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Managing Alberta's Energy Futures at the Landscape Scale

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PREFACE

The energy sector has been a dominant factor in Alberta's development and growth over the last half-century. The large capital investments and operating expenditures associated with finding and producing oil and gas have directly provided a major stimulus to the economy. But the indirect and induced impacts have been equally important. The development of many other industries supplying inputs to the energy sector, the generation of substantial export and government revenues, and the stimulus for large inflows of people have resulted in large 'multiplier' effects. In combination, these have also played a major role in shaping Alberta's 'character' which is generally distinguished by its highly educated, adjustable and entrepreneurial labour force, low unemployment and high labour force participation rates, strong work ethic and sense of self reliance, and its optimistic outlook.

In recent years the energy sector has become even more dominant and has increasingly made Alberta a key driver of the national economy. In a world with a rapidly growing demand for energy, having one of the largest concentrations of energy resources in the world might seem to translate into an assured, prosperous future. There is clearly huge potential associated with unconventional oil and gas, coal, remaining conventional resources and with alternative and renewable energy. However, translating this potential into reality will be daunting. Increasing constraints related to resource access, environmental impacts, infrastructure requirements, and availability of highly qualified people need to be addressed. Other challenges include the massive long-term investments in developing and implementing new technologies and making the right changes in the policy and regulatory framework. Indeed, the fact that relatively few nations have managed to convert resource wealth into high standards of societal welfare is a useful reminder of the magnitude of the challenges.

Alberta is in many respects at a crossroads. On the one hand complacency will almost certainly mean a dimming of the province's long-term prosperity. Declines in the conventional oil and gas sector will significantly dampen growth and prosperity. There are no other sectors of the province's economic base that could realistically expand sufficiently to offset significant declines in the dominant energy sector. On the other hand, visionary, strategic investments today can unlock non-conventional and other energy resources critical to securing a strong and prosperous long-term, sustainable future for the province.

It is in this context that ISEEE has undertaken a series of papers focused on Alberta's energy futures. The intent is to take a longer term look at the challenges, opportunities and choices and what they mean for Alberta's future.

Managing Alberta's Energy Futures at the Landscape Scale

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Executive Summary

- The choices among potential energy futures for Alberta will have profound implications for Alberta's landscapes because of the growing footprint of the energy sector and other land uses across much of the province.

- Informed decisions about energy futures require an understanding of the implications of that growing footprint. Furthermore, making and implementing decisions about energy futures will only be possible if the necessary decision-making processes and management tools are in place.

- This paper shows how integrated and interdisciplinary research can contribute to understanding the nature and implications of landscape change associated with energy development and to identifying options for managing that change more effectively.

- The starting point for understanding the relationship between energy futures and landscape change is Alberta's endowment of hydrocarbon reserves, including conventional oil and gas, bitumen in oil sands, and coalbed methane. The paper includes maps of the hydrocarbon resources that extend under much of Alberta. It also includes maps and time-series data showing the historical rate of growth and the spatial distribution of energy development (i.e., oil and gas wells and pipelines).

- Alberta has seen exponential increases over the past 50 years in the number of oil and gas wells, pipelines and other facilities associated with energy development. Even as production from conventional reserves declines over the coming decades, the energy sector's footprint will continue to grow rapidly because of the increased effort required to locate and produce remaining conventional reserves and the intensity of wells and infrastructure associated with unconventional energy sources such as oil sands and coalbed methane.

- The effects of these physical disturbances can be quantified in terms of changes in landscape characteristics that are significant for ecological, social, cultural and economic reasons. This paper uses ALCES® cumulative effects simulations to show how projected land uses in Alberta will significantly affect the following landscape metrics: total anthropogenic area, area in forest, average forest landscape age, total anthropogenic edge and culverts (i.e., stream-crossings). These simulations distinguish between total change due to all land uses combined and change due to all land uses except the energy sector. This analysis can therefore identify the metrics where the energy sector makes the greatest relative contribution to landscape change.

- Although the energy sector's total footprint is smaller than agriculture and forestry, it creates significantly more anthropogenic edge than these other land uses and its relative impact increases significantly if disturbance buffers are applied around the actual physical footprint.

- The two landscape metrics where the energy sector makes the greatest contribution to change are anthropogenic edge and culverts. These are also the metrics that exhibit the greatest expected rate of change over the coming decades. They capture the effects of the extensive network of linear disturbances and relatively small patch disturbances that characterize the expanding energy footprint across much of Alberta.

- In ecological terms, these metrics represent habitat fragmentation and the associated edge and barrier effects. Other ecologically relevant changes include a reduction in core forest area and increased human access. The paper explores the implications of these changes by reviewing the theory of habitat fragmentation as developed by landscape ecologists. It also examines the rationale for using focal species as ecological indicators. This theory is then applied to land use in Alberta. Ecological analysis examines the fragmentation of aquatic systems by hanging culverts and the effects of landscape change on two focal species, woodland (or boreal) caribou and grizzly bear. ALCES simulations show that projected landscape change attributable to the energy sector and other land uses will have significant adverse impacts on all three of these ecological indicators.

- Furthermore, the paper surveys concerns relating to the social, cultural and economic impacts of the expanding and increasingly intense footprint of energy development in Alberta. These concerns focus on human health, culture and way of life, Aboriginal people, and impacts on the forestry sector.

- The paper then turns to the management of landscape change. The proliferation of linear and small patch disturbances is a classic illustration of how a multitude of individual projects and activities can create significant cumulative effects. Cumulative effects are therefore central to the challenge of managing landscape and energy futures in Alberta. Unless decision-makers have the capacity to set and achieve landscape-scale objectives in a context where multiple human activities affect land-use values, the cumulative effects of development are likely to be unplanned, unmanaged, and quite possibly undesirable.

- The paper explores two key requirements for managing this type of landscape change. The first is the institutional capacity to manage cumulative effects. Second, the decision-making processes for land and resource use must accommodate and be responsive to a broad range of interests and values that are affected by landscape change.

- Institutional capacity to manage cumulative effects requires an integrated institutional regime for land and resource management and the ability to integrate science and policy in decision-making. The paper explores the significant challenges relating to both types of integration.

- From an institutional perspective, Alberta does not currently have the type of integrated legal and policy regime that is required to set and achieve landscape-scale objectives given the growth trajectory and disturbance patterns of the energy sector and other land uses. Unplanned incrementalism and institutional fragmentation are entrenched in the current management regime.

- The principal challenges for integrating science and policy include strengthening the scientific underpinnings of landscape management, particularly in a context where decision-makers are confronted with considerable uncertainty and must deal with a complex mix of scientific information and value-based choices. The paper examines two promising methods for managing uncertainty and anticipating landscape change: ecological risk assessment and the use of multi-attribute functions and utility-based approaches to uncertainty.

- While far-reaching systemic changes needed to implement these integrated approaches to landscape management, a variety of specific tools are also available to address the types of landscape change that will result from a 'business as usual' approach to energy development in Alberta. These tools include the setting and implementation of disturbance thresholds, measures to reduce linear disturbance density and improve public access management, and the mitigation of impacts through abandonment and reclamation. All of these options raise important questions relating to institutional design and implementation strategies.

- Finally, the paper examines the incorporation of landscape perspectives into decision-making. Options include enhancing the role of municipalities and regional health authorities, Aboriginal consultation, and increased public participation in the disposition of mineral rights. Here again, Alberta's current management framework presents significant challenges for the incorporation of diverse values and interests into the decisions that shape energy and landscape futures.

- The projected growth trajectory for Alberta's energy sector raises significant challenges for landscape management because it threatens the sustainability of a variety of other land uses and land-use values. This paper shows clearly that unplanned and unmanaged cumulative effects from the proliferation of linear and small patch disturbances have the potential to transform Alberta's landscapes. Land-use simulations and integrated interdisciplinary research provide a clear indication of the significant ecological, social, cultural and economic implications of this transformation. The research and analysis presented here also identify the origins of this problem within Alberta's current management regime and suggest a variety of options for improving our capacity to set and achieve landscape-scale objectives by managing cumulative effects and incorporating a broader range of interests and values into decision-making.

- Alberta's energy and landscape futures are closely intertwined and raise significant sustainability issues. Shaping these futures through forward-looking social and political choice requires the capacity to understand and manage landscape change. This paper demonstrates that a focused and interdisciplinary research effort can provide decision-makers and other interested Albertans with the tools needed to meet this significant challenge.

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1 Introduction

Alberta's booming energy industry is competing – usually with success – for space on a land base that is subject to increasing human demands from a multitude of industrial, agricultural, residential and recreational land uses. The ability of that land base to support these land uses and to sustain the province's diverse natural ecosystems is therefore a critically important issue when considering energy futures for Alberta and the opportunities and choices associated with these alternative futures.

The growth of Alberta's energy sector has been associated with significant increases in the extent and intensity of development across much of the province. Even as production of conventional oil and gas declines over the coming decades, the development footprint will continue to increase. This growing footprint reflects the numbers of wells, pipelines and other facilities that are being constructed by the energy sector. For example, the oil and gas industry drilled a record 19,365 wells in Alberta in 2004, up from 8,175 in 1998. These raw numbers provide an indication of the magnitude of expansion, but they do not convey much meaning in terms of the landscape-scale changes resulting from energy development and the ecological and human implications of these changes.

This paper is intended to show how the implications of energy development at the landscape scale can be understood. It also discusses key issues and options for the management of this landscape change. The data and analysis presented here illustrate the potential for integrated and interdisciplinary research to focus and inform the debate that has already begun in Alberta as decision-makers, stakeholders and individual Albertans confront inevitable and difficult choices regarding energy and landscape futures.

2 Scope and Methodology

This paper is the product of an interdisciplinary collaboration that brings together expertise in landscape ecology, GIS, spatial and non-spatial analysis of land-use and its ecological implications, decision-support tools for land-use planning and ecosystem management, and the legal, institutional and policy issues relating to land and resource management in Alberta. Given the breadth of knowledge of project team members and the potential scope of the topic, a selective approach to issue identification and analysis was required in order to complete this work within the available time and budget. Consequently, this report reflects a series of important decisions that were made at the outset of the project.

Several of these decisions related to the scales to be used for various components of the project. For example, the metrics of landscape change associated with the expanding energy footprint are described at the provincial scale. Similarly, the options for managing landscape change address issues that are generally relevant across the province as a whole. The focal species used as part of the analysis of ecological effects do not, however, have province-wide ranges. Grizzly bears and woodland caribou were selected due to their sensitivity to landscape change and their high public value. Some of the other issues examined below are also more significant in certain regions of the province than in others. Analysis of the energy sector's footprint and landscape change in Alberta could, therefore, be expanded to include more complex multi-scale analysis than could be undertaken for this paper.

The analytical techniques used to present metrics of landscape change and to assess their ecological and other implications are, however, readily applicable to multiple scales. The discussion of management options also highlights the opportunities for intervention at different scales – from broad provincial policy and legislation to the development and implementation of land-use plans and impact management tools at the regional and sub-regional levels. The intent here is to provide issue identification, an analytical framework, decision-support tools and a set of policy and management options that can readily be adapted to different scales.

In addition to the decisions regarding the scale for analysis, a multitude of other choices were required to determine what material should be presented in this paper. These choices were based in large part on the professional judgment and expertise of the project team. Our selection of landscape metrics, the analysis of ecological and other effects, and the discussion of issues and options for managing landscape change are not intended to be comprehensive. Other research teams might well have made different choices regarding the data to be presented, the analysis to undertake, and the issues to address. However, the intent here is to demonstrate how interdisciplinary research and analytical capacity can be deployed to address a complex and interrelated set of issues relating to the energy sector's footprint and the future of Alberta's landscapes. Further research and analysis is needed, of course, to explore the many implications of energy development for landscape change in Alberta and the options for managing that change. The authors of this paper are confident, however, that the material presented here provides a solid basis for defining that research agenda and also for making immediate progress in addressing this important set of issues.

The project team also considered the breadth of the term "energy futures" when determining what issues to examine. For this paper, we have focused primarily on the footprint of the upstream oil and gas industry, recognizing that the energy sector in Alberta includes other activities (e.g., coal mining, electrical power generation, wind generation) that may also contribute to landscape change in certain parts of the province. The project team decided, however, that the key trends and issues were sufficiently well demonstrated without incorporating all components of the energy sector. The authors are also well aware of the important landscape-scale impacts associated with the rapid development of Alberta's vast oil sands resource and the challenges of addressing those impacts. This paper focuses, however, on landscape change caused by the *extensive* footprint of the oil and gas industry across the province, rather than examining issues that are specific to the very *intensive* footprint of open-pit oil sands mining and associated infrastructure and land use (e.g., tailings ponds).

The land-use and landscape analyses presented in this paper are based on simulations conducted using the ALCES® landscape model (http://www.foremtech.com). The methodologies deployed, and the input assumptions used, were based on procedures adopted in several previous regional cumulative effects assessments in Alberta using ALCES. The structure and dynamics of the ALCES model, as it applies to simulating land-use scenarios in Alberta, is discussed in detail by Schneider *et al*. 2003. Whereas historical "back-casting" in the model is guided by known historical trajectories extracted from the land-use literature in Alberta, future land-use simulations represent a plausible "business as usual" scenario. This future scenario can be described as one that attempts to simulate each land use (forestry, energy, agriculture, transportation, settlements), and its associated metrics, as guided by the general business plans of each sector detailed in governmental or industrial business plans. Important primary sources of data used to compile a "plausible" future development scenario for Alberta's energy sector include documents published by Alberta Energy (*Energy Business Plan, 2006-2009*, Alberta Energy 2006), Alberta Energy and Utilities Board (*Oil Reserves and Production*, EUB 2003a), Canadian Association of Petroleum Producers (*CAPP Statistical Handbook*, CAPP 2005), Canadian Energy Research Institute (*Oil Sands Supply Outlook*, Denbar *et al.* 2004), and Raymond James Ltd. (*The Oil Sands of Canada*, Mawdsley *et al.* 2005). The temporal place between history and future is Alberta's contemporary landscape. This current composition of the province was summarized from assembled GIS layers that detailed both landscape types and anthropogenic (man-made) footprint types (Figure 1).

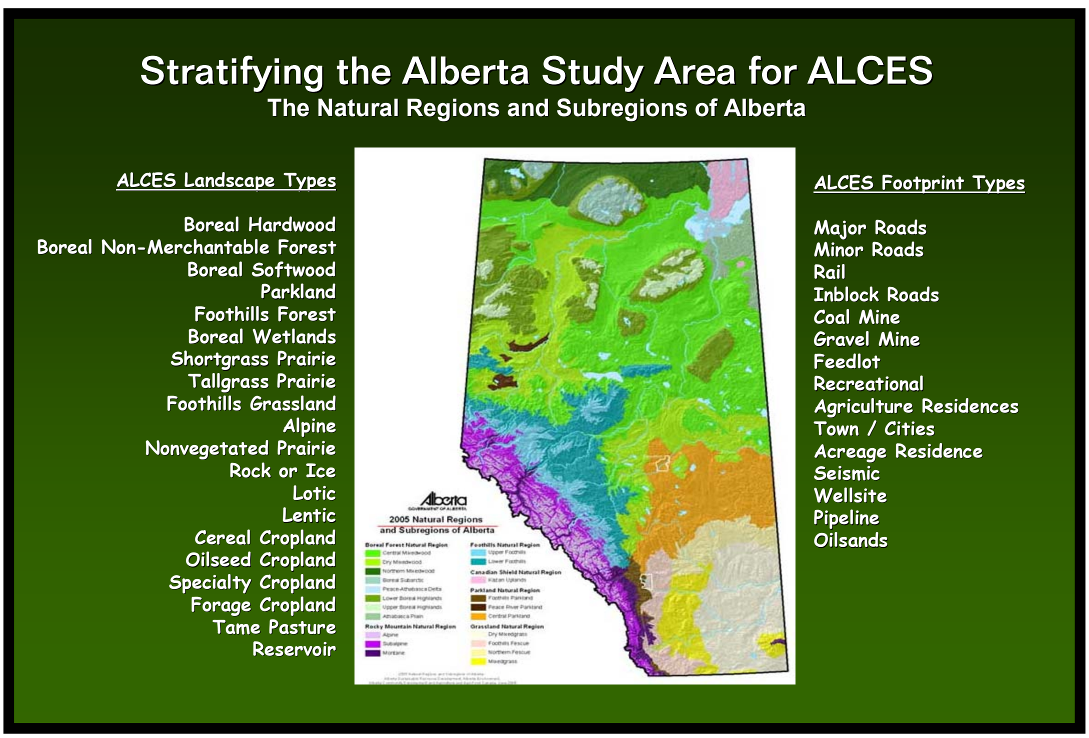


Figure 1: Stratifying the Alberta study area for ALCES®

The other analyses presented in this paper are based on the original research of the authors and on the secondary literature.

3 Understanding Landscape Change

The first major objective of this paper is to demonstrate how landscape-scale change associated with the expanding energy footprint and other land uses in Alberta can be understood in ways that are meaningful for decision-makers, stakeholders, and Albertans who are concerned with 'energy futures' and with the future of Alberta's landscapes. In particular, this analysis focuses on the type and magnitude of landscape change, the rate of change, and the ecological and other impacts associated with that change. To this end, it is important to bear in mind how land use in Alberta has expanded over the past 100 years since significant human impacts began to change the pre-industrial landscape. The analysis presented here also examines how plausible land-use scenarios may alter Alberta's landscapes over the coming century.

The discussion begins by briefly describing the current spatial distribution of energy development in Alberta. We have also included a map of Alberta's road network to show the distribution of a broader suite of land uses. The paper then presents a series of non-spatial metrics of change, selected to show how important features of the landscape have been altered by human land use and how they are likely to change in the future given plausible development scenarios. This analysis highlights aspects of landscape change where the oil and gas industry is a significant causal factor. On this basis, we present a representative analysis of ecological effects associated with the expanding energy footprint and other land uses. Finally, concerns regarding the socio-economic and cultural implications of the increasing extent and intensity of energy development are summarized.

3.1 Spatial Analysis: The Energy Sector's Footprint on a 'Multiple- use' Landscape

The spatial distribution and intensity of the energy sector's current and future footprint on the surface of Alberta reflects the province's subsurface geology. As shown by Figures 2 and 3, Alberta is largely underlain by the Western Canadian Sedimentary Basin and possesses globally significant volumes of oil, gas, bitumen, coal, and coal-bed methane. The energy sector has systematically pursued the exploration and development of oil and gas across the significant areas of Alberta where these resources are present.

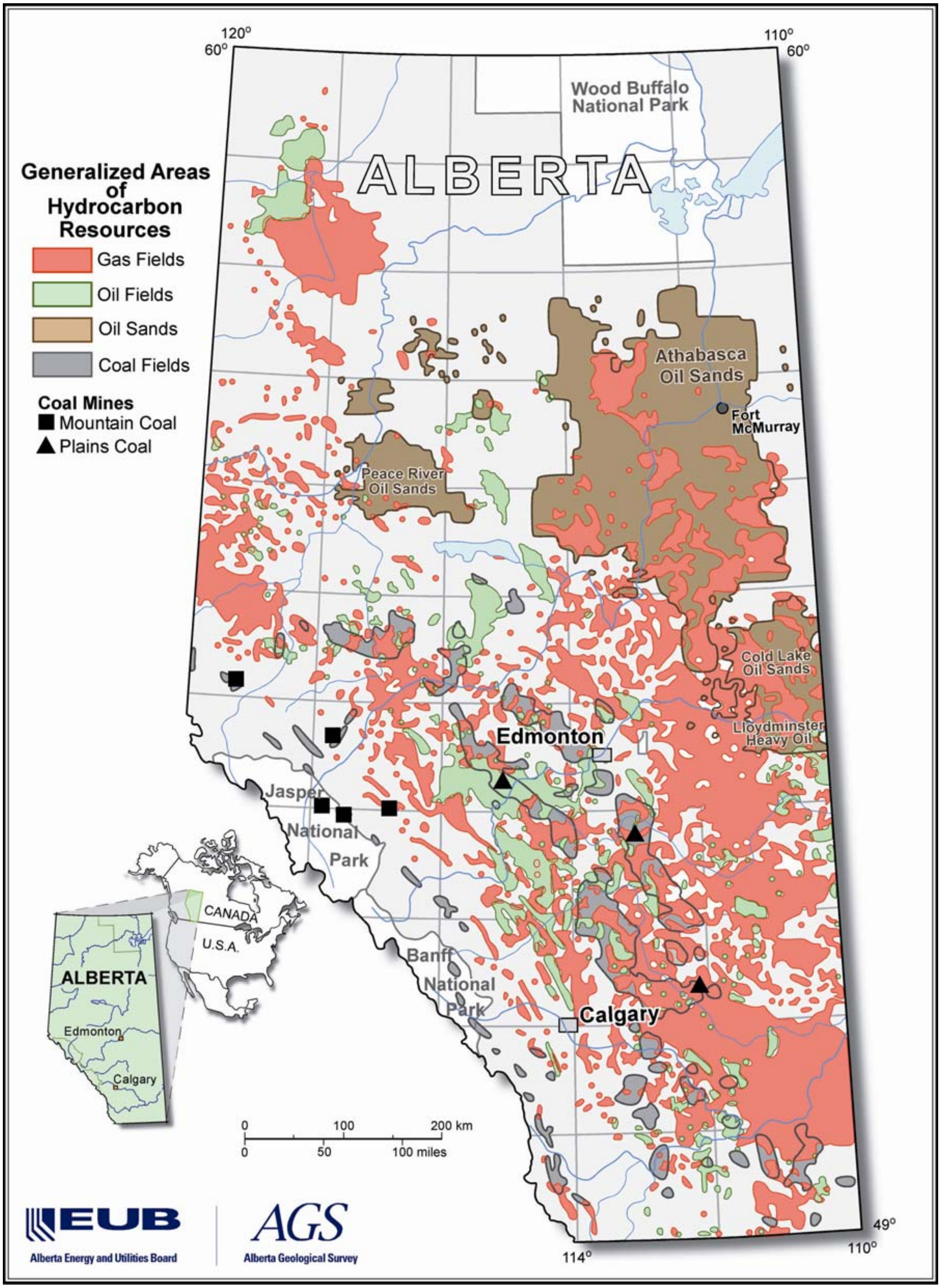


Figure 2: Generalized areas of hydrocarbon resources in Alberta

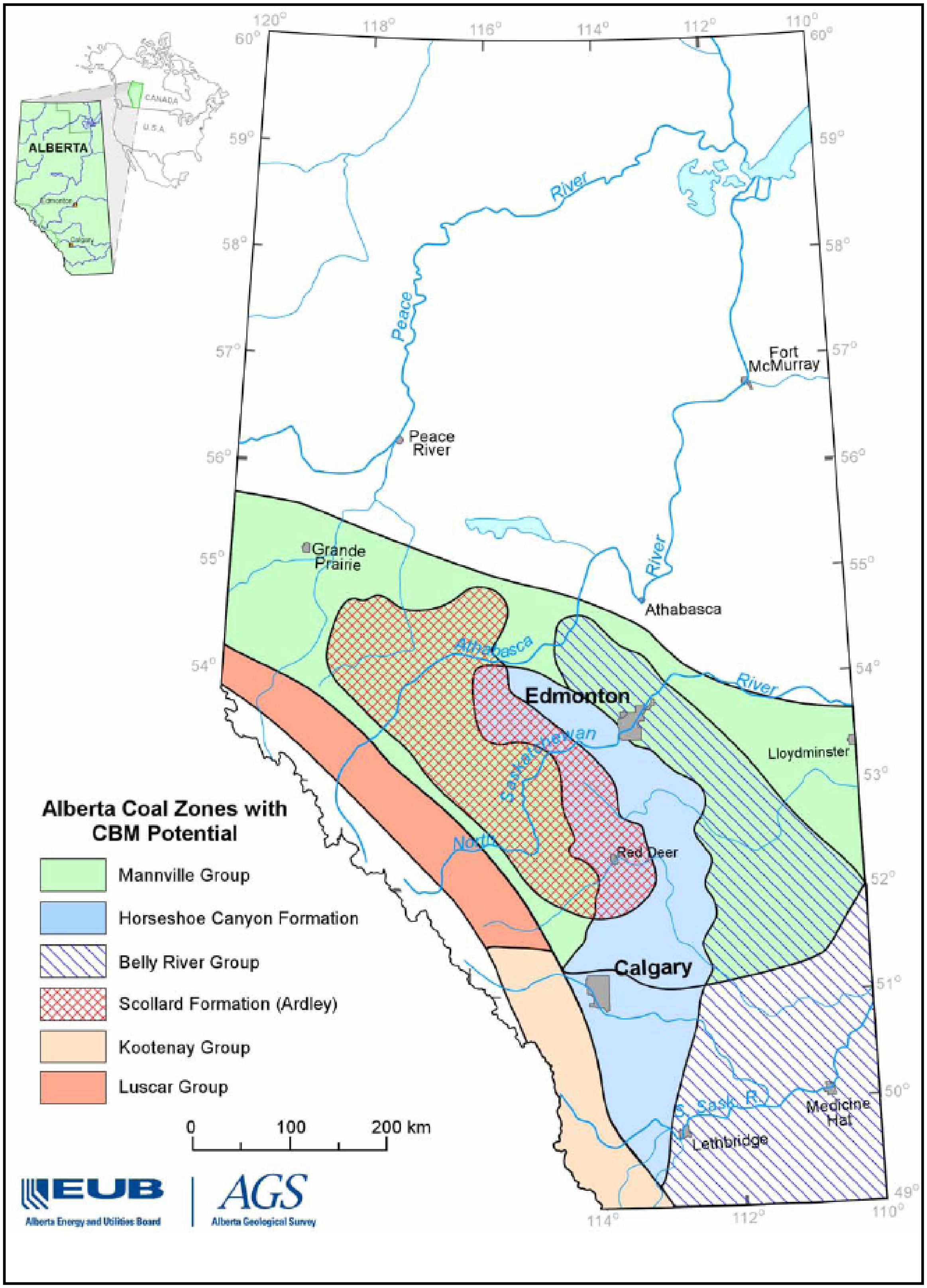


Figure 3: Alberta coal zones with coalbed methane potential

Alberta's proven reserve volumes for conventional oil and gas are now declining quickly, reflecting a pattern where annual extractions consistently exceed new discoveries (Figure 4). This reduction in reserves does not, however, translate into slower growth for the energy sector's footprint (e.g., seismic lines, wellsites, pipelines). In fact, this footprint is likely to increase in both extent and intensity as energy companies find it progressively more difficult to locate and produce viable reserves. In addition, smaller and unconventional gas sources require a greater intensity of wellsites per unit of recoverable gas.

