cannot be recommended at this time.

3.2. Thresholds for Grizzly Bear Protection and Habitat Conservation

> "Conservation of grizzly bears is not only about restoring and maintaining the biological requirements of a species, it is also about people's values, their beliefs about bears and science, and what they expect and demand from land-use policies. To some, grizzly bears symbolize wilderness, our abundant natural heritage, and an economic opportunity. For others, grizzlies symbolize our struggle to tame the land, loss of opportunity, economic hardship, and can engender fear and anxiety. Positive or negative, the grizzly bear is a potent and recognizable icon that elicits strong emotional responses. Differences in values and attitudes may be couched as arguments about scientific knowledge or land-use practices" (Alberta Grizzly Bear Recovery Team 2005:12).

Grizzly bears have a unique mystique; they are both feared and revered. Human attitudes towards grizzly bears are reflected in both conservation efforts and the rate of human-caused mortality of bears. The grizzly bear (*Ursos arctos*) was selected as a valued ecosystem component for the Southern Foothills Study because the persistence of grizzly bear populations is an indicator of ecosystem health and landscape change. Landscapes that support grizzly bears have natural vegetation, native species and functional ecological processes (Paquet et al. 1999).

The biological characteristics of grizzly bears coupled with past research examining thresholds-based management of grizzly bear habitat are discussed. The candidate thresholds selected for the Southern Foothills are based on a literature review on grizzly bear management and interviews with grizzly bear biologists. The extent to which the candidate thresholds may be exceeded in 2055 according to the Southern Foothills Study is evaluated.

3.2.1. Grizzly Bears as Umbrella Species

The Alberta Draft Grizzly Bear Recovery Plan states "the long-term persistence of grizzly bear populations in combination with other large predators could be used as a barometer with which to measure current and historic land-use practices and sustainable resource management practices" (Alberta Grizzly Bear Recovery Team 2005:12). Grizzly bears have been used as an umbrella species for conservation purposes indicating a species whose needs are thought to encompass the needs of many other species. This is because of their large habitat requirements and sensitivity to human disturbance (Weaver, Paquet, and Ruggiero 1996).

There are numerous studies on the value of grizzly bears as an umbrella species, which assume that when conservation measures are directed at this species, the needs of other species are protected (Carroll, Noss, and Paquet 2001; Lambeck 1997; Noss et al. 1996; Roberge and Angelstam 2004; Simberloff 1998; Carroll, Noss, and Paquet 1995). Critics of the umbrella species approach argue that focusing on one species is not effective in protecting the majority of species (Roberge and Angelstam 2004). Alternatively, Lambeck (1997) recommends a focal, multi-species approach to umbrella species selection. Lambeck proposes four criteria for selecting a suite of focal species to measure ecosystem health and protect the majority of species in an area: sensitivity in terms of area requirements, resources, connectivity and natural processes (i.e., fire, flooding) (Lambeck 1997). Grizzly bears meet several of these criteria as they are area-limited, and have limited ability to disperse due to the mortality risk in areas with human activity and disturbance. The selection of grizzly bears for this study can be considered part of a multi-species approach that could be applied in the future by land and wildlife management organizations.

3.2.2. Conservation Status of Grizzly Bears in Canada and Alberta

In Alberta, grizzly bears are listed as “may be at risk of extinction or extirpation” (Alberta Fish and Wildlife Division 2006). Resource development and recreational activity is cited as the greatest threat to wilderness grizzly bear habitat. In 2002, the Alberta Endangered Species Conservation Committee recommended that grizzly bears be listed as “threatened” under the *Wildlife Act* (Alberta Grizzly Bear Recovery Team 2005). The Committee’s recommendation was based on Alberta’s small grizzly bear population, and the species’ low reproductive rates, limited immigration from outside Alberta and sensitivity to habitat disturbance (Ibid).

Nationally, the Committee on the Status of Endangered Wildlife in Canada lists grizzly bears as a species of “special concern” indicating that it is sensitive to human activities but is not yet endangered or threatened (Committee on the Status of Endangered Wildlife in Canada 2002). Grizzly bears have not yet been given a status under the *Species at Risk Act* (Environment Canada 2006). In British Columbia, Yukon and the Northwest Territories, grizzly bears are recognized to be in need of special protection (Government of Yukon 2006; Government of the Northwest Territories 2006; Government of British Columbia 2006).

3.2.3. Management of Grizzly Bears in Alberta

Grizzly bear populations in Alberta have fluctuated over the past century in response to different government management actions, such as hunting restrictions, the introduction of grizzly bear licenses and monitoring of kills (Nagy 1990).

Records of grizzly bear mortalities and sightings exist from 1971 but estimates of the grizzly bear population in Alberta were not made until 1988 (Kansas 2002; Nagy 1990). In the first grizzly bear management plan written in 1990, the Alberta grizzly bear population was estimated at 790 (including national parks), with a goal of increasing that number to 1000 (Alberta Grizzly Bear Recovery Team 2005). The population on provincial lands was thought to increase from 575 bears in 1988 to 841 bears in 2000 (Kansas 2002). Recent DNA studies that suggest the number is under 500 (Boyce and Stenhouse pers. comm.).

A provincial Grizzly Bear Recovery Team was established in 2002 (Alberta Grizzly Bear Recovery Team 2005). The team is responsible to "guide recovery efforts in Alberta through development of a plan outlining recovery strategies and actions to support recovery of grizzly bears in the province" (Alberta Sustainable Resource Development 2005:2). In February 2005 the Team released the Draft Grizzly Bear Recovery Plan which is still under review by the Alberta Government (Stenhouse pers. comm.).

3.2.4. Life History Characteristics

Grizzly bear populations in Alberta have been studied through the Eastern Slopes Grizzly Bear Project (ESGBP; 1994-2002) and the Foothills Model Forest (FMF; 1997-ongoing). These research programs provide important information on grizzly bear life history characteristics, habitat use, resource selection, spatial and environmental aspects of human-caused mortality, and policies to improve landscape-scale conservation of the species (Herrero 2005; Foothills Model Forest 2007).

Grizzly bears are at the highest trophic level as top predators (Weaver, Paquet, and Ruggiero 1996). Grizzly bears are omnivores and their habitat corresponds with the availability of food such as grasses, sedges, forbs, berries, pine seeds, ungulates, rodents and insects (Weaver, Paquet, and Ruggiero 1996). When there is a shortfall of food, grizzly bears may travel long distances and into areas with humans, increasing the risk of human-caused mortality (Weaver, Paquet, and Ruggiero 1996).

In the Eastern Slopes of Alberta, grizzly bears have large home ranges; averaging from 520 km^2 for females to 1405 km^2 for males (Stevens and Gibeau 2005). In comparison to other carnivores, grizzly bears have a low dispersal rate. Female grizzly bears maintain their maternal home ranges and male bears tend to travel beyond the maternal home ranges (Weaver, Paquet, and Ruggiero 1996). Females may move into poorer quality habitat in their range to avoid human-caused landscape changes. This may reduce female reproduction rates as the bears are forced to spend more time and energy to find food sources in poorer quality habitat (Merrill 2005). The low dispersal rate and low reproductive output contributes to the species' low ecological resiliency in areas with large amounts of human disturbance (Weaver, Paquet, and Ruggiero 1996).

In Alberta, grizzly bears are found primarily in the Rocky Mountains and higher elevations of the Foothills and Boreal Mixedwood natural regions in west-central, south-western and north-western Alberta (Kansas 2002). Grizzly bear habitat in the Southern Foothills is in the Subalpine, Montane, Alpine, Parkland and Foothills Fescue subregions. Agricultural land within the study area could still be habitat for grizzly bears if it were not for the high mortality risk in areas with higher human population densities (Stenhouse pers. comm.).

Grizzly bear populations have been declining across North America since 1850. The grizzly bear's historic range is throughout the contiguous United States and in west and central Canada (Mattson and Merrill 2002). The prairie grizzly bear population has been extirpated, a process which started with the development of settlements, ranches and farms in Alberta in the 1870s (Nagy 1990). Today, due to hunting and the conversion of lands for agriculture, grizzly bear ranges are further restricted to corridors between the foothills and the Rocky Mountains in British Columbia and Alberta and in wilderness areas in Yukon and Northwest Territories (Kansas 2002). A study in the southwest of Alberta estimated 74 bears in a 5,030 km^2 area or a density of approximately 1.5/100 km^2 (Mowat, Russell, and Strobeck 1998).

A source-sink spatial population structure is created by human land use activity and access into grizzly bear habitat. A higher mortality rate in southwest Alberta than in Montana and British Columbia is evidence of a sink area. Sinks are areas with greater human presence and where the death rate exceeds the birth rate (Merrill 2005). Grizzly bear populations in a region are likely to decline when the ratio of sink habitat increases relative to source habitat (Mattson et al. 1996).

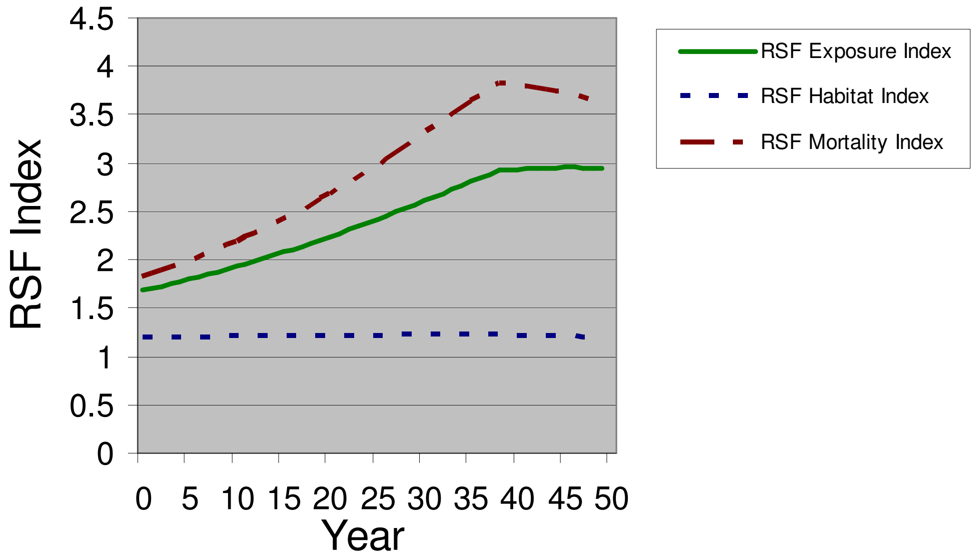
Source areas are remote areas, such as in protected areas with little human access where the birth rate exceeds the death rate. Kananaskis Provincial Park and Banff National Park may be source habitat for grizzly bear populations (Herrero 2005). Outside of national parks, increases in human activity and presence are leading to more human-bear conflicts. Where there are conflicts between cattle and bears, the bears are usually the first to be killed, "creating a population sink in the Castle-Crown area outside of Waterton Lakes National Park" (Merrill 2005:31).

The biggest threat to grizzly bears in Alberta is human-caused mortality (Kansas 2002). Grizzly bears are killed by humans as trophy kills, in defence of perceived attacks, to protect livestock, from vehicle collisions, and as a result of conflicts with hunters over the remains of big game. Wildlife managers may be called out to defend humans from bears who become habituated to areas with humans. Two factors influence the rate of human-caused mortality: the likelihood of encounters and the odds that a bear will be killed as a result of this encounter (Mattson et al. 1996).

3.2.5. Projected Cumulative Impact of Land Use

A Resource Selection Function (RSF) model is built into ALCES, with information from the Grizzly Bear Program of the Foothills Model Forest and analyzed by grizzly bear biologist Scott Neilsen (Stelfox pers comm.). The RSF model identifies the probability of bear presence in a given habitat (Habitat Index) and the probability that a bear will be killed in a habitat type (Mortality Index). The indices of habitat selection and mortality risk are combined into an Exposure Index (Figure 3.5).

Figure 3.5 Resource Selection Function Indices for Grizzly Bear Exposure, Mortality and Habitat from 2005 to 2055



At year 2055, grizzly bear habitat in the study is expected to increase by 0.25%. This is due to the projected increase in human land use footprint that can create habitat. For example, a roadside can contain grasses and shrubs for foraging bears. The projected changes in human land use activity could increase the grizzly bear mortality risk by 75%. Finally, the exposure index, representative of the changes in grizzly bear habitat and mortality risk, is expected to increase by 98% by 2055. While the grizzly bear habitat in the study area is maintained, a greater number of bears are likely to be killed as a result of conflicts with humans.

3.2.6. Indicators and Potential Thresholds for Grizzly Bears

Cumulative effect assessments (CEA) can measure the impact of human activities on grizzly bear habitat, displacement and mortality (US Department of Agriculture (USDA) Forest Service 1990; Gibeau 1998; Apps 1993). CEAs have been used to inform management actions and identify ecological or land use thresholds that specify the conditions necessary for grizzly bear persistence in an area. Thresholds may be based on the indicators of habitat effectiveness, core security area, connectivity and road density.

3.2.6.1. Habitat Effectiveness and Core Security Area

Habitat effectiveness is a measure of the amount of habitat available after accounting for human disturbance. Bears tend to avoid areas with human disturbance and are more likely to be killed near linear disturbances that facilitate human access into grizzly bear habitat (Mace et al. 1996; Benn 1998). The zone of influence (ZOI) is the area of less desirable habitat around a human disturbance (e.g., <500m from motorized access route) (Horejsi 2004)

Building on the zone of influence theme, is the concept of core security areas, a measure of the amount of land greater than a certain distance from high human use areas (Horejsi 2004). Merrill argues that preventing the decline of grizzly bears depends on our ability to protect large unfragmented core areas (Merrill 2005). The Interagency Grizzly Bear Committee (1994) determined a core security area is roughly equivalent to the amount of land used by a female grizzly bear in a 24 to 48 hour period (AXYS Environmental Consulting Ltd. 2001). Gibeau determined that an average of 39% of adult female home ranges were secure (low probability of encounter with humans) in the Eastern Slopes of Alberta, well below the recommended 68% for core security as set for the Montana portion of the North Continental Divide (Gibeau 2005).

Thresholds and standards for grizzly bear management have been recommended in Montana, Idaho, British Columbia, and Yukon to address habitat effectiveness, zone of influence and core area, as shown in Table 3.5.

Table 3.5 Habitat Effectiveness, Edge and Core Area Thresholds and Standards

Threshold/Standard	**Location**	**Source**
Habitat Effectiveness		
No net loss of critical habitats	To maintain existing habitat conditions in Alberta	(Nielsen, Stenhouse and Boyce 2006)
No net loss of habitat effectiveness for grizzly bear	Recommended British Columbia threshold	(British Columbia Ministry of Forest and British Columbia Ministry of the Environment 1999: Step 6)
80% habitat effectiveness in all but 3 of the 33 Landscape Management Units	Threshold adopted for Jasper National Park	(Parks Canada 2005)
Edge/ Zone of Influence		
Grizzly bear consistently under-use habitat within	Based on research in Montana, Yellowstone	(Mace et al. 1996; Benn 1998)

500 m of high use roads; most grizzly bear mortality occurs within 500m of roads and facilities and 200m of backcountry facilities and trails	National Park and the Central Rockies Ecosystem	
Core Area		
>68% of each female home range as core habitat	Recommended for Castle Corridor in southwest Alberta	(Horejsi 2004)
Minimize loss of core habitat	Recommendation for recovery of grizzly bear in the North Cascade of B.C	(North Cascades Grizzly Bear Recovery Team 2004)
>60% of available habitat as core area	Grizzly bear management threshold for Banff National Park	(Gibeau 2000)

3.2.6.2. Connectivity

Habitat fragmentation occurs when the continuity of habitat is disrupted and human land uses cause barriers to the movement of wildlife. Linkage zone predictions or fragmentation analysis can be conducted to determine the degree of fragmentation within an area, the critical movement corridors, and barriers to movement. Habitat connectivity is necessary for young male bears to disperse from their maternal home range and to sustain the genetic diversity of the metapopulation (Weaver, Paquet, and Ruggiero 1996). As such, contiguous tracts of wilderness and connectivity are essential to the species' persistence (Weaver, Paquet, and Ruggiero 1996; Merrill 2005). Thresholds could be set for minimum corridor widths and minimum distance between habitat patches (The Environmental Law Institute 2003), although no literature with specific values for grizzly bear habitat conservation was found.

Highways are known to impede the migration of wildlife. For example, Highway 3 within the Crowsnest Pass has been termed a Fracture Zone that impedes the movement of bears (particularly females) and reduces gene flow from north and south (Merrill 2005). The populations north and south of the highway are at risk of becoming isolated (Merrill 2005). In general, the significance of effects increases where there are wider road widths, and greater frequency and intensity of human use. Maintaining connections between populations requires creative management and mitigation actions to ensure development does not encroach on the portions of the highway that are known to have wildlife crossings and to ensure that there are adequate population numbers in the surrounding landscapes (Merrill 2005).

3.2.6.3. Road Density

Not all human disturbances affect grizzly bears the same way. Roads in particular are cited as having the greatest influence on grizzly bears (Mace et al. 1996; Mattson et al. 1996; Noss et al. 1996; Trombulak and Frissell 2000; Gibeau et al. 2002). Table 3.6 lists published road density thresholds for grizzly bear habitat conservation. Roads create barriers to movement, disrupt bear behaviour and facilitate human-bear interactions often leading to conflict. In the Central Rockies Ecosystem, Benn (1998) found that 85% of human –caused grizzly bear mortalities were within 500 m of roads and 200 m of trails. The risk of grizzly bear mortality has been measured by proximity to roads; more roads have been equated with greater human presence (Alberta Grizzly Bear Recovery Team 2005). The 1993 U.S. Grizzly Bear Recovery Plan stated “the management of roads is the most powerful tool available to balance the needs of bears and all other wildlife with the activities of humans” (Servheen 1993:145).

Not all roads affect grizzly bears the same way. In general, higher volumes of traffic and wider roads are more likely to be a barrier to movement (Mace et al. 1996).[5] The greater frequency and intensity of human use of a road, the more likely that human-bear conflict will arise.