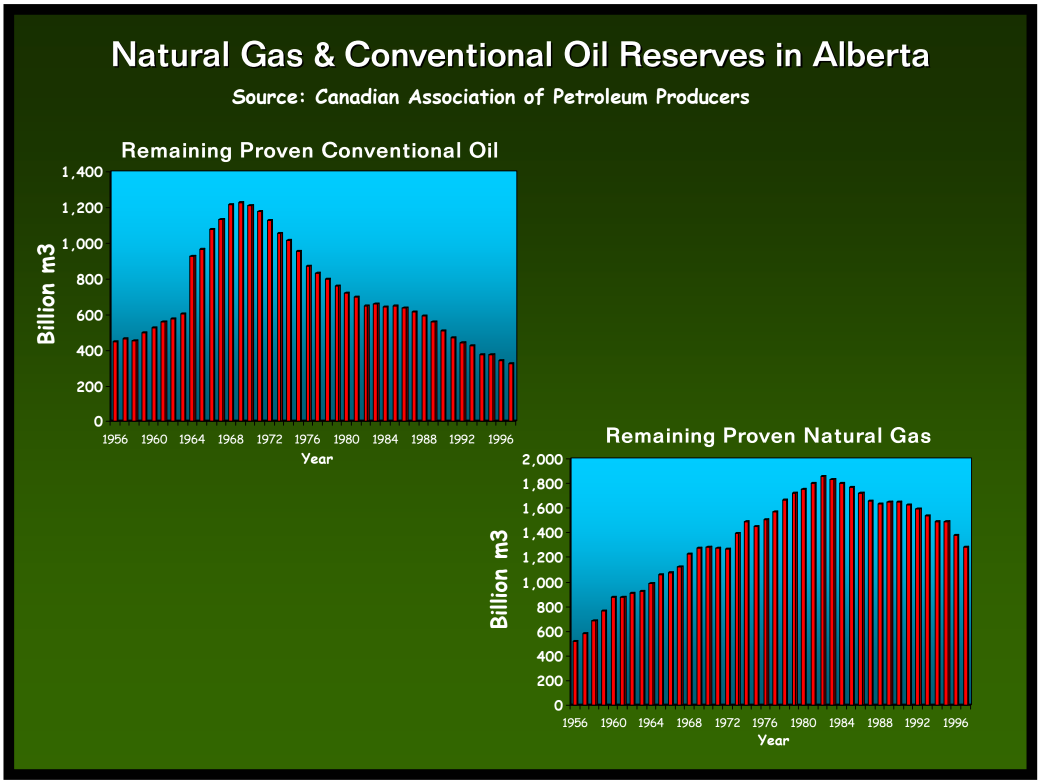


Figure 4: Remaining proven natural gas and conventional oil reserves in Alberta

Most of the large and easily identifiable hydrocarbon pools in Alberta have likely been found already. More intensive exploration (e.g., three dimensional seismic) and drilling will be necessary to extract the remaining hydrocarbons as reserves become more scarce and fragmented. The combination of improved technologies and high commodity prices has further fuelled interest in exploring for reserves that were previously considered unattractive because of their small size, complex geology or remoteness from transportation infrastructure. Additional effort may also be devoted to recovering remaining hydrocarbons from reserves that had been considered 'exhausted', thereby prolonging (and possibly expanding) the energy footprint associated with these reserves.

As conventional gas reserves continue their downward slide, the industry has also responded by shifting attention to non-conventional stocks such as coal-bed methane and "tight" gas. This shift also has important implications for the energy sector's footprint.

Coal-bed methane requires a higher well density than most conventional gas production and the relatively low pressures associated with these reserves means that wells and associated infrastructure may be in place for longer periods of time. Declining conventional reserves, high commodity prices and technological advances have also led to significant growth of both open-pit mining and in situ recovery in the oil sands region. Landscape transformation resulting from oil sands mining is obvious and reclamation techniques will likely be unable to recreate pre-existing boreal landscapes and ecosystems (Woynillowicz *et al.* 2005). In situ recovery also has significant surface impacts, given the network of injection and recovery wells, pipelines, roads and other infrastructure that is needed to extract and transport the resource.

These characteristics of the energy sector in Alberta explain an important paradox when energy futures are considered from a landscape perspective. The Western Canadian Sedimentary Basin in Alberta is now at a 'mature' stage of exploration and development from the perspective of the conventional oil and gas industry, but the energy sector's total footprint and the intensity of its surface impacts are nonetheless likely to increase significantly over the coming century.

The precise spatial configuration of the future energy footprint is difficult to predict. Nonetheless, data are available to show how the footprint and number of facilities have increased historically. Figures 5, 6 and 7 (and the underlying time-series data) show that Alberta has witnessed an exponential growth in the population of producing natural gas

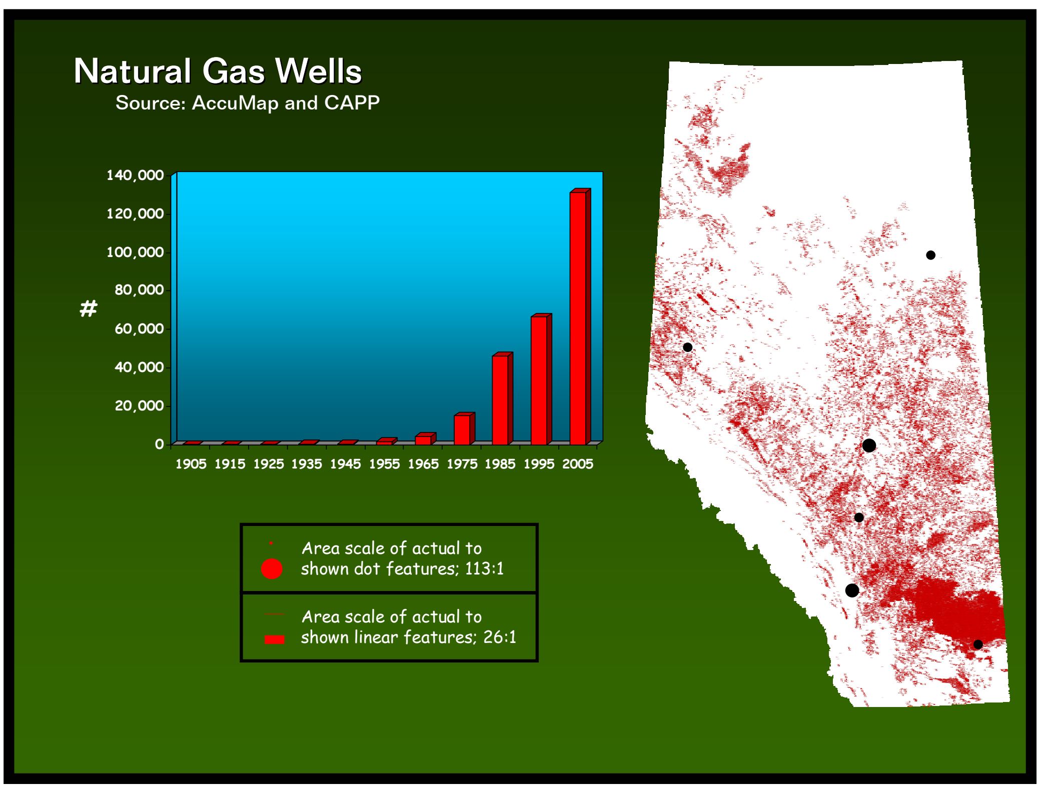


Figure 5: Number of natural gas wells in Alberta, 1905-2005

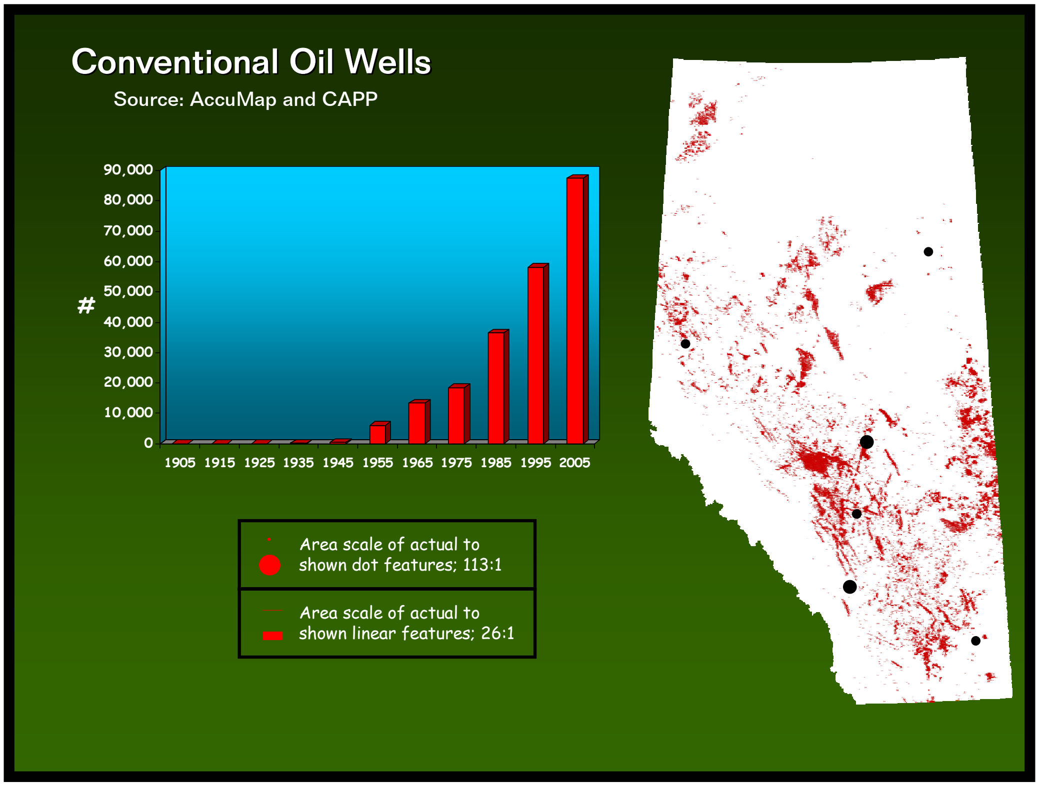


Figure 6: Number of conventional oil wells in Alberta, 1905-2005

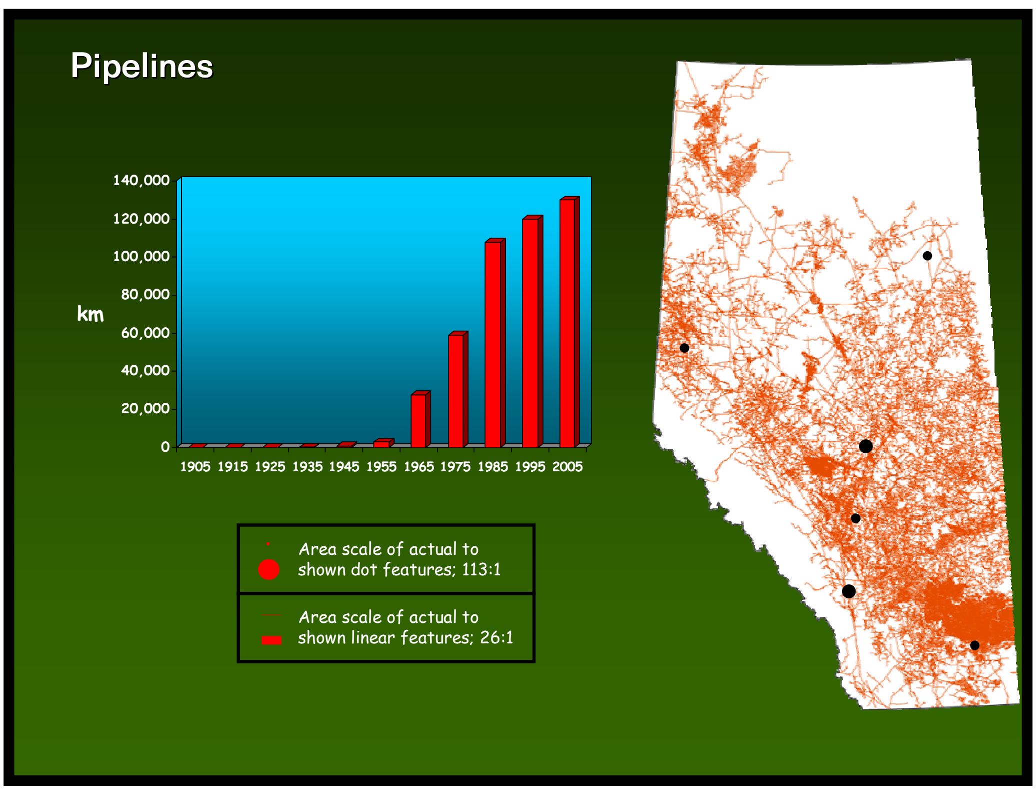


Figure 7: Kilometres of pipelines in Alberta, 1905-2005

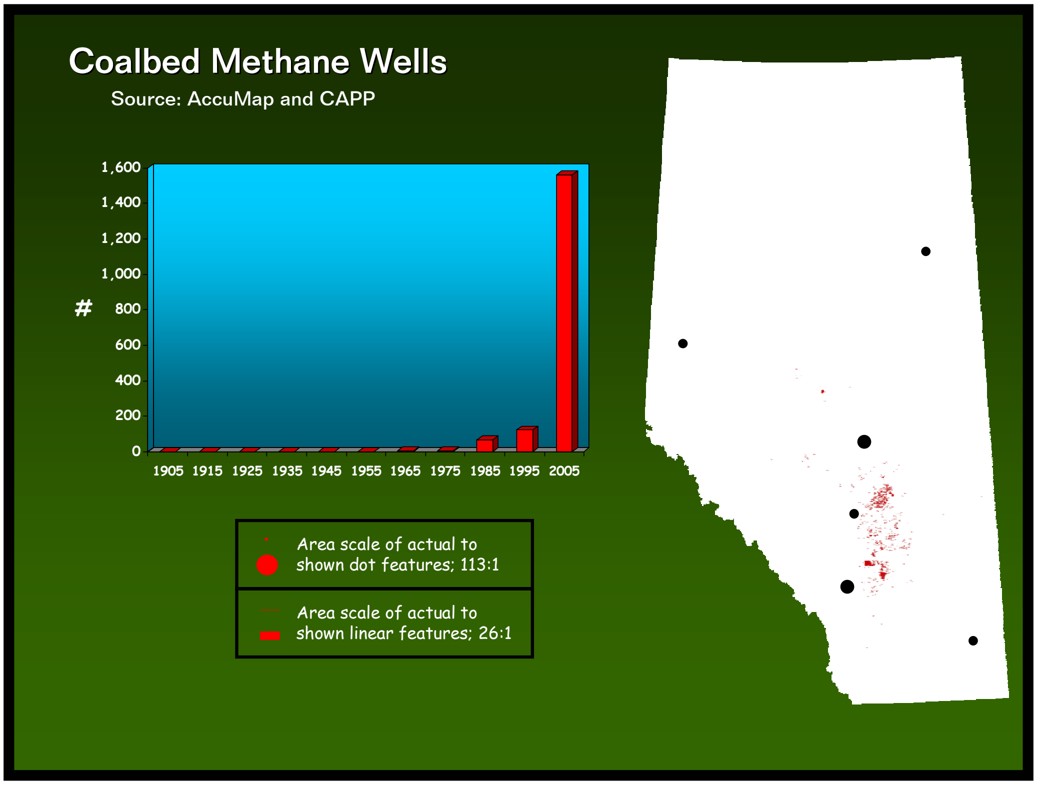


Figure 8: Number of coalbed methane wells in Alberta, 1905-2005

and oil wells and associated pipelines. The distribution of coal-bed methane wells, shown in Figure 8, represents the early stages of development of this energy source. Although wells and energy infrastructure are distributed widely throughout the province where there are not federal parks, the distribution is non-uniform. Spatial analysis at regional and local scales would therefore reveal distinctive patterns of development in different parts of the province.

The growth trajectory of the energy footprint over time will be influenced by the duration of active operations for well sites and facilities and by the time lines and standards for abandonment and reclamation. The spatial distribution of abandoned wells tracks the overall industry footprint, as shown by Figure 9. Not surprisingly, the numbers of these wells also reflects the increase in overall exploration and development. The number of wellsites that are no longer producing hydrocarbons, or never did, is growing exponentially.

By the mid-point of this century, Alberta will likely host an abandoned population of greater than 250,000 wellsites totaling more than 250,000 ha. These numbers emphasize the magnitude of the task of properly reclaiming these sites back to conditions that contribute to natural capital. As shown in the graph prepared by CAPP (Figure 10), there is a growing gap between the number of wellsites abandoned and the number that have been successfully reclaimed. This gap will only continue to grow unless more aggressive reclamation efforts are undertaken, a topic returned to below in Section 4.5.2.

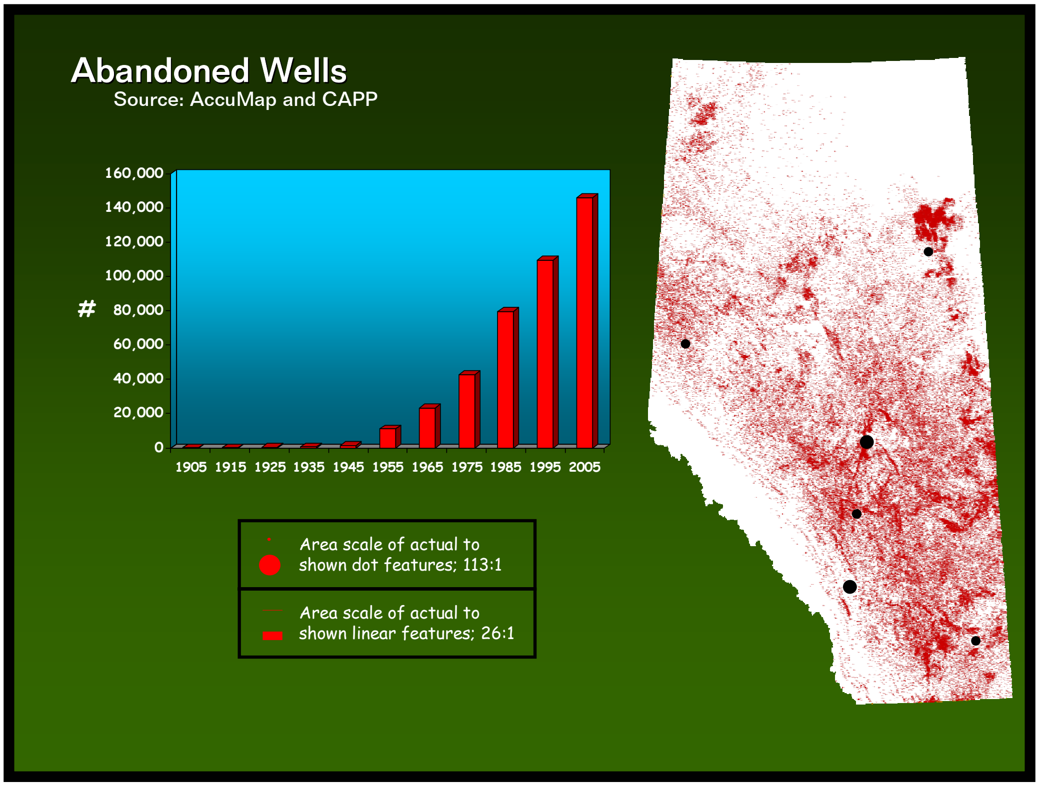


Figure 9: Number of abandoned wells in Alberta, 1905-2005

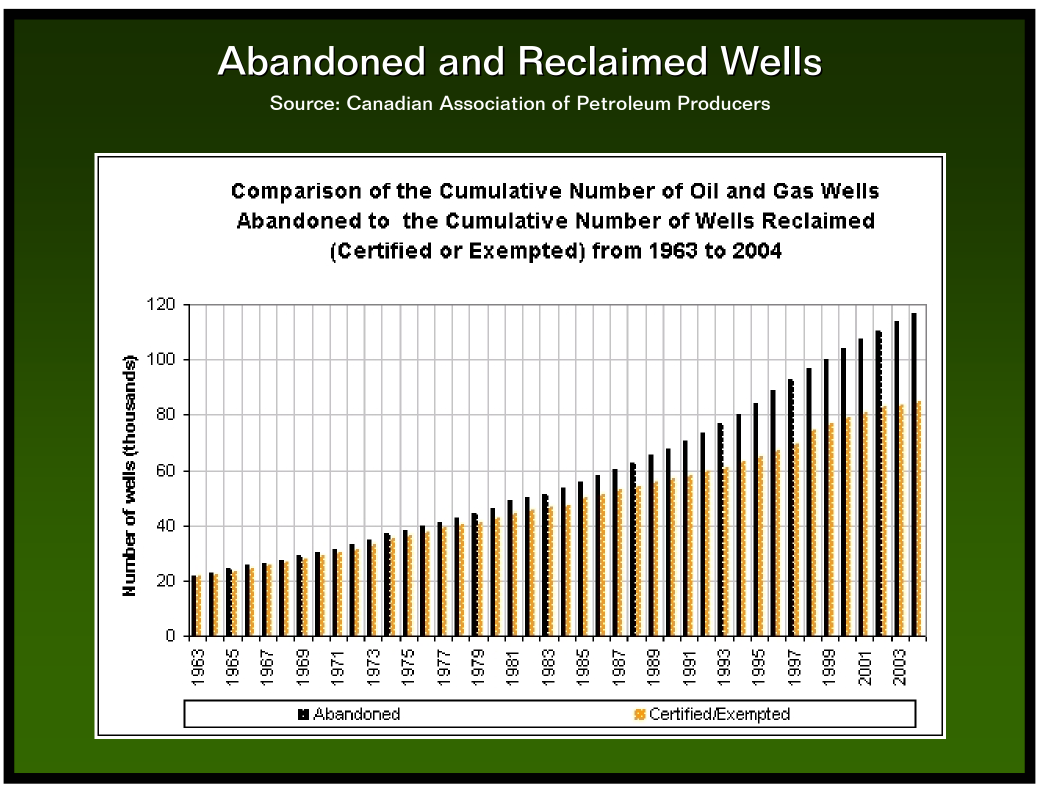


Figure 10: Comparison of cumulative number of abandoned and reclaimed wells, 1963-2004

The spatial configuration of Alberta's energy footprint is superimposed on a landscape that is being used for many other purposes, most of which also create a physical footprint. Agriculture, forestry, transportation, urban development, rural residential development, and recreation are among the principal land uses that will contribute to shaping Alberta's future landscapes. A detailed review of the entire 'multiple-use' footprint is beyond the scope of this paper, but a sense of its expansion over time can be gained by looking at the road network that literally ties together human land uses at the landscape scale. Roads provide a reasonable indication of the overall human footprint because all human land uses require access and most uses rely on the road network to provide this access. Figure 11 presents the spatial distribution Alberta's road network, again including time series data that shows the growth of that network over time. For reasons discussed in more detail below, linear disturbances such as roads are a principal component of the energy sector's contribution to landscape-scale change and these disturbances are linked to significant ecological and other impacts.

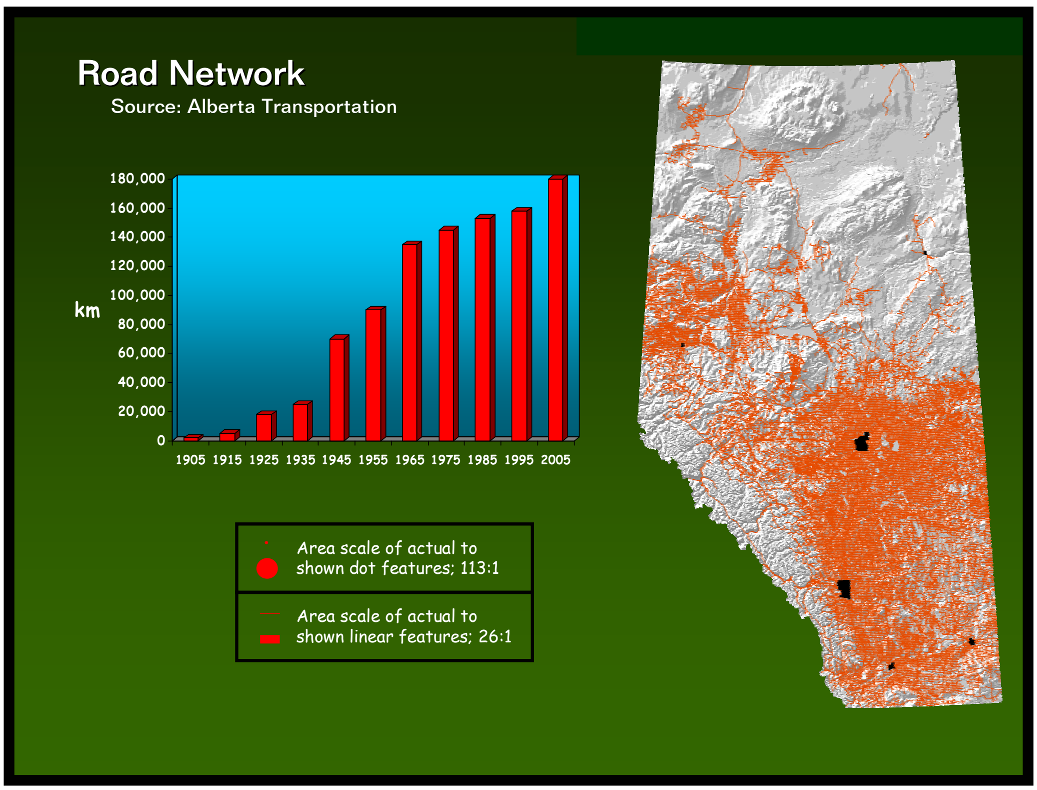


Figure 11: Kilometres of roads in Alberta, 1905-2005

In summary, the spatial information presented above shows the extent and intensity of the energy sector's footprint across much of Alberta. Data and mapping that show the proliferation of well sites, pipelines and other facilities and the progressive expansion of Alberta's road network to serve the needs of the energy industry and a multitude of other land users is, however, only the first stage in understanding how energy development has driven landscape-scale change and how future energy development will have a profound influence on the future of Alberta's landscapes. The next stage is to move from the spatial visualization of the footprint to a measurement of changes in fundamental landscape characteristics.

3.2 Metrics of Landscape Change

The biophysical impacts associated with the energy sector's expanding footprint can be quantified in ways that highlight changes in landscape characteristics that are significant for ecological, social, cultural and economic reasons. Tracking and projecting changes in these landscape metrics over time reveals the magnitude and rate of change of the energy sector's impact on the landscape. The relative importance of impacts caused by the energy sector can also be assessed by comparing metrics of landscape change generated for all land uses with metrics that include all land uses except the energy sector.

The landscape metrics presented in this section of the paper were selected by members of the project team to capture landscape characteristics that are recognized as important within the science of landscape ecology, are understandable to a broad audience, and demonstrate the absolute and relative contribution of the energy sector's footprint to landscape change in Alberta. Analysis of these metrics, including both historical 'backcasting' and landscape simulations, was undertaking using ALCES. The ALCES methodology was introduced above in Section 2 and is further elaborated upon in Figures 12 and 13. Landscape metrics are described over a 200 year time frame. Metrics of landscape change from Alberta's pre-industrial landscape in 1900 to the present time are based on available data. Land-use simulations to 2100 have been generated by ALCES using plausible but conservative projections that are based on trends in historical land-use metrics, published government land-use trajectories, and industry projections of land and resource use.

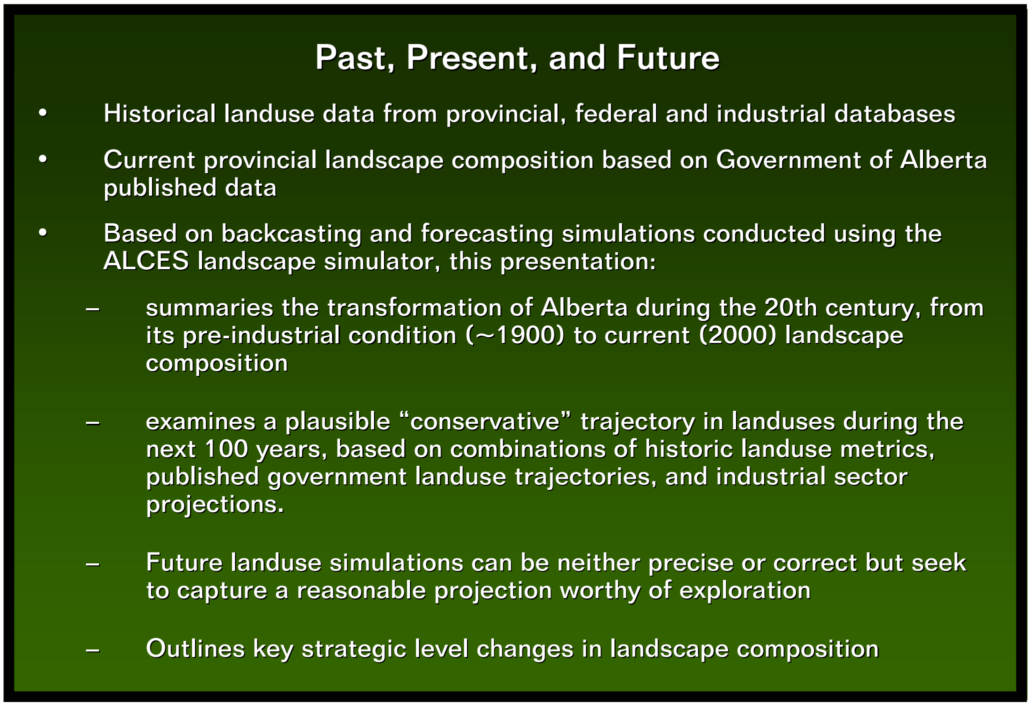


Figure 12: ALCES® methodology: sources, backcasting and forecasting

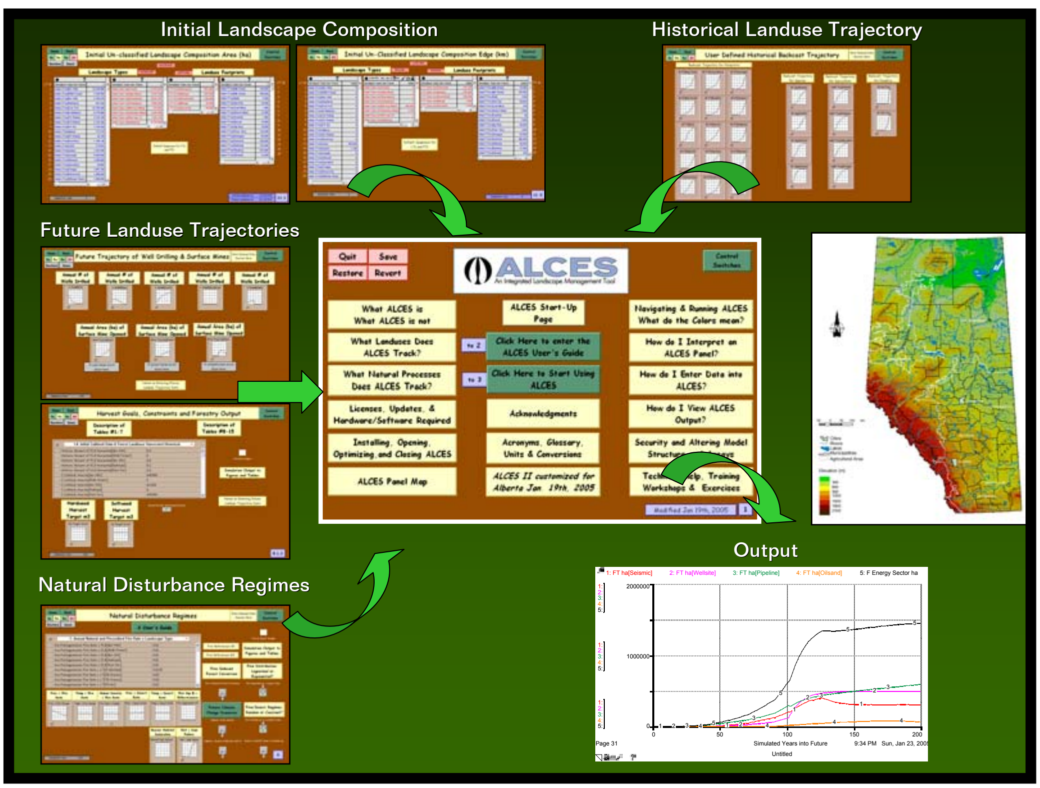


Figure 13: Conceptual diagram of ALCES® modeling inputs and outputs

Perhaps the most obvious landscape metric is the change in total footprint over time. Figure 14 presents the growth in the energy sector's footprint in hectares. This footprint has expanded at a steadily increasing rate since the mid-1900s and is projected to continue a steep increase until approximately 2025, at which time the growth curve flattens considerably. ALCES includes reclamation of landscape disturbance and the values presented here represent the net footprint (i.e., reclaimed well sites are returned non-industrial land use). This graph confirms the point made earlier regarding the significant increase in footprint that can be expected as the industry matures in Alberta and as attention shifts to non-conventional reserves and oil sands.

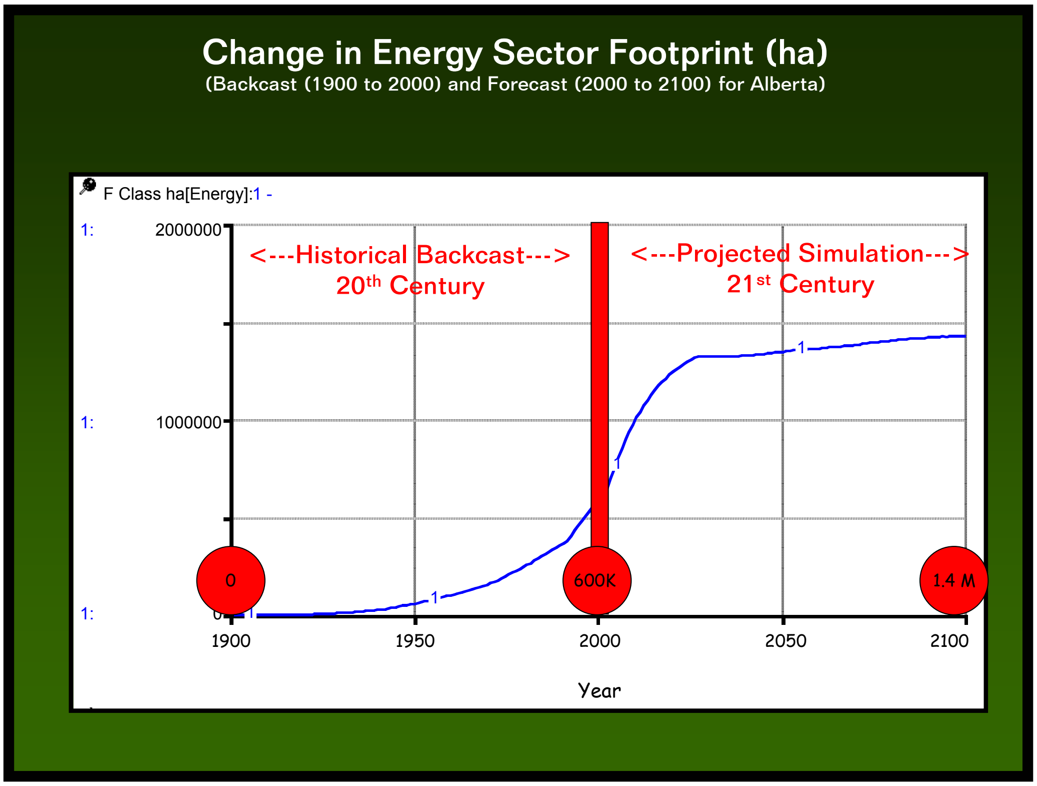


Figure 14: Energy sector land use footprint, backcast and forecast 1900-2100 (ALCES® modeling output)

The energy sector's absolute change in footprint should be viewed in the context of other land uses in order to better understand its contribution to landscape-scale change. Figure 15 shows that this sector has used and will continue to use significantly less surface area than agriculture and forestry. Total area used (or disturbed) does not, however, capture all relevant information regarding the extent and impact of footprint.

Figure 16 shows that the energy sector's footprint already creates more anthropogenic edge than other land uses and is expected to significantly outpace all other uses in creating anthropogenic edge over the next 100 years. This feature of the energy footprint compared with other major land uses reflects differences in the configuration of disturbance. While forestry and agriculture tend to create blocks of disturbance connected

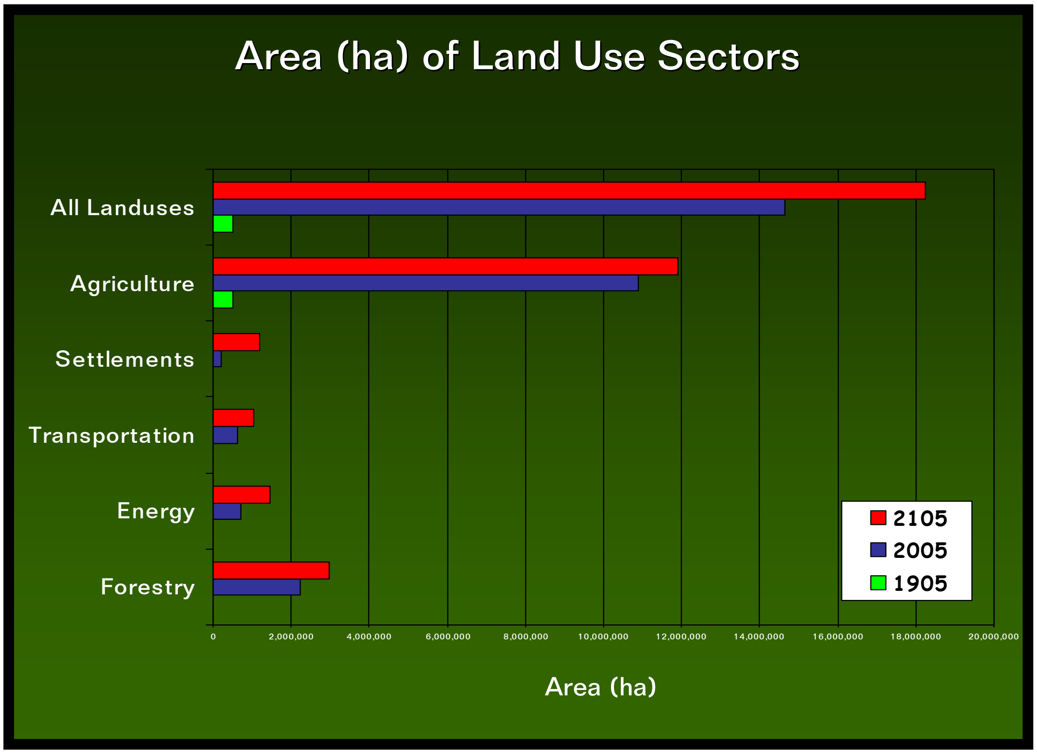


Figure 15: Relative area of major land use sectors, 1905/2005/2105 (ALCES® modeling output)

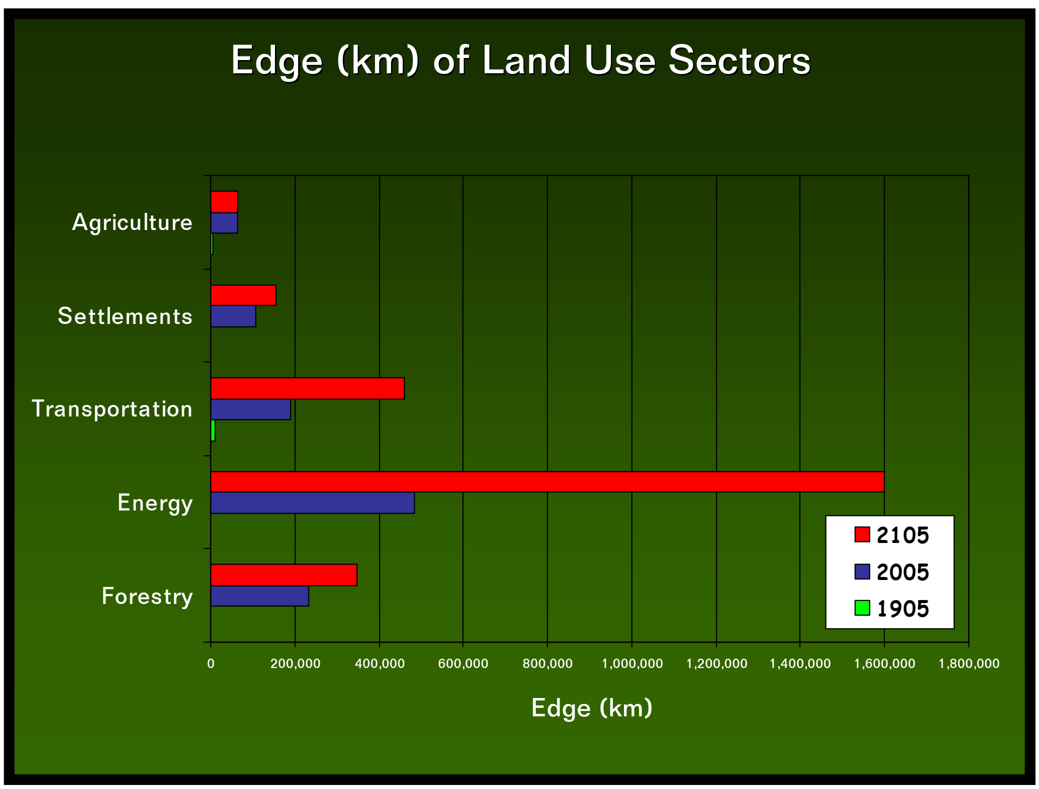


Figure 16: Comparison of edge effect of major land use sectors, 1905/2005/2105 (ALCES® modeling output)

by a transportation infrastructure, the energy sector typically produces a multitude of much smaller disturbances with an extensive network of linear transportation corridors. Oil sands mining is, of course, an exception to this pattern within the energy sector. The metric of anthropogenic edge and its significance in terms of ecological effects linked to habitat fragmentation and increased human access are returned to below.

A second key point when considering total disturbance as a landscape metric is the fact that the biophysical impacts of human activities may extend beyond the physical disturbance footprint. For example, some wildlife species may be displaced from habitat adjacent to disturbed areas (see the discussion below in Section 3.3.1). For certain types of impacts, therefore, it is appropriate to apply a buffer area around the physical footprint. The appropriate size of this buffer – or whether it is appropriate to apply a buffer at all – will depend on the type of disturbance in question and its effects on surrounding land and wildlife. Clearly, impacts will vary depending on species and habitat type. While these variables may limit the explanatory value of provincial-scale data using standard disturbance buffers, Figure 17 is nonetheless instructive because it shows clearly that the relative magnitude of the energy sector's contribution to landscape change increases significantly if disturbance buffers are applied. Once again, this dramatic increase in relative impact reflects differences in the configuration of the energy footprint when compared with other land uses. A more precise analysis of impacts beyond the physical footprint might require the application of different buffers for specific species and within specific habitat types.

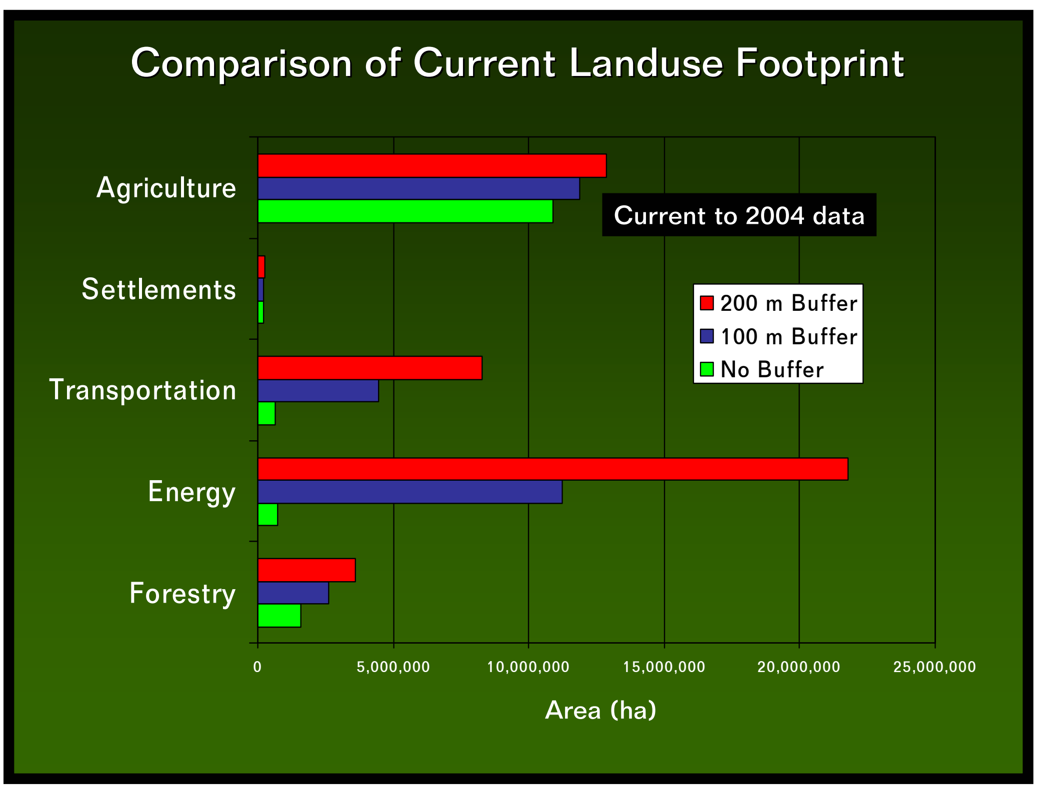
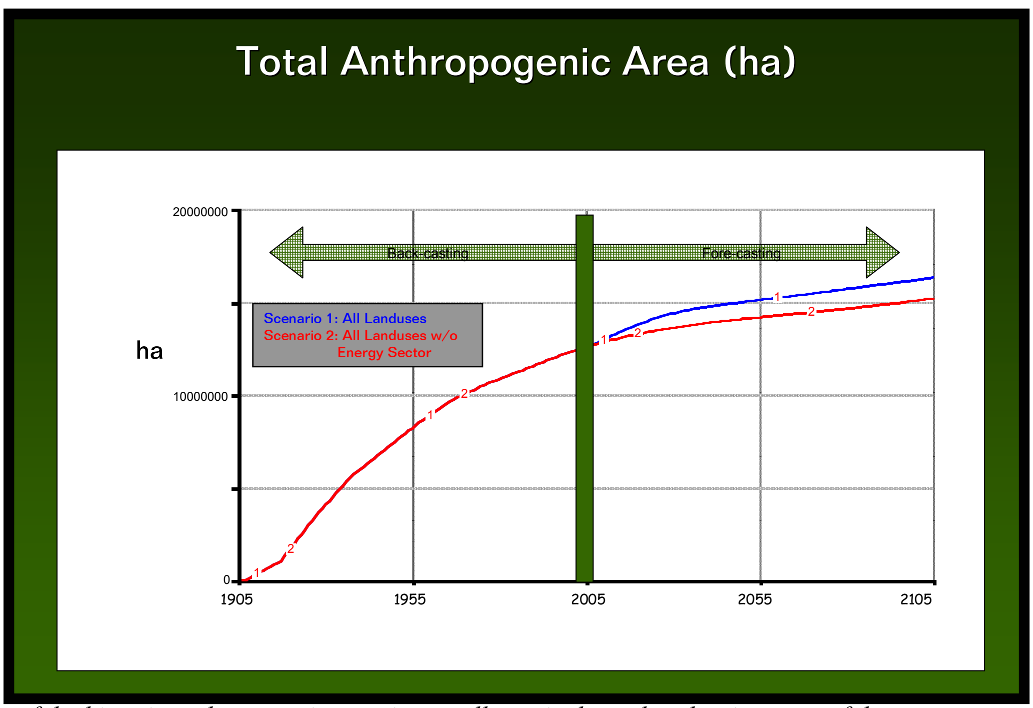


Figure 17: Relative area of major land use sectors when buffered, 2004 (ALCES® modeling output)

A more complete and nuanced understanding of the energy sector's contribution to landscape change is gained by using a suite of metrics that capture important landscape characteristics. The figures that follow present ALCES outputs showing changes over time in the following metrics:

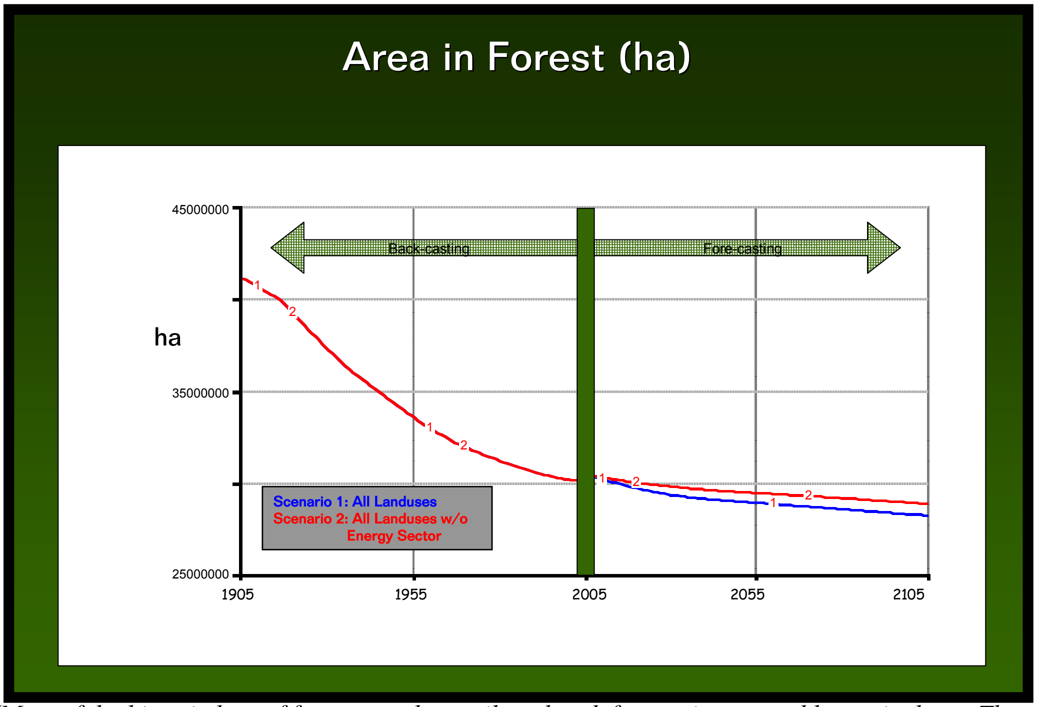
- Total Anthropogenic Area (ha) – Figure 18;
- Area in Forest (ha) – Figure 19;
- Average Forest Landscape Age (years) – Figure 20;
- Total Anthropogenic Edge (km/km^2) – Figure 21; and
- Total Number of Culverts – Figure 22.