Table 3.6 Summary of Road Density Thresholds and Standards

Threshold/Standard	**Location**	**Source**
Road Density		
0.6 km/km^2 or less	Open road density found to support grizzly bears in northern Montana	(Mace et al. 1996; Noss et al. 1996)
0.68 km/km^2	Average road density in areas selected by bears in Southern B.C.	(McLellan and Hovey 2001)
0.6 km/km^2	Standard for high quality	(British Columbia

[5] There are several ways to calculate road density: total road density by a percentage of the landscape; open road density by a percentage of the landscape; overall road density of the management area. An open road is any right-of-way that is passable by a motorized vehicle (Servheen 1993). Open road densities can be considered as a surrogate for human use (Alberta Grizzly Bear Recovery Team 2005). Closed roads are defined as rights-of-way not accessible to motorized vehicles when the bears are out of the den (April 1 to November 15) or for not more than 14 days during that time (Servheen 1993). Access can be restricted by building gates, piling slash, soil and debris and replanting vegetation (Ibid). The Total Road Density and Overall Road Density consider both open and closed roads.

	grizzly bear habitat in B.C.	Ministry of Forests and British Columbia Ministry of Environment 1999)
0.6 km/km^2	Road density thresholds recommended for the persistence of a number of species (including grizzly bear)	(Antoniuk and Ainslie 2003)
0.6 km/km^2	Road density threshold recommended for Grizzly Bear Recovery in U.S. National Forests in the North Continental Divide Ecosystem	(Servheen 1997)
Short term (5-7 years)- not more than 13% of area with total road density of >1 km/ km^2 and not more than 11% of the area with a total road density of >2 km/km^2 Long term (7-15 years)- 6% or less of the area with a total road density of >1 km/km^2 and 6% or less of the area with total road density of >2 km/ km^2	Total road density recommended for southwest Alberta in core security areas	(Horejsi 2004)
0.6 km/km^2	Total motorized access route density for Yellowstone Ecosystem	(Interagency Conservation Strategy Team 2003)
1.2 km/km^2	Total motorized access route density for Yellowstone Ecosystem	(Interagency Conservation Strategy Team 2003)
0.6 km/km^2	Recommended for high quality grizzly bear habitat in Alberta	(Alberta Grizzly Bear Recovery Team 2005)
1.2 km/km^2	Recommended for all other grizzly bear habitat outside of Conservation Zones in Alberta	(Alberta Grizzly Bear Recovery Team 2005)

3.2.7. Candidate Thresholds for the Southern Foothills

Road density is the recommended threshold for the protection of grizzly bear habitat in the Southern Foothills. Road density is an indicator of habitat effectiveness, habitat fragmentation and the risk of human-caused mortality. Road density is a practical indicator as data are accessible and affordable. Road density calculations can be done with the help of a geographic information system (GIS). In calculating the road density, one must decide what quality of road will be included (paved or unpaved) and the level of access or type of activity on the road (highway, off-road vehicle route, road to a cutblock). Stenhouse (pers. comm.) suggests that road density should be calculated from known roads and trails. Sawyer et al. (1997) suggested that all off-road vehicle routes be included in the road density analysis as there exists very little access control in the Southern Foothills.

An appropriate open road density threshold west of Highway 22 in the forested, alpine and sub-alpine areas of the study area is $0.6 km/km^2$. This is the recommended threshold for Conservation Zones (high quality grizzly bear habitat) in Alberta under the 2005 Draft Alberta Grizzly Bear Recovery Plan (Alberta Grizzly Bear Recovery Team 2005). The same thresholds has also been applied in the United States and British Columbia, and recommended as part of land use planning processes in Yukon and in the Dehcho region of the Northwest Territories (Salmo Consulting Inc. et al. 2004; AXYS Environmental Consulting Ltd. 2001; British Columbia Ministry of Forests and British Columbia Ministry of Environment 1999; Antoniuk and Ainslie 2003).

A road density threshold appropriate for the grassland and mixed forest landscape types in the study area is $1.2\ km/km^2$. An open road density threshold of $1.2\ km/km^2$ is recommended in the draft Alberta Grizzly Bear Recovery Plan for all grizzly bear habitat outside of Conservation Zones (Alberta Grizzly Bear Recovery Team 2005). This threshold has also been used as a total motorized road density (included restricted roads and trails) threshold in the U.S. Yellowstone Ecosystem for grizzly bear conservation (Interagency Conservation Strategy Team 2003).

Figure 3.6 Road Density in the Study Area versus the Grizzly Bear RSF Mortality Index

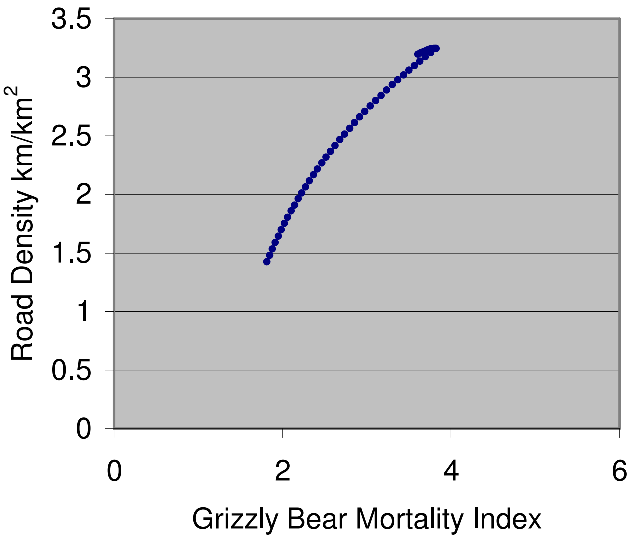
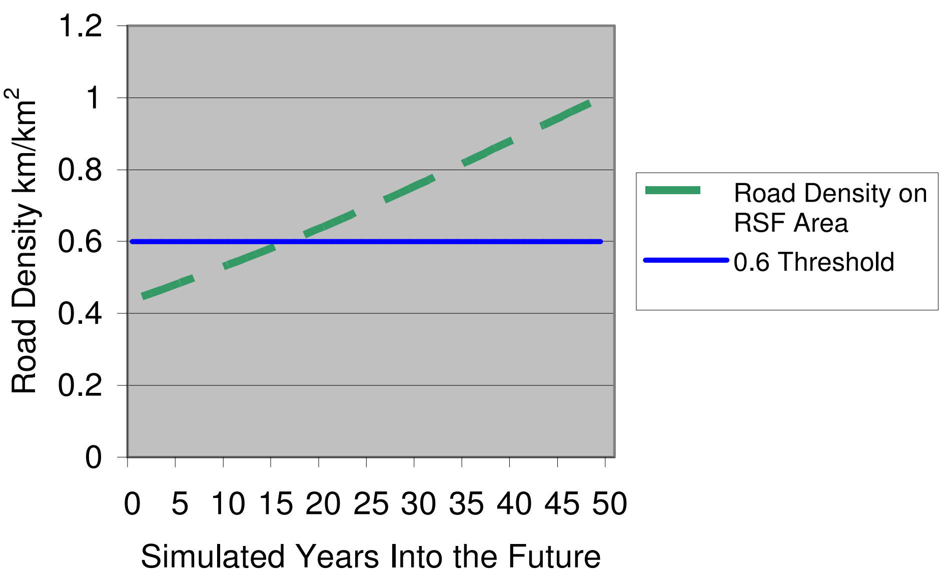


Figure 3.6, above, shows a correlation between the expected increase in road density in the Southern Foothills and the potential increase in grizzly bear mortality.

Figure 3.7 Projected Total Road Density and Road Density on RSF Area with Candidate Threshold from 2005-2055



In grizzly bear habitat, the 0.6 km/km^2 road density threshold is projected to be exceeded in 2022 (year 17) and in 2055 by 66%, as shown in Figure 3.7.

The above road density thresholds do not take into account the condition (e.g., paved or unpaved), the width and traffic volumes of the roads. A higher road density threshold may be applied where the roads or trails do not have motorized access (Stenhouse pers. comm.).

Biologists caution that we will likely never know the exact road density threshold that corresponds with grizzly bear persistence in an area (Mattson et al. 1996). Road density does not relate directly to exact grizzly bear population numbers (Merrill 2005; Stenhouse and Boyce pers. comm.). In addition to road density, grizzly bear persistence depends on: human attitudes/values, type of road, human population density and more. Gaining public support for grizzly bear conservation is critical to management success. Local public opinion that is antagonistic towards restrictive management measures can result in little or no 'biologically'-based grizzly bear conservation (Mattson et al. 1996).

Hypothetically, humans could co-exist well with grizzly bears if humans settled in the poorest habitat, were unarmed, and non-competitive for common resources (Mattson et al. 1996). Yet given the continued encroachment of human land use activities on grizzly bear habitat, cumulative effects assessment and a road density threshold are crucial to protect grizzly bear habitat and limit grizzly bear mortality risk.

3.3. Thresholds for Conservation of Fescue Grassland

In Alberta's Southern Foothills ranching community, Foothills Rough Fescue is a revered plant species. Rough fescue grassland has sustained a rich assemblage of native wildlife, since modern ungulates first roamed the area over 10,000 years ago. Since European settlement, native fescue grassland has been used as forage for cattle year round because fescue retains its physical and nutrient qualities throughout the winter (Aiken et al. 1997). Rough fescue is Alberta's provincial grass and is considered the most productive forage species on grassland (Willms, Smoliak, and Dormaar 1985). Fescue grassland was selected as a valued component for the Southern Foothills Study because of its cultural and economic value to ranching practices, and because of its water retention and carbon storing capabilities.

Fescue grassland is also declining rapidly. Since the early 1900s, half of the native fescue grassland has been lost in the Southern Foothills (Stelfox 2006). This is due to the conversion of grassland to agricultural crops, residences and settlements, roads, and the encroachment of non-native plant species.

Calls for the protection of native rough fescue grassland in the Southern Foothills from landowner and environmental groups are increasing (Obad and Cross 2007). Conflicts between oil and gas companies and landowners over the protection of fescue grassland have heightened in recent years as evidenced by the number of regulatory challenges (Alberta Energy and Utilities Board 2003, 2000, 2000, 2002).

A literature review was conducted to identify indicators and thresholds for fescue grassland. Interviews were conducted with experts familiar with fescue grassland in the study area, and the challenge of fescue restoration and conservation.

Four topics are covered here:

1. Status and value of existing fescue grassland;
2. Indicators of cumulative effects of human land use on fescue grassland;
3. Quantity of restoration possible and quality of restoration; and
4. Conservation strategies for fescue grassland.

Based on a literature review and interviews with grassland ecologists, a candidate threshold is identified for the study area, in Section 3.3.6 below.

3.3.1. Plant Ecology, Species, Distribution, Community, and Status

Rough Fescue is Alberta's provincial grass. Mountain Rough Fescue *(Festuca campestris)* is found in the study area, in the natural subregions of Foothills Fescue, Foothills Parkland and Montane (Alberta Sustainable Resource Development 2005). Other common names are Big Rough Fescue, Foothills Rough Fescue and Buffalo Bunch Grass. It is one of three rough fescue species in Alberta, originally classified as a single species, *Festuca scabrella* (Aiken et al. 1997).

Festuca campestris is the most drought tolerant of the fescue plant species and is found at high elevations (>800m) and north of 50^{o}N (Looman 1982). The blue-gray-green plants grow in tufts that stand erect and spread into tussocks 30-40 cm in diameter (Aiken et al. 1997). *Festuca campestris* flowers every five to ten years, less often than the plains rough fescue, F*estuca hallii* (Desserud pers. comm.). It is a late seral stage species, and takes 3-5 years to establish from seed (Desserud 2006). Fescue can grow under forests with open canopy (Looman 1982).

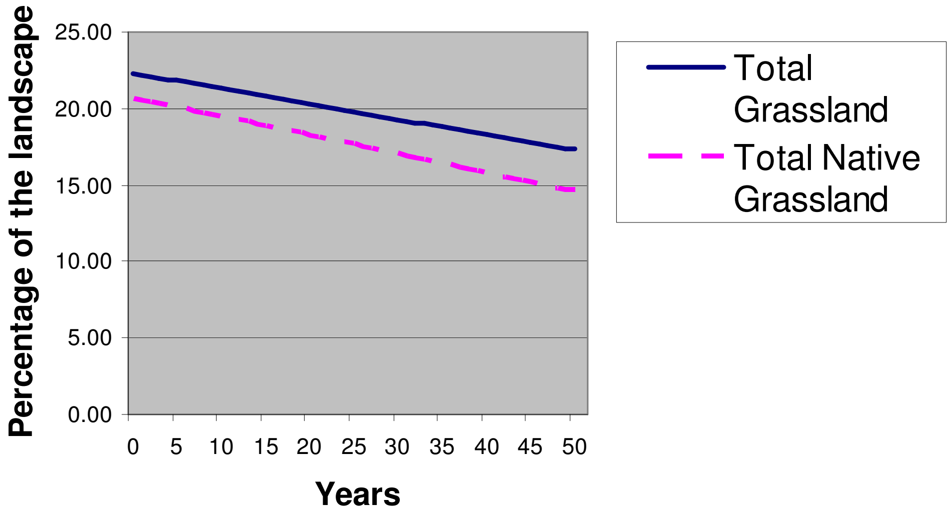
This species is listed as a species of concern, ranked nationally, provincially and internationally as secure, although there is uncertainty of the ranking in some parts of the species' range (Canadian Endangered Species Conservation Council 2006; Alberta Fish and Wildlife Division 2006; Gould 2006; NatureServe 2006). A drought tolerant plant, it is resilient to herbivory, provides soil stability, stores water, and, because of its extensive root system, sequesters a significant amount of carbon.

Fescue grasses can not be isolated from the plant communities within which they exist (Bradley pers. comm.). Plant communities are a combination of plant species that occur together because they favour the same site characteristics (Allen 2006). There are at least six rare native grassland communities found with the study area (Allen 2006; Allen 2007 pers. comm.). There are also a number of rare forest/woodland and shrubland communities with fescue undergrowth (Ibid).

For the Southern Foothills Study, the amount of fescue grassland was estimated at 270,562 ha or 22% of the study area (Stelfox 2006). Estimates were made by Barry Adams and Ron McNeil who used soils map of the area to identify the areas without cultivated crops, and where there are dark brown or black soils, known to support fescue grassland communities (Bradley pers. comm.). Low elevation areas were excluded from the analysis as they were already likely invaded or disturbed (Bradley pers. comm.). Estimates of grassland in the study area were necessary in absence of a completed native prairie vegetation inventory for the province, currently under development (Bradley pers. comm.).

In the SFS Business-As-Usual Scenario grassland is expected to decline by 10% of 2005 levels to 243,358 ha by 2055; a loss of 27,204 ha (Figure 3.8) (Stelfox 2006). This includes a small amount (approximately 7,700 ha) of mixed grassland in the study area, in which foothills rough fescue is not a dominate plant type (Adams et al. 2003). Excluding invasives, the total native habitat is 251,129 ha, declining to 178,650 in 2055. The percentage of grassland invaded is expected to climb from 7% in 2005 to 15% in 2055.

Figure 3.8 Projected Total Grassland and Total Native Grassland in Hectares from 2005-2055 (includes Foothills Fescue, Fescue Parkland/Montane and Mixed Grassland) in the Southern Foothills



The spread of non-native species from current land use footprint projected into the future without any additional land use activity, results in a grassland decline of 7.4% by 2055.

The ALCES model inputs for fescue grassland reclamation and non-native species invasion were first compiled by a group of experts at a workshop for the Southern Alberta Sustainability Strategy in 2003 (Bradley 2003). ALCES tracks the invasion rate from each land use footprint into each native vegetation type. The rate of invasion of non-native species is calculated in metres per year. For the purposes of the ALCES model, only the spread of invasive agronomics (such as awnless brome, crested wheatgrass, Kentucky bluegrass) was calculated. Invasive agronomics are commonly used for agricultural and reclamation purposes and are rarely controlled (Bradley 2003). The two other categories of non-native species, invasive noxious weeds and poor site specialists, were left out of the analysis as they are less commonly used, and because there are control measures available for these species through provincial and municipal laws (Bradley 2003).

Within ALCES, the invasion of non-native species was considered from linear footprint types only (Bradley 2003). The rates of invasion range from 0.3 metres/ year to 0.6 metres/ year for grassland within the Foothills Fescue, Fescue Parkland, Montane and Mixed Grass natural subregions (Bradley 2003). Much of the research on the non-native species dispersion has been linked to linear footprint types, such as pipelines, trails, roads, rails and seismic lines (Bradley 2003). Less is known about the rate of invasion from non-linear disturbances, such as well sites, recreational facilities, mine sites and other industrial disturbances and impact (Ibid).

The rate of invasion was applied to all linear footprints except those created prior to 1975, which were assumed to be restored to native grassland. Prior to 1975, disturbed sites were not reclaimed with invasive agronomic species and native species may have re-established in these places (Bradley 2003).

3.3.2. Value of Fescue Grassland

Fescue grasses are considered indicators of range health (Russell pers. comm.) because climax communities such as rough fescue dominated ones, were traditionally considered the best range condition for cattle forage (Willoughby 1997). Adapted to the dry Foothills climate, they are a stable source of food even in drought conditions (Bradley, Quinn, and Duke 2002). Fescue grasses are highly productive and can withstand significant stocking rates throughout the four seasons. Their economic value to ranchers goes beyond their productivity as there is reduced reliance on expensive machinery as cattle feed themselves, and less weeding expense as compared to early seral stage grass communities (Bradley, Quinn, and Duke 2002).

3.3.3. Cumulative Impacts of Land Uses on Grassland

Fescue grassland is affected by the cumulative impact of cattle grazing; the conversion of land for agricultural cultivation; rural residential growth; mining and oil and gas development; forestry operations; forest and shrub encroachment; and the invasion of non-native plant species, described in subsections below. Indicators and potential thresholds are identified.

3.3.3.1. Range Health Assessments

The Alberta Government's range health assessments measure the condition of the grassland and the quality of ecosystem function (Adams et al. 2003; Adams et al. 2005). Range health assessments consider 5 components (Adams et al. 2005:12-19):

1) Integrity and ecological status – Is the plant community native or modified to non-natives species and, what is the successional status of the plant community?

2) Plant community structure – Are the expected plant layers present or are any missing or significantly reduced?

3) Hydrologic function and nutrient cycling – Are the expected amounts of organic residue present to safeguard hydrologic processes and nutrient cycling?

4) Site stability – Is the site subject to accelerated erosion?

5) Noxious weeds – Are noxious weeds present on the site?

3.3.3.2. Grazing

Fescue grassland is damaged by overgrazing (Willms, Smoliak, and Dormaar 1985; Willoughby 1997, 1997). Overgrazing can create bare soil, cause the conversion from black to brown soils and accelerate the switch to a mixed grass community (Desserud pers. comm.). Initially the grazing of rough fescue will facilitate the spread of other native species and an increase in species diversity. However, under continued grazing pressure, a decline in native species will be followed by invasion of non-native species (Willoughby and Alexander 2005). Willms et al. (1985) determined that native fescue species that had been overgrazed (provided it was not invaded by non-native species) might return if fenced from grazing for 20-30 years.

Conducting a range health assessment is a condition of holding grazing leases on public land (Adams pers. comm.). Grazing dispositions are issued for ten years (Ibid). Two years prior to the renewal of a lease, a range health assessment must be completed. If the lease does not meet the government's guidelines, the lease may be restricted to a one year renewal or cancelled altogether (Adams pers. comm.).

3.3.3.3. Invasion of non-native species

The persistence of native species is a measure of range health (Adams et al. 2005). Therefore, non-native plant communities have lower ecological status (Willoughby and Alexander 2005). The impacts of non-native species invasion include: decreased forage quality, and altered fire cycles, nutrient cycling and wildlife grazing patterns (Stohlgren et al. 1999).

Rough fescue is more susceptible to non-native plant invasion than other grassland types (Bradley 2003). Rough fescue is a late seral species with deep roots that, once disturbed, is easily displaced by early seral species such as bluegrass and wheatgrass with shallow roots. Clark (1998) found that the black soils in the fescue prairie and parkland regions are more easily invaded by non-native species than in Mixedgrass or Tall Grass Prairie regions (Clark 1998). The native grasses have difficulty re-establishing when faced with competition from non-native perennials, a pattern enhanced geographically as one moves west across the prairies to Alberta (Clark 1998).

The condition of the native grassland affects how susceptible it is to non-native species invasion. If a site is in fair to poor range condition, and has some non-native species present, then it is more likely to be invaded following disturbance (Bradley 2003).

3.3.3.4. Grassland Conversion for Other Land Uses

Historically, the conversion of land for agricultural purposes was the largest cause of loss of fescue grassland (Stelfox and Bradley pers. comm.). Today, rural residential growth is one of the largest contributors to the decline of fescue grassland (Bradley, Neville, Craig, pers. comm.). Subdividing the land breaks up large blocks of land, providing more access points for the spread of non-native species into previously contiguous areas. The introduction of domestic horses can result in overgrazing small parcels of land (Craig pers. comm.). Non-native species seeded on acreages can spread onto the surrounding landscape (Ibid).

Industrial activities, such as mining, wind energy and oil and gas development all require the clearing of land. In the rolling foothills, more soil displacement may be required to level out the surface than on the flat prairie (Neville pers. comm.). In addition, oil or gas drilling time is longer in the Southern Foothills as the gas is generally farther below the surface, requiring larger equipment and larger well pad site than in other places (Neville pers. comm.).

Uncontrolled access from roads to adjoining native range land can result in non-native species invasion. A study conducted in Powder River Basin, Wyoming documented higher salinity rates on coalbed methane well sites causing a change in vegetation types and facilitating the establishment of non-native species (Bergquist et al. 2006).

Linear corridors such as seismic lines, roads and pipelines are "sources and vectors for non-native species invasion" (Bradley 2003). The invasion from linear disturbances is likely to have a greater spatial extent than from an individual well site or building footprint (Ibid). Linear corridors provide access to an area; trucks, off-road vehicles, bicycles and horses traveling along them can transport the seeds of non-native species.

Fire suppression in the region has resulted in forest encroachment on fescue grassland. Interviewees indicated that this is a significant impact on native fescue grassland (Craig pers. comm., Allen pers. comm.). The forestry industry practice of piling trees on landings for storage on fescue grassland was also mentioned as an impact (Neville pers. comm.).

3.3.3.5. Indicators and Potential Thresholds

Stocking Rates

The optimal stocking rates for the maintenance and health of fescue grassland are well documented (Adams et al. 2003; Willms, Smoliak, and Dormaar 1985). Also called carrying capacity, stocking rates refer to the number of livestock in a given area during a month or grazing season. The measure of animal unit months (AUM) per hectare relates to “the relative quantity of forage that will be harvested during the grazing period of a given year” (Willms, Smoliak, and Dormaar 1985:220). The stocking rate is intended to balance the availability of forage while maintain the range condition and species composition. Willms et al. (1985) determined that a stocking rate of 1.6 AUM per hectare was ideal to maintain the health and diversity of native species. Alberta’s Range Health Assessments recommend stocking rates for different plant community types (Adams et al. 2003). The stocking rates for plant communities in the Foothills Fescue Subregion range from 0.3- 1.5 AUMs/ hectare (Adams et al. 2003).

Grazing Seasons

Healthy fescue grassland provide a stable supply of winter forage for cattle. Fescue tufts that poke through the snow are easily located. Operators should limit or prevent cattle grazing of fescue in the spring because spring grazing can cause the removal of newly formed foliage preventing the flowers from producing (Looman 1982).

Bare Soil

The creation of bare ground (also called soil exposure), as in the building of a road or well site, or from overgrazing has been shown to facilitate the spread of non-native species (Burke and Grime 1996; Watkins et al. 2003). The bare ground makes nutrients and space available to species that are quick to establish (Stohlgren et al. 1999). The creation of bare soil also facilitates water evaporation and a decline in water infiltration. Runoff rates on heavily grazed sites are magnified during spring melting and summer storms (Adams et al. 2003). For Rangeland Health

Assessment on grassland, full scores are granted to sites that have less than 10% soil exposure (Adams et al. 2005). One interviewee suggested that 2-10% bare soil threshold could be set for grassland in bottom lands where non-natives are more likely to move in due to higher moisture levels (Craig pers. comm.).

Soil Moisture

Invasive species have been shown to persist in moister areas such as valley bottoms and riparian zones (Adams pers. comm.) (Bradley 2003:4). The moist and fertile soil of native grassland in the Foothills Fescue, Foothills Parkland and Montane Natural Subregions makes them more susceptible to invasion by agronomic grass species than in the Mixed Grass, Dry Mixedgrass, Subalpine, and Lower and Upper Foothills Natural Subregions (Bradley 2003).

Soil Compaction

Road construction creates soil compaction and contributes to non-native species invasion by reducing native plants and creating areas for quickly establishing non-native species. The level of road improvement can be used as an indicator of the frequency of non-native plants. For instance, paved roads enhance the spread of non-native species more than un-paved roads (Gelbard and Belnap 2003). In the Pekisko area, the non-native species, crested wheat grass, was found along a 50 metre corridor beside a road to a gas well constructed in 1980 (Bradley, Quinn, and Duke 2002). Nearby in Glacier National Park, a study of invasive species along paved and unpaved roads found non-native species up to 100 metres from the road. The study recommended avoiding road-building in fescue grassland communities (Tyser and Worley 1992).

Species Diversity

Grassland ecosystems tend to have high species diversity (Stohlgren et al. 2002; Willoughby and Alexander 2005). Stolgren et al (1999, 2002) found that species-rich plant communities were likely to be invaded by non-native species (Stohlgren et al. 1999; Stohlgren et al. 2002). This is attributed to soil fertility and water available in areas with increased diversity (Stohlgren et al. 1999).

Minimum Patch Size

Several interviewees suggested that a minimum patch size for the persistence of fescue grassland exists. The minimum patch size would consider the rate of invasion per year from the edge of a patch. A minimum patch size would be based on the amount of area left after a certain number of years of invasion (e.g., 50 years) and one that can still be considered a healthy reference plant community. Alternatively, the minimum patch width could be determined. No literature was found to document either a minimum patch size or minimum patch width.

The invasion of non-native species in Alberta's native grassland has been well documented (Bradley 2003; Stohlgren et al. 2002; Gelbard and Belnap 2003; Stohlgren et al. 1999). Intensive human disturbances and activities continue to result in the loss of fescue grassland and encourage the spread of non-native species. These disturbances combined with the sensitivity of fescue grassland, and the long time fescue takes to establish, has made the restoration to the reference plant community virtually impossible.

3.3.4. Restoration of Fescue Grassland

Restoration means "the re-establishment of sound ecological function and… the original range of variability in biological structure and diversity" (Neville 2002:21). There are few proven examples of restoring rough fescue grassland after disturbance or invasion by non-native species (Bradley 2003). Rough fescue grassland with black soils, have proven more difficult to restore than areas with brown soils, such as mixed grass and dry mixed grass vegetation (Bradley 2003). Attempts to reclaim fescue using fire, mowing and glyphosate (Roundup) have proven largely unsuccessful (Bradley 2003).

The ability to restore native grassland depends on the condition of the native plant community prior to disturbance. If the surrounding plant community type (e.g., around a well site) is not the reference plant community, it will be difficult to restore the site to the reference plant community type (Neville pers. comm.).

The type of activity and topography also affects restoration success. For example, the restoration of a pipeline right-of-way that is near several other rights-of-ways and subject to grazing will be more difficult than if the pipeline right-of-way is subject only to traditional grazing (Neville pers. comm.).

Table 3.7 describes some of the research studies on the restoration of fescue grassland.

Table 3.7 Fescue Grassland Restoration Studies

Summary of research studies	
Documentation of failed restoration attempts in Rumsey area of central Alberta and the Cypress Hills of southeastern Alberta. Seed mixes of rough fescue grassland would not establish and could not compete with the non-native perennial species	(Bradley 2003)
Native fescue grassland in rangeland was unable to recover once invaded by Kentucky bluegrass on sites by the Castle and Carbondale Rivers.	(Willoughby 1997, 1997)
A restoration project in Calgary of 0.6 ha of transplanted rough fescue sod revealed some positive results. Within a year, the plants in the transplanted sod were re-establishing. However, a change in plant community structure toward early seral species, shallow root species and greater species diversity was observed.	(Revel 1993)
Reclamation on pipeline rights-of-way successful only when conducted in post-growing season and when minimum disturbance trench-only stripping techniques are used.	(Desserud 2006)

The Alberta Energy and Utilities Board requires that oil and gas and pipeline operators reclaim native prairie to “establish equivalent capability on the landscape” (Native Prairie Guidelines Working Group 2002:24). Seeding with native species is recommended whenever possible (Native Prairie Guidelines Working Group 2002). Neville (pers.comm.) argues that the goal should be to bring it back to the reference plant community type. Bradley (pers. comm.) argues that sites should be reseeded to native plants even if not rough fescue; especially native species that can compete with non-native species.

3.3.5. Conservation and Protection of Fescue Grassland

The advice common amongst all interviewees and the scientific literature is that avoiding development on native grassland is the best way to conserve and protect it (Native Prairie

Guidelines Working Group 2002). When fescue must be disturbed, there are best practices to employ that reduce the associated impacts and increase the likelihood for successful restoration. These best practices include minimizing disturbance by overlapping corridor rights-of-way and in the oil and gas industry - drilling multiple wells on one pad. For road or well pad construction, geotextiles can be used to avoid disturbing the grassland (Neville pers. comm.) Geotextiles are woven polypropylene products that can be placed on the well pad or access road instead of stripping the topsoil. This permeable layer allows water to pass through to the soil and vegetation below (Neville pers. comm.).

More research is needed to clearly map the current distribution and condition of fescue grassland. Alberta Sustainable Resource Development is currently conducting a grassland inventory for the province that will be completed in 2010. This will improve the current vegetation inventory in which grassland is misrepresented as forests in areas where it occurs under the canopy of some tree species (Adams pers. comm.).

3.3.6. Candidate Threshold for Fescue Grassland

A “no loss” of fescue grassland threshold is recommended for the Southern Foothills as a result of the literature review and interview results.

The loss and alteration of fescue grassland follows a linear trend, declining at a steady rate in response to land use change in the Southern Foothills. With every new development on fescue grassland, area is lost or converted to other vegetation types. Similarly, invasive species continue to spread from the edges of disturbances.

Most interviewees agreed that the fescue grassland we have now is all we can expect to have in the future. This is due to the experience of poor restoration and the fact that large amounts of fescue grassland have already been lost. Given the existing development in place, it is likely that through the invasion of non-native species, fescue grassland will continue to be lost or converted in the future.

Adoption of a no loss threshold on private and public land would require multiple actions on the behalf of the provincial government and private landowners. Some interviewees suggested that the Alberta Government should establish protective notations to prohibit the disturbance of fescue grassland on public lands (Neville pers. comm.). Protective notations would not prohibit the grazing of cattle provided the grassland is maintained in healthy condition.

On private land, landowners have control of the amount of fescue grassland they protect. Conservation easements placed on private lands could include conditions to protect fescue grassland and to maintain grassland to a certain range quality. The water storing and meting capabilities of grassland ecosystems are important to protecting the flow rates and quality of water sources for downstream users. Landowners could be economically compensated for the maintenance and protection healthy grassland, as has been done in other regions.[6] In addition, landowners could be paid to protect grassland based on its value as a carbon sink. The value of a hectare of grassland would be based on the amount of carbon absorbed by the vegetation. This is referred to as a carbon credit, which, " enables the person who manages the land in a way that maximizes this carbon absorption and retention to receive compensation for their effort from the industry (or person) that emits it into the atmosphere" (University of New England 2007:1). Grassland may have greater carbon storing capabilities than trees because, if well managed, they can store carbon at a faster rate in their roots (Ibid).

A threshold of 0% direct loss of fescue grassland would be similar to the principle of no net loss of productive capacity of fish habitat set by the Department of Fisheries Oceans (DFO 1986). The DFO principle means that fish habitat will be avoided as much as possible and where disturbed an equivalent amount of habitat will be restored in another location. The principle allows for habitat "offsets" in another location. Fescue grassland "offsets" are only feasible if the operator or individual can demonstrate effective restoration. This leads to another question: Does the site need to be restored to the reference plant community or is the establishment of a community with other native species adequate?

A threshold of no loss of fescue grassland would not prohibit all activities on fescue grassland. Activities on grassland could continue provided the health of grassland is maintained. Range health assessments can be used to monitor the condition of the grassland and different management actions (Adams et al. 2003). The threshold based on soil exposure level and stocking rates could be set to measure whether or not the grassland health is maintained to an acceptable level.

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[6] see for example, http://www.deltawaterfowl.org/alus/index.php

Similarly some development may be allowed to proceed if it adheres to defined best practices (e.g., does not clear the top soil or is at a maximum width). Greater protection of fescue grassland may catalyze research into no-stripping techniques, weed control, and fescue restoration.

3.4. Conclusion

A literature review and key informant interviews were conducted to identify appropriate indicators and thresholds for each of the three valued components for the Southern Foothills Study: water, fescue grassland, and grizzly bears. Table 3.8 lists the indicators and candidate thresholds identified. The extent to which they are exceeded within the ALCES Business-As-Usual Scenario was also evaluated.

Table 3.8 Indicators for Valued Components

Valued Component	Indicator	Threshold
Water	Water Quality Index- Percent Change	Socially determined
	Total Landscape Disturbed	Between 20-30%
	Road Density	0.9 km/km^2
Grizzly Bear	Road Density on Grizzly Bear Habitat	0.6 km/km^2
Fescue Grassland	Total Percentage of Grassland on Landscape	No loss

There were several other indicators for which thresholds could be determined, given more information. It is recommended that these indicators be evaluated in the future.

Social values are important to consider at every stage of threshold development. The values of the members of the Southern Foothills Study led to the choice of the valued components in the first place. In the same way, the candidate thresholds were influenced by social values. For example, the candidate threshold for grassland considers the importance of grassland to the local ranching economy, and the protection of rare native plant communities for the enjoyment of future generations. As shown by the grizzly bear road density threshold, there are few magic threshold numbers. The threshold value will depend on humans' willingness to accept risk of cumulative effects to valued components.

Defining thresholds can be informed by science but are ultimately social and political decisions. As described in the next chapter, the candidate threshold values were used as a basis for a discussion at a workshop with members of the Southern Foothills Study Advisory Group (Chapter Four). The indicators were evaluated within alternative scenarios of development to identify the amount of land use footprint associated with particular indicator levels. This was used to build understanding and engage participants in a discussion about the impact of setting thresholds on other environmental, social or economic factors. Only two of the three water-related indicators and thresholds were used in the workshop. The road density indicator for water was excluded at this time, as a road density indicator was identified as a candidate threshold for grizzly bear habitat. Further research is needed to determine if a more specific threshold for road density on erodable soils or near water bodies is appropriate.

4. Addressing the Social Acceptance of Thresholds in the Southern Foothills

4.1. Introduction

> *How do we respect and protect the essential qualities and existing valuable assets of this landscape while still recognizing and allowing the continued evolution of land uses?*
> (Southern Foothills Study 2007)

This quote was used to set the stage for the evaluation of thresholds at a workshop with members of the Southern Foothills Study Advisory Group held September 22, 2007. The focus of the workshop was on evaluating the social acceptability of thresholds for the three valued ecosystem components given projected land use change in the region. Alternative scenarios of development were simulated and evaluated in order to understand the likelihood that thresholds would be exceeded given different projections of land use change. The workshop participants also provided input on what changes to land use practices and regulations might be used to respect the thresholds.

The results of the social acceptability component of this research provide insights about stakeholders' opinions. However, because of the low sample size, the results are not representative of the opinions of the general public. The intent of this component of the research is to determine an effective process for defining thresholds by testing ideas in the form of a workshop. There were five components to the evaluation of thresholds: a workshop with small group discussions; plenary discussions; an individual survey; a pre-workshop survey; and a post-workshop interview. The results of this research inform recommendations for an effective process to determine thresholds; further information needs; how to frame the thresholds discussion; and how to evaluate the tradeoffs of land use decisions.

4.2. Workshop Agenda and Objectives

All members of the Southern Foothills Study Advisory Group were invited on June 26th, 2007 to participate in a thresholds workshop. Included with the invitation was a pre-workshop survey to identify indicators that could be used to evaluate the tradeoffs with alternative scenarios of development.

The workshop was held at the Municipal District of Ranchland Building at Chain Lakes on Highway 22 in the Southern Foothills. Twenty members of the Southern Foothills Advisory Group attended (*Appendix C* for list of participants and organizations). The participants have all been involved with the Southern Foothills Study either since its inception or within the past year. The participants were from diverse organizations and sectors:

- Six representatives from five different landowner or local organizations.
- Five representatives from five different environmental organizations.
- Two representatives of two municipalities in the region.
- One consultant in landscape assessment and management.
- One representative from the Alberta Energy and Utilities Board.
- One representative from the Alberta Sustainable Resource Development.
- One representative from the Agriculture Canada.
- Three representatives from resource companies.

The three objectives of the workshop were:

- To identify appropriate thresholds for water, fescue grassland and grizzly bears;
- To identify what information is needed to make a decision on appropriate thresholds;
- To identify what changes would be needed to implement thresholds (e.g., practices, policies, regulations and attitudes).