The ALCES analysis of these metrics combines all land uses for historical data, but generates land-use simulations that distinguish between changes in the metrics due to all land uses and changes attributable to all land uses except the energy sector. It is thus possible in these simulations to identify extent to which expected changes in these landscape metrics over the next 100 years can be attributed to the energy sector.



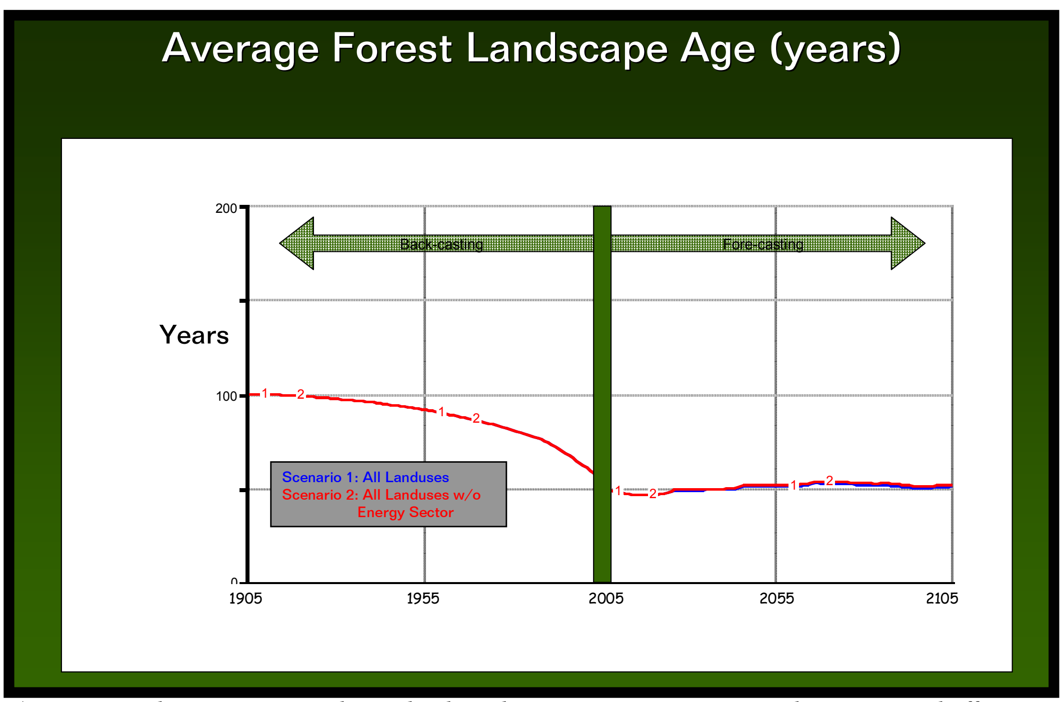
(Most of the historic anthropogenic area is actually agriculture, but the signature of the energy sector is visible for future simulations. Most of the future area is settlements, transportation, energy, and logging)

Figure 18: Total anthropogenic area with and without energy sector, backcast and forecast 1905-2105 (ALCES® modeling output)



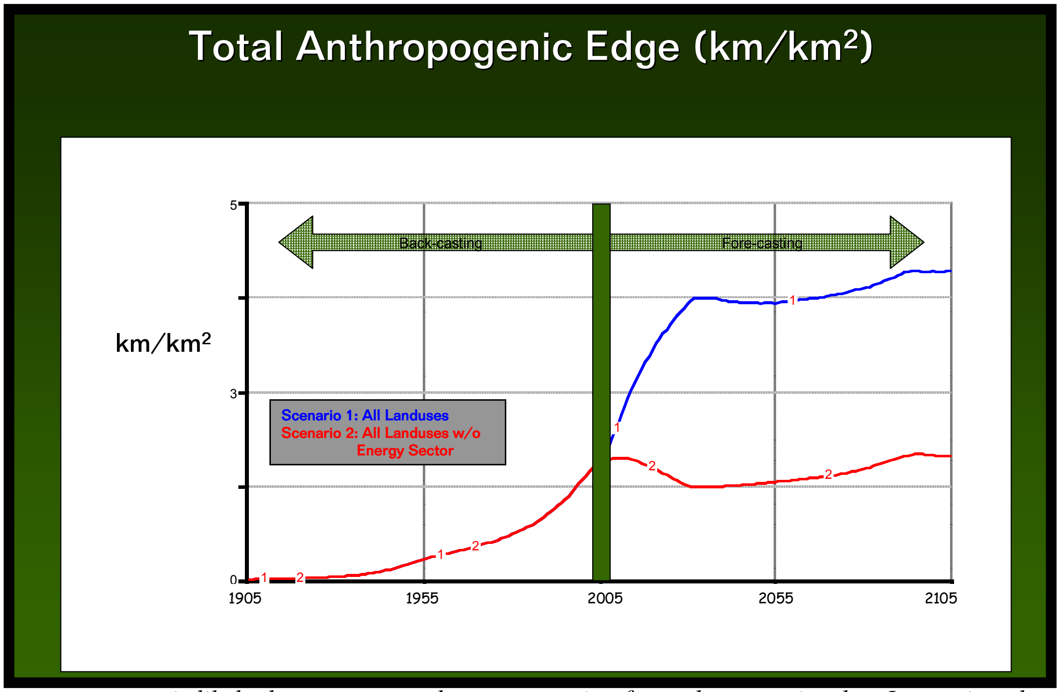
(Most of the historic loss of forests can be attributed to deforestation caused by agriculture. The role of the energy sector in the future is apparent)

Figure 19: Area in forests with and without energy sector, backcast and forecast 1905-2105 (ALCES® modeling output)



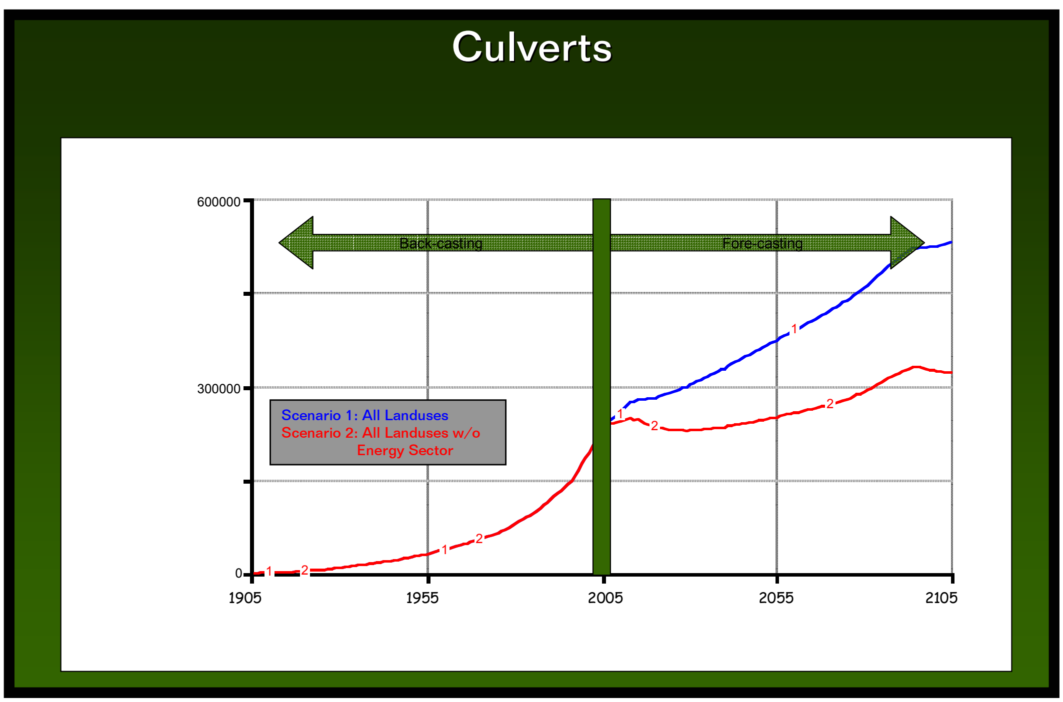
(Forest age class structure is driven by disturbance rates. Energy sector has a minimal effect in comparison to forestry and fire)

Figure 20: Average forest landscape age with and without energy sector, backcast and forecast 1905-2105 (ALCES® modeling output)



(The energy sector is likely the paramount player accounting for anthropogenic edge. Its continued existence, or disappearance, will have a massive effect on the amount of anthropogenic edge)

Figure 21: Total anthropogenic edge with and without energy sector, backcast and forecast 1905-2105 (ALCES® modeling output)



(The number of crossings is proportional to the amount of transportation network. Many crossings have been built; many remain to be built. The amount of wellsite access roads is a major contributor to historic and future culverts)

Figure 22: Total number of culverts in Alberta with and without energy sector, backcast and forecast 1905-2105 (ALCES® modeling output)

It is not possible in this paper to present a detailed discussion of the scientific rationale for selecting each of these metrics and the implications of the historical data and simulations that are presented in these figures. Nonetheless, several conclusions emerge clearly from the ALCES analysis.

- All of the metrics exhibit significant change over the 200 year time frame. They show that human land use has changed Alberta's landscapes in fundamental ways over the past 100 years and for all metrics these changes are likely to continue under plausible land-use scenarios.

- The amount and rate of projected change compared with past change vary among landscape metrics. In some instances, the rate of change appears likely to diminish over time, while other metrics will continue to exhibit high rates of change over the coming decades.

- The two metrics that exhibit the greatest rates of change in the land-use simulations – total anthropogenic edge and culverts – are also the metrics where the energy sector makes the greatest relative contribution to the total change. These scenarios suggest a correlation between the growth of the energy footprint in Alberta and rapid landscape change.

- For several of the other metrics where change is somewhat more gradual (e.g., total anthropogenic area, area in forest), the scenarios for future land use indicate that the energy sector will likely make a discernable contribution to landscape change that will progressively increase in importance relative to all other land uses. Among the metrics presented here, average forest landscape age is the only one where the energy sector has no discernable effect.

- The metrics where the energy sector's relative impact is most significant include total anthropogenic edge and culverts. These metrics capture the effects of the extensive network of linear disturbances and relatively small cleared areas that characterize the energy footprint.

The overall conclusion is that the energy sector's contribution to landscape change relates primarily to the proliferation of linear corridors and small patch disturbances that fragment core forest areas, create anthropogenic edge, and result in stream crossings which, in many cases, involve the installation of culverts. The projected expansion of the energy sector's footprint will also contribute significantly to the increase in total anthropogenic area and the decrease in total forest area across Alberta's landscapes.

ALCES analysis of landscape metrics thus provides important information about the types of landscape change that are associated with plausible energy futures in Alberta and the relative significance of these changes in the context of overall land use trajectories. These metrics do not, however, explain the effects of these changes on landscape attributes or values. The next section of this paper combines ecological theory and

ALCES simulations to evaluate the implications of these historical and projected changes in landscape metrics.

3.3 Indicators and Analysis of Ecological Impacts

The project team has examined three indicators that capture significant ecological effects associated with the changes in landscape metrics described in the previous section. These indicators are: (1) fragmentation of aquatic habitat by hanging culverts; (2) caribou population response; and (3) grizzly bear exposure index. All of these indicators are sensitive to the distinctive landscape changes associated with the energy sector's footprint. As described above, these changes include landscape fragmentation, especially by linear disturbances, and associated increases in anthropogenic edge, decreases in forest core area, and alterations in aquatic systems resulting from the installation of culverts at stream crossings.

The discussion of the selected indicators begins with an overview of ecological theory on habitat fragmentation. Fragmentation of aquatic habitat by hanging culverts is then examined. The theoretical basis for using focal species to evaluate ecological effects is described next, followed by a discussion of the effects of landscape change on caribou and grizzly bear populations in the regions of the province where these species are found.

3.3.1 Habitat Fragmentation: The Theory

Habitat fragmentation is one of the principal ways that human land uses affect natural ecosystems (Debinski & Holt 2000, Wilcox & Murphy 1985). The term "habitat" is used broadly to describe the natural vegetation or landscape required by any given species. Habitat fragmentation begins when a disturbance, such as a road, creates a gap in continuous habitat which reduces the total amount of habitat and creates isolated patches (Meffe & Carrol 1997, Andren 1994). For instance, the penetration of a road, seismic line or pipeline into previously continuous habitat partitions that habitat into two separate patches.

Habitat fragmentation may be quantified in terms of habitat loss and habitat isolation (i.e., the loss of connectivity between habitat patches). In theory, the more patches that remain after a disturbance, the more fragmented the habitat and the more likely it is that certain species will fail to thrive. However, conclusively demonstrating such biological effects is challenging, especially for rare or sensitive species. This is because of the difficulty of conducting true replication and the absence of controls in ecological research (i.e. it is not feasible or ethical to tag or to manipulate all populations of rare species).

In general, to determine the effects of habitat loss and isolation, we must rely on inference from other research that examines less or non-threatened species, such as insects or rodents. Based on such research, it has been found that the reduction of area and connectivity results in changes to community structure, community composition, competitive interactions, and predator-prey dynamics, all of which may have negative demographic consequences (Debinski & Holt 2000, Alexander *et al.* 2005). Depending on the scale and extent of these demographic changes vulnerable species may become locally or globally extinct (Weaver *et al.* 1996). Fahrig and Merriam (1985) demonstrated, for example, that white-footed mice (*Peromyscus leucopus*) in fragmented woodlots had lower growth rates and were more prone to extirpation than those in connected woodlots.

3.3.1.1 Edge Effects

The effects of habitat fragmentation that are characterized by more and smaller habitat patches are compounded by the creation of edge habitat. For example, when a road is constructed there is not only a loss of habitat and isolation of forest patches; there is also an increase in edge habitat, which is defined as the transition between the forest patch and the road. Edge can be problematic for a variety of reasons. It intensifies the penetration of light and sound into areas of the patch previously not disturbed (Debinski & Holt 2000, Saunders *et al.* 1991, Hobbs 1993) and decreases immigration and emigration rates for certain species (Forman & Alexander 1998, Stamps *et al.* 1987). The creation of edge also has been demonstrated conclusively to alter the composition of the community, change predator-prey and competitive interactions, and disrupt inter-specific interactions (Forman & Alexander 1998).

If the edge-to-area ratio of all remaining habitat patches is large (i.e., lots of edge), then edge-sensitive species may not persist or may move out and be replaced by edge-tolerant species (Weaver *et al.* 1996, Noss 1983). Moreover, the contrast between the habitat patch and external disturbance may decrease the likelihood of individuals or species moving across the matrix to alternative patches. This effect is not exclusive to sensitive "focal" species like grizzly bear and caribou. For instance, Verbyla and Chang (1994) found that deer did not cross disturbance patches greater than 100 metres in width. If a species will not cross a disturbance patch or linear disturbance corridor then a "barrier effect" has been manifested, the biological implications of which are discussed in more detail below. Importantly, the barrier effect is in many cases most profound for the edge habitat that is created by roads.

3.3.1.2 Barrier Effects

The barrier effect results from physical constraints or psychological disturbance (Stamps *et al.* 1987). In general, a physical barrier will prohibit or reduce movement of an animal across the landscape. In the extreme case a physical barrier kills animals that attempt to cross it. Specific to this study, roads can act as barriers with a range of effects on movement. Traffic on roads may reduce movement and act like a "filter", but in many cases traffic on roads is a complete physical barrier because it kills animals. It is notable that even decommissioned roads (such as those used in exploration or extraction of oil and gas) may result in the death of animal when used opportunistically by humans who intend to kill.

The psychological effect of disturbance is based on a fear response of individual animals and may either reduce or eliminate movement of species across a disturbance. A reduction in movement, whether via death or fear, has biological consequences. Firstly, adult animals may not be able to leave a patch to find necessary resources for survival or reproduction. Secondly, juvenile animals may not be able to disperse to new habitat, which will increase the pressure on existing patch resources. This heightened pressure of more animals on the existing patch may change inter-specific and intra-specific interactions, may alter predation rates, and ultimately, either response may lead to fewer new recruits to a species' local population and a slow demise of the larger population (Wilcox & Murphy 1985, Jackson 1999).

In Alberta, it is critically importance understand the effects of linear disturbance on wildlife as it relates to oil and gas development, particularly because of the extent of road network that is coincident with this development. Roads are now considered the single greatest mortality threat to wildlife, and Malo *et al.* (2004) estimated that vehicle related mortality of wildlife totals several millions of animals per year.

3.3.1.3 Fragmentation and Total Physical Footprint

The ecological theory of habitat fragmentation provides additional insights into the landscape metrics discussed in Section 3.2, notably the link between total footprint and ecological impacts and the rationale for buffering disturbance to capture effects on adjacent habitat. The ALCES simulations presented earlier indicate that the direct physical footprint of the energy sector is projected to increase from the existing 600,000 ha (less than 1% of provincial area) to 1.4 million ha (~2.1% of provincial area) by 2100 (Figure 14). Although the extent of this footprint may seem insignificant in a provincial context, and it is less than other land uses (e.g., forestry, agriculture; Figure 15), it is the spatial distribution and ecological implications of the change that make this value detrimentally significant.

The dispersion of linear and small patch size disturbances associated with the energy sector results in the creation of more edge than all other major land uses combined – 1.6 million km or 40 times around the circumference of the Earth. This magnitude of disturbance equates to approximately 2 km of edge/km^2. If one assumes a very modest edge effect of 100 m into a patch, the average overall landscape effect would be 40 ha/km^2 (i.e., 40 percent of the provincial landscape). An average edge effect of 400 m, which is consistent with values reported for many interior forest species, suggests that 100 percent of the provincial landscape would be negatively influenced by the footprint of the energy sector. As indicated above, the fragmentation effects of edge creation are highly detrimental to many species, especially those requiring interior forest habitat conditions. Our modeling results of all land uses indicate a 500 percent increase in the number of forest patches compared to the year 1900.

3.3.2 Hanging Culverts and the Fragmentation of Aquatic Systems

The network of roads that we construct on the landscape is superimposed on an existing ecological infrastructure that provides movement corridors for other species. These two systems intersect and interact in many complex ways and the study of this interface constitutes the science of 'road ecology' (Forman *et al.* 2003). One of the most significant system interactions of interest to both transportation engineers and ecologists is that between roads and lotic systems (rivers and streams). The construction of roads inevitably leads to stream crossings. While larger stream channels are spanned by bridges, the majority of stream crossings involve the installation of culverts.

Historically, the design and installation criteria for culverts have been dominated by hydraulic and economic efficiency; the objective was to maximize water conveyance while minimizing pipe size and cost. Until recently, little consideration was given to maintaining critical in-stream ecological conditions (Baker & Votapka 1990, Bates 2003). The installation of culverts results in deleterious effects to aquatic species that may include: direct habitat loss, changes to water quality, upstream and downstream channel effects, and impairment of ecological connectivity (Bates 2003). Maintaining ecological connectivity in aquatic systems is considered to be critical in conserving the distribution and abundance of stream fish assemblages (Rieman & McIntyre 1993), while reductions in connectivity impede fish movements, alter fish community structure, and likely threaten population viability (Morita & Yokota 2002).

Culverts generally have a diameter significantly less than the maximum natural stream channel and consequently alter the stream flow characteristics both through and downstream of the culvert. The increased velocity associated with conveyance of water through a culvert results in an increased resistance or barrier to upstream travel by aquatic species (Warren & Pardew 1998). In addition, increased velocity raises the erosive potential downstream of the culvert. Such changes can have detrimental effects on the connectivity of lotic systems through the creation of barriers to fish passage. These barriers may be complete, seasonal or species/lifestage specific. Improper design and maintenance of culverts can result in serious habitat discontinuities for aquatic species (Belford & Gould 1989, Thormann *et al.* 2004). The barrier effect here is functionally analogous to the situation described above for terrestrial species and may result in disruption of dispersal to critical habitats, limited gene flow and isolation of populations to the point of local extirpation.

Although there are designs to improve the fish habitat within culverts and lessen their barrier effects (e.g., box culverts with internal structure), the typical culvert installation has been shown to affect fish populations negatively through a variety of mechanisms including: becoming blocked by debris or ice, becoming elevated relative to the river bed, increasing stream velocity, and providing insufficient water depth. For example, Eaglin and Hubert (1993) found that the biomass of brook trout (Salvelinus fontinalis) and brown trout (Salmo trutta) was negatively correlated with the number of culverts/km^2 within a drainage area, leading the researchers to conclude that culverts significantly reduce stream productivity through harmful alteration or fragmentation of habitat.

When water travels through a culvert at increased velocity (e.g., stream constriction during high flow runoff conditions in spring), it scours the streambed at the exit end of the pipe and creates a deepened area known as a plunge pool. The plunge pool created below the culvert will continue to erode and deepen over time. When water levels drop during periods of low flow, the culvert exit is left perched or 'hanging' above the water surface creating a freefall condition (Figure 23). This condition requires fish to leap from the pool into the culvert to move upstream. The ability of fish to swim against increased stream velocities and jump barriers is affected by water depth, dissolved oxygen concentration and the biokinetic potential of the age, size and swimming mode of the species concerned (Beamish 1978, Katopodis & Gervais 1991).

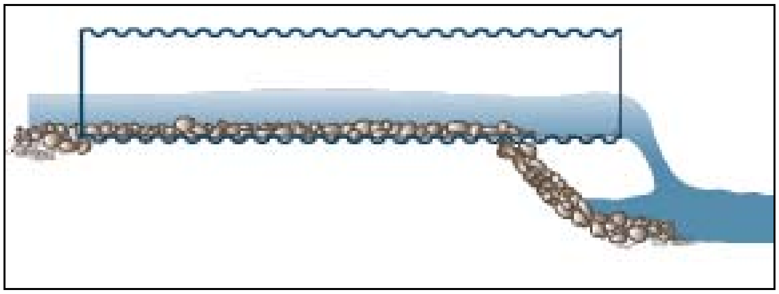
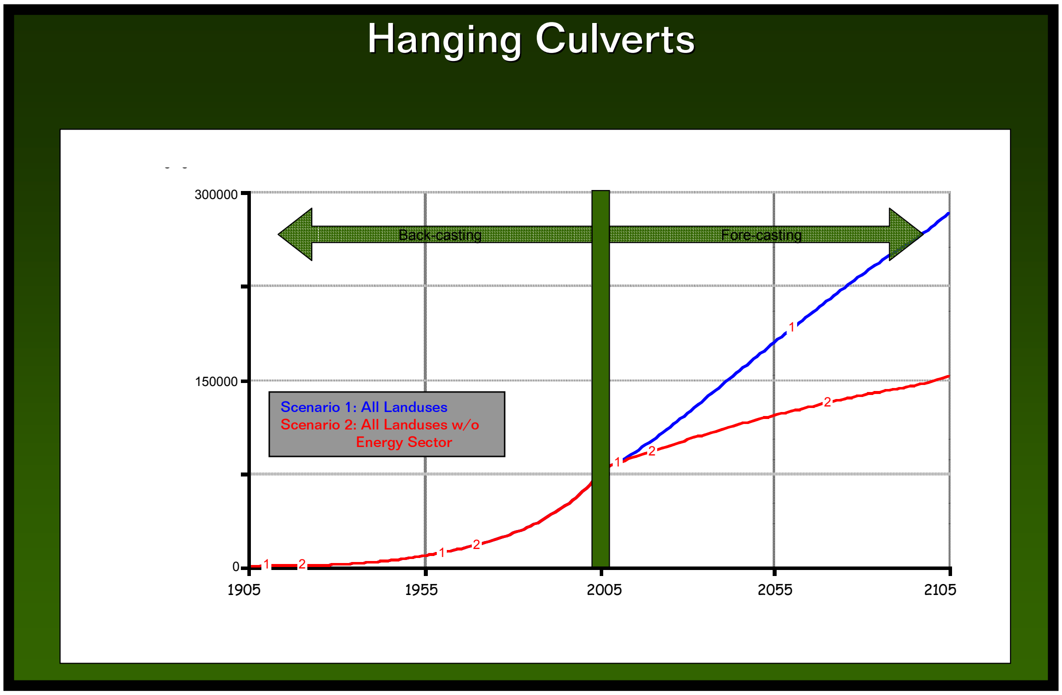


Figure 23: Diagram of a hanging (or perched) culvert
(adapted from University of Wisconsin Extension, n.d.)

Park (2006) examined 509 culverts in four northern Alberta watersheds and found that 42 percent of culverts were hanging and constituted barriers to upstream movement. He estimates that there are currently over 40,000 hanging culverts in northern Alberta with a rate of increase of 14,000 hanging culverts/year. Similarly, Tchir *et al.* (2004) reported that the majority of culvert road crossings in the Swan and Notikewan River basins (61 percent and 74 percent respectively) of northern Alberta constituted potential barriers to fish passage. The status report for Arctic grayling in Alberta (Government of Alberta 2005a) states that: "Stream fragmentation, as a result of road construction and culvert barriers, is a critical limiting habitat feature for Arctic grayling." As the need for road crossings is concomitant with industrial activity and the effects of such crossings are a critical factor in maintaining ecological connectivity, we have selected hanging culverts as an appropriate indicator of significant changes to aquatic ecosystems.

The primary driver for a negative trend in hanging culverts is the proliferation of roads and other linear disturbance which, as noted above, is a principal feature of the expanding energy footprint in Alberta. Although the bulk of published literature on habitat connectivity and barrier effects is focused on terrestrial systems, the ecological effects in aquatic systems are even more critical because of the potential implications of fragmentation for numerous aquatic species.

There are currently 200,000 km of roads in Alberta and the modeling completed for this report suggests that this number will increase to 800,000 km by 2100. The linear disturbance of roads corresponds to a direct footprint of 700,000 ha and is projected to increase to 1.3 million ha by 2100. These roads contribute increased sedimentation to streams and provide increased access for anglers, contributing to the potential for over-exploitation of fish stocks. The total number of culverts associated with existing roads is 225,000 and is projected to increase to 800,000 by 2100. We estimate that there are currently 90,000 hanging culverts and, if current practice continues, this number will



(Hanging culverts are a function of 2 things: # of culverts, and flood events. Future simulations in this run assume "no" level of replacement for hanging culvert)

Figure 24: Number of hanging culverts with and without energy sector, backcast and forecast 1905-2105 (ALCES® modeling output)

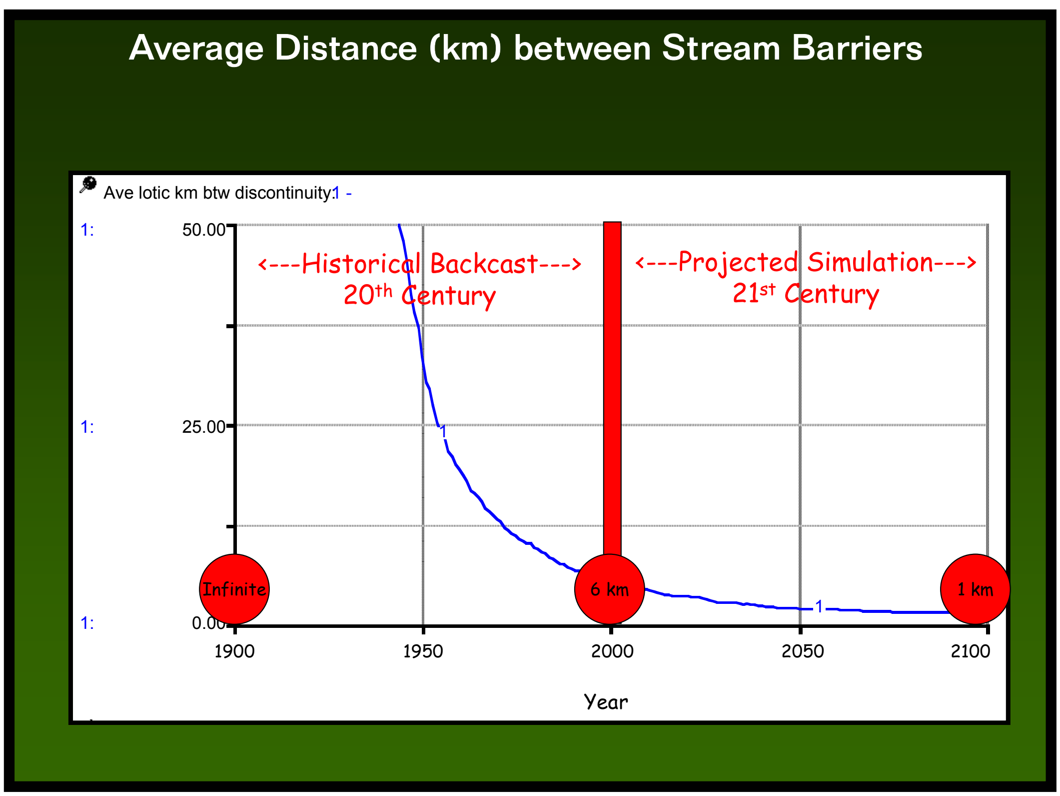


Figure 25: Average distance between stream barriers in Alberta, backcast and forecast 1900-2100 (ALCES® modeling output)

increase to 370,000 by 2100 (Figure 24). On average, the current situation results in a lotic discontinuity every 6 km. The projected value for 2100 indicates a significant barrier effect for every 1 km of stream (Figure 25). The significance of this value in fragmenting the habitat of fish and other aquatic biota cannot be overstated.

Aquatic species require linear connectivity to access critical habitat during different life stages and across different seasons. Populations also display unique life history strategies that require movement between stream reaches and between lotic and lentic systems (e.g., stream resident, fluvial and adfluvial strategies). Habitat diversity and connectivity allow for the expression of all types of life history strategies, and the persistence of aquatic species (Rieman & Clayton 1997). For example, fish often feed, spawn, rear, and over-winter in very different stream conditions and locations. Some populations of bull trout, Alberta's provincial fish and a species of special concern (Post & Johnston 2002), are known to travel over 250 km to reach their spawning grounds (Burrows *et al.* 2001, McLeod & Clayton 1997). Seasonal movements for other species may require lesser distances, but are no less important for population viability. Fish often display strong fidelity to spawn at their natal site and inability to return to that area may result in a failure to spawn or spawning in unfavourable conditions. Connectivity is also essential for maintain metapopulation structure and recolonization following local extirpation (Dunham & Rieman 1999). The exchange of genetic material between local populations is essential for the persistence of stream fish species (McCart 1997) and blockages of this exchange greatly increase the risk of population extinction and eventual species extinction.

In conclusion, the barriers to fish passage created by hanging culverts may constitute the most significant ecological effects of expanding industrial activity. Better methods of stream crossing and managing the net increase in roads will be essential if many aquatic species are to persist in Alberta.

3.3.3 Using Focal Species to Analyze Ecological Effects

The focal species approach is a "reductionist" strategy. It is based on the use of one species to understand the effects of human disturbance on wildlife populations, to assess the effects of pollution on system health, to identify areas of high biodiversity, and to estimate minimum viable areas for reserve design and management (Caro & O'Doherty 1999, Lambeck 1997).

The focal species approach is predicated on the assumption that the species one chooses to study the effects of disturbance or habitat loss is a valid surrogate for many others (Landres *et al.* 1988). Species whose habitat requirements are large and encompass those of other species are often selected as focal species. If the same species are also negatively affected by (i.e., sensitive to) human disturbance then they may prove to be a more effective focal species. The criteria that define species' sensitivity are based on life history traits, including age of sexual maturity, number of offspring, niche requirements and home range size, among many others (Weaver *et al.* 1996).

Focal species can contribute to conservation planning as keystones (ecological definition), umbrellas (management definition), flagships (public relations and fundraising), or indicators (monitoring quality). By protecting the habitat or restoring connectivity of habitat for these focal species we aim to conserve the larger biotic community. Although the categories listed previously are functionally different, a species may fall under more than one heading, which emphasizes the need to define the purpose of each focal species carefully. These categories can be summarized as follows:

1) *Keystone Species*: Keystone species affect ecosystems disproportionately to their abundance. They are often, but not always, restricted to higher trophic levels (Power *et al.* 1996). For instance, large carnivores may hold keystone roles if they regulate system dynamics. Keystone species exert an effect through consumption, competition, mutualism, dispersal, pollination, disease, and by modifying habitats and abiotic factors (Power *et al.* 1996). An example of a well known and lower trophic order keystone species is the Canadian beaver.

2) *Indicator Species*: An indicator species is an organism "whose characteristics (e.g., presence or absence, population density, dispersion, reproductive success) are used as an index of attributes too difficult, inconvenient or expensive to measure for other species or environmental conditions of interest" (Landres *et al.* 1988). Indicator species are used to examine the "presence and effects of environmental contaminants, population trends of other species and habitat quality for other species or entire ecosystems", and as an early warning of environmental change (Landres *et al.* 1988, Noss 1990). The desirable qualities of indicator species include a broad geographical distribution, sensitivity to a wide range of stresses, cost-effectiveness of research and monitoring, and ecological relevance (Noss 1990).

3) *Umbrella Species*: Umbrella species are those whose "requirements for persistence are believed to encapsulate those of an array of additional species" (Lambeck 1997). Some species may have life history traits, such as large home range size and high dispersal capability, which translate into the use of broad and varied habitat types. It is hypothesized that such species can thus act as "umbrellas", encompassing the needs of other species that fall within their niche (Miller *et al.* 1998).

4) *Flagship and Vulnerable Species*: Flagship species are charismatic species, such as wolves or grizzly bears, that stimulate public awe, sympathy and action (Noss 1990, Miller *et al.* 1998). Vulnerable species are those that are rare, genetically impoverished, have low resilience and are threatened by human persecution.

The focal/single species assumption has been criticized on many grounds (Landres *et al.* 1988, Lambeck 1997). For example, a single species in a guild may exploit similar resources as other guild members, however it may not be alike in breeding characteristics, foraging behaviour, diet or habitat requirements (e.g., the wolverine and lynx) (Landres *et al.* 1988). Landres *et al.* (1988) concluded that these differences make it ecologically unsound to extrapolate from one species to an entire guild, or more importantly to an ecosystem. They contend that ill-applied, single species approaches may result in the loss of some species. Other criticisms include the inability of a single species approach to be conducted at a rate fast enough to deal with urgency of threats and that they consume a disproportionate amount of funding (Lambeck 1997). However, including all species in management plans generally is not possible because of financial constraints (Landres *et al.* 1988). Consequently, the focal species approach remains popular among resource management agencies, where cost effectiveness may be a significant factor in decision making.

There are many considerations in the selection and use of focal species. Beyond the limitations of using one species to encapsulate the needs of many, there is the problem of variation in representation by context and scale. It has been noted that the sensitivity of focal species may change geographically because of slight biogeographic changes (Power *et al.* 1996). Likewise, habitat may vary subtly across geographic areas and the responses of individuals within species may also vary geographically at local, regional and global scales. Moreover, individuals and populations of species may differ in their sensitivity to disturbance type. Some species may be more sensitive to road disturbance and others to fragmentation that creates large open patches in a matrix of forest.

Holling (1992) argued that a select few processes structure terrestrial ecosystems, entrain system variables and define ecosystem dynamics. Moreover, these processes operate at specific "frequencies" or spatio-temporal scales, and are "discontinuous" – they are organized in clusters. He further argued that body size clusters in animal communities mirrors this organization, because of the relationship between species morphology and their use of habitat. That is, home ranges and resource needs tend to scale with body size, and small species cluster together and operate at spatio-temporal scales that are independent of medium or large sized species.

Holling's argument provides a foundation for using a multi-species or focal species approach. For example, if a few key species can be identified to be correlated significantly with others in their body size category, then maintaining representative landscape connections for a set of focal species (i.e., a set of small, medium and large), will help to achieve functional connectivity in the landscape.

To examine the cumulative effects of roads and other linear disturbances associated with the energy sector and other land uses in Alberta, we have selected two focal species that represent different trophic levels. A multi-species approach is valued because it represents a variety of functional ecosystem levels, rather than just one single level (as would be the case if only one species were used). The following sections present data and analysis on the response of woodland (or boreal) caribou and grizzly bears to landscape change.

3.3.4 Woodland (or Boreal) Caribou

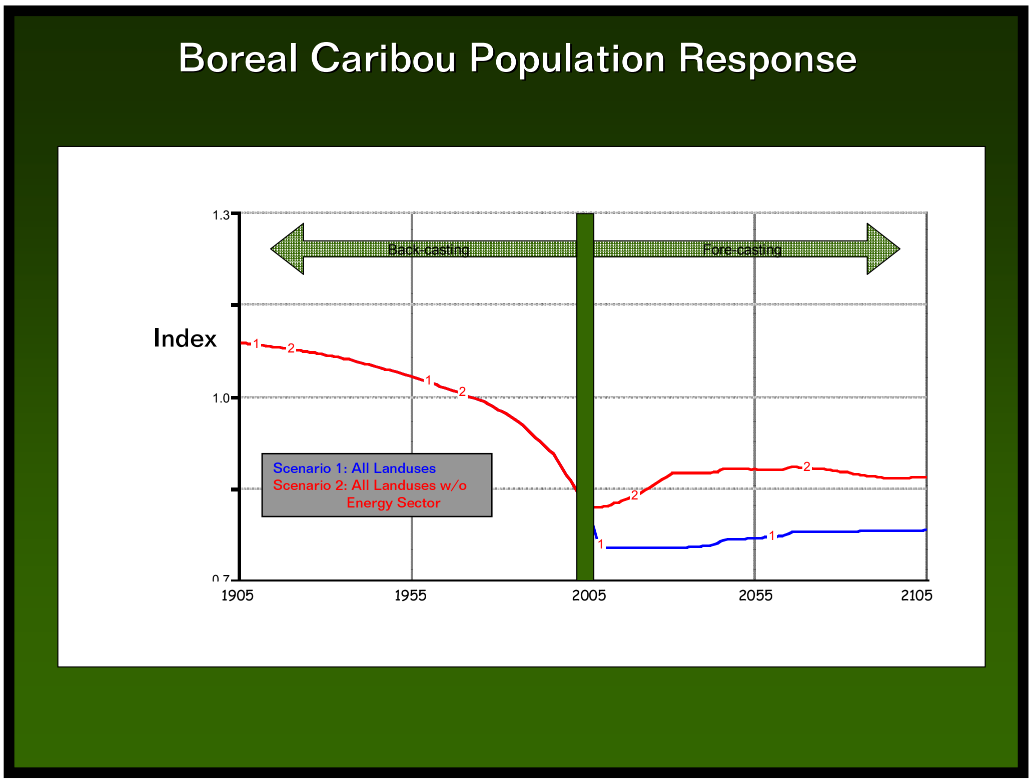
The woodland caribou (Rangifer tarandus caribou) occurs in the forested boreal and mountain regions of Alberta. The southern mountain and boreal populations are considered "threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2002) and "threatened" under the *Alberta Wildlife Act* (Dzus 2001). The species has specific habitat requirements, low reproductive potential and displays sensitivity to human disturbance. Woodland caribou rely on lichens as a core part of their diet, especially during the winter. Lichens are slow growing and dispersal limited, which largely confines them to old and undisturbed forests. Woodland caribou are therefore an excellent indicator of changes to relatively old growth forests. As noted by COSEWIC: "Caribou are also symbols of a healthy natural environment and reduced local populations in areas where old-growth forests have been seriously reduced indicate that human activities are altering their range and the ecosystem to a significant degree" (COSEWIC 2002:56). Woodland caribou thus constitute an appropriate focal species and have been selected as a key indicator for this paper.

Woodland caribou populations are negatively affected by linear disturbances and associated human use (Dzus 2001, Dyer *et al.* 2001). The mechanisms for population effects include direct mortality, increase susceptibility to poaching, predator-prey dynamics and habitat avoidance. Direct mortality as a result of vehicle collisions has been documented as a significant effect on Highway 40 in west central Alberta. For example, 32 mortalities were recorded in the winters of 1991/92 and 1992/93 (Brown & Ross 1994) from an estimated total population of 150 to 200 caribou (Brown & Hobson 1998). Roads and seismic lines also provide increased potential for human access and illegal harvest.

Linear disturbance and well pads have been shown to alter the movement and habitat use patterns of both predators and prey. Caribou (and other ungulates) may be attracted to the vegetation along disturbed corridors and patches when human activity is not present. Wolves are known to preferentially select linear corridors as travel paths as more efficient travel routes (Thurber *et al.* 1994). This combination increases the chance of encounter between caribou and wolves. In Alberta, caribou mortalities have been documented to be significantly higher in close proximity to linear disturbance (James & Stuart-Smith 2000).

Finally, woodland caribou exhibit habitat avoidance and increased energy expenditure in response to human activity associated with the petroleum industry (Fuller & Keith 1981; Edmonds 1988, 1991). In a study of GPS collared woodland caribou in northern Alberta, Dyer (1999) reported statistically significant habitat avoidance within 250 m of roads and seismic lines and up to 1000 m from wellsites. Horejsi (1979) also documented habitat avoidance by caribou during active seismic exploration in Alberta. The activities associated with Alberta's petroleum industry are clearly related to the decline of the woodland caribou, especially in the boreal regions of the province, and the species is therefore an indicator of the potential significance of future landscape changes attributable to the type, distribution and intensity of land use by the energy sector.

The footprint, edge generation and fragmentation associated with the energy sector's land use combine to create the conditions for continual decline of caribou populations (Figure 26). These simulations of Alberta's caribou population dynamics, based on equations developed by the Alberta Caribou Research Committee, suggest that the viability of populations has declined significantly during the past century. The primary landscape variables correlated with this dynamic include the development of a significant network of linear features and adverse changes in forest age class structure. The loss of continuous old growth forest patches is particularly detrimental to caribou. The overall effect of current and projected land uses is for progressively younger and more fragmented forests, the antithesis of good caribou habitat.



(A value of 1 represents a landscape condition where caribou populations can "hold their own" and not experience a directional decline. Values below represent conditions where studies have demonstrated a negative popn trend. The energy sector is a major part of the problem here. Removal of energy sector would significantly improve conditions but would not lead to populations that can sustain themselves)

Figure 26: Boreal caribou population response to land use, backcast and forecast 1905-2105 (ALCES® modeling output)

Most, but not all, of the linear features created historically in the boreal forest were created by the energy sector. As seen in the forecasting portion of the simulation, the further activities of the hydrocarbon sector will ensure that viability of caribou populations will remain low, and may very well lead to the extinction of most remaining boreal herds. Even if the energy sector were to discontinue all new exploration and extraction activities, the index of population viability is unlikely to return to values approaching 1.0, the index level at which populations are considered to be sustainable.

Although the exact number of caribou in Alberta is unknown, experts concur that populations have been in decline in Alberta since 1900 and future land use projections show little hope for a change in this trend (Dzus 2001). Woodland caribou naturally exist at low densities and have relatively low reproductive rates compared with other ungulates. These life history characteristics result in a weak ability to respond to population declines.

The vulnerability of this species is particularly significant when one considers the magnitude and extent of landscape change within Alberta's forests. Applying the reported value of a 250 m disturbance buffer to the average edge density (2 km/km^2) projected for the energy sector results in 100 percent of the landscape being negatively affected for caribou use. This value does not take into account the cumulative effects of other land uses and synergistic effects. Dzus (2001) reports a loss of habitat effectiveness between 28 percent and 70 percent for woodland caribou range assessed in Alberta and concludes that:

> "The current distribution, intensity, amount and type of human activity on and near caribou range, is compromising the 'integrity' of caribou habitat. To correct this situation the following actions are needed: (1) develop and rigorously implement land use guidelines that address research findings; these guidelines should deal with cumulative effects; (2) continue research and monitoring programs, and review government and industry policies and practices which limit caribou conservation. New information and constructive changes to policies and practices must be applied as they become available; (3) and cumulative effects thresholds must be developed and incorporated into management of caribou ranges as part of a comprehensive strategy to integrate caribou conservation and human activity on a common land base (p. 30)."

The long term persistence of woodland caribou in Alberta is unlikely if the projected land use changes continue as per historic trends. As we approach and exceed critical ecological thresholds for particular wildlife species, challenging trade-offs for land-use management must be addressed. Scenario modeling as presented in this paper provides a valuable platform from which to evaluate the balance between competing objectives.

3.3.5 Grizzly Bear

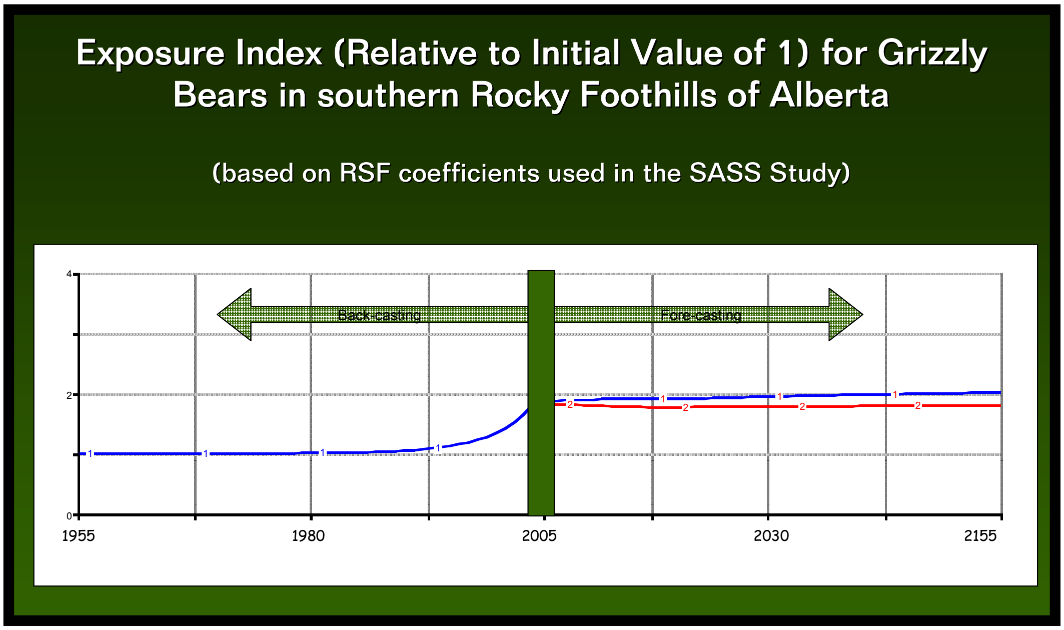
In Canada, the grizzly bear (*Ursus arctos*) is recognized by COSEWIC as species of "special concern" (Ross 2002). In Alberta, the grizzly bear is currently considered a species that "may be at risk of extinction or extirpation" (Alberta Fish and Wildlife Division 2001). However, based on a comprehensive review of the species in 2002, the Alberta Endangered Species Conservation Committee recommended that the grizzly bear be upgraded to "threatened" under the *Wildlife Act* (this recommendation remains under consideration by the Minister). The recommendation was based on the small population of grizzly bears in Alberta, which is further limited by a slow reproductive rate, limited immigration from populations outside Alberta, and increasing alteration of habitat. Threats to grizzly bear populations include both habitat loss and direct, human-caused mortality.

Human causes, primarily licensed hunting and illegal and self-defence kills, are the main sources of grizzly bear mortality in Alberta. Illegal and self-defence kills are linked to increasing human activity in grizzly bear range, particularly where access (e.g., motorized vehicle routes) has also increased. Furthermore, increasing human activity can increase human/bear conflicts, which in turn may increase bear mortality rates (Alberta Grizzly Bear Recovery Team 2005).

The sensitivity of grizzly bears to human densities and behaviour make it a good indicator to monitor the significance of land-use change (Mattson *et al.* 1996, McLellan 1998). Grizzly bears are large carnivores with wide area and general habitat requirements and are thus considered to be an effective umbrella species (Noss *et al.* 1996). By maintaining habitat and area requirements of an umbrella species, the ecological requirements of many other species may also be conserved (Caro 2003, Roberge & Angelstam 2004). In addition, grizzly bears have a keystone ecological role through their activities as ecosystem engineers (Tardiff & Stanford 1998), contributing to the transport of nutrients (Tardiff & Stanford 1998, Hilderbrand *et al.* 1999) and the movement and germinations of seeds (Krefting & Roe 1949, Applegate *et al.* 1979; Welch *et al.* 1997). Their activities as excavators of roots, tubers and small mammals cause soil disturbance that also enhances local plant diversity (Tardiff & Stanford 1998).

Grizzly bears are also species of considerable economic and social value to many Albertans. Scientifically robust modeling data exist for grizzly bears in Alberta and these models have been effectively integrated in ALCES. The species also depends on the Eastern Slopes of the Rocky Mountains which is a region of significant historical, current and future petroleum development. In summary, the grizzly bear is a species of special concern that is sensitive to human disturbance and serves as a useful indicator for evaluating the effects of land-use change.

Habitat changes and increased access to previously remote areas have resulted in a significant rise in the mortality rates of grizzly bears. Mortality rates have doubled over the past 50 years and a continued increase is projected in our modeling exercise (Figure 27). The coefficients used for the modeling were developed by Nielsen and Boyce (2003) for application in southern Alberta, using 2764 radio telemetry points from 45 grizzly bears tracked in the Eastern Slopes Grizzly Bear Project.



(These analyses generally demonstrate that grizzly bear mortality has doubled during the past 50 years, and would be expected to increase further with inclusion of the energy sector and would basically remain at current levels in the absence of the energy sector)

Figure 27: Exposure index for grizzly bears in southern rocky foothills of Alberta, backcast and forecast 1955-2155 (ALCES® modeling output)

The primary threat to the long term persistence of grizzly bears is the increasing human presence within areas of critical habitat and movement corridors. Grizzly bears are documented to use areas within 500 m of roads less than would be expected (Aune & Stivers 1985, Mattson *et al.* 1987, Kasworm & Manley 1990). Previous work has documented a direct correlation between increased human activity and the decline of grizzly bears (Woodroffe 2000, Matson & Merrill 2002). It is not only the direct activity of the energy sector that negatively affects grizzly bears; it is also the increased human use and concomitant mortality that inevitably follows road and trail development.

The viability of maintaining grizzly bears on the Alberta landscape will largely be a function of managing human-caused mortality. Access management planning that includes energy sector activities must be a part of this equation. The modeling completed for this report suggests that the activities of the upstream oil and gas sector are contributing to landscape conditions that are unfavourable for grizzly bears.

3.4 Selected Social, Cultural and Economic Impacts

In addition to its ecological impacts, landscape change caused by the energy sector and other land uses across Alberta has a range of social, cultural and economic impacts. Some of these impacts are the direct result of the same phenomena that produce the ecological effects described above. The energy sector's contribution to increased anthropogenic area, reduction in total forest cover, increased habitat fragmentation, and increased human access via linear disturbances are all examples of incremental landscape changes that can have significant implications for other land uses and values.