The workshop format, shown in Table 4.1, consisted of short presentations, small group discussions, plenary discussions and the completion of an individual survey. Participants were given the opportunity to ask questions of clarification immediately after each presentation.

At various points throughout the day, participants were asked to form groups to familiarize themselves with the information and answer key questions related to each topic of discussion (e.g., are the results acceptable or unacceptable? Why? What more information would you need to make a decision?)

Table 4.1 Workshop Agenda

Time	Description
9:30 am- 10:00 am	Arrival of participants
10:00 am- 10:30 am	Introductions
10:30 am- 11:00 am	Review workshop agenda and objectives
11:00 am- 11:15 am	Presentation: SFS Business-As-Usual scenario and effects on water, grizzly bears and fescue grassland
11:15 am- 11:30 am	Group discussion on SFS Business-As Usual
11:30 am- 12:00 pm	Presentation: Candidate thresholds from research
12:00 pm- 1:00 pm	Lunch
1:00 pm- 1:30 pm	Group discussion on candidate thresholds and plenary
1:30 pm- 2:00 pm	Presentation: Alternative scenarios of development and impact on water, grizzly bears and fescue grassland
2:00 pm- 2:30 pm	Group discussion on alternative scenarios
2:30 pm 3:00 pm	Individual survey on scenarios
3:00 pm- 3:40 pm	Decision matrix
3:40 pm- 4:30 pm	Plenary discussion and wrap up
4:30 pm	End

4.3. Alternative Scenarios of Development and Thresholds Refinement

Five alternative scenarios of development were presented at the workshop and evaluated in groups and through an individual survey. The five scenarios were:

- Scenario A: 50% of Business-As-Usual
- Scenario B: 25% less than Business-As-Usual
- Scenario C: Business-As-Usual
- Scenario D: 25% greater than Business-As-Usual
- Scenario E: No Development on Grassland

Please see *Appendix E* for descriptions and tables of information for each scenario.

Scenarios A, B and D were variations of the Business-As-Usual Scenario. Using what is called a "land use modifier" in ALCES, the development trajectories for each land use sector were either restricted or enhanced from the Business-As-Usual Scenario (BAU). All land uses were varied by the same proportional amount. As a result, the footprint of development of all land use sectors was reduced or enhanced by a percentage of the growth rate in BAU. For example, in Scenario A, land use sectors were only permitted to grow by half of the footprint projected in BAU. In all scenarios (forestry sector excluded) each sectors' footprint continued to grow but at a reduced rate. The forestry sector in Scenarios A and B declined as the reforestation rate exceeded the rate of footprint growth.

Scenario E was developed to reflect the candidate threshold "no loss of fescue grassland" (see Chapter 3). In this scenario, all land uses were directed to grow as per BAU but not on grassland landscape types. Therefore, the land uses were permitted to continue growth into other landscape types but the grassland landscape type remained at the same percentage. Most sectors continued to grow at the same rate; only the energy industry's total projected footprint was reduced from 0.89% of the landscape in BAU to 0.82% of the landscape under Scenario E. The energy sector's footprint declined from BAU because its development was most affected by restriction from grassland.

The human population growth rate for the region (3%/ year) was not altered in any scenario.

The participants were given these questions to answer for each scenario (see *Appendix E* for scenario descriptions):

- What are the advantages of this scenario? What are the disadvantages of this scenario?
- What do you think about the land use change in this scenario? Is this scenario possible/feasible? How could we achieve it?

4.3.1. Selecting Indicators for Alternative Scenarios: Pre-Workshop Survey

A pre-workshop survey was conducted to identify: 1) indicators that could be used to evaluate the outcomes of alternative scenarios of development; 2) the level of concern of participants with indicators; and 3) the desired direction of change for the indicators to gain insights on the value individuals place on the indicator.

Eleven respondents completed the pre-workshop survey. Most participants found the survey difficult to complete. Participants argued that it was difficult to state their desired direction of change without first understanding what the current level of the indicator was or if ecological thresholds had been exceeded. Some participants felt that some of the indicators were not meaningful without understanding the full implications of them. For example, what level of road density is associated with a particular amount of land use activity, commodity production or habitat fragmentation? The respondents concern for the indicators on a scale from one to five is listed in Table 4.2

Table 4.2 Mean, Median and Mode Level of Concern for Indicators

Indicator	**Mean**	**Median**	**Mode**
Total Water Demand (m^3)	4.6	5	5
Road Density (km/km^2)	4.4	4	5
Grizzly Bear Exposure Index	4.3	5	5
Hydrocarbon Production (m^3)	4.3	5	5
Number of Active Oil and Gas Wells	4.3	5	5
Native Vegetation (Total % of the landscape)	4.2	4	5
Fescue Grassland (Total % of the landscape)	4.1	4	5
Nutrient Loading Index	4.1	5	5
Population	3.7	4	4
# of Cattle	3.4	3	4
Total Tourism Activity days in a year	3.4	3	3
Jobs (Full Time)	3.1	3	3
Tonnes of Crops Produced	3.1	3	3
Wages ($) (all sectors combined)	3.1	3	3

Some land and resource use indicators were of concern but it was difficult to identify through the survey what aspects concerned the participants and why. For example, if the respondents were concerned about the number of oil and gas wells and desired a decrease in this indicator, it was unclear what information they were using to make this assertion. What issues associated with oil and gas wells are of concern? Are they concerned with contaminants, royalty rates, or the roads and seismic lines that are associated with well development and the impacts on wildlife? In many cases, the land and resource use indicators appeared to be surrogates for ecological or social conditions of concern.

Other indicators that respondents identified were protected areas, footprint of the oil and gas sector, residential footprint, biodiversity, ATV use, the number of abandoned, unreclaimed oil and gas wells, timber harvest, planning and integration between all industries, range health, riparian health, and human health.

Indicators and Information Presented in Alternative Scenarios

The responses to the pre-workshop survey confirmed the importance of the valued ecosystem components selected for the Southern Foothills Study: water, fescue grassland and grizzly bears. The indicators for the valued ecosystem components were considered more understandable than the many of the other social or economic indicators. As a result of the survey, the following indicators, as shown in Table 4.3, were tracked within each scenario.

Table 4.3 Indicators of Valued Components

Valued Component	Indicator
Water	Water Quality Index- Percent Change
	Total Landscape Disturbed
Grizzly Bear	Road Density on Grizzly Bear Habitat
Fescue Grassland	Total Percentage of Grassland on Landscape

Changes in land use activity and footprint were also presented in table format. The scenarios showed the increase or reduction in the amount of footprint per type of land use. The percent of each land uses' footprint on the landscape and the percent change in each land use's footprint was shown for year 2005 and 2055. Recommendations for how to incorporate other economic indicators are made at the end of this chapter.

On the first two pages of an individual survey distributed during the workshop, predevelopment values for each indicator were presented, as well as a table for participants to list their desired threshold values for each indicator and to rank the indicators from one to four. The ranking was later used in the decision matrix part of the survey (see *Comparing the Scenarios: Decision Matrix* section below).

4.3.2. Scenario Evaluation

Part A of the individual survey had participants evaluate the scenarios separately and Part B allowed them to compare the scenarios to each other using a decision matrix.

Scenario A: 50% of Business-As-Usual

All participants agreed that Scenario A would have the least negative impact on the indicators. Representatives from the landowner and environmental groups felt that the thresholds were all exceeded within this scenario. Several people questioned how we might reverse the declining trend of the indicators. Three participants argued that Scenario A would leave more resources to future generations and result in generational equity. One participant asked if this reduced growth rate might result in a reduced standard of living for future generations.

This scenario, most agreed, could not be achieved solely through the implementation of best practices. While there was some disagreement on whether this scenario was acceptable, most agreed that some reduction in activity and production would have to occur to achieve this scenario. Four people stated that this scenario may also catalyze the use of best practices to reduce footprint. Most people argued that the means to achieve this scenario includes a combination of regulations, policy and incentive programs. A shift in public attitudes was also cited as a key factor. Some other issues raised include:

- Monetary compensation for restriction of growth may need to be paid to certain land users who have existing rights to resources (e.g., oil and gas lease owners).
- Combining the reduced footprint growth scenarios with a system that pays landowners to maintain ecological goods (e.g., water and carbon) and services to further improve ecological indicators.
- Revising current policies/acts that may make resource extraction activities a priority land use (e.g., Surface Rights Act and the Right of Entry component of the Energy Resources Conservation Act).

- Identifying and restricting those land uses that have a larger effect on the valued components than other land uses.
- Implementing a land use planning process under which cumulative effects can be managed and monitored.
- Enforcing best practices may not be acceptable to industry. The question was asked: if best practices were legislated, how would they be enforced?
- Creating a tiered thresholds system (explained in detail in Chapter 2). Voluntary best practices could be expected prior to reaching the cautionary thresholds and more authoritative management practices could be employed the closer the indicator moves to the target and critical thresholds.

Scenario B: 25% Less than Business-As-Usual

The participants, with six exceptions, stated that this scenario was better than Business-As-Usual, yet was still unacceptable because the three key valued components were not sustained on the landscape. On the other hand, it was also called the “most likely” scenario as it was viewed as a moderate change in practices and an improvement in indicator levels that the general public and industry would accept as it wasn’t too radical.

Many people thought this scenario was feasible through the use of best practices. This does not necessarily imply the reduction of commodity production in the region. A Best Practices Scenario for the Southern Foothills Study is currently under development and could be compared to all the scenarios, to evaluate the feasibility of reducing cumulative effects through the use of voluntary best practices. The social and political feasibility of this scenario, one participant observed, would be dependent on the willingness of people to accept tradeoffs in economic values.

Scenario C: Business-As-Usual

This scenario was deemed unacceptable by 19 out of 20 participants. It was thought to be a continuation of the status quo, achievable by making no substantial changes to land management or regulation. Four participants also stated that it was feasible only if economic goals were considered most valuable.

One participant argued that this scenario would ensure that we keep our standard of living (in terms of economic assets); conversely, another argued that as our natural assets decline so would our standard of living. One participant mentioned the present-day labour shortage and high housing costs in Alberta as reasons this scenario could not be sustained and could have negative effects on the economy and society.

Other comments received on this scenario include:

- No incentive would exist to reduce footprint or make tradeoffs between land uses.
- This scenario does nothing to manage cumulative effects and socially-desirable outcomes.

Scenario D: 25% Greater than Business-As-Usual

The comments were limited on this scenario because it was one of the last scenarios and was viewed by many as an extension of the Business-As-Usual Scenario. The majority of participants referred to this scenario as unsustainable and unacceptable. Most argued that economic development would be the major focus of this scenario and it would come at the expense of the valued ecosystem components. The current problems with growth (e.g., labour shortages, cumulative effects, etc.) would not be addressed through this scenario. Specific issues mentioned were:

- Water quality treatment costs would increase.
- Low royalty rates on mineral resources could facilitate development as in this scenario.
- This scenario is unlikely because of the current labour shortages in Alberta.

Scenario E: No New Direct Footprint of Development on Grassland

This scenario prevents the loss of grassland due to the footprint of development. The growth of land use footprint as in BAU was permitted in this scenario but not onto grassland landscape types. This constraint was the main criticism of this scenario by participants - that the protection of grassland appears to be at the expense of other ecological indicators. Most felt this scenario was too simplistic an approach to complex challenges like regional land management. It was useful to see this management practice in isolation so as to be clear on the impact of focusing on the protection of one valued component.

One participant argued that implementation of this scenario would be simple as there was only one focus of management. Another participant expressed concern that this scenario would be difficult to implement on private land as it might interfere with private property rights. Protective notations on grassland were suggested as a means of preventing the development of grassland on public land. Other issues and comments included:

- “This is like giving you all the air you want but no water!” (Participant A).
- This scenario is not feasible because it may mean making a road longer than it needs to be to avoid the grassland and as a result increasing the road density.
- Two participants wrote that a combination of Scenario A and Scenario E may represent the ideal future.
- The government should stop the issuance of mineral rights where they exist below grassland.
- A minimum amount of grassland protected should be set as well as a maximum road density on grassland.
- Minimum disturbance practices could be employed, such as no stripping of soil and grazing control.
- This protection has existed on ranches for 100 years.
- The companies with mineral rights under grassland may need to be compensated for restricted access.

The responses from Scenario E make it clear that land management is a complex issue in the Southern Foothills. While participants are concerned about the loss of fescue grassland, they are not willing to accept protection of it without also managing land use impacts on other valued components. It was useful to have this scenario included as it generated much discussion about tradeoffs between valued components.

4.3.3. Candidate Thresholds Evaluation

Several opportunities were provided for participants to discuss appropriate threshold values. An interactive activity was used to identify socially acceptable threshold values. The participants were asked to indicate their preferred threshold values on charts taped on the wall. There were four charts, one for each indicator, and each with a scale between low and high threshold values.

The participants were directed to place an “x” and their initials beside the threshold value they would accept, based on their own values and on the information presented about candidate thresholds for each of the three valued components. In small groups, participants were asked to compare with each other the rationale behind each of their threshold values.

In plenary discussion, many people expressed surprise at how close all participants’ chosen threshold values were. There appeared to be consistency among participants’ views. This commonality was less evident when one reviewed the individual surveys where participants were possibly more candid.

The biggest discrepancy in values was for the indicator of road density on grizzly bear habitat, likely due to the disparate views on the importance of protecting of this species. Although grizzly bears were selected as an indicator of ecosystem health for the region, this distinction was not always evidently made by participants.

The survey and post-workshop interviews showed that there was significant difference of opinion on threshold values, the need for more information, as well as the most desirable scenario. In general, landowner and environmental groups agreed that thresholds should exceed or be set at current levels. Resource company representatives were willing to accept lower threshold values in exchange for growth in land use activity and commodity production. Responses from government representatives - municipal, provincial and federal - were mixed, some accepting higher and some accepting lower threshold values.

There was reluctance among some participants to set “arbitrary” values for thresholds without knowing all of the information that contributed to the model and the function of it. Several participants also had difficulty differentiating the impact of different value points along the scale; for example, what is the difference between 26% and 28% total landscape disturbed in terms of actual water quality? Information needs specific to each indicator are further explained below.

<u>Threshold values</u>

Water Quality Index (Percent Change)

The threshold value for this indicator was perhaps the most difficult to determine because it is based on social acceptability. The threshold values ranged from 100% increase to 30% decrease in the water quality index by 2055. Seven respondents set a threshold value that would require improvement in water quality from current levels and six respondents set the threshold at current levels. Seven people were willing to accept some decline in the indicator.

Some respondents desired more information on the implications of the index to water treatment costs, to downstream users, and to actual physical and chemical parameters as listed in the Canadian and Alberta Water Quality Guidelines. Participants expressed concern that the water quality index is not tied directly to water quality measurements on the landscape and that it only measures three components of water quality (sedimentation, phosphorus and nitrogen).

Figure 4.1 Mean Threshold for Water Quality Index (% Change) by Participant Group

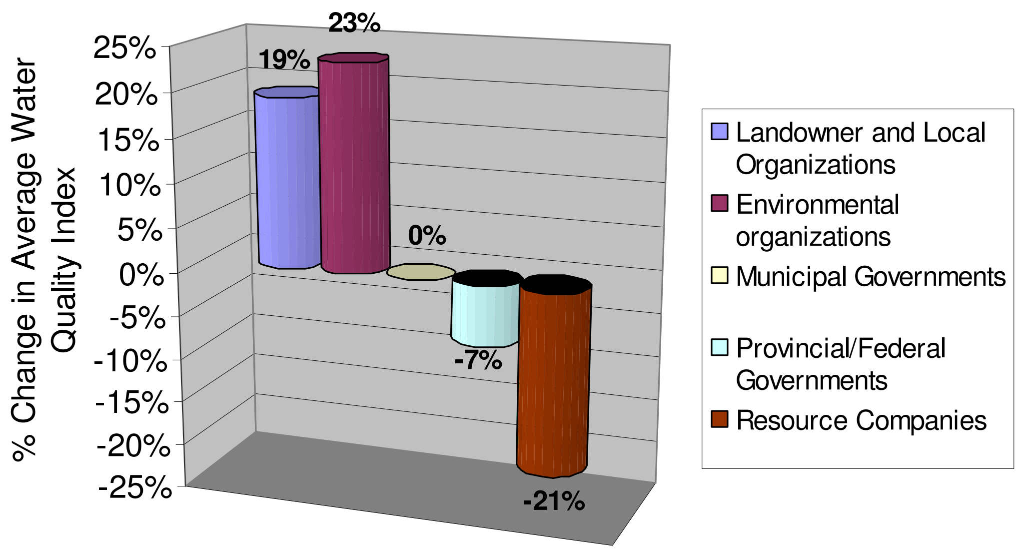
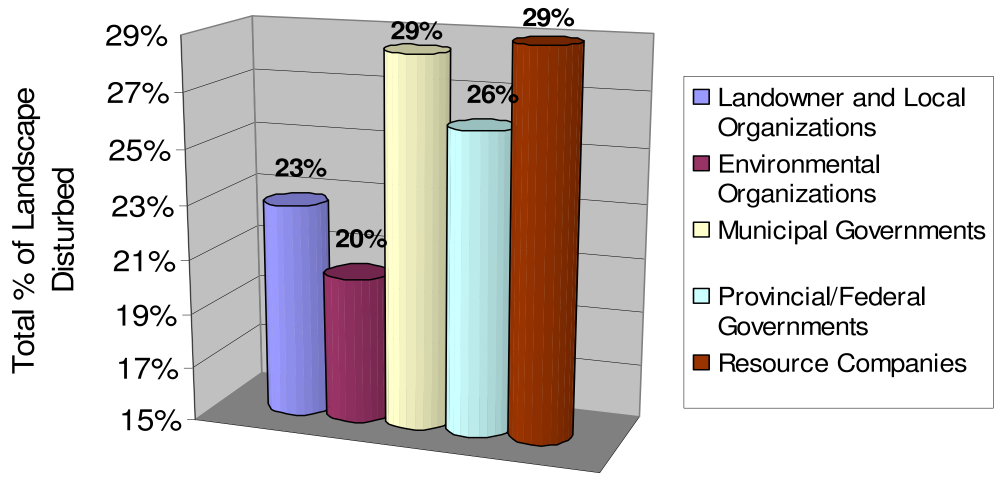


Figure 4.1 shows that for representatives from landowner, local and environmental organizations, thresholds for water quality have already been exceeded. They desired an improvement in water quality from today's levels. The municipal government representatives were not willing to accept a decline in the water quality index, while the provincial and federal government representatives were willing to accept some decline. The resource company representatives set thresholds below current water quality index levels.

Total Landscape Disturbed

The candidate threshold for this indicator was between 20% and 30%. In 2005, 26% of the landscape was disturbed. Nine responses set the threshold for total landscape disturbed at 2005 levels; nine were willing to accept a decline; and two respondents wanted no decline. The range of thresholds values from participants was between 15% to 30% total landscape disturbed. Some participants found this threshold difficult to set as the difference in amount of landscape disturbed between each scenario varied only between 28% and 33%.

Figure 4.2 Mean Threshold for Total % of Landscape Disturbed by Participant Group

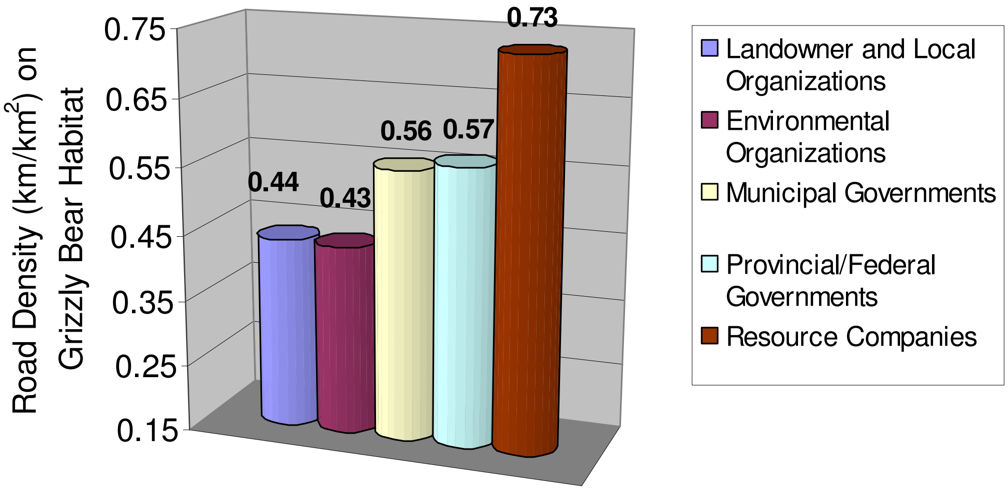


In general, government representatives and resource company representatives expected an increase in the amount of landscape disturbed in order to accommodate future land use activities, as shown in Figure 4.2. On average, the representatives from landowner and environmental groups wanted a decline in the total landscape disturbed from 2005 levels.

Road Density on Grizzly Bear Habitat

The candidate road density threshold for grizzly bear habitat was 0.6 km/km^2. The threshold values selected by respondents were between 0.3 and 0.8 km/km^2. Four respondents were willing to accept an increase of over 0.6 km/km^2; three desired a threshold at 0.6km/km^2; and thirteen respondents desired a threshold value of 0.5 km/km^2 or less. The responses less than 0.6 km/km^2 were based on a precautionary approach. The average of all responses was 0.5km/km^2.

Figure 4.3 Mean Threshold for Road Density on Grizzly Bear Habitat by Participant Group



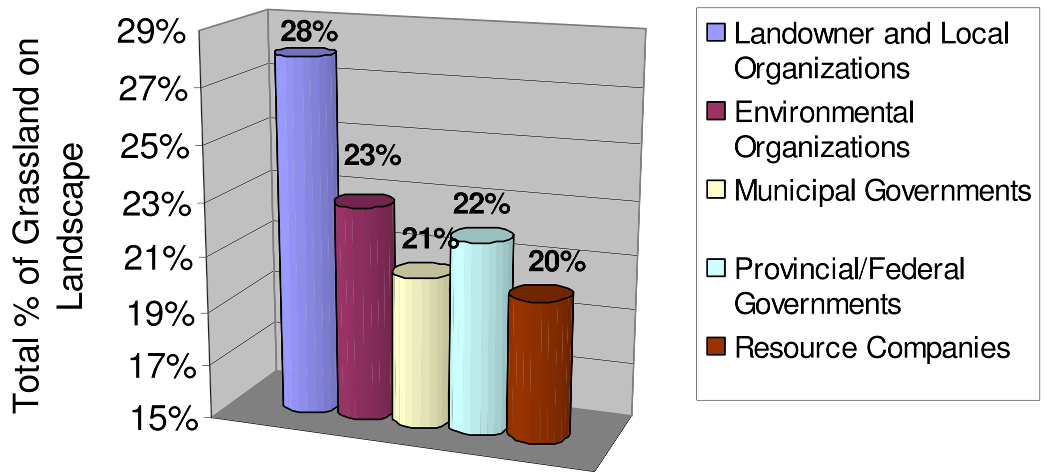
In general, resource companies were more willing to accept an increase in road density on grizzly bear habitat in exchange for land use activity, as shown in Figure 4.3.

Total % of Grassland on Landscape

The threshold values for this indicator selected by participants ranged from 20% to 40% grassland on the landscape. Representatives from landowner and local organizations desired an increase in the amount of grassland on the landscape. Six participants set their thresholds for grassland at the current level of 22% of the landscape. This is consistent with the candidate threshold of no loss of grassland. Eight participants desired an increase in grassland on the landscape. Six participants were willing to accept some loss of grassland.

It was suggested that the fescue grassland indicator should include a measurement of the health, functionality and extent of invasion of non-native species onto the grassland.

4.4 Mean Threshold for Total % of Grassland on Landscape by Participant Group



Grassland is a more important component of the landscape for representatives of landowner and local organizations than for any other group, as shown in Figure 4.4. They desire an increase in grassland in the future, while the other groups set the threshold at 2005 levels or accepted some decline.

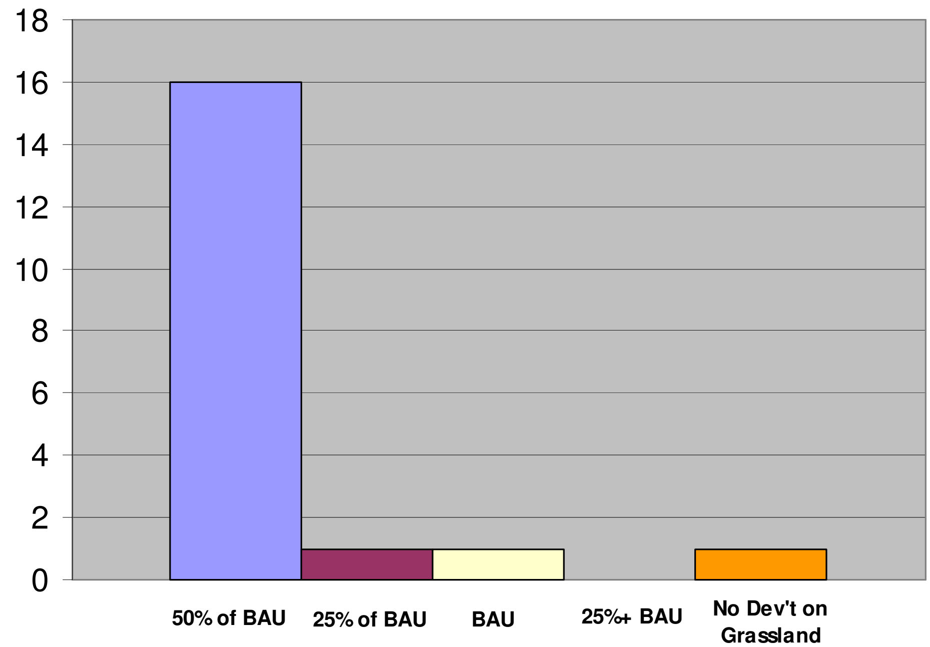
4.3.4. Comparing the Scenarios: The Decision Matrix

A decision matrix was provided in Part B of the survey so that participants could evaluate all scenarios against each other, while considering their selected threshold values. After completing the decision matrix, participants were asked three additional questions:

1. Please explain if you agree or disagree with the most desirable scenario determined through the decision matrix? Describe your desirable scenario.
2. What more information do you need to make a decision on an appropriate threshold for each indicator?
3. How might we ensure that we do not exceed the thresholds?

The results from the decision matrix are shown in Figure 4.5.

Figure 4.5 Most Desirable Scenario (as selected through decision matrix, 19 completed, one did not complete the decision matrix)



One participant did not fill out the matrix but did respond to the questions and stated that the components of value on the landscape are not reflected in numbers on tables and graphs.

Although the majority of participants felt that Scenario A was the most desirable, many of them also expressed that it was simply the "least worst" option. One person suggested that a scenario with 75% of BAU may be the most desirable future. At least nine of the 16 participants that selected Scenario A argued that a reversal of trends for the indicators is desirable, something not achieved by the land use growth rate in Scenario A. The other five participants agreed that Scenario A was their "most desirable." One participant observed that "none of the scenarios permit the improvement of any indicators and confines us to trajectories where they decline" (Participant C). Government and industry representatives were less likely than the other participants to say that Scenario A was feasible, citing economic and social issues such as current development policies and maintenance of standard of living.

One participant felt that residents' standard of living would be reduced by restricting the land use activity and footprint, while another felt that protecting ecosystem components would improve it. One participant, for instance wrote: "Certainly the most desirable scenario is one that maximizes our clean water and environmental assets, not just because it's nice to have them, but because these are the assets that will support our standard of living in the next few decades" (Participant D). On the other hand, another participant felt that too much and too little development would negatively affect our standard of living. Too much growth might exceed the availability of labour forces or infrastructure. Restriction on land use growth might mean a loss of jobs and economic revenue from the production of commodities.

4.3.5. Information Needs

Some participants felt a need to understand more about the current baseline values, such as how the water quality index relates to the Alberta Water Quality Guidelines. Others wanted to know more about the level of indicator performance within particular areas in the region. As the values are averaged over the whole study area, the differences between areas that have more or less development are masked. Two participants wondered if all the ecological indicators decline in a linear form or if there are any "tipping points" in the ecosystem. A couple of participants expressed a need to understand the ALCES model and the detailed information behind the projection of land use change.

Three participants stated that there was enough information from the model and from scientific sources to set thresholds. These participants were satisfied with the information on ecological indicators because they are the factors of most concern and of most value to them. One participant stated that the ecological bottom lines are clear, but wondered what amount of deviation from these would make significant changes in other values (such as economics).

Five participants argued that choices will need to be made of one type of activity, or ecological, social and economic value, over another. For the representatives from landowner, local and environmental organizations, economic factors were less important to them than ecological ones. Government and industry representatives requested information about economic indicators. Although given the opportunity, only one participant added the amount of growth in a land use footprint into the decision matrix.[7] In post-workshop interviews, other economic indicators were mentioned: amount of ecotourism, the economic value of undisturbed natural resources, cost of water treatment, number of cattle per acre, carbon value of grassland, and land prices.

[7] The participant set a limit for the total footprint of the residential sector.

Three participants expressed the desire to restrict some land uses over others. This implies there may be some land uses that are more desirable than others. One participant suggested conducting a life cycle assessment of different land uses to determine the net economic, social and environmental benefits of each. Another wrote: "I would like to explore scenarios in which sustainable land uses and those with positive contributions to ecological goods and services are encouraged to grow while non-sustainable land uses or those with negative ecological goods and services are discouraged/restricted" (Participant B). Land uses could be evaluated based on benefits and costs per unit of disturbance. This would include an evaluation of aesthetics, reclamation rates, contribution to the economy, and environmental impact.

The pace of land use development was raised on several occasions. Should development be permitted until thresholds are exceeded or should we reduce the pace of development to ensure we expand the length of time before the threshold is reached?

One participant raised questions about who should be making decisions on appropriate thresholds valued (i.e. whose views and values were important in order to set thresholds.) Should thresholds be set by residents, those with financial interest, Albertans, or all Canadians?

4.3.6. Thresholds Implementation

Participants were given the opportunity to consider how thresholds could be respected, such as through a reduction in activity, production or different practices.

The responses to the question "How might we ensure that we do not exceed the thresholds?" were varied. Some of the suggestions included:

- Public education.
- Political will.
- Monitor indicator levels over time.
- Oil and gas exploration "time out."
- Attach an economic value for ecological goods and services.
- Adopt best practice standards by all industry.
- Reduce the production of commodities.

- Reduce the footprint of development per commodity unit.
- Accelerate reclamation.
- Increase industry cooperation to reduce footprint.
- Align incentives and regulation to keep below the threshold.
- Shift the land use mix; prioritize land uses from low value land uses to high value land uses.
- Slow down the growth rate of land uses.
- Prevent the subdivision of land in rural municipalities.
- Develop new "best practices."
- Implement a tradable land rights system.

4.4. Evaluation of Workshop Process and Recommendations

The research and workshop were a compressed version of what could be conducted through a land use planning process. Defining thresholds should be done over several months and developed through many meetings. As was done in this research, the first steps in setting threshold values should be to review the concept of thresholds, allow participants to rank the importance of indicators, present research on candidate thresholds and identify information needs. From this research, several recommendations for developing and applying thresholds through land use planning can be made.

Within such a multi-stakeholder group as the Southern Foothills Study Advisory Group, open discussion is critical. Participants appreciated the opportunity to hear others' perspectives and to have an open discussion about how thresholds could be developed and implemented to manage cumulative effects. Several participants said they were leaving with a renewed sense of optimism and urgency for the need for land management. Other participants expressed the desire to strengthen relationships and communication among land users as they felt that their land use sector was often misrepresented and unduly blamed for land use impacts. The differences among participants' views were tempered through open discussion of threshold values. It appeared that in the public forum, participants were willing to listen and cooperate with each other. This gives justification for making such processes open and transparent, allowing lots of discussion in order to bring participants' views closer together, if not achieving consensus.

To further evaluate the economic and social implications of setting thresholds, representatives from land use sectors could be asked to reflect on how their land use sector would adapt to respect the thresholds. They could be asked how it might affect the pace, scale and intensity of the development of their sector. After this reflection, each sector could come back to the group to present the implications of setting thresholds on their sector.

Scenarios of alternative development that restrict some land uses over others could be developed to look at the relative ecological impact of each land use. While this method may be controversial, it would help to begin discussion about which land uses have the most economic benefit and least ecological impact. It would also highlight which land use sectors would be most affected should thresholds be set.

The evaluation of different land uses may be limited by conventional measurements of economic wealth. Several respondents expressed a desire to understand the economic value of preserving ecological goods and services and maintaining culture. The valuation of ecological goods and services and consideration of alternative economic models such as the genuine progress index (GPI) are two areas where further research is warranted.

Economic indicators need to be explicitly included in the evaluation of alternative scenarios. Economic indicators are difficult to set for this area because, as shown by the pre-workshop survey, they have different implications for different people. Some represent economic gain, while others represent environment impact or loss of ecological values. The implications of economic indicators and their connection to other indicators must be evaluated (i.e., infrastructure, the cost of living, recreational opportunities, health care etc.).

To incorporate economic indicators, one would have to consider which indicators have significance to different sectors of society: residents, land users, levels of government, and at what scale: regionally, provincially, nationally, and beyond. The renewable or non-renewable resources of this region have value to people beyond the study area. For example, while the production of oil from a well may have economic value to the landowner (e.g., surface access payments) it has greater value in terms royalties to government, profit to the company's shareholders, and as an energy source for consumers in Alberta, Canada and the United States.

Once some economic indicators are included in the scenarios, an open plenary discussion of economic, social and ecological tradeoffs should occur. Questions could be asked about what tradeoffs in economic and social outcomes might need to be made to respect ecological thresholds. Alternatively, "Would a reduction in commodity production be accepted in order to respect the thresholds?" This discussion would allow participants to learn from one another and come to common understanding about the implications of setting thresholds.

Threshold values for the valued components need to be set at a smaller scale than the whole Southern Foothills Study area. While the regional analysis is useful to evaluate thresholds strategically, the scale at which the threshold is set should depend on the scale that is meaningful to the indicator. For instance, a watershed scale (i.e., a drainage basin based on topographical features) for total landscape disturbed may be more meaningful to water quality and quantity. The road density on grizzly bear habitat may be best set at the scale of the average home range of grizzly bears. Threshold values may differ between areas depending on the amount of human activity, residency, and present indicator values.

The creation of the Southern Foothills Study is evidence that ecological change may have already exceeded social acceptability for some people. The workshop provided the opportunity for stakeholders to look at the end result of land use change and discuss possible bottom lines for the degradation of ecosystem components. This is the opposite of current land management practices in which the continued decline of ecological indicators has not been tested against social values. An effective process for setting thresholds should consider science, public values and a clear understanding of the tradeoffs among ecological, economic and social factors given different threshold levels.

5. Implementation of Thresholds-Based Management of Cumulative Effects: Recommendations and Conclusions

5.1. Introduction

> *Limits must be in place before any development is considered. These limits should be clear, transparent and politicians must be held accountable for their policies. There must be a process in place for meaningful public involvement. What is not acceptable is for the Province to continue down the path of NO PLAN, NO VISION & NO ACCOUNTABILITY.*
>
> Comment from the results of the public workbook survey on Alberta's Land Use Framework (Alberta Government 2007).

The purpose of this chapter is to make explore how thresholds could be implemented in the Southern Foothills given Alberta's current and proposed land management processes. The history of land management in the Southern Foothills is followed by a description of recent Alberta Government initiatives to address the cumulative impact of land use changes. The drivers and barriers to applying thresholds in Alberta are presented. Overcoming these barriers requires building acceptance of the value of setting thresholds, examining the implications of thresholds application, and ensuring stakeholder involvement. Thresholds are best implemented within a cumulative effects management framework, through land use planning and integrated decision-making. Final conclusions are provided on thresholds-based management of cumulative effects within Alberta and specific to the Southern Foothills.

5.2. History of Resource Management in the Southern Foothills

Between 1948 and 1973, through joint Federal-Provincial legislation, the Eastern Rockies Forest Conservation Board was created as the main planning agency for the Eastern Slopes (of which the southern portion includes the Southern Foothills). The area was then called the Rocky Mountains Forest Reserve and was specifically recognized as "being the headwaters of the Prairie Provinces" (Alberta Government 1977). In the 1970s, the Alberta Government conducted two land use studies in the Eastern Slopes, initiating a comprehensive land use planning process. A series of public hearings were held in 1973 to discuss land and resource use activities in the region (Alberta Government 1977). The Environment Conservation Authority, the organization responsible for conducting the hearings, submitted 232 recommendations to the Alberta Government a year later (Ibid.).