Land-use conflicts are also triggered by concerns with the impacts of specific projects. As Alberta's Energy and Utilities Board (EUB) has commented, "[d]isputes between residents and petroleum companies seem to be increasing in number and intensity" (EUB 1999b). These disputes tend to arise at the application stage for energy projects and often arise from impacts and risks associated with the specific projects in question. However, in many instances the underlying concerns also relate to cumulative environmental effects and to broader patterns of land use and landscape change (Kennett & Wenig 2004). The upward trend in land-use conflicts is a landscape-scale phenomenon to the extent that it reflects concerns with landscape change and with the implications for landowners and other interested parties of the multitude of increasing demands on Alberta's fixed land base.

As with ecological impacts, the review of social, cultural and economic impacts in this paper is selective. Furthermore, the project team does not include individuals whose research focuses primarily on the assessment of these types of impacts. Our objective here is simply to highlight some of the principal areas where the energy sector's development footprint is associated with impacts on other land users and values. The following sections examine four areas: concerns with health risks and effects, impacts on culture or way of life, impacts on Aboriginal peoples, and economic effects and risks for Alberta's forestry sector.

3.4.1 Concerns with Health Risks and Effects

Given the environmental risks and impacts of oil and gas development, (Petroleum Communication foundation 1997, Forest Watch Alberta 2001) Albertans are increasingly concerned about the possible links between these environmental effects and their health and safety. Air pollution from accidental blow-outs, gas flaring and venting, gas processing plants, and oil sands refineries is one source of concern. As well, the contamination of soil and water from pipeline failures, well sites, holding sites, and processing sites are major concerns. With the proliferation of oil and gas facilities across Alberta's landscapes, these issues are receiving increased attention from landowners and other stakeholders.

In a 1999 report, Marr-Laing and Severson-Baker examine the air, surface, and groundwater impacts of oil and gas activities in Alberta. They also focus upon the potential for harm to human health from these impacts. With respect to air impacts, the authors identify a number of air contaminants of concern. These include sulphur dioxide, nitrogen oxides, volatile organic compounds, ground level ozone, fine particular matter, and air toxics. Within Alberta, the oil and gas industry is the predominant contributor of such air emissions. They can impact significantly upon human health in various ways. For example (Marr-Laing & Severson-Baker 1999):

- acute exposure to high concentrations of sulphur dioxide can irritate the upper respiratory tract and increase susceptibility to respiratory infections; long term exposure may increase the risk of developing chronic respiratory disease;

- volatile organic compounds (including compounds such as benzene) are known carcinogens and are toxic to humans;

- ground level ozone causes adverse effects on humans, including irritation of the eyes, nose and throat, reduced lung function, and the development of chronic respiratory disease;

- fine particulate matter has been linked to respiratory and cardiac disease because it can penetrate into the lungs and have serious effects on respiratory function; and

- air toxics such as benzene, styrene and tolene are known carcinogens.

With respect to surface impacts, the key impact from a human health perspective is the potential for contamination of soil and surface water. This contamination can be caused by permitted waste disposal practices, or it may be the result of inadvertent or deliberate spills or surface and subsurface leaks at wells, facilities or pipelines (Marr-Laing & Severson-Baker 1999). The primary soil and surface water contaminants associated with oil and gas operations are hydrocarbons, salts, heavy metals, and process chemicals. While hydrocarbon compounds (such as crude oil) vary in their complexity, they include substances such as benzene which can be toxic and carcinogenic. At low concentrations, salts can affect water and soil quality, but they can also be toxic to plants and aquatic life at higher concentrations. Similarly, some heavy metals (introduced largely during the drilling and processing stages of oil and gas production) are toxic and carcinogenic. And finally, process chemicals (which include drilling mud additives, lubricants, cleaners, pesticides, and numerous other compounds used in oil and gas operations) can have various impacts on soil and surface water.

Although the *potential* impacts to human health from air emissions and from soil and groundwater contamination associated with oil and gas development are well known, there remains disagreement on the level of risk involved. There is also significant disagreement on whether oil and gas operations, as currently regulated, are in fact adversely affecting the health of Albertans living near such operations. In the case of low-level exposure to various emissions, for example, the EUB has repeatedly noted the lack of clear scientific consensus on whether there are any significant health effects (EUB 2001a, 2000b). Indeed, studies have reached different conclusions (EnviroLine 2004). Commentators agree that further scientific and medical research should be carried out to examine properly the long-term and short-term health impacts of oil and gas development in Alberta, especially for those people living and working near oil and gas facilities.[1] In

[1]To date, the largest human health study carried out in Alberta was the Medical Diagnostic Review conducted between 1983 and 1989. It failed to find any difference in most health outcomes between a community near extensive sour gas operations and a community without such operations. Nonetheless, the study did show that there were more respiratory symptoms reported in children aged five to fifteen living downwind

the meantime, stories from Albertans about alleged health impacts abound, and are increasingly being recited before the EUB (Vlavianos 2006).

3.4.2 Effects on Culture and Way of Life

Along with impacts on health, many rural Albertans are concerned about the effects of increasing oil and gas development upon their way of life, including their ability to make a living from traditional land-based activities such as farming and ranching. There are stories emerging of fifth-generation farmers and ranchers worrying that oil and gas development is currently impacting, or has the potential to impact, their ability to farm or ranch in significant ways (Gregory 2006). Three main reasons for concern relate to: (i) the disturbance to the landscape from oil and gas activities; (ii) the actual (or potential) contamination to air, soil and water and the effects on livestock; and (iii) the effects of oil and gas development on property values.

In terms of impacts on way of life resulting from landscape disturbance, the ranchers in the foothills of the Rockies south of Calgary provide a good example. They have argued that increased oil and gas activity in the area could ruin the ecological basis for their ranching way of life. They have evidence that the fescue grasses, which are essential to successful ranching in the region, have not regenerated after the drilling of earlier wells. In their view, the destruction of the native ground cover that comes with oil and gas development is incompatible with their ranching way of life (Nikiforuk 2004**,** Keeping 2004).

In addition to landscape disturbance, the potential for contamination of air, soil and water from routine and non-routine oil and gas operations could affect farming and ranching activities, especially in relation to impacts upon animal health. To date, two cases that have been litigated before Alberta courts have found direct causal links between the health of cattle and soil and groundwater contamination from upstream oil and gas activities on farmland. The first was *Girletz* (1975), where the court found that a number of cattle had died from crude oil poisoning after grazing in an area where oil had spilled or leaked from two producing well sites. In the second case (*Jones* 1999), the court found that the chronic poor performance of Jones' cattle was caused by exposure to and ingestion of oil and gas contaminates from facilities on the farm.

Another concern of farmers and ranchers relates to the potential for significant decreases in property values as a result of oil and gas activities on the land. One study found that the mere presence of oil and gas operations on land has the effect of lowering property values by approximately 10 percent (Molik *et al.* 2003). Another study concluded that neighboring properties may be affected as well (Boxall *et al.* 2005). In

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from two gas processing plants: see Petroleum Communication Foundation (2000:26). More recently, a project intended to include the four western provinces was initiated in early 2001 to study the health effects on animals and humans from flaring emissions. In January 2002, however, the human health component was deferred indefinitely: see Thompson (2001).

addition, stories are emerging from farmers who say they are unable to obtain loans by way of mortgage on their properties because lenders are leery of decreasing property values and of actual or potential contamination of the land (Gregory 2006).

3.4.3 Effects on Aboriginal People

A significant number of Aboriginal peoples in Alberta live on Indian reserves, and many still strive to maintain traditional land-based activities on what they consider to be their traditional lands. The treaties that the British Crown entered into with various Indian bands in the 19th century guaranteed that, in exchange for the surrender of their lands, the Indians' rights to hunt, trap and fish (in essence, their traditional livelihood) would be protected, subject only to certain limitations. In 1982, these treaty rights were enshrined in the Constitution of Canada.[2]

Hunting, trapping, fishing and gathering continue to be important activities for many Aboriginal peoples today, and until recently trapping still provided a substantial supplementary income as well as subsistence food in many northern Alberta communities. These activities are much more than simply a means of earning an income or procuring food; they represent a unique, social, spiritual and cultural relationship to the land and its resources. The concept of land as "homeland" is central to the Aboriginal worldview. It encompasses their personal and cultural identities, their histories, and their religions. Traditionally, Aboriginal peoples living on the land maintained bonds with the animals, fish and spiritual world, and believed they had to live responsibly to avoid upsetting the "natural order". To destroy these bonds is to destroy their cultural identity.

Aboriginal land-based rights and uses can only be retained if healthy ecosystems supporting healthy populations of wildlife are maintained. Otherwise, these rights are empty. Starting in the 1970s, intensive resource development (first oil and gas, then forestry) on traditional lands has had severe impacts on the lands and resources supporting Aboriginal uses. In the vast majority of cases, Aboriginal peoples have been powerless to prevent these developments or to mitigate their adverse impacts.

The case of the Lubicon Lake First Nation illustrates the difficulties encountered by many Aboriginal communities confronted with industrial encroachment on their lands. Until 1979, the Lubicon Cree lived a traditional way of life in their homelands. Starting in 1979, the government opened the land to an oil boom. Between 1979 and 1983, more than 400 wells were drilled within a 25-kilometre radius of the community of Little Buffalo, thousands of kilometers of seismic lines were cut, and numerous roads and pipelines were built. Traplines were bulldozed and fires resulting from resource-exploitation increased. This landscape change led to dramatic reductions in wildlife populations (notably moose) and a significant decline in the Lubicon's land-based livelihood. Welfare dependency increased from less than 10 percent before 1979 to more than 90 percent in the space of a few years, and the community experienced social and

[2] Section 35 of the *Constitution Act, 1982* reads: "The existing aboriginal and treaty rights of the aboriginal peoples of Canada are hereby recognized and affirmed."

health problems that they had never known before (e.g., asthma, respiratory problems, cancers, skin diseases, miscarriages and still births) (Goddard 1991, Ominayak 2002). The Lubicon took their case unsuccessfully to the EUB, to the courts, and ultimately to the United Nations, where they obtained a decision against the Canadian government in 1990. However, this victory has not yet resulted in a settlement of their claim.[3]

The situation of the Lubicon is not unique. In the Fort McMurray area, the impacts of oil sands developments on the traditional territories of Aboriginal peoples are substantial. For some communities, the opportunities to hunt, trap and fish have vanished altogether. The health impacts are only now beginning to be understood and addressed (CBC 2006). In the northwest corner of Alberta, the Dene Tha' have also long experienced the impacts of oil and gas development and forestry on their traditional lands. The Dene Tha' have recently taken the federal government to court, alleging that they have not been adequately consulted on the environmental and regulatory review of the proposed Mackenzie Valley Pipeline, a portion of which goes across their traditional territory. They point out that their traditional lands have already been negatively impacted by thousands of oil and gas wells, thousands of kilometers of seismic lines, pipelines, and roads, the activities associated with this oil and gas development, and extensive timber harvesting. This resource development has made it difficult, and in some areas impossible, to exercise their rights and to maintain their way of life and culture.

In sum, the impacts of energy development on lands traditionally used by Aboriginal peoples in Alberta have been significant. These impacts have contributed to the erosion of traditional livelihoods and ways of life, which ultimately results in the loss of identity and culture.

3.4.4 Economic Effects and Risks – Impacts on the Forestry Sector

The adverse impacts of petroleum exploration and extraction on Alberta's forest resources have been recognized for many years. In 1979, the Environment Council of Alberta noted that the exploration activities by petroleum companies had more negative impact on the Green Area than any of their other operations, and that the amount of land disturbed by seismic lines alone was almost equivalent to the area cut in 20 years of timber harvesting operations (Environment Council of Alberta 1979). The Council compared the acreage cleared by the petroleum industry for well sites, access roads, pipeline rights-of-way and seismic lines with that harvested by the forest industry, and concluded that the combined effects of extraction of the non-renewable resources of gas, oil and coal on the renewable forest resources were considerable.

[3] In 1990, the United Nations Human Rights Committee ruled that recent developments threatened the way of life and culture of the Lubicon Lake Cree and that Canada was in violation of Article 27 of the International Covenant on Civil and Political Rights (ICCPR). As a result of a recent submission filed by Amnesty International about the Lubicon people, Canada has been asked to appear before the United Nations Committee on Economic, Social and Cultural Rights in May 2006.

At the time the Environment Council was writing its report, the forest industry in Alberta occupied a peripheral position in the provincial economy and had not yet expanded significantly into the boreal forest. After 1985, the provincial government embarked on the commercial development of the province's northern hardwood resource, notably trembling aspen which was, until then, considered a "weed" and without economic value. In the late 1980s, Alberta allocated to forest companies seven new Forest Management Agreements (FMAs) and renegotiated two existing FMAs. These FMAs covered a total of 136,120 square kilometers of boreal forest, about one-fifth of the province. The provincial Annual Allowable Cut (AAC) went from four million cubic meters of wood a year in the mid-seventies, to over twenty million cubic meters in 1995.

This tremendous expansion of the forest industry in the boreal forest, an area also actively developed by the oil and gas industry, has given rise to tensions and conflicts between the two resource sectors. Forest companies acquire exclusive rights to establish, grow and harvest trees within their tenure areas. However, they acquire these rights subject to the undertaking to build and operate wood-processing facilities. Once an AAC level has been calculated for the FMA area, the tenure holder is both entitled to, and required to, harvest the AAC volumes. The availability of sufficient wood supplies to keep these mills operating is a major concern of tenure holders. However, the government also reserves the right to allow oil and gas exploration to be conducted on FMA lands, and to allocate the underlying reserves of minerals to energy companies. In the event that the subsurface minerals prove valuable and can be extracted, lands may be withdrawn from the FMA area.

Forest companies have expressed concerns about the long-term implications of the steady encroachment of the oil and gas industry on their FMA areas, a phenomenon over which they have no control. The three following issues are particularly problematic for the forest industry: 1) loss of standing timber; 2) quantum of compensation for timber damage; and 3) loss of productive forest land-base.

To begin with, a large proportion of oil and gas activities (62 percent for the northwest area of the province) occur on productive forest lands, and the volumes of timber harvested by the energy sector are substantial. Some of this timber is salvaged and is made available to and utilized by surrounding sawmills or pulp and paper mills. However, the majority of the merchantable timber harvested is left behind in the woods, either because it is unsalvageable, or because of logistical or financial considerations. In the Daishowa FMA, it has been calculated that from 1989 to 1993, 1,288,795 m^3 of trees were harvested as a result of linear disturbances (seismic lines, pipelines and roads) (Stelfox & Wynes 1999). During the same period, the company's total harvest amounted to 4,579,693 m^3. Of the merchantable-sized trees harvested between 1989 and 1997, only 50.4 percent were salvaged. When merchantable timber cannot be salvaged, the net effect is a reduction of the AAC allocated to forest companies. The lost volumes of timber must be found elsewhere in order to continue supplying the company mills. Alternatively, the harvest levels may have to decline or forest management may have to become more intensive.

A second related issue is the quantum of compensation paid by energy companies for timber loss or timber damage. This has long been one of the most contentious issues between the oil and gas and the forestry sector (Government of Alberta 1992**,** Cohen 1993). Oil and gas companies using FMA lands for exploration and development are legally required to pay timber damages to FMA holders. The amount of timber damage is determined by the FMA holders and the two sectors tend to disagree about the value of the trees and the quantum of compensation to be paid. The non-renewable resource industry has also argued that timber damages should be paid to the Crown, not to FMA holders. The provincial government has adopted and regularly updates a Timber Damage Assessment (TDA) Table which is used as a guide by FMA holders in their calculation of compensation (Government of Alberta 1992).

At the present time, the conflict between the two sectors over timber damage assessment appears to be less acute than it was in the early 1990s. The current debate centers around the amount of timber damage that should be paid when low-impact seismic or avoidance cutting is utilized. The Alberta government offers a rebate to companies using low-impact seismic, and some forest companies are considering adopting a similar policy. The difficulty lies in calculating the exact decrease in damage resulting from low-impact seismic as compared to conventional seismic activity.

The third and perhaps most critical issue for the forest industry is the loss of productive timber lands resulting from the lack of regeneration of disturbed sites. It has been calculated that in certain FMA areas, the amount of land removed for oil and gas development is almost as large as the area harvested for timber production (MacKendrick *et al.* 2001). Seismic lines do not have to be replanted after they have been cut; they are simply reseeded to ensure some vegetation cover on the site. Well sites and access roads are reclaimed after abandonment, which may be several years after construction, and in most cases they are not replanted, but simply reseeded.

If productive lands do not grow back, forest land is removed from production either permanently, or at least for one rotation. Preliminary research on revegetation rates of seismic lines indicates that these linear features may persist for decades (Stelfox & Wynes 1999). Even if the trees grow back, regeneration may be out of phase with the surrounding stands and the trees may not have grown to merchantable size by the time the area is harvested by a forest company. They will be cut, but may not be commercially usable. With new energy developments being announced, the area taken out of timber production, either temporarily or permanently, is expected to increase. Stelfox and Wynes suggest that "the rate at which current and future land-base deletions revegetate to commercial tree species will significantly affect the long-term sustainability of current harvest levels of forest companies operating in northwest Alberta" (Stelfox & Wynes 1999:9-1).

3.5 Summary and Research Directions

The preceding sections show that landscape change in Alberta can be described in spatial terms and through landscape metrics that capture important landscape characteristics. ALCES analysis enables us to present historical data and land-use simulations describing the rate and magnitude of significant landscape-scale changes resulting from the energy sector and other land uses in Alberta. This analysis shows clearly that Alberta's landscapes have undergone profound changes over the past 100 years and that more change is likely in this century. For many metrics of change, the energy sector is a significant contributing factor. For a few of the metrics examined here, this sector appears likely to be the dominant agent of change over the coming decades and beyond. This change is linked directly to the network of linear disturbances and relatively small clearings (e.g., for wellsites and other facilities) that characterize land use by the upstream oil and gas industry, with the exception of oil sands mining.

This information provides a starting point for understanding landscape change. However, it is necessary to go beyond the spatial representation of development and the non-spatial analysis of landscape metrics. The significance of landscape change in Alberta is determined by its ecological, social, cultural and economic consequences. The information and analysis presented above serves two purposes in this respect. First, it demonstrates that the landscape change to which the energy sector is contributing is associated with significant impacts and concerns in each of these areas. Second, it illustrates methods for using data and analysis to identify a range of impacts associated with landscape change.

As a template for understanding landscape change, the preceding sections suggest issues and opportunities for further research and analysis. Descriptive and analytical techniques can be further developed and applied in different contexts. The value of applying both spatial and non-spatial analysis to regional and sub-regional scales was noted above and will be returned to later in this paper in the discussion of regional land-use planning as a central component of cumulative effects management. Furthermore, the landscape metrics examined above are simply illustrative of the type of detailed analysis that is required to understand how changing patterns of land use affect important landscape attributes. Additional metrics can be identified, relevant data collected, and analysis undertaken using ALCES.

More theoretical and empirical work could also be undertaken in the area of ecological and other impacts. A fundamental question is the identification of the most appropriate ecological indicators at landscape or regional scales. The analyses of fragmentation in aquatic systems and impacts on focal species represent two promising approaches, but there are other options as well. One of these options that is worth exploring is the use of ecological process indicators to complement the focus on individual species.

Our understanding of the ecological implications of landscape change will also be enhanced by increasing the range of indicators examined within each category. The analysis of two focal species presented in this paper captures a range of important ecological values and functions in areas of the province where these species are present, but additional insights would obviously be gained by the examination of impacts on other species. Given regional variations in ecosystems and in the distribution of species across

Alberta, there is clearly a need to pursue this type of analysis at multiple scales and using a wider variety of indicators.

Similar theoretical, methodological and empirical issues can be identified for the range of social, cultural and economic values that are affected by energy development and the suite of other land uses that contribute to landscape change. For example, further research is needed to understand the health risks associated with oil and gas operations; understanding the spatial distribution of these risks and the underlying causal mechanisms are challenging tasks for researchers in the social and medical sciences, as is the development of metrics to evaluate risk. Innovative research can also shed light on the overall socio-economic and cultural impacts of economic development, including energy development. For example, research on sustainability accounting – such as the development of 'genuine progress indicators' and their application to Alberta – could be linked to metrics of landscape change in order to improve our understanding of the implications of alternative energy futures (Anielski 2001, Taylor 2006).

Perhaps the most important lesson from the foregoing analysis is that historical data and land-use simulations can be used to understand how human activities are changing Alberta's landscapes and what those landscapes may look like in the future under various scenarios. On this basis, it is possible to evaluate the implications of landscape change for ecological, social, cultural and economic values. The land-use simulations presented in this paper apply conservative assumptions regarding 'business as usual' growth scenarios. These same analytical techniques should also be used to develop a broader range of land-use scenarios that explicitly highlight the trade-offs that will be required and the choices that are available under various assumptions. In other words, our efforts to understand landscape change should go beyond describing the logical implications of existing patterns and trends; we also need to explore the broader universe of options for combining alternative energy and landscape futures. Extending the development of land-use scenarios in this way will provide the nexus between the focus of the preceding sections – understanding landscape change – and the challenging task of managing landscape change which is the subject of the remaining sections of this paper.

4 Managing Landscape Change

The discussion to this point shows that the energy sector's footprint will continue to grow across most of Alberta during the coming decades. Much of this footprint will take the form of an expanding and increasingly dense network of linear disturbances and relatively small clearings, contributing to significant changes in important landscape metrics such as forest core area, anthropogenic edge and culverts (i.e., stream crossings). From a biophysical perspective, this landscape change is an incremental process of habitat fragmentation and the proliferation of access routes, resulting in a variety of effects on natural ecosystems and other land uses and values. From a resource and environmental management perspective, the landscape change described above is the product of a multitude of individual projects and activities, each of which is authorized through decision-making processes that may or may not be integrated in a manner that takes account of their cumulative contribution to landscape change.

Cumulative effects are therefore central to the challenge of managing landscape and energy futures in Alberta. While each individual seismic line, road, wellsite and pipeline right-of-way may have an insignificant impact on regional ecosystems and other land uses, the cumulative effect of a multitude of these disturbances is to change landscapes in important ways. These elements of the energy footprint, in turn, combine with other land uses such as forestry, agriculture, transportation, residential development and recreation. Unless decision-makers have the capacity to *set and achieve landscape-scale objectives in a context where multiple human activities affect land-use values*, the cumulative effects of development are likely to be unplanned, unmanaged, and quite possibly undesirable.

There are two fundamental requirements for managing landscape change of the type described in Section 3 of this paper. The first requirement is the institutional capacity to manage cumulative effects. Second, the decision-making processes for land and resource use must accommodate and be responsive to a broad range of interests and values that are affected by landscape change. This section of the paper examines important issues and options relating to both of these requirements.

We begin by examining two core components of cumulative effects management: the institutional architecture for integrated landscape management and the integration of science and policy to address environmental and resource management issues characterized by uncertainty. The next section considers the identification and implementation of thresholds or limits as a way of managing cumulative effects. The discussion then turns to improved inter-sectoral integration between the energy and forestry sectors and to impact mitigation through access management and reclamation. Finally, we discuss how values and interests relating to landscape change could be incorporated into decision making by giving a greater role to municipalities and regional health authorities, consulting more effectively with Aboriginal people, and incorporating public participation into the process for mineral rights disposition.

4.1 Institutional Architecture for Integrated Landscape Management

The capacity of Alberta's policy, planning and regulatory regime to manage cumulative environmental effects of the type described in Section 3 of this paper has been examined in several detailed studies (Creasey 1998, Kennett & Ross 1998, Timoney & Lee 2001, Schneider 2002, Schnieder *et al*. 2003, Barss 2003, Farr *et al*. 2004). All of these studies highlight serious deficiencies in the ability to set and achieve landscape-scale objectives. These deficiencies relate to fundamental institutional and policy problems that are well recognized obstacles to cumulative effects assessment and management (Duinker & Greig 2006, Kennett 1999).The authors of these studies are therefore unanimous in concluding that Alberta currently lacks the substantive policy and planning direction and the integrated decision-making processes that are required to manage the landscape change resulting from energy development and other land and resource uses.

The detailed legal, institutional and policy analysis presented in previous studies will not be repeated here. However, it is important to understand the key deficiencies at the principal stages of decision-making – policy, planning, rights disposition and project review – in order to chart a course towards better management of cumulative effects. Two issues noted above are highlighted in this overview. The first is the ability of existing decision-making processes to set and achieve landscape-scale objectives relating to the types of impacts associated with energy development in Alberta. The second is the incorporation within these processes of the interests and values of landowners, land and resource users and others who are likely to be affected by landscape change and who are best able to articulate a range of land-use values.

4.1.1 The Policy Context

The proliferation of land uses that contribute to cumulative effects has its origins in broad policies for land and resource use in Alberta. The Government of Alberta has established growth mandates for major land uses such as energy, forestry and agriculture, without providing much specific direction on how these activities should be reconciled with each other and with other land-use values on an increasingly crowded land base (Timoney & Lee, 2001) Increasing pressures on the land are also fueled by policies that promote or accommodate the expansion of urban areas, low-density rural residential development, transportation infrastructure and the construction of facilities and infrastructure for recreation and tourism (Kennett 2005, 2003). While the Government of Alberta has also adopted various environmental and resource management policies, including a policy entitled *Alberta's Commitment to Sustainable Resource and Environmental Management* (Government of Alberta 1999), these general statements of principle have yet to translate into a comprehensive set of initiatives to manage the increasing cumulative pressures on ecosystems and other land-use values.