As a result, the Alberta Government released "A Policy for Resource Management in the Eastern Slopes" (Eastern Slopes Policy) in 1977, announcing a policy of multiple use and integrated land management for the region (Alberta Government 1977). The Policy recognized that the resource base of the Eastern Slopes was limited and outlined land use zoning for the region, guided by key priorities for the area. The highest priority was placed on watershed protection. Other priorities were recreation and aesthetic quality, wildlife habitat, protected areas, and renewable resources (Alberta Government 1977). In 1984, the Policy was revised with a less direct focus on watershed protection and more emphasis on integrated resource management (Alberta Government 1984). Integrated resource plans (IRP) for sub-regions of the Southern Foothills were developed in the mid 1980s to refine the zoning proposed in the Eastern Slopes Policy. They were completed for the Livingstone-Porcupine, Castle River, Crowsnest Corridor and Kananaskis Country areas.

In 1993, an information letter (IL 93-09) was developed by the Energy Resources Conservation Board (now the Alberta Energy and Utilities Board) to guide oil and gas development in the Southern Foothills. The letter was written to address the deficiency of single project-based assessment and the need for cumulative effects assessment in recognition of the special environmental value of the region as expressed in the 1977 and 1984 Eastern Slopes Policy. The letter requires petroleum operators to disclose the full extent of proposed development, "to avoid piecemeal proposals and to ensure that the overall scope and potential impacts of the development, if permitted, are clearly understood" (Alberta Energy and Utilities Board 1993:1). The information letter was considered progressive yet controversial (Bannister 2007, pers. comm.). In October 2007, the EUB issued a Bulletin clarifying the intent and guidelines in IL 93-09 and announced a stakeholder engagement process to discuss the development of oil and gas resources in the region (Alberta Energy and Utilities Board 2007).

The Eastern Slopes Policy, the integrated resource plans, and IL 93-09 are among the only land use policy documents for the region, and are still used in project reviews and to guide the issuance of mineral rights (Alberta Energy and Utilities Board 2000; Alberta Energy 2007). In

2000, in a decision report on the application to develop sour gas well facilities in the Castle River area, the AEUB wrote:

> The Board notes that both the public and the industry participants took a common view that it was possible or even likely that the biological thresholds for at least some key species identified as important in the IRP may now have been exceeded in the region. This would appear to strongly suggest that the current publicly available planning tools for the region may now be outdated and inadequate to address the current level of development (Alberta Energy and Utilities Board 2000:10).

The Board goes on to explain that without these threshold values, the acceptability of incremental impacts of individual projects and appropriate mitigation actions to address cumulative effects are difficult determine (Alberta Energy and Utilities Board 2000).

The multiple-use and integrated resource management (IRM) philosophy that shaped land management in Alberta has been widely criticized (Kennett 2002; Kennett and Wenig 2005; LUCAT 2002). Critics suggest the reasons for the failure of IRM include: the lack of provincial land use vision; little means of enforcement and monitoring of land use policies; the absence of a legal framework for implementation; and the lack of political or financial commitment to land use planning (Kennett 2002; LUCAT 2002; Davidson and MacKendrick 2004). The multiple use approach failed to recognize that tradeoffs must be made between environmental, social and economic factors. A multiple use approach assumes “we can have everything, everywhere, all the time” (Stelfox 2006) and includes no measurable objectives or goals to guide land use decisions and determine the appropriate levels of cumulative impact. IRM policies did little to deal with increasing land use conflicts or change the structure of decision making in Alberta. In the 1990s, the Alberta Government sought to redefine integrated resource management, by emphasizing sustainable development, an ambiguous term popular on the international scale, while at the same time touting the “Alberta Advantage,” a philosophy in support of ‘neoliberal’ economic policy (Davidson and MacKendrick 2004). Integrated resource management discourse allowed the Alberta Government to continue the development of the province’s resources without significant institutional restructuring (Ibid).

In the late 1990s, the Alberta Government released its Sustainable Resource and Environmental Management (SREM) initiative, a commitment between the three Ministries of Energy, Sustainable Resource Development, and Environment to work together, align policies and share information. In that document, the Government asserted that "environmental decisions will take into account economic impacts and economic decisions will reflect environmental impacts" (Alberta Government 1999:4). In 2006, under the SREM banner, the Government announced its intention to develop the Land Use Framework (LUF), led by Alberta Sustainable Resource Development, with the cooperation of six other government ministries.[8] The Framework was initiated in recognition that "Alberta is experiencing unprecedented activity on our land. Alberta's land and natural resources have limits—we need to look at the future and how we will balance all the competing demands for our land and our natural resources" (Alberta Government 2007). The Framework will define a new approach to manage Alberta's public and private lands and resources and is expected to be completed in early 2008 (Ibid).

In October 2007, Alberta Environment released a policy paper for a new regulatory framework for cumulative effects management. In what is termed "results-based approach to environmental sustainability," the framework proposes to have objectives for environmental quality set geographically at different spatial scales across the province. The objectives would be based on knowledge about the environment, impact of human activities and social values. As in thresholds-based management, indicators would have to be set and defined for each objective in order to monitor progress towards the objectives. Strategies for achieving the objectives would be defined through regulation, policy, education and voluntary agreements. To complement the framework, the Alberta Government will also introduce new legislation for cumulative effects management (Alberta Government 2007).

5.3. Drivers and Barriers to Thresholds Implementation

There is growing interest in thresholds-based management of cumulative effects in Alberta. This is evident by the growing body of literature and public discourse about the need to set limits on the amount of human land use activity and development for environmental protection reasons (Alberta Government 2007, 2007; Obad and Cross 2007). As mentioned in Chapter Four, many

[8] The ministries working on the Land Use Framework are Alberta Sustainable Resource Development, Alberta Agriculture and Food, Alberta Energy, Alberta Environment, Alberta International, Intergovernmental, and Aboriginal Relations, Alberta Municipal Affairs and Housing, and Alberta Tourism, Parks, Recreation and Culture (Alberta Government 2007).

stakeholders in the Southern Foothills feel the amount of change to ecosystem components has already exceeded social acceptability.

The Alberta Government conducted a public survey on land management issues for input to the Land Use Framework. The majority of respondents were in support of setting limits to development, especially for environmental protection, as shown in Table 5.1.

Table 5.1 Public Opinion on Limits to Land and Resource Use from Alberta's Land Use Framework Public Survey

Topic/ Statement	Response/Results
Willing to accept limits to different land uses (energy, residential, agriculture, forestry and recreation) in exchange for watershed protection and protected areas.	Between 66% and 73% of respondents (depending on the land use)
Agreed with the statement that the balance between developing land and conservation is "too focused on economic development and growth."	74.3 % respondents
Agreed somewhat or strongly with the statement: "Balance intensive development in one area by limiting development and use in another area."	~ 60% of respondents
Agreed with the statement: "Set limits for growth and resource development."	Over 80% of respondents
Agreed with the statement: "Consider cumulative (combined) effects on the environment when reviewing new development applications."	95% of respondents
Agreed with the statement: "I would be willing to restrict some activities on the land in order to meet a land use objective."	82% of respondents

Source: (Alberta Government 2007:18-39).

The Alberta Government's proposed regulatory framework for cumulative effects management states, "they [Albertans] recognize that there are environmental limits and pushing those limits can result in significant impacts to our environment, our way of life, and our quality of life" (Alberta Government 2007:4). The Framework mentions the need to identify environmental thresholds, and to determine their acceptability by balancing environmental, economic and social values (Ibid).

While the government and public recognize the cumulative impact of human activities and limits to the ecosystem, there still exists a reluctance to set thresholds. A common concern is that setting thresholds will ultimately limit development activities and therefore economic opportunities. This perception, real or imagined, is a barrier to setting thresholds. Respondents to the Land Use Framework public survey cited concerns that limits might "serve as disincentives to development and fuel conflict" (Alberta Government 2007:23). Respondents also felt that limits would not be appropriate if they: were a result of pressure from one sector of society; were set without full public consultation; created hardship for communities; dramatically slowed economic growth; or infringed on individual's property rights and people's ability to earn a living (Ibid). Some participants of the Southern Foothills Study thresholds workshop were uncomfortable with the idea of setting thresholds based on social values. These participants argued that scientific certainty should exist before thresholds are set.

Overcoming Barriers

Listed in Table 5.2 below are the barriers to thresholds implementation (categorized as technical, political and administrative) and some strategies to overcome these barriers. The strategies are explained in further detail in the following section.

Table 5.2 Strategies to Overcome Barriers to Thresholds Implementation

Barrier Category	Barriers	Strategies to Overcome Barriers
Technical	Lack of scientific certainty about cause and effect relationships. Lack of site specific information.	Acknowledge that setting thresholds are partly social and political decisions. Monitoring and adaptive management. Model a range of possible futures rather than one most likely future.
Political	Perception that thresholds are a barriers to development, infringe on property rights, etc. Differences of opinions on how cumulative impacts should be managed. Concern that thresholds will be set by one interest group.	Model alternative scenarios of development to understand the implication of setting thresholds. Emphasize the positives of thresholds implementation. Multistakeholder approach to decision making. Legal framework for thresholds implementation making clear roles and responsibilities.

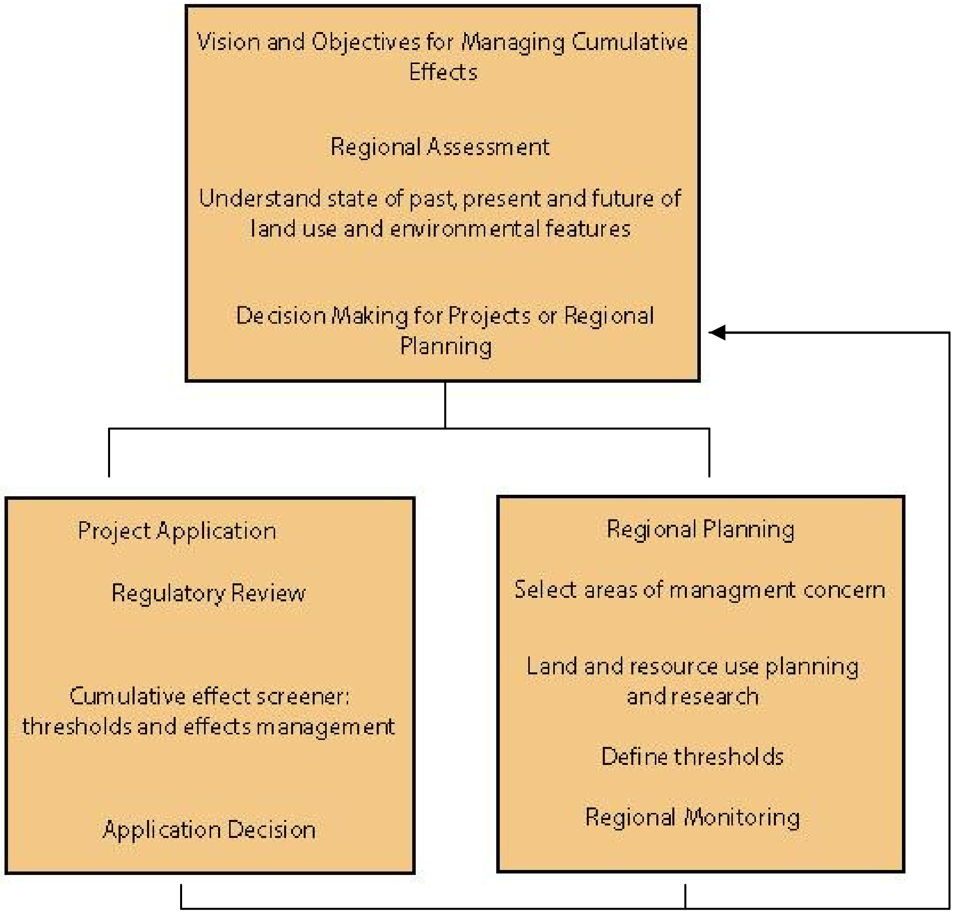
Administrative	Thresholds favour operations approved early. Lack of integration between government agencies. Thresholds are administratively difficult and onerous. Concern that new regulatory controls will act as disincentives to industrial development.	Tiered thresholds can make clear the actions associated with threshold levels. Time-bounded thresholds may govern the rate of change and pace of development.

5.4. Approaches to Thresholds Implementation

5.4.1. Cumulative Effects Assessment and Management Framework

Thresholds can be applied through a cumulative effects assessment and management (CEAM) framework, as has been proposed for northeast British Columbia (AXYS Environmental Consulting Ltd. 2003). The framework involves a dual-track approach to cumulative effects management: through project specific reviews and regional planning. The CEAM Framework, as shown in Figure 5.1, is intended to coordinate the pace and amount of land use activity through the integration of various initiatives and decision-making processes.

Figure 5.1 Cumulative Effects Assessment and Management Framework Decision Making and Information Flow



Source: (Adapted from AXYS Environmental Consulting Ltd. 2003: 4-49).

Thresholds are a central part of the Framework; "The collective contributions of human activities are compared to thresholds, which if exceeded, result in adjustments to projects, implementation of regional initiatives, and possibly, the temporary or indefinite rejection of projects" (AXYS Environmental Consulting Ltd. 2003:iv). Individual project assessments are screened for their potential contribution to cumulative effects, as a first stage of review. If a threshold level is exceeded, the project proceeds from a routine screening to an expanded level of review. The project's applicant(s) may be asked for more information and to implement additional mitigation measures before a decision on whether to approve the project or not.

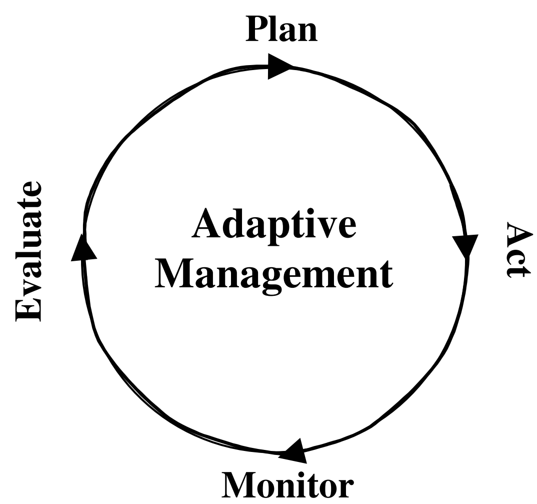
At the regional level, land use and resource use planning can be used to focus on the long-term sustainability of resources, land and communities (Kennett 1998). Comprehensive planning should set goals, strategies and objectives in a proactive manner. Planning should formalize the roles of decision makers and the processes for public input. Within land use planning, applied landscape ecology research, ecological response studies, future scenario modeling and monitoring can contribute to defining thresholds. Systematic monitoring should occur continually at both the project and regional levels to update information on human land use activities and cumulative effects.

The Alberta Government's proposed cumulative effects management framework and the Land Use Framework have the potential to be built into a comprehensive CEAM framework as outlined above. The objectives described in the proposed policy are akin to thresholds. Guided by the Land Use Framework, thresholds could be geographically specific, measurable and quantitative levels of acceptable environmental quality. In the Southern Foothills, regional planning would be the best forum to determine thresholds for the management of cumulative effects.

5.4.2. Adaptive Management

The monitoring of cumulative effects and threshold values can feed into an adaptive management process, a cyclic process of modifying an action based on new information. Adaptive management "incorporates research into conservation action. Specifically, it is the integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn" (Salafsky, Margoluis, and Redford 2001). The stages in adaptive management can be simplified into plan, act, monitor, and evaluate. Adaptive management is a way for decision makers to experiment with policies and learn from the results, see Figure 5.2.

Figure 5.2 Adaptive Management Cycle



Source: (Adapted from Stankey, Clark and Borman 2005:4).

Using adaptive management, lack of scientific certainty no longer needs to be a barrier to thresholds implementation. Threshold values could be set at a precautionary level and revised as new information arises. Monitoring can occur over time to determine if land use activity is having the anticipated effect on valued components (Stankey, Clark, and Bormann 2005). Monitoring is most effective when reference conditions are defined for comparison.

5.4.3. Regional Land Use Vision and Objectives

A regional land use vision and objectives, critical components of a land use plan, are missing to guide threshold development for the Southern Foothills. The vision and objectives make clear the valued components, acceptable rates of change and desirable future conditions. Thresholds should be quantitative measurements defined to fulfill the vision and meet those objectives. Since the Southern Foothills Study began as an educational and scientific study and is without mandate for land use planning, the vision and regional objectives are missing to aid in the development of thresholds. As a result, this research was guided by the Southern Foothills Study's selection of valued components, interviews with experts and a literature review. The discussion of a land use vision, objectives and thresholds would help to determine the boundaries of acceptability, from what is most desirable to least acceptable. The boundaries of acceptability need to be defined because "too little change in conditions may be unacceptable just as too much change" (Brunson 1998:46). As in the limits of acceptable change methodology, the maximum and minimum amounts of change need to be defined in areas with many land uses.

Regional land use planning requires a visioning process. A visioning process can help to clarify which land uses are appropriate and which components of the environment are most important. Visioning can help stakeholders determine their common ground and identify differences of opinion. The limits of acceptable change methodology suggests that an ultimate constraining goal should be defined; the most valuable component on the landscape that supercedes all others. The lowest acceptable level of that component would need to be defined and the performance of this component would be a constraint to all other goals. To do this, the ranking of valued components is necessary. In the Southern Foothills, this ultimate constraining goal is likely water. If so, all land use decisions would be subject to ensure this component is respected first and foremost.

5.4.4. Conceptual Frame for Thresholds

The conceptual frame with which the concept of threshold is communicated must be carefully considered to overcome political barriers to thresholds implementation. Thresholds should not be framed as a moratorium, or a restriction on personal or business rights. Rather, the positive aspects of thresholds should be emphasized: the potential to manage cumulative effects; to encourage innovation; to balance development and conservation; and to ensure generational equity. As in northeastern B.C., the term threshold may be dropped altogether in exchange for a term like management target. The term target may be more politically palatable but it may also have a slightly different meaning. A threshold represents the furthest point from the highest quality that is acceptable; the point at which a component passes established criteria; or the point at which it is no longer present on the landscape. Targets on the other hand, are desired goals, something to be reached for and achieved. The risk is that the term threshold could be misinterpreted as desirable, when it may mean a point that we should avoid by managing human action (Francis and Dyer 2006). Clear definitions of target, threshold, objective, etc. should be used at all times.

In the Southern Foothills, the term target may be more appropriate given that many stakeholders' desire an improvement in indicators from the current level. The term target may help to make the distinction that the target level is defined by social values, as well as science.

5.4.5. Administration of Thresholds

The general approach to thresholds administration is to continue to approve developments through conventional regulatory processes up to the threshold value (Kennett et al. 2006). The "first in time, first in right" principle may seem to prevail. The older operators in an area have precedence over newer ones. As Zeimer (2004) writes "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). Once the threshold is reached, the risk is that the pressure to continue business-as-usual land use practices results in the revision of the threshold so that it is no longer a restriction to development.

The tiered threshold approach has been recommended for implementation in British Columbia and the Northwest Territories. It involves setting strategies and actions associated with varying threshold levels. The levels of thresholds, cautionary, target and critical correspond to different and more stringent levels of assessment as the critical threshold is approached. The tiered threshold approach makes clear the actions associated with different threshold levels, which can provide certainty of access and transparency in decision-making for land users. The tiered threshold approach is outlined in Chapter Two (*Section 2.6.2*).

Thresholds implementation could also be time-bounded. Desired rates of change to an indicator could be determined and management strategies employed to achieve this. This approach may be especially useful if the threshold requires the improvement of an indicator from current levels. This approach would also avoid the situation where thresholds are seen as far away restrictions that have no effect on current practices. The pace of development and the amount of landscape disturbance could be managed by determining an appropriate rate of change to key indicators.

A tradable land rights system can complement thresholds implementation. Under such a system, the thresholds would provide the limit to land disturbance. Land would be allocated up to that limit as a tradable right. Once the threshold is reached, new operators would have to trade land rights with another operator or reclaim a previously disturbed site (Weber and Adamowicz 2002). This system also provides an incentive to use best practices and accelerate reclamation, and coordinate between land users to reduce the overall footprint of disturbance. The system does not determine the exact locations for development, as long as the cumulative total does not exceed the threshold. As such, ecologically or culturally sensitive places would need to be set aside as protected areas in advance of issuing the tradable land rights. Under this system rights to disturb land would become a scarce resource which would be allocated based on willingness to pay and market values. Generally, available disturbance rights would be allocated to the firms or organizations with the highest willingness to pay (Ibid). Within the tradable land rights system, disturbance will occur in areas with higher development potential and by land uses that generate greater expected returns. Environmental and social impacts (for example preservation of First Nations rights) would be managed through setting the disturbance limit, zoning, and establishing protected areas for ecological and social values.

5.4.6. Decision- Making

Thresholds can have implications to all stages of decision making, from helping to meet objectives at the strategic level in land use planning, and to informing rights disposition, to determining significance in project-based cumulative effects assessments. Necessary to thresholds implementation is the integration of decision-making at all stages and among all agencies with land and resource management responsibilities. Part of this is achieved through a cumulative effects assessment and management framework. A single land and resource use agency could be developed in Alberta, with oversight for the land use framework, regional land use planning, project-specific environmental assessment review and dispositions. An example of this is the Integrated Land Management Bureau in British Columbia, a cross-ministry organization responsible for managing land and resource use on crown lands. The Bureau administers land tenure, permits and sales; maintains a repository of natural resource information; conducts species-at-risk recovery planning; and develops regional land and resource use plans (Government of British Columbia 2007).

Ensuring that all stakeholders are involved in defining and negotiating threshold values will ensure greater buy-in and acceptance of the thresholds. Thresholds implementation requires participation from government, industry and individuals; “Implementation is a shared responsibility that will be most effective when indicators and limits are accepted as both reasonable and based upon accepted science and traditional knowledge” (Salmo Consulting Inc. et al. 2004:vi). A modeling exercise can be very valuable, as in the Southern Foothills Study, to provide a focus for discussion. The importance of discussions between stakeholders cannot be understated. A multistakeholder process can be used to build greater understanding and appreciation by land users of their respective contribution to cumulative effects and the implications of setting thresholds. Rather than seeking to set blame, effective stakeholder engagement processes should emphasize the collective effort of all parties.

In setting thresholds, a multistakeholder process does not necessarily need to employ a consensus model. A multistakeholder process can seek to achieve agreement and with government commitment to set threshold levels even if consensus is not reached. The threshold values should be considered acceptable by the majority of people in the planning area. Some diverging opinions are an inevitable part of a discussion on thresholds and tradeoffs.

Thresholds implementation through land use planning could be formalized into law. Government responsibility and accountability for defining thresholds would then have legal force. The law can also help to structure decision making by making clear the relationships between decision makers and the stages of decision-making. Laws can help to define rights, obligations, standards and rules of conduct for industry, government and individuals (Kennett 1998).

5.5. Conclusions

Applying thresholds through land use planning is a proactive approach to cumulative effects management. Developing thresholds requires the integration of ecological science and social values. Determined at the regional or sub-regional scale, thresholds can be set to protect ecosystem components for future generations. At the project level, thresholds can provide guidance to decision makers on the significance of a project's contribution to cumulative effects.

Through the application of thresholds we can address not only where development can occur (as in past land use planning initiatives) but how much should occur. Thresholds should be set at the spatial scale relevant to the valued components of concern. If applied over too large an area, the threshold may not have value to the component of concern; applied over too small an area and it may be vehemently opposed as a restriction to development. Different threshold values may need to be applied to different areas. For example, in urban areas, more lenient thresholds may be applied to allow for higher density of residential developments. In the mountainous areas, more stringent thresholds may be required for the protection of water resources.

Overcoming the barriers to thresholds implementation begins with open, transparent discussion and clear mechanisms for implementation. Land use planners and resource managers should be careful in how thresholds are communicated. It should be clear what pushing an indicator beyond the threshold would mean. Alternatively the term target could be used to represent desirable landscape conditions created to achieve a balance between conservation and development.

In the Southern Foothills, the social acceptability of change to water quality and fescue grassland may have already been exceeded. A summary of the recommendations for an effective process to define thresholds are listed in Table 5.3.

Table 5.3 Recommendations for an Effective Process to Defining Thresholds

Recommendation
Define a vision for the future, involving all stakeholders.
Determine valued components and indicators.
Rank valued components to determine a possible 'ultimate constraining goal.'
Model landscape changes to understand the potential impacts of land use activities within a range of possible futures.
Use both science and social values to inform appropriate threshold values.
Ensure all stakeholders are involved in the discussion on threshold levels, scientific evidence, social values and tradeoffs.
In a multistakeholder process, encourage open discussion of threshold values and potential implications to other social, environmental or economic factors.
Use clear definitions for thresholds, targets and objectives.
Set the thresholds at the scale relevant to the ecosystem component.
Set different threshold values for different regions depending upon the desired future landscape conditions.

A good process for determining thresholds must involve the following steps: a landscape vision; ecological and social objectives; participation of all stakeholders; the incorporation of ecological science and social values; measurable and meaningful indicators; research and education on the impact of land uses; and an explicit discussion of tradeoffs. The Alberta Government's new Land Use Framework and proposed policy on cumulative effects management, although in their infancy, contain some of the steps necessary for thresholds implementation.

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Appendix A: Southern Foothills Study Members and Supporters

Southern Alberta Land Trust Society
Pekisko Group
Livingstone Landowner Group
South Porcupine Stewardship Association
Municipal District of Ranchland
Municipal District of Willow Creek
Municipal District of Pincher Creek
OH Ranch
Petro-Canada
Shell Canada Limited
Alberta Wilderness Association
Alberta Environmentally Sustainable Agriculture (AESA)
Oldman Watershed Council
Alberta Native Plant Council
Alberta Sustainable Resource Development
Alberta Energy
Alberta Conservation Association
Environment Canada - Invasive Alien Species Partnership Program
Environment Canada - EcoAction Community Funding Program
Agriculture Canada
Alberta Energy and Utilities Board
Nature Conservancy
Southern Alberta Sustainability Community Initiative (SASCI)
Yellowstone to Yukon Initiative
Priddis Millarville Ratepayers Association
Town of Nanton
Win Energy
Compton Petroleum

Southern Foothills Study Contact Information:

http://www.salts-landtrust.org/sfs/

salts_ed@shaw.ca

Appendix B: Key Informant Interviews Conducted

Water

Lorne Fitch, Oldman Watershed Council, February 20, 2007

Brian Hills, Sustainable Resource and Environmental Management Coordinator, Alberta Environment, March 2, 2007

John Russell, Biologist/Ecologist and Rancher, March 5, 2007

Barry Adams, Provincial Rangeland Specialist, Sustainable Resource Development, March 9, 2007

Bill Berzins, Chair, Bow River Basin Council, April 9, 2007

David Mayhood, Principal, FWR Freshwater Research Limited, April 18, 2007

Al Sosiak, Bow River Basin Council, April 26, 2007

Grizzly Bears

Gordon Stenhouse, Grizzly Bear Project L,eader, Foothills Model Forest, February 20, 2007

John Russell, Grizzly Bear Biologist and Consultant, March 5, 2007

Mark Boyce, Professor, Biological Sciences, University of Alberta, March 14, 2007

Stephen Herrero, Professor of Environmental Science, (Emeritus), Faculty of Environmental Design, March 29, 2007

Fescue Grassland

Cheryl Bradley, Vegetation Ecologist, Alberta Native Plant Council, February 20, 2007

Lorne Fitch, Oldman River Basin Council, Cows and Fish Program, February 20, 2007

Peggy Desserud, Former Master's student in the Faculty of Environmental Design, March 2, 2007

Marilyn Neville, Principal, Graminea Services Ltd., March 5, 2007

John Russell, Rancher, Biologist/Ecologist, March 5, 2007

Varge Craig, Principal, Alta Rangeland Services Ltd., March 5, 2007

Barry Adams, Provincial Rangeland Specialist, Alberta Sustainable Resource Development, March 9, 2007

Lorna Allen, Senior Community Ecologist, Alberta Tourism, Parks, Recreation and Culture, March 16, 2007

Thresholds Based Management of Cumulative Effects

Heidi Weibe, Executive Director, Dehcho Land Use Planning Committee, March 5, 2007.

Wayne Sawchuk, Board Member, Muskwa-Kechika Advisory Board, April 4, 2007.

Terry Antoniuk, Principal, Salmo Consulting Inc., April 26, 2007

Ken Banister, Section Leader, Environmental Services, Alberta Energy and Utilities Board, March 7, 2007

Shawn Francis, Land and Resource Planner, North Yukon Planning Commission, March 20, 2007

Appendix C: Thresholds Workshop Participants

Pre-Workshop Survey

Neil Darlow, Yellowstone to Yukon

Dylan Adderley, Nature Conservancy

Representative from the Alberta Energy and Utilities Board

John Blake, Town of Nanton

Cheryl Bradley, Alberta Native Plant Council

Nigel Douglas, Alberta Wilderness Association

David Green, Southwest Alberta Sustainability Community Initiative (SASCI)

John Lawson, Livingstone Landowner Group

Representative from Petro-Canada

Ted Smith, Municipal District of Pincher Creek

Nicholas Worthington, Priddis Millarville Ratepayers Association

Workshop Participants

Representative from Agriculture Canada

Lorne Fitch, Oldman Watershed Council

Representative from the Alberta Energy and Utilities Board

Cheryl Bradley, Alberta Native Plant Council

Dylan Adderley, Nature Conservancy

Michael Alexander, Alberta Sustainable Resource Development

Greg Brkich, Municipal District of Ranchland

Nigel Douglas, Alberta Wilderness Association

Alan Gardner, Southern Alberta Land Trust Society (SALTS)

Francis Gardner, Pekisko Group

David Green, Southern Alberta Sustainability Community Initiative (SASCI)

Steve Kennett, Pembina Institute

Representative from Petro-Canada

Bruce Mowat, Livingstone Landowner Group

William K. Newton, South Porcupine Stewardship Association

Raymond Nadeau, South Porcupine Stewardship Association

Ted Smith, Municipal District of Pincher Creek

Brad Stelfox, Forem Technologies

Joe Stepaniuk, Win Energy

Representative from Compton Petroleum

Appendix D: Pre-Workshop Letter and Survey

June 26, 2007

Hello Members of the Southern Foothills Study,

I have been researching the development and use of thresholds as part of managing cumulative impacts of landscape change in the Southern Foothills.

A threshold "is a technically or socially-based standard that identifies the point at which an indicator changes to an unacceptable condition" (Salmo Consulting Inc. 2006).

I am developing a workshop to be held later in the summer, to explore the implications of setting thresholds on ecological, social and economic change for the Southern Foothills. This work builds on the ALCES modeling.

This work is part of my graduate studies in environmental science at the Faculty of Environmental Design, University of Calgary. I am asking for your participation to assist me in this research. There are four components to participation: pre-workshop short survey (15 minutes), a focus group discussion (during a workshop approx. 10 am to 5 pm), a survey (during workshop) and a follow-up interview (20 minutes). Participation will be an opportunity to learn about and provide input on thresholds to manage cumulative effects in the Southern Foothills Note: some costs for the workshop will be covered for participants from non-profit and landowner organizations.

Prior to the workshop, I am developing alternative scenarios of development for the Southern Foothills that are informed by my research on thresholds.

I need your help to develop the workshop materials and methods.

The workshop will be most effective if it is tailored to meet your needs. Please fill out the attached table by identifying your level of concern and understanding of ecological, land use, economic and social indicators. The selected indicators will be used to compare alternative scenarios of development in the workshop.

As a university researcher, I am also required to have you complete the attached ethics consent form that will give me permission to use your responses in my study.

If you are willing to participate, please submit the table below and ethics form to me by July 9, 2007.

Please contact me with any questions you have- by email pmcholro@ucalgary.ca or phone 403-282-3671.

Thanks you for your time,

Peggy Holroyd
Graduate Student in Environmental Science
Faculty of Environmental Design
University of Calgary

Pre-Workshop Survey
Indicators of landscape change for comparing alternative scenarios

When the Southern Foothills Study was initiated, three valued components of the region were identified as important: 1) fescue grassland, 2) water quality and 3) grizzly bears.

Based on a literature review and interviews with key informants I have identified some candidate thresholds to protect theses values on the landscape. But as always, setting these thresholds requires tradeoffs. The use of thresholds includes the best available scientific information, but also requires an understanding of community values. I am developing a method to evaluate the implications of setting thresholds in terms of the economic, social and environmental outcomes.

In order to understand the tradeoffs associated with setting thresholds, we need to identify the indicators of landscape change. I have developed of list of indicators that can currently be tracked in ALCES.

Please review the description of each indicator and complete the table below. The table below provides an opportunity for you to identify your level of concern with change to the selected indicators. Please indicate whether or not the indicator is understandable to you and if there are any missing indicators.

Please fax the completed table below with your name to Peggy Holroyd at Fax # 269-3377.

Definitions of indicators:

<u>Ecological</u>

Water Quality Index- This is an index that factors in nitrogen, phosphorus and sediment; all important factors in water quality. The index value is a relative expression compared to the pre-industrial value set at 1.00.

Grizzly Bear Exposure Index- This index combines habitat quality and mortality risk. It ranges from 0 (no exposure) to 3 (high exposure).Grizzly bears are an indicator and umbrella species whose decline are considered a warning of environmental change and whose characteristics and needs encompass the needs of other species.

Total Percentage Native Vegetation – Total percentage of the landscape made up of native vegetation. Native vegetation performs a key role in basic hydrological functions ensuring water quality and quantity, and healthy aquatic and riparian ecosystems.

<u>Land Use</u>

Total Road Density: all roads and trails in the study area measured in kilometres per square kilometre. An increase in road density: elevates the risk of sedimentation, lowers surface water permeability, increases fragmentation of habitat, facilitates human access, and increases the risk of human caused mortality or disturbance to animals.

Total Percentage of Fescue/Native Grassland- Total percentage of the landscape made up of native grassland. Fescue grasslands consist of native vegetation communities that are adapted to the climate and natural disturbance regimes of southern Alberta. Alteration of the grassland has implications to water quality (through soil erosion and sedimentation) and to ranching way of life (affecting economics and culture).

Total Water Demand- Demand for water measured in cubic metres for all land uses per year (ranges from 27,000,000 m^3 in 2005 to 67,000,000 m^3 in 2055).

Economic/Social

Number of Cattle- The number of cattle on the landscape (in feedlots and on ranchland). Ranges from 205,000 to 320,857.

Number of Full Time Equivalent Jobs- The number of full time equivalent jobs. A combination of jobs from all sectors.

Number of Active Oil and Gas Wells- Number of wells in the Southern Foothills (gas, oil and coal bed methane combined). It is one indicator of landscape disturbance although doesn't predict ecological impact.

Tonnes of Crops Produced- The tonnes of crops (cereal, oilseed, specialty, forage and tame grass combined). Ranges from 745,590 tonnes to 879,038 tonnes.

Cubic Metres of Hydrocarbon production- Total cumulative hydrocarbon produced in the Southern Foothills.

Population- Total human population in the Southern Foothills at any one time –ranges from approximately 40,000 to 95,000.

Tourism Activity Days- the number of days per year of tourism activity in the Southern Foothills. Ranges from 23 million to 27 million.

Total Wages- Wages paid by all jobs combined by all sectors in dollars. It is a function of the growth of employment in each sector.

Please identify which indicators you think best describe the landscape change that you are concerned about. Please rate your degree of concern and how understandable the indicator is to you

Indicator (sample below)	**Desired Direction of change (increase or decrease or unsure)**	**Concern 1- 5**	**Understandable 1-5 (tell us what information is missing in order to make it more understandable)**
Ecological			
Nutrient Loading Index (0-3)			
Grizzly Bear Exposure Index (0-3)			
Native Vegetation (Total % of the landscape)			
Land Use			
Road Density (km/km^2)			
Fescue Grasslands (Total % of the landscape)			
Total Water Demand (m^3)			
Economic/Social			
# of Cattle			
Tonnes of Crops Produced			
Total Tourism Activity days in a year			
Population			
Hydrocarbon Production (m^3)			
Jobs (Full Time)			
Wages ($) (all sectors combined)			

Number of Active Oil and Gas Wells			
Other indicators you would like to see?			

Other comments:

Appendix E: Workshop Survey for Southern Foothills Study Advisory Group

This survey is intended to help determine the appropriateness of candidate thresholds for managing the cumulative effects of land use change. Imagine you have a choice of futures.

Name:

____

Organization:

____

Address:

____

____

Email:

____

Southern Foothills Study Business-As-Usual Scenario

The Southern Foothills Study (SFS) Business-as-Usual Scenario is a projection of land use change 50 years into the future. Future land use information was acquired from government and industry sources. The Business-as-Usual represents development path that would occur if the business plans for the various sectors were to unfold as expected.

Method: ALCES

The Southern Foothills Study Business-as-Usual Scenario was developed using the computer model ALCES (a landscape cumulative effects simulator), which allows resource managers to quantify and track the response of landscape conditions in response ecological processes and human land use practices.