4.1.2 Land-Use Planning

The ability of land-use planning in Alberta to address cumulative effects is limited by structural and operational weaknesses in the planning regime and by the types of land-use parameters that have been used for planning. The Integrated Resource Planning (IRP) process that applies to some public lands in Alberta was eviscerated by budget cuts in the 1990s, leading Creasey to conclude that it "essentially ceased to exist within government policy initiatives" (Creasey 1998:79). Existing plans remain in effect, however, and are occasionally updated. However, the IRP process was never extended to all areas of public land, many of the plans are out of date, and there does not appear to be a systematic planning process in use for public lands. Furthermore, plans have no legal force; they are intended only to provide policy guidance and do not bind subsequent decision-makers, such as the Energy and Utilities Board (EUB) that approves individual energy facilities.

The IRP process has also proven incapable of managing cumulative effects because it embodies a 'multiple-use' zoning approach that appears to assume that most activities and values can be accommodated on a given land base (Creasey 1998, Kennett & Ross 1998). Permitted activities are listed for each zone, but there is generally no guidance regarding the acceptable intensity of development, the total amount of disturbance to be allowed, or the mechanisms for coordinating activities so as to minimize cumulative footprint and impacts. The multiple-use approach embodied in IRPs has been criticized not only by commentators but also by both the Natural Resources Conservation Board (NRCB 1993) and the EUB (2000c). For example, without intensity thresholds there is no planning mechanism to limit the proliferation of linear disturbances that is a major driver of the energy sector's contribution to landscape change.

On private land in Alberta, regional and municipal planning has little capacity to address landscape-scale cumulative effects associated with energy development (Barss 2003) Regional planning commissions were abolished by the provincial government in the 1990s. Furthermore, the ability of municipal governments to establish land-use objectives and constraints in relation to energy development is severely limited by section 619 of the *Municipal Government Act*. Reversing the normal decision-making hierarchy for land use, this provision subordinates municipal planning to project-specific approvals issued by the EUB and the NRCB. The role of municipalities in decision-making is discussed in greater detail below in Section 4.6.1. The point here is simply that cumulative effects management is virtually impossible in a situation where incremental decision-making in the form of project approvals trumps regional (i.e., landscape) planning.

4.1.3 Mineral Rights Disposition

The next stage of decision-making, the disposition of mineral rights, occurs through a sealed bidding process administered by Alberta Energy. This process has also been the subject of detailed analysis from the perspective of cumulative effects management (Creasey 1998, Wenig & Quinn 2004, Farr *et al*. 2004). Several key deficiencies can be highlighted.

First, incremental decision-making of this type is severely limited in its capacity to address cumulative effects in the absence of an adequate policy and planning framework. Rights disposition in Alberta does, of course, reflect a strong overall policy direction: the mandate of Alberta Energy to generate revenue and economic activity through the sale of mineral rights and the development of the province's energy resources (Farr *et al.* 2004). It is not clear, however, that competing policy objectives – such as the management of cumulative environmental effects at the landscape scale – are effectively incorporated into this stage of decision-making.

Second, the internal government mechanism for reviewing proposed mineral rights dispositions to identify potential environmental impacts, the Crown Mineral Disposition Review Committee (CMDRC), is generally viewed as unable to consider cumulative effects. Limitations of the CMDRC have been documented elsewhere and include the cursory nature of the environmental review and various procedural deficiencies of the review process, including the absence of a clear mandate, express legal authorization, and mechanisms to ensure transparency and public accountability in its decision-making (Creasey 1998, Wenig & Quinn 2004, Farr *et al.* 2004).

Third, the rights disposition process provides no opportunities for the involvement of land-owners, other land users and the public at large in the decision to issue mineral rights (Kennett & Ross 1998, Wenig & Quinn 2004). The voices of those who are most likely to raise concerns regarding the pace, extent and intensity of development and its cumulative impacts at the landscape scale are therefore not at the table when that development process is set in motion by the sale of publicly-owned mineral rights to private companies. This issue is discussed in more detail below in Section 4.6.3.

Fourth, rights disposition in Alberta often results in a patchwork quilt of small mineral rights holdings owned by different companies (Farr *et al*. 2004). In cases where rights to different subsurface formations are sold separately, several companies may own rights under the same surface area. This pattern of rights holding makes it difficult to coordinate surface infrastructure such as roads, wellsites and pipeline rights-of-way in order to minimize disturbance and manage landscape change.

Finally, Alberta's mineral rights regime contains strong incentives to accelerate the pace of development (Farr *et al.* 2004). The highly competitive bidding process and the inclusion in tenure instruments of a five year 'use it or lose it' provision mean that companies are obliged to move quickly to identify and produce commercially viable reserves once mineral rights have been purchased. This time pressure reduces the ability of mineral rights holders to coordinate surface operations among themselves and with other land users such as forestry companies.

The process for mineral rights disposition thus lacks the policy guidance, the integration with other decision-making regarding land and resource use, and the opportunities for stakeholder involvement that would enable it to contribute to managing landscape change. The rights disposition process and mineral tenure regime also include substantive and procedural attributes that impede the assessment and management of cumulative environmental effects.

4.1.4 The EUB's Project Review Process

Turning to the environmental assessment (EA) and project review stage of decision-making for energy development, capacity to manage cumulative effects and landscape change is also weak. For energy development in Alberta, the EUB has found itself on the front lines when dealing with concerns about cumulative effects. Reliance on the EUB to address this issue is in part the result of the Board's statements of regulatory policy and its interpretation of its general statutory mandate. In addition, the EUB's project review process is the most open, accessible and transparent stage in the decision-making continuum that governs energy development. It thus provides an opportunity, albeit a limited one in some circumstances, for individuals concerned with landscape change to transmit their views directly to decision-makers. Project-specific review processes are, however, poorly equipped to address cumulative effects, particularly in the absence of clear policy direction for land and resource use and an effective planning process.

A considerable body of research documents the deficiencies of project review processes as instruments of cumulative effects management. For example, Kennett has argued that these deficiencies include:

- The inability of these processes to generate adequate baseline information and analysis regarding cumulative effects;

- The difficulty of determining the significance of cumulative effects within the confines of project-specific review; and

- The limited choice of regulatory and management options that is available within the scope of typical project review processes.

These deficiencies have had two principal results. First, project review processes have often been unable to respond effectively to cumulative effects, either through the terms and conditions attached to project approvals or by influencing the broader set of land-use decisions. Second, the efficiency and fairness of project-specific review has been undermined as the task of addressing cumulative effects has been shifted inappropriately to decision-makers and to project proponents who lack the resources and authority to respond effectively.

To address these deficiencies, Kennett recommends a proactive and planning-based approach to cumulative effects management. Central to this approach is the adoption of a regional focus for cumulative effects management that includes the establishment of landscape objectives and thresholds. These topics are returned to below in Section 4.3.

A recently published paper by Duinker and Greig (2006) presents another analysis of what the authors refer to as the ‘impotence’ of cumulative effects assessment (CEA) in Canada. They argue that the CEA as applied in EA processes, including project review of the type conducted by the EUB, “has not lived up to its glowing promise of helping to achieve sustainability of diverse valued ecosystem components.” Duinker and Greig argue that this failure can be traced to six major problem areas:

- Application of CEA in project-level environmental impact assessments (EIAs);

- An EIA focus on project approval instead of environmental sustainability;

- A general lack of understanding of ecological impact thresholds;

- A separation of cumulative effects from project-specific impacts;

- Weak interpretations of cumulative effects by practitioners and analysts; and

- Inappropriate handling of potential future developments.

Like Kennett, they conclude that the solutions lie mainly in the domain of regional-scale cumulative effects assessments and the establishment of regional environmental effects frameworks or land-use plans.

The direct relevance of these general problems to Alberta is well recognized by commentators (Creasey 1998, Kennett & Wenig 2005) and has been acknowledged by the EUB when it has confronted clear evidence of adverse cumulative effects. For example, the Screwdriver Creek decision in 2000 contains a remarkably candid indictment of the provincial government's management of the Castle Crown region in south-western Alberta (EUB 2000c) The Board noted the common view of the industry and public participants in the hearing "that it was possible or even likely that the biological thresholds for at least some key species identified as important in the IRP [Subregional Integrated Resource Plan] may now have been exceeded in the region" (EUB 2000c:10). It concluded that this finding "would appear to strongly suggest that the publicly available planning tools for the region may now be outdated and inadequate to address the current level of development" (EUB 2000c).

Turning to the implications for its decision-making, the Board admitted that the absence of thresholds against which to measure ecological effects made it "difficult" to evaluate whether incremental impacts from new development would be "acceptable" and what mitigation measures might be useful "to reduce the cumulative effects to suitable levels" (EUB 2000c). It therefore called for an "updated integrated resource management strategy" to determine whether or not the region's environmental values were being adequately protected (EUB 2000c). Alternatively, it recommended the creation of strategies "to address the future cumulative effects of human activities, including energy development, in the Castle Crown Region" (EUB 2000c).

A similar pattern is evident in north-eastern Alberta, where a series of EUB decisions contain increasingly pointed requests for direction from the multi-stakeholder Cumulative Environmental Management Association (CEMA) on how to manage the cumulative effects of oil sands development (EUB 1999a, EUB 2000a, EUB 2002b, EUB 2004a, EUB 2004b, EUB 2004d). In a 2004 decision, the Board directed its comments on cumulative effects to provincial government decision-makers, recommending that Alberta Environment and Alberta Sustainable Resource Development "consider developing management plans or objectives" if CEMA fails to meet its timelines (EUB 2004b:78). The Board has also cautioned applicants that it may review approvals in light of eventual management guidelines on cumulative effects.

4.1.5 The Consequences of Incrementalism and Institutional Fragmentation

The preceding analysis leaves little doubt regarding the inability of the policy, planning and regulatory regime for energy development in Alberta to manage the cumulative environmental effects that are causing the landscape change described earlier in this paper. As Schneider *et al.* (2003) conclude in a paper that applied ALCES modeling and policy analysis to a case study of cumulative effects in north-eastern

Alberta: "Nothing within the current regulatory framework will prevent further increases in the cumulative industrial footprint." Stepping back from the individual components of this regime, it is evident that this inability reflects two systemic problems: incrementalism and institutional fragmentation.

Incrementalism takes the form of decision-making on a disposition-by-disposition or project-by-project basis, without clear direction regarding longer term, landscape-scale objectives. As noted above, the problem stems in part from the absence of a detailed and effective policy and planning context for project-specific decision-making. Without a comprehensive and integrated approach at the level of land-use policy and planning, land and resource management will default to unplanned incrementalism. The tendency to unplanned incrementalism is amplified by the narrow mandates of key decision-makers and well-recognized imperatives of human nature and institutional behaviour.

Fragmented decision-making is institutionally entrenched in Alberta in two principal ways. As described above, the decision-making processes that apply to energy development cannot provide an integrated approach to managing landscape change at the policy, planning, rights disposition and project review stages. Cumulative effects management is further complicated by institutionally entrenched fragmentation among resource sectors and activities sharing a common land base. Alberta's legislation and institutional arrangements for land and resource management have evolved over time in response to particular issues, needs and priorities. The outcome is a loosely structured regime, the principal components of which focus on specific resource sectors (e.g., oil and gas, forestry, water, wildlife) and discrete decision-making processes (Kennett & Ross 1998). The organizational structure within government is characterized by sectoral 'silos'; linkages across sectors and among decision-making processes tend to be weak (Schneider 2002).

In summary, the problems of incrementalism and institutional fragmentation in Alberta create the following obstacles to the management of cumulative effects and landscape change:

- Multiple activities and decisions are altering landscapes in ways that do not reflect conscious choice (i.e., the 'tyranny of small decisions') and may be undesirable from ecological, social, cultural and economic perspectives.

- Resource management and regulatory processes are inefficient and may increase the risk of conflict. For example, landscape-scale issues that are not addressed at the policy and planning stages may surface after resource rights have been issued and after significant investment has been made in project planning (e.g., in project-specific environmental assessment and regulatory processes). When broad land-use issues arise at these stages, the result is increased uncertainty for decision-makers, project proponents and other interested parties.

- Institutional fragmentation on sectoral and geographic lines means that decision-makers often focus primarily on a narrow set of interests, issues and impacts – as opposed to considering how the landscape-scale implications of multiple activities will determine what ecological and other objectives will in fact be achieved.

- Important decision-making processes are unable to meet public expectations and discharge their mandates as established through law or policy (e.g., the difficulty of addressing cumulative effects within EA and project review processes (Kennett 1999)).

- Environmental, economic and social objectives, where defined, may be unachievable because of the effects of uncoordinated and inconsistent activities on the same land base (e.g., oil and gas or recreational development on forestry land (Ross 2002)) or on surrounding lands (e.g., external threats to the ecological integrity of protected areas (Government of Canada 2000, Dearden & Doyle 1990).

Until these challenges are addressed, it will be difficult, if not impossible, to manage the future development of the energy sector and other land uses in a way that sets and achieves landscape-scale objectives relating to metrics of landscape change such as those discussed in Section 3.2 of this paper.

The antidote to incrementalism and fragmentation is improved integration in decision-making processes used for land and resource management in Alberta and the incorporation of landscape values at all stages (Kennett 1998, Kennett 2002, Farr *et al*. 2004). Subsequent sections of this paper set out some options for enhancing integrative capacity at key stages of decision-making. Before turning to these management options, however, we consider another form of integration – the integration of science and policy – that is critically important for managing energy and landscape futures in Alberta.

4.2 Integrating Science and Policy

The capacity to anticipate change is vital for decision-making regarding all aspects of Alberta's energy futures. Tertzakian's (2006) best selling book on energy futures, *A Thousand Barrels a Second*, states that "Successful investing in energy, or any other industry for that matter, is about anticipating the type and character of changes to come". Successful management of Alberta's landscapes and associated natural capital also requires anticipating the landscape change that is likely to occur in the short and long term with energy development.

Anticipating landscape change, like all predictions of the future, is empirically limited by what can be known with any degree of certainty. Typically, ecological systems exhibit a considerable degree of unpredictability (Holling 1986) because of the indefinitely large number of variables and complex process interrelationships they represent over space and time. As "carriers of ecosystems" (Forman & Godron 1986), landscapes physically manifest aspects of ecological complexity and its associated uncertainty over time. Anticipating landscape change associated with energy development will therefore involve consideration of scientific uncertainty, scale and threshold effects, development intensity, risk assessment and cumulative effects.

The integration of science and policy is essential to address all of these issues. Effective partnerships between land managers, policy makers and scientists are therefore needed to undertake the research necessary to support ecosystem management and land use planning at large scales. Identifying and developing methods that can effectively anticipate and manage the changes to come at the landscape scale should be considered a priority in energy futures research.

4.2.1 The Scientific Underpinnings for Managing Landscape Change

Carpenter (1998:299) has identified ecology as the "supporting science for ecosystem management". The goal of ecosystem management is to sustain long term multiple uses and harvestable production without impairing or degrading the functioning of the systems involved. However, ecosystem management is also a social construct which involves core values, economic self sufficiency, cultural heritage, stakeholders and public-private partnerships. Ultimately, ecosystem management requires more than scientific knowledge. The relationship between science and public policy can be complicated as illustrated in Figure 28.

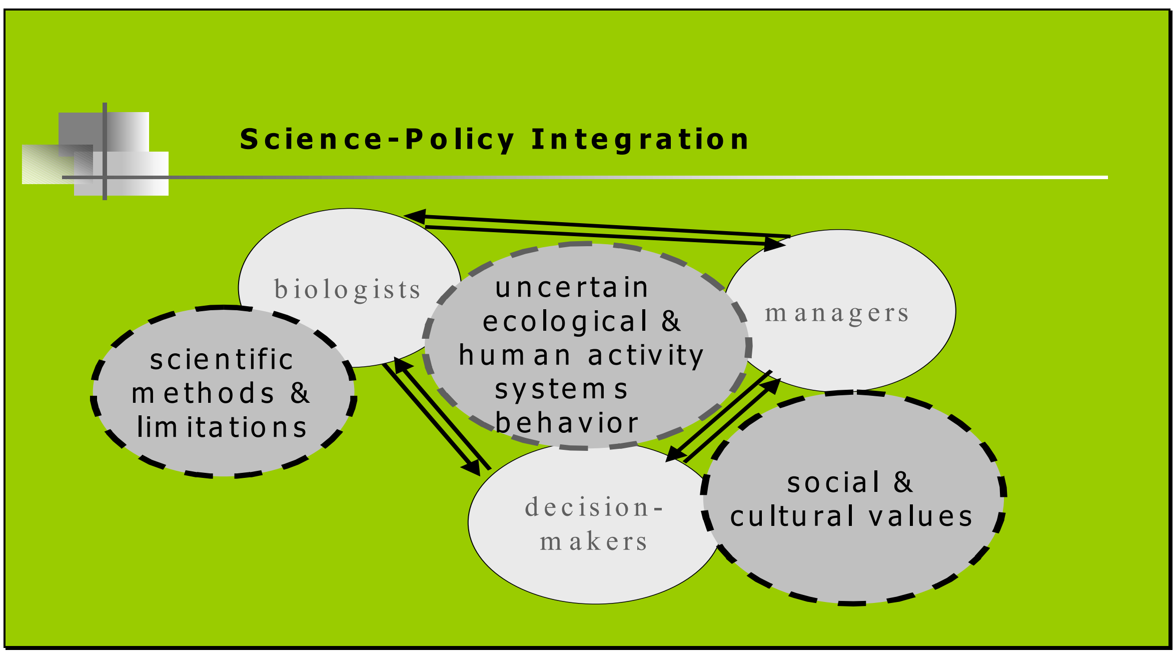

Figure 28: Relationship between science and public policy

Lemons (1998:81) describes the science-policy dynamic as follows:

> "Because there may be alternative assessments and answers to an environmental problem, policy solutions may require a choice involving non-scientific considerations. To the extent that the science solution is uncertain or disputed, the latitude of the policymaker to act or postpone action is broadened."

Scientific uncertainty in ecosystem management is magnified because environmental problems, like land use conflicts, are 'more-than-science' problems (Lemons 1998) involving socio-cultural and economic considerations and values. While environmental problems and land use conflicts may or may not have a scientific solution, ultimately they find societal resolution through public policy and decision-making.

Public policy frameworks, like those for energy, agriculture and forestry in Alberta, have traditionally been driven by socio-economic priorities (like employment or labour shortage or 'value added' economic multiplier effects). However, increasing intensification of land use across the province and the resulting potential for land-use conflict create the need for policies capable of managing ecological, social and economic values at a regional landscape scale. Land-use policy to date represents social and economic values, in large part because there has been very little agreement or certainty as to what ecological land values should be and how they can be determined in either a scientific or policy context.

The dominance of the non-science aspects of ecosystem management in the face of scientific uncertainty makes it appear that ecosystem management has been 'politicized'. It has also led to taking for granted that the 'science' will ultimately be there when needed. However, to date, there has been little ecological research done at the large spatial and temporal scales relevant to ecosystem management to support this assumption. The continued dominance of scientific uncertainty in complex environmental and ecological management decision-making encourages the role of political and economic expediency in the absence of 'scientific proof'. The comprehensive landscape science that is needed to generate principles for provincial land-use policy has not yet been done in sufficient detail.

One reason for this gap in knowledge is the fact that conventional research in the natural sciences does not address the type of interdisciplinary policy and management questions that need to be answered in dealing with complex relationships between human activity and ecological systems over time. As the Ecological Society of America's (2004) *21st Century Vision and Action Plan* states: "It is no longer enough to just do the science; the new knowledge must be conveyed in a way that allows policy makers to translate science into actions, as well convince those policy makers that action is important." This approach to generating new knowledge that is relevant to policy making, sustainable management practices and decision-support has been referred to as "post-normal science" (Ravetz 1999). The key features of this approach are illustrated in Figure 29.

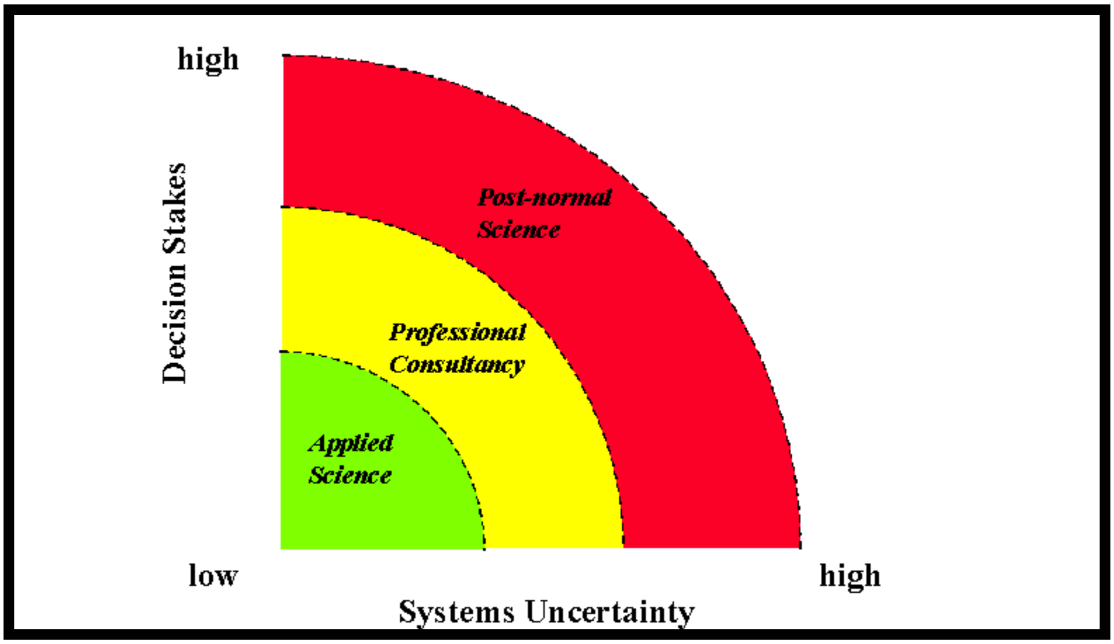

Figure 29: "Post-Normal Science" approach to generating new knowledge

With methodological roots in information theory and the science of complex systems, post-normal science is characterized by an emphasis on conceptual analysis and heuristic understanding of problem complexity and its associated uncertainty. The usefulness of this approach is supported by Lemons (1998:94):

> "[M]ost results from scientific studies will not yield reasonably certain predictions about future consequences of human activities and … many problems of protecting the environmental resources therefore should be considered to be 'trans-science' problems requiring research directed toward useful indicators of change rather than precise predictions.

This recognition of the need to expand the parameters of conventional science and address uncertainty in the integration of science and policy has important implications for the type of research and analysis that is required to support decision-making on issues such as cumulative effects management and landscape change.

There is growing acceptance among scientific associations and management agencies, such as the Ecological Society of America and the United States Environmental Protection Agency (EPA), that new approaches to applied research are needed to address complex interdisciplinary problems. For example, the EPA's (2003) *Ecological Research Multi-Year Plan* identifies four different types of management-oriented ecological research:

1. "*Condition Research*" – What are the current ecological conditions of concern/interest, what are the trends of these conditions, what stressors are involved?

2. "*Diagnosis Research*" – What techniques can be used to "diagnose" ecosystem problems?

3. *"Forecasting Research*" – How can ecological "vulnerabilities" to resource development be reliably identified and how can the responses of ecological systems to best management practices and sustainable development strategies be identified?

4. "*Restoration and Management Research*" – What practices should be used to control risks and protect ecological systems from degradation and what restoration techniques are effective for degraded systems?

The ALCES landscape simulation modeling undertaken for this paper represents "Condition Research" and "Forecasting Research" in that the effects of current resource sector and land use practices are combined with current ecological conditions and indicators to generate trends in both human and natural disturbance regimes over time. ALCES is also capable of generating "best practice" scenarios to identify ecological responses and demonstrate improvements in ecological outcomes with alternative management approaches. As described in Schneider *et al.* (2003:13), ALCES "does not predict the future, it simply demonstrates the logical outcomes of trends described by the user".

What sets the ALCES approach apart from convention scientific modeling is its intended purpose. Specifically, ALCES is intended to facilitate land-use planning among different groups of stakeholders. As such, it actively incorporates stakeholder involvement, integrated planning and cumulative effects assessment of current management practices into modeling scenarios that anticipate future land-use change.

Six categories of ecological principles can be identified at the landscape scale to address future energy development in Alberta's major biophysical regions. These principles "… deal with time, species, place, disturbance, and the landscape" and serve as guidelines for incorporating ecological needs into land-use decision-making (Ecological Society of America, Committee on Land Use 2000). Of these categories, time, disturbance and the size, shape and spatial relationships at the landscape scale are the least understood.

The rationale for selected ALCES indicators (grizzly bear, woodland caribou and hanging culverts) reflects the critical relationship between spatial landscape patterns and ecological processes. Landscape ecology and spatial analysis need to become integrated parts of regional land-use policy and planning in order to identify the critical spatial relationships at the landscape scale that are connected to ecosystem function. For example, ALCES together with related landscape ecology metrics can provide all four recommended actions identified by Weller *et al*. (2002) for anticipating spatial landscape change related to gas field development:

- generate infrastructure scenarios prior to field development

- generate landscape metrics for all infrastructure
- assemble regional habitat-use data
- integrate results into management plans.

The use of ALCES and landscape metrics is therefore representative of "Diagnosis Research" in so far as these metrics can be used to spatially 'diagnose' ecosystem problems by identifying landscape change over time resulting from five spatial processes (Forman 1995): *perforation, dissection, fragmentation, shrinkage and attrition.* Landscape connectivity typically decreases with fragmentation; habitat loss and isolation increase with all five processes. As illustrated by the ecological implications of the ALCES results for the three selected ecological indicators, landscape change leads to changes in ecological processes. The spatial pattern of energy development including its supporting infrastructure (such as roads) both changes and determines spatial organization at the landscape level. This landscape change, in turn, affects both terrestrial and aquatic processes over time.