PART A- Scenario Evaluation

Five scenarios are provided on the following pages. Please evaluate each one of these alternative scenarios separately. In Part B, you will compare all scenarios using a decision matrix.

- **Scenario A:** -50% of BAU Scenario
- **Scenario B:** -25% of BAU Scenario
- **Scenario C:** Business-As-Usual
- **Scenario D:** +25% of BAU Scenario
- **Scenario E:** No Development on Grassland

Here is the performance of the key indicators in the predevelopment and recent (2005) scenarios.

Indicator	Predevelopment	2005
Avg Water Quality Index	1	0.5
Total Landscape Disturbed	0	26.7%

Road km\km^2 on Grizzly Bear Habitat	0	0.41
% of Grasslands	56.2%	22.0%

Your selection of appropriate thresholds

You have received an introduction to thresholds and some information about the performance of key indicators. Given the information you have received so far:

1) What do you think are appropriate thresholds for these indicators?

2) Please explain briefly why you have selected these thresholds (information, values, willingness to accept change)

Indicator	Threshold	Rationale for selecting the threshold
Avg Water Quality Index (% Change)		
Total % Landscape Disturbed		
Road Density (km\km^2) on Grizzly Bear Habitat		
Total % Grasslands on Landscape		

This can be just your initial thoughts on this. You will be asked this question again after you evaluate the different alternative scenarios.

Importance value of indicators

Please rank which indicators represent conditions you are most concerned about from 4-1 (4=higher importance, 1= lower importance). You will apply these values in Part B.

Indicator	Importance Value
Avg Water Quality Index (% Change)	
Total % Landscape Disturbed	
Road Density (km\km^2) on Grizzly Bear Habitat	

Total % Grasslands on Landscape	

Scenario A- 50% of Business-as-Usual

2055: 50% of Business-as-Usual

All land uses are restricted by 50% of the growth projected in the “Business-as-Usual” scenario

In the future, 5% more of the landscape will be converted to land use footprint.

The average water quality index will decline by 16%.

The road density on grizzly bear habitat will be 0.65km/km^2

The land use sectors that will change **the most** (three selected) in hectares are:

- Residential (+52%)
- Energy (+66%)
- Assorted (recreational facilities, feedlots and industrial plants; +122%).

See *Appendix A* for detailed information on the land uses in this scenario

Table 2: Outcome Indicators- Scenario A- 50% of Business-as-Usual

Indicator	2005	2055	Percent Change
Avg Water Quality Index	0.5	0.42	-16.0%
Total Landscape Disturbed	26.7%	28.0%	+4.9%
Road km\km^2 on Grizzly Bear Habitat	0.41	0.65	+58.5%
% of Grasslands	22.0%	20.9%	-4.8%

1) What are the advantages of this scenario? What are the disadvantages of this scenario?

2) What do you think about the land use change in this scenario (see *Appendix A*)? Is this scenario possible/feasible? How could we achieve it?

Scenario B- Decrease of 25% of Business-as-Usual

2055: Decrease of 25% of Business-as-Usual

All land uses are restricted by 25% of the growth projected in the "Business-as-Usual" scenario

In the future, 9% more of the landscape will be converted to land use footprint.

The average water quality index will decline by 22%.

The road density on grizzly bear habitat will be 0.79 km/km^2

The land use sectors that will change **the most** (three selected) in hectares are:

- Residential (+96%)
- Energy (+125%)
- Assorted (recreational facilities, feedlots and industrial plants; +214%).

See *Appendix A* for detailed information on the land uses in this scenario.

Table 3: Outcome Indicators- Scenario B- Decrease of 25% of Business-as-Usual

Indicator	2005	2055	Percent Change
Avg Water Quality Index	0.5	0.39	-22.0%
Total Landscape Disturbed	26.7%	29.1%	+8.9%
Road km\km^2 on Grizzly Bear Habitat	0.41	0.79	+92.7%
% of Grasslands	22.0%	20.4%	-7.3%

3) What are the advantages of this scenario? What are the disadvantages of this scenario?

4) What do you think about the land use change in this scenario (see *Appendix A*)? Is this scenario possible/feasible? How could we achieve it?

Scenario C- "Business-as-Usual"

2055: Business-as-Usual

In the future, 15% more of the landscape will be converted to land use footprint.

The average water quality index will decline by 26%.

The land use sectors that will grow **the most** (three selected) in hectares are:

- Energy (+180%)
- Residential (+158%)
- Assorted (recreational facilities, feedlots and industrial plants; +339%).

See *Appendix A* for detailed information on the land uses in this scenario

Table 1: Outcome Indicators- Scenario Business-as-Usual

Indicator	2005	2055	Percent Change
Avg Water Quality Index	0.5	0.37	-26.0%
Total Landscape Disturbed	26.7%	30.6%	+14.7%
Road km\km^2 on Grizzly Bear Habitat	0.41	0.93	+126.8%
% of Grasslands	22.0%	19.8%	-10.1%

5) What are the advantages of this scenario? What are the disadvantages of this scenario?

6) What do you think about the land use change in this scenario (see *Appendix A*)? Is this scenario possible/feasible? How could we achieve it?

Scenario D- Increase of 25% of Business-as-Usual

2055: Increase of 25% of Business-as-Usual

All land uses are increased by 25% of the growth projected in the "Business-as-Usual" scenario

In the future, 24% more of the landscape will be converted to land use footprint.

The average water quality index will decline by 32%.

The road density on grizzly bear habitat will be 1.09 km/km^2

The land use sectors that will change **the most** (three selected) in hectares are:

- Residential (+247%)
- Energy (+231%)
- Assorted (recreational facilities, feedlots and industrial plants; +510%).

See *Appendix A* for detailed information on the land uses in this scenario.

Table 4: Outcome Indicators- Scenario D- Increase of 25% of Business-as-usual

Indicator	2005	2055	Percent Change
Avg Water Quality Index	0.5	0.34	-32.0%
Total Landscape Disturbed	26.7%	33.0%	+23.7%
Road km\km^2 on Grizzly Bear Habitat	0.41	1.09	+165.9%
% of Grasslands	22.0%	18.9%	-14.1%

7) What are the advantages of this scenario? What are the disadvantages of this scenario?

8) What do you think about the land use change in this scenario (see *Appendix A*)? Is this scenario possible/feasible? How could we achieve it?

Scenario E – No Development on Grassland

2055: No Development on Grassland

No new direct footprint is permitted in grassland.

Invasion of non-native species continues from current footprint.

The land uses continue to grow but only into other natural landscape types.

In the future, 8% more of the landscape will be converted to land use footprint.

The average water quality index will decline by 24%.

The road density on grizzly bear habitat will be 1.09 km/km^2

The land use sectors that will change **the most** (three selected) in hectares are:

- Residential (+158%)
- Energy (+157%)
- Assorted (recreational facilities, feedlots and industrial plants; +339%).

See *Appendix A* for detailed information on the land uses in this scenario.

Table 5: Outcome Indicators- Scenario E- No Development on Grassland

Indicator	2005	2055	Percent Change
Avg Water Quality Index	0.5	0.38	-24.0%
Total Landscape Disturbed	26.7%	28.8%	+7.8%
Road $km\backslash km^2$ on Grizzly Bear Habitat	0.41	1.09	+165.9%
% of Grasslands	22.0%	21.9%	-0.2%

9) What are the advantages of this scenario? What are the disadvantages of this scenario?

10) What do you think about the land use change in this scenario (see *Appendix A*)? Is this scenario possible/feasible? How could we achieve it?

B: A Choice of Futures

Imagine the following choices are different “futures.” Suppose that a regional referendum on land use planning was being held today, which of the scenarios would you favour for the Southwest Foothills? Please review the next few pages and complete the decision matrix.

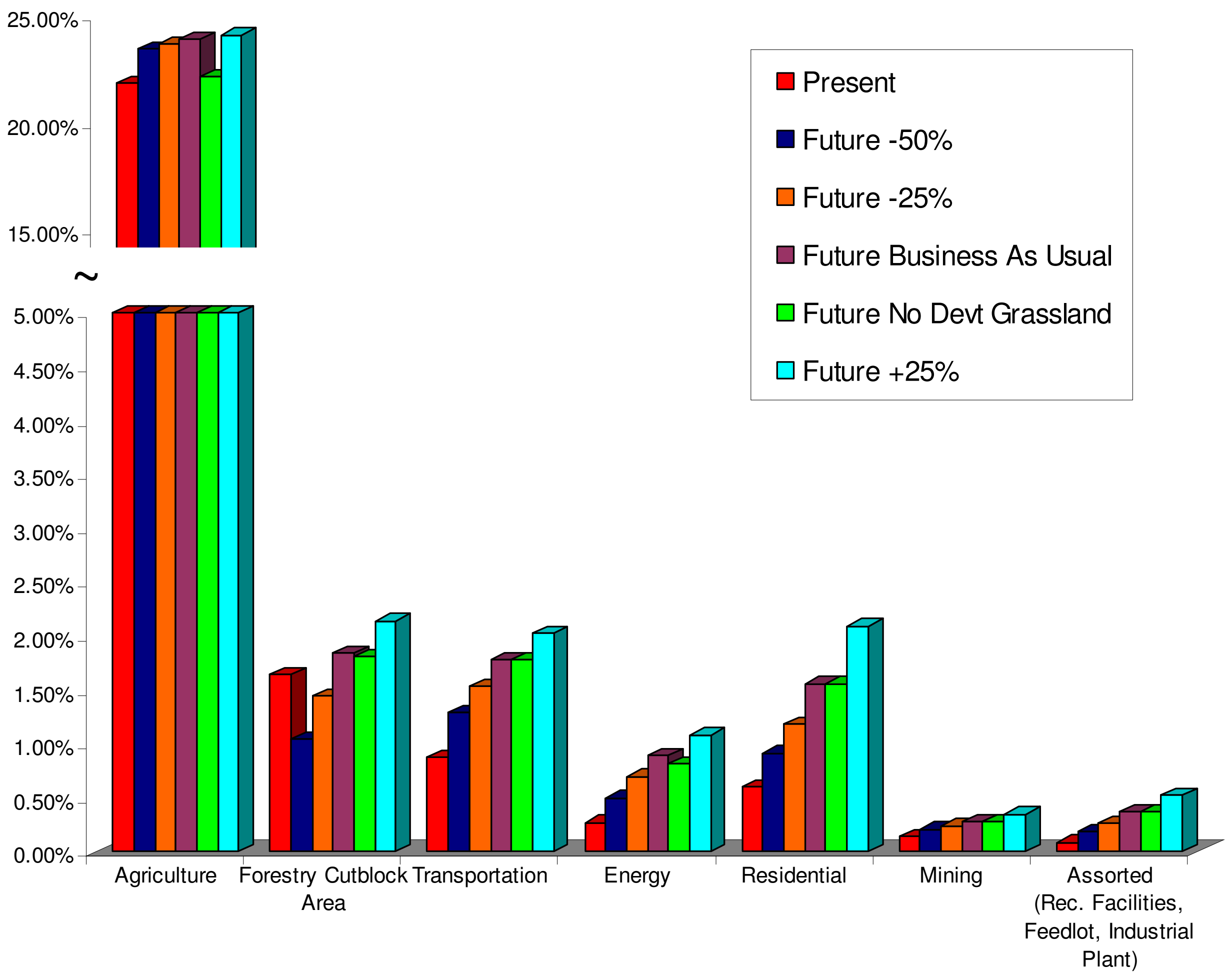

Table 6: Outcome Indicators- All Scenarios Compared

Indicator	2005	A) 50%	B) -25%	C) BAU	D) +25%	E) No Devt on Grassland
Avg Water Quality Index -% Change	0	-16.0%	-22.0%	-26.0%	-32.0%	-24.0%
Total Landscape Disturbed	26.7%	28.0%	29.1%	30.6%	33.0%	28.8%
Road km\km^2 on Grizzly Bear Habitat	0.41	0.65	0.79	0.93	1.09	1.09
% of Grasslands	22.0%	20.9%	20.4%	19.8%	18.9%	21.9%

Table 7: Land Uses - All Scenarios Compared

Land Use/ Landscape	2005	A) 50%	B) -25%	C) BAU	D) +25%	E) No Devt on Grassland
Agriculture	23.03%	23.45%	23.71%	23.90%	24.12%	22.18%
Forestry Cutblock	1.63%	1.05%	1.45%	1.75%	2.14%	1.81%
Transportation	0.88%	1.29%	1.53%	1.78%	2.03%	1.78%
Energy	0.31%	0.50%	0.70%	0.89%	1.08%	0.82%
Residential	0.60%	0.91%	1.18%	1.56%	2.10%	1.56%
Mining	0.14%	0.21%	0.24%	0.28%	0.34%	0.28%
Assorted (Rec. Facilities, Feedlot, Industrial Plant)	0.08%	0.19%	0.26%	0.37%	0.52%	0.37%

Table 8: Landscape Types and Linear Density – All Scenarios Compared

Indicator	2005	A) 50%	B) -25%	C) BAU	D) +25%	E) No Devt on Grassland
Natural Landscape Types	73.30%	72.41%	70.93%	69.39%	67.67%	71.21%
Linear Density km/km^2	1.37	2.00	2.59	3.17	3.76	3.04

Decision Matrix

a. Write down what you think is an appropriate threshold for each indicator (Table 9 below)

b. Determine how important each indicator is to you. The importance value of each indicator should be rated from 1-4 (1= low, 4= high).

c. Evaluate each scenario for the performance of the indicators. This will require comparing all scenarios and rating the scenarios a scale from 1-5 (1 =low, 5 =high) for how **close** the numbers are to your acceptable thresholds.

d. Multiply the importance value by how well each option respects the thresholds. Add all the multiplied numbers in each column to get a total.

e. Which ever column has the highest total is the most desirable scenario.

Table 9: Thresholds

Indicator	Threshold
Avg Water Quality Index -% Change	
Total Landscape Disturbed	
Road km\km^2 on Grizzly Bear Habitat	
% Grasslands of Landscape	

1) Please explain why you have selected the threshold values for each indicator.

Average Water Quality Index % Change:

Total % Landscape Disturbed:

Road Density km\km^2 on Grizzly Bear Habitat:

Total % Grasslands on Landscape:

Table 10: Sample Decision Matrix

Indicator	How Important 1-5	Scenario A- How well it satisfies the threshold	Scenario B	Scenario C Business-as-Usual	Scenario D	Scenario E
Ex. Change in Water Quality Index	5	5 times factor 5= 25	4 times factor 5= 20	3 times factor 5 = 15	2 times factor 5= 10	3 times factor 5= 15

Table 11: Decision Matrix

Indicator	How Important 1-4	Scenario A	Scenario B	Scenario C Business-as-Usual	Scenario D	Scenario E
Avg Water Quality Index % Change						
Total Landscape Disturbed						
Road km\km^2 on Grizzly Bear Habitat						
Total Grasslands % of Landscape						
Total						

Questions on Decision Matrix and Appropriate Thresholds

Please explain if you agree or disagree with the most desirable scenario determined through the decision matrix? Describe your desirable scenario.

What more information do you need to make a decision on an appropriate threshold for each indicator?

How might we ensure that we do not exceed the thresholds?

Appendix A: Detailed Information on Each Scenario

Table 11: Scenario A: Land Uses and Landscape Types- 50% of Business-as-Usual

Land Use/ Landscape	2005	2055	Percent Change
Agriculture	23.03%	23.45%	+1.86%
Forestry Cutblock Areas	1.64%	1.05%	-34.63%
Transportation	0.88%	1.29%	+48.17%
Energy	0.32%	0.50%	+66.70%
Residential	0.60%	0.91%	+52.47%
Mining	0.14%	0.21%	+49.17%
Assorted (Rec. Facilities, Feedlot, Industrial Plant)	0.08%	0.19%	+122.20%
Natural Landscape Types	73.30%	72.41%	-1.22%
Total	100.00%	100.00%	

Table 12: Scenario B: Land Uses and Landscape Types, Decrease of 25% of Business-as-Usual

Land Use/ Landscape	2005	2055	Percent Change
Agriculture	23.03%	23.71%	+2.99%
Forestry Cutblock	1.64%	1.45%	-10.81%
Transportation	0.88%	1.53%	+75.30%
Energy	0.32%	0.70%	+125.44%
Residential	0.60%	1.18%	+96.19%
Mining	0.14%	0.24%	+73.52%
Assorted (Rec. Facilities, Feedlot, Industrial Plant)	0.08%	0.26%	+214.33%
Natural Landscape Types	73.30%	70.93%	-3.24%
Total	100.00%	100.00%	

Table 13: Scenario Business-as-Usual Land Uses and Landscape Types

Land Use/ Landscape	2005	2055	Percent Change
Agriculture	23.03%	23.90%	+3.77%
Forestry Cutblock Area	1.64%	1.84%	+11.97%
Transportation	0.88%	1.78%	+102.87%
Energy	0.32%	0.89%	+180.36%
Residential	0.60%	1.56%	+158.32%
Mining	0.14%	0.28%	+97.72%
Assorted (Rec. Facilities, Feedlot, Industrial Plant)	0.08%	0.37%	+339.02%
Natural Landscape Types	73.30%	69.39%	-5.34%
Total	100.00%	100.00%	

Table 14: Scenario C: Land Uses and Landscape Types- Increase of 25% of Business-as-Usual

Land Use/ Landscape	2005	2055	Percent Change
Agriculture	23.03%	24.12%	+4.72%
Forestry Cutblock	1.64%	2.14%	+28.52%
Transportation	0.88%	2.03%	+130.38%
Energy	0.32%	1.08%	+231.49%
Residential	0.60%	2.10%	+246.61%
Mining	0.14%	0.34%	+144.00%
Assorted (Rec. Facilities, Feedlot, Industrial Plant)	0.08%	0.52%	+509.65%
Natural Landscape Types	73.30%	67.67%	-7.69%
Total	100.00%	100.00%	

Table 15: Scenario D: Land Uses and Landscape Types- No Development on Grassland

Land Use/ Landscape	2005	2055	Percent Change
Agriculture	23.03%	22.18%	-3.68%
Forestry Cutblock	1.64%	1.81%	+10.04%
Transportation	0.88%	1.78%	+102.68%
Energy	0.32%	0.82%	+157.00%
Residential	0.60%	1.56%	+158.32%
Mining	0.14%	0.28%	+97.72%
Assorted (Rec. Facilities, Feedlot, Industrial Plant)	0.08%	0.37%	+339.02%
Natural Landscape Types	73.30%	71.21%	-2.86%
Total	100.00%	100.00%	