4.2.2 Emerging Methods for Managing Uncertainty and Anticipating Landscape Change

Anticipating future landscape change comes with an implicit expectation that undesirable changes can be managed if identified. However, the degree of uncertainty involved in predicting landscape change and the ability of decision-making processes to deal with this uncertainty often make this assumption tenuous. Uncertainty is distinguished from risk in that risk represents 'measurable' uncertainty. True uncertainty cannot be assigned a probability and may not be reduced by obtaining more information about the phenomena in question (Knight 1921).

Uncertainty affects both science and policy, but each area has significantly different evidentiary standards for establishing fact or certainty. Consequently, science can inadvertently fail to provide or communicate information that may be valuable for policy-making. Similarly, the inability to quantify uncertainty about unknowable futures can result in valuable information not being identified or communicated at all (Kinzeg & Starrett 2003). Uncertainty in both science and policy making needs more explicit recognition and communication from regulators, scientists, industry and the public.

The challenges of dealing with uncertainty when integrating science and policy have important implications for decision making. Although it may seem counter-intuitive from a traditional quantitative or 'predictive' scientific perspective, more data does not necessarily mean better results from models or better decision-making. This paradox is illustrated by the incorporation of scientific information into decision-making on energy development.

As energy-related environmental work is increasingly contracted out by government and energy companies, contractors are usually required to use specific models – which may or may not be appropriate to specific locations. This problem can be compounded by short turn-around times for oil and gas project approvals which allow no opportunity for model validation. In practice, habitat suitability index (HIS) and population viability analysis (PVA) used in environmental impact assessments (EIAs) for oil and gas projects have to be 'quantified' by assigning 'values' supported by published research literature and any available local data. For example, PVA uses HIS which is only as good as the data that goes into it – usually one year of baseline data plus any past work that may (or may not) be available. However, PVA is assumed to be accurate with no expression of error propagation. The result is a very subjective approach in which temporal factors (changes over time) are not currently taken into account (Gillingham 2005, Boutin 2005, Jalkotzy 2005).

The best assessment of ecological risk is the one that most directly addresses the needs of risk management decision-making. Although, PVA and HIS don't necessarily do this, they have become the accepted information standard requirement in most energy project EIA processes. There is thus a real need for data integration at different scales and across scales. Government has the authority and the opportunity to specify common data formats and protocols for energy project contractors but currently does not do so.

More generally, ecological information supporting energy futures should target landscape change and management questions at meaningful scales. Since decision-makers ultimately decide what is 'uncertain', ecological information must be communicated in an accessible manner that frames uncertainty in the context of the questions needing answers. Currently, two approaches that show promise are: (1) Ecological Risk Assessment; and (2) Value Functions in Multivariate Decision-Making.

4.2.2.1 Ecological Risk Assessment

Ecological risk assessments are developed in a risk management context to evaluate human-induced changes in ecological systems. This process provides information on adverse effects or stressors associated with different management alternatives. Assessment can involve either qualitative (i.e., judgement) or quantitative (i.e., measurement) methods.

Ecological risk assessment explicitly addresses uncertainty (EPA 2006). The definition of what constitutes an 'adverse effect' is critical to this process. What may negatively affect one ecosystem component may be neutral or beneficial in another. Undesirable changes usually affect structural, functional or component inter-relationships within landscapes and ecological systems depending upon their type, intensity, scale, and potential for recovery. Figure 30 illustrates this general framework (EPA 2006).

Ecological risk assessment has several characteristics that make it useful in managing energy futures at the landscape scale. Specifically, it considers management goals and objectives as well as scientific issues when developing conceptual models and assessment

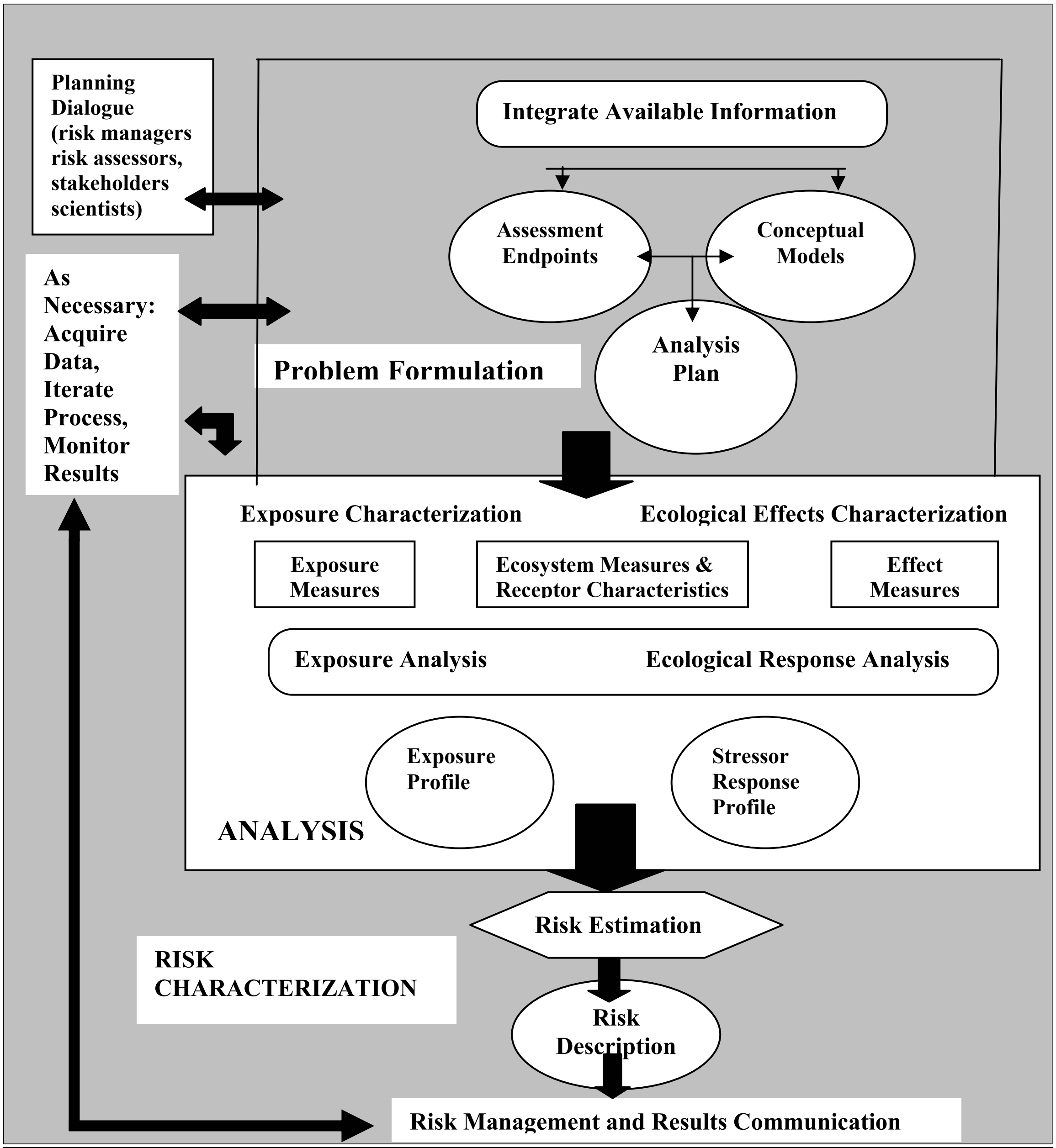

Figure 30: A general ecological risk assessment framework

'endpoints'. It also establishes criteria for prioritizing, ranking and comparing risks and results and can therefore be used in cost-benefit analyses. By expressing ecological changes as a function of stressors or stress processes over time, it can assist with evaluating trade-offs, comparing management alternatives and targeting stressor effects that must be reduced to achieve desired outcomes.

Since the process is flexible, something learned in analysis or risk characterization can lead to problem re-formulation or the identification of new data requirements. Problem formulation is interactive and can involve scientists, managers, regulators and stakeholders. Ecological risk assessment can be used to anticipate future change as well as to evaluate the effect of past events on current conditions. It includes uncertainty analysis to identify degrees of confidence in specific assessment components which can then result in research being directed to those areas requiring greater certainty for management decisions. Perhaps most importantly, it provides a forum and a process for identifying the most important management and research questions that need to be answered for future development. These questions typically include (EPA 2006):

- What is the nature of the problem and the best scale for assessment?
- What are the goals and decisions needed and how will risk assessment help?
- What are the ecological values of concern?
- What are the policy concerns?
- What level of uncertainty is acceptable?
- What are the critical ecological endpoints and ecosystem receptor characteristics?

Ecological risk assessment has much to offer the management of landscape change, but it is far from a simple process and it is still under development as a research and analytical tool. One area for further investigation is the use of ALCES for elements of ecological risk assessment such as interactive problem formulation. Research could also be directed to the use of ecological risk assessment as a decision-support tool for the development of land-use policy and for land-use planning processes.

4.2.2.2 Multi-Attribute Functions and Utility-Based Approaches to Managing Uncertainty

Multi-objective decision-making methods are well suited to environmental management and policy-making. As noted above, scientific knowledge and human judgement have complementary roles in complex decision-making; decisions typically involve integrating factual information with value judgement. However, it is difficult to actually separate 'fact' from evaluation. In the context of ecological risk assessment and cumulative effects assessment, this problem arises because ecological responses and human activities need to be managed if certain thresholds or limits are exceeded. However, an important issue is whether the trigger to take action is based on facts or values?

Similarly, while stakeholders are likely to agree on the need to address and limit negative changes to landscapes and ecological systems, they may not agree on how to do so. Once again, structuring and analysing complex multi-objective decision problems is a matter of values as much as facts. Reaching agreement among stakeholders on how to structure a problem is a fundamental requirement if agreement is to be found on acceptable solutions.

The management of cumulative effects and landscape change thus raises fundamental questions regarding the application of 'post normal science'. Since multi-objective decision-making involves complex environmental systems and a high degree of uncertainty, there is usually no empirical basis for evaluating the pros and cons of alternative management decisions. The application of values to decision-making or "expert judgement" may therefore be the only way forward. Ideally, experts provide facts to decision-makers. In reality, experts supply information which relies on factual knowledge as well as experience, training, skills and non-formalized knowledge. As the complexity of the judgement required increases and the available background knowledge decreases, the precision and reliability of expert judgement also decreases.

These problems are illustrated by the fact that experts appearing before regulatory panels often disagree, thereby introducing a high degree of uncertainty into the panels' decision-making. Experts also vary in their qualifications and the relevance of their expertise to the issues in question. The use of expert opinion and judgement in decision-making therefore raises three basic questions (Beinat 1997):

- Do experts assess facts or values?
- How should expert judgements be assessed?
- How should differences in expert opinion be tackled?"

Given the significance of uncertainty and the 'more-than-science' nature of ecosystem management and policy decision-making, research into how these types of decisions are made is critical to developing meaningful decision-support systems for managing energy futures at the landscape scale.

Two methods for decision analysis that show promise in this regard are utility-based approaches and expert-based value function approaches (Beinat 1997). In this context, value functions are representations of human judgements and, as described by Beinat (1997:8), "… they offer an analytical description of the value system of the individuals involved in the decision and evaluation of alternatives".

Utility-based approaches use environmental indices, the purpose of which is to simplify complex issues while still conveying necessary meaning. These indices can be used as a management substitute for missing scientific knowledge. They share many structural assumptions with value functions, including the need to:

- state the role of each individual variable and how multiple variables combine together; and
- analyse how each individual variable behaves independently and how to aggregate individual variable contributions.

An illustration of this approach is the use of a cumulative effects index to represent a wide range of industrial land use activities at a regional landscape scale. Similarly, a landscape intensity index or ‘stressor’ index could be developed in ecological risk assessment.

Expert-based value functions could also provide decision support for managing landscape change. The ‘value’ in a value function is either 1 or 0, where 1 represents the best available choice or high achievement of decision-making objectives and 0 represents the worst available choice or low achievement. In value functions, decision variables are analysed for their meaning in order to make explicit what people want to achieve through decision-making. However, since people do not normally express their preferences and values in this way, value functions have to be estimated through a specially designed interview process.

The potential benefit of using this approach is to enable the values and judgements of individual or stakeholder groups to be explicitly and systematically identified in the decision-making process. Operationally, this can involve ascribing an implied weighting to different decision objectives in order to determine what an individual or stakeholder group is willing to trade off in one aspect of the decision in order to improve another. This approach has potential for identifying acceptable limits of change or thresholds in cumulative effects assessment and acceptable levels of risk in ecological risk assessment. It could also contribute to the development of land-use scenarios in ALCES that highlight the consequences of explicit choices and trade-offs.

Further research is needed to explore the potential for using these decision-support tools for managing landscape change in Alberta. However, both of these techniques have already been used to build consensus through multi-criteria and multi-objective modeling and sensitivity analysis in a variety of decision-support applications including environmental impact assessment (Bojorquez-Tapia *et al.* 2005).

4.2.3 Conclusion

Managing landscape change requires the capacity to anticipate that change and to accommodate uncertainty, risk and a complex mix of scientific fact and human values when determining how to respond. In essence, the challenge is to integrate science and policy in the process of setting and achieving landscape-scale objectives. Alberta’s ability to address this challenge can be strengthened by applied landscape ecology and decision-making research that can generate effective modeling for risk assessment and land-use management at a regional scale. Central to this research agenda is the design and implementation of decision-support tools to assist the decision-makers and stakeholders who are determining the future of Alberta’s landscapes.

4.3 Setting and Implementing Thresholds at the Landscape Scale

There is widespread agreement among commentators on cumulative effects management that land-use planning is necessary to set and achieve landscape-scale objectives (Court *et al.* 1994, Contant & Wiggins 1991, Bardecki 1990, Hirsch 1988, Dickert & Tuttle 1985). The benefits of proactive planning are often contrasted with the limitations of conventional environmental assessment (EA) and project review processes. In particular, anticipatory and comprehensive regional planning is more consistent with the purposes, scope and decision-making needs of cumulative effects management than are incremental, reactive and project-specific review and regulatory processes (Stakhiv 1988, Bardecki 1990).

Bardecki argues, for example, that while both EA and the consideration of cumulative effects "involve the attempt to link cause and effect to predict likely changes in environmental conditions, the management issues arising from each work in contrary directions" (Bardecki 1990:322). Project-specific EA, he suggests, is essentially a reactive process that requires predicting and assessing the impacts of a proposed activity and developing means to mitigate concerns that are expected to arise in the future. In contrast (Bardecki 1990:322):

> "The management of cumulative impacts … involves a proactive component in that it is undertaken through assessing some goal, some ideal future end-state or some acceptable threshold and moving backwards towards today to provide a framework for managing environmental change toward those goals or to limit change to assure those thresholds are not exceeded. Assessing and managing cumulative impacts is planning."

Rees (1988) pursues the same line of analysis in an article examining the role for environmental assessment in achieving sustainable development. The conventional EA paradigm is inadequate, in his view, because "EA is typically still a reactive, quasi-regulatory instrument, expected to have only a marginal effect on project design and implementation" (Rees 1988:283). "By contrast", Rees argues, "sustainable development requires a proactive planning approach in which ecological integrity is the governing factor and the permissible level of economic activity is the dependent variable" (Rees 1988).

The principal role of planning in cumulative effects management is to set landscape-scale objectives. When dealing with incremental disturbance of the type described in Section 3 of this paper, these objectives should define the limits of acceptable landscape change. As demonstrated by the analysis presented above, the upstream oil and gas industry is a significant vector of landscape change in Alberta, especially with respect to linear disturbance and fragmentation, but these aspects of the energy sector's expanding footprint are not addressed in any long-term land-use planning process.

The importance of limits and thresholds is a recurring theme in the literature on cumulative effects assessment and management. For example, Rees argues that "Measuring cumulative effects has no practical utility unless it is in relation to permissible limits of ecological or social impact" (Rees 1988:285). The United States

Commission on Environmental Quality (CEQ) elaborated on this theme as follows in its guide to cumulative effects assessment (CEQ 1997:7):

> "A critical principle states that cumulative effects analysis should be conducted within the context of resource, ecosystem, and human community thresholds – levels of stress beyond which the desired condition degrades. The magnitude and extent of the effect on a resource depends on whether the cumulative effects exceed the capacity of the resource to sustain itself and remain productive. Similarly, the natural ecosystem and the human community have maximum levels of cumulative effects that they can withstand before the desired conditions of ecological functioning and human quality of life deteriorate."

The CEQ observes that involving government officials, project proponents, environmental analysts, environmental organizations and the public at large is desirable for defining desired conditions and thresholds. It therefore concludes that cumulative effects analysis should ultimately be incorporated into environmental and regional planning.

The need to establish thresholds or limits through regional planning is widely accepted in the commentary on cumulative effects. Dias and Chinery, for example, discuss the importance of thresholds in an article examining the potential role for Alberta's integrated resource planning process in addressing cumulative effects (Dias & Chinery 1994:311-312):

> "A key element in translating policy direction into decision-making is using the planning process to identify a set of ecological thresholds that integrate social and ecological values. Ecological thresholds defined in plans would state the socially acceptable limits of change that will be permitted for a valued ecosystem component. Developing ecological thresholds would involve tough trade-offs based on ecological, social and economic values. However, once established, ecological thresholds would provide an explicit yardstick by which proponents, the public and decision-makers could assess proposed developments and evaluate the potential impact on a region."

The key point is that cumulative effects management requires not only identifying the kinds of activities that are appropriate for a specific area, but also focusing on the intensity of those activities and the "acceptable levels of impacts to the ecosystem" (Dias & Chinery 1994:314).

Eccles *et al*. make the same point in relation to cumulative effects assessment for oil and gas projects in Alberta. They advocate the development of regional thresholds for ecologically-defined management areas and state that these thresholds should be based on wildlife indicator species and should reflect the relative sensitivity of the areas in question to oil and gas development. In their view: "Such thresholds must specify maximum levels of activity at any given point in time, as well as maximum levels of effective habitat supply loss through alteration, alienation and fragmentation" (Eccles *et al.* 1994:195). Arguing that regional thresholds will facilitate the development of more predictable and workable guidelines for oil and gas development, they also underline the need for monitoring and feedback procedures in order to refine threshold values where adjustments are required.

It is clear from this analysis that the goal setting required for cumulative effects management must go far beyond the multiple-use zoning for specified landscapes that has characterized land-use planning in Alberta to date (Kennett 1998, Kennett & Ross 1998, Dias & Chinery 1994). Instead, planning should identify values, objectives and principles for land and resource use and then confront directly the limitations on activities and the trade-offs among them that are required to reach desired end states (Spaling & Smit 1993, Wight 1994). Concepts such as 'carrying capacity' and 'limits of acceptable change' are sometimes used to capture the essence of this exercise in establishing priorities and constraints (Court *et al.* 1994).

One attempt to identify the key components of this approach is Stakhiv's discussion of what he terms cumulative impact analysis. He argues that (Stakhiv 1988:740-741):

> "Cumulative impact analysis … requires that we integrate several levels of analysis with different sets of information: (1) a set of development-conservation goals against which alternative actions and policies may be evaluated; (2) a set of forecasts of expected growth and development scenarios that attempt to fulfill the desired goals; (3) a set of biophysical … constraints operating within a developed theory or model of ecosystem response to natural and human perturbations; and (4) a set of environmental protection standards and criteria that serve as minimal constraints, defining acceptable carrying capacity, within which a comprehensive assessment of impacts on an area can be made."

The key underlying elements in this model are, in his view: "(1) the available resources, together with constraints, representing the carrying capacity; and (2) the choices for development (or preservation), reflecting the planning objectives" (Stakhiv 1988:741). Implementing this approach requires precisely the integration of science and policy that was discussed above in Section 4.2 of this paper.

While there is no single template for setting thresholds or limits, the process could begin with the identification of impact thresholds using indicators of the health or integrity of the biological communities or other landscape values. As noted by the CEQ's report on CEA: "The concept of 'indices of biotic integrity' … is a powerful tool for evaluating cumulative effects on natural systems, because biological communities act as integrators of multiple stresses over time" (CEQ 1997:26). This approach has proven particularly useful in relation to aquatic effects. The CEQ also identifies the discipline of landscape ecology as a fruitful source of indicators of resource or ecosystem conditions. In particular, it has produced indicators for habitat fragmentation at the landscape scale (e.g., habitat pattern shape, dominance, connectivity and configuration) (CEQ 1997). For some landscape values, preserving viable populations of indicator or focal species may provide a proxy for a wide range of other ecosystem components. It is thus evident how the landscape metrics and ecological analysis presented in Sections 3.2 and 3.3 of this paper could provide the basis for identifying impact thresholds.

The second step is to translate these biotic or landscape indicators into specific thresholds for land and resource use. Road density, for example, may be a useful threshold variable in areas where habitat fragmentation and increased accessibility constitute significant drivers of landscape change. As noted in the Canadian Environmental Assessment Agency's *Cumulative Effects Assessment Practitioner Guide* (Hegmann *et al.* 1999):

> "Mapping the road network over many years can be used to demonstrate how various actions have contributed cumulatively to large-scale regional changes in the landscape. Roads can then be used as a quantitative indicator of cumulative effects. … Taking this approach one step further, a specific road density may be selected as a regional threshold for a particular species."

Finally, the planning process involves an exercise in social choice which is likely to involve trade-offs among competing ecological, social, cultural and economic values. The translation of ecological thresholds into regulatory limits requires a determination of what level of ecological impairment is acceptable in order to achieve economic or other objectives. In some instances, societies may choose to disregard ecological thresholds in order to achieve desired levels of development. An explicit consideration of thresholds and limits in the planning process ensures, however, that these trade-offs are the result of deliberate choice, as opposed to being the by-product of unplanned incrementalism.

Once cumulative thresholds or limits have been set, the next set of challenges relate to implementation. There is a growing literature on this topic and evidence of increasing interest among commentators and environmental managers. Thresholds have been set for air and water quality in some jurisdictions, but there is relatively little practical experience with this approach to cumulative land disturbances of the type caused by Alberta's expanding energy footprint and other land uses. Ecological and land-use thresholds have, however, been included in pre-tenure plans for oil and gas development in the Muskwa-Kechika Management Area of north eastern British Columbia (McManus & Salmo 2004). Land use thresholds have also been proposed in the draft Dehcho Land Use Plan in the south western NWT, an area with significant oil and gas potential just north of the Alberta border (Dehcho Land use Planning Committee 2005). In both instances, the rationale for land-use and ecological thresholds is to manage precisely the type of incremental and unplanned growth in the energy sector's footprint that, along with other land uses, is transforming landscapes in Alberta.

The general approach to implementation that has been proposed for threshold-based approaches to cumulative effects management is for the land or resource use in question to continue subject to standard regulatory requirements until a limit is approached or reached. At that point, additional management action is required to reduce impacts in order to stay within the limit. In a 'tiered' threshold approach, different management actions are specified depending on the level that is reached. Important questions therefore arise regarding the 'appropriate' management action as thresholds are approached or reached and how coordination among many decisions is to be achieved.

Ideally, the planning process will provide some guidance about how land-use decisions are to be coordinated or integrated in order to achieve the desired collective outcome. However, broad land-use planning is unlikely to anticipate all of the individual projects and activities that may occur on a landscape. To the extent that limit setting through planning provides objectives and parameters for subsequent decisions, implementation of a plan is less about following through on prescribed actions and more about ensuring that subsequent decisions, taken together, produce landscape-scale results that are consistent with the plan.

More specific guidance may be provided through a planning hierarchy, where detailed planning focuses on smaller geographic areas or specific resources. At this level, it may be easier to prescribe management actions in order to ensure that the total level of activity that results from the individual decisions is within the prescribed limit. Even with this level of planning, however, aggregating individual decisions will often involve more than mechanically implementing a plan.

This challenge might be also addressed through institutional coordination or integration – perhaps making a single decision-maker responsible for a broader range of land and resource uses. For example, the allocation of resource rights (e.g., forestry and oil and gas rights) might be undertaken by a single land management agency that would be responsible for looking at aggregate expected impacts when considering individual decisions. Similarly, project review processes could be integrated across sectors. Even this degree of integration will not, by itself, fully resolve the aggregation issue; decision-makers must also have mechanisms for making trade-offs.

As collective limits are approached, management actions to maintain activities within these limits will involve either explicit or implicit allocation rules that determine how trade-offs are made. These rules will have important consequences for competing land and resource users. They will also have broader social implications, since they embody judgments about the allocation of scarce resources among alternative uses. Overall welfare will be increased if these decisions favour higher valued uses over lower valued ones. However, not all allocation rules are well suited to making this type of choice.

A simple but rigid rule is to give priority to older land uses over more recent ones. More flexible management responses are also possible, using various mechanisms to encourage or require substitution from lower to higher value land uses or to modify activities in order to permit continuing development while remaining within cumulative effects thresholds. A cap-and-trade allowance system has also been proposed as an alternative to conventional regulatory models (Weber & Adamowicz 2002). Under this system, transferable allowances to undertake the activity in question would be allocated among users. The maximum number of allowances corresponds to the regulatory limit. Actual and potential land users are then free to trade allowances, thereby letting market forces determine which activities are entitled to proceed.

The establishment and implementation of cumulative effects thresholds and limits raises a series of important scientific, planning and regulatory issues that cannot be explored further in this paper. Research in applied landscape ecology, ecological responses to disturbance and scenario forecasting could contribute to the development of thresholds specific to Alberta's regional landscapes. ALCES is an effective tool, as illustrated in this project, for incorporating applied landscape ecology into the forecasting of ecological response. It can also be used for exploring various land-use scenarios and associated trade-offs as part of a planning process. The design and implementation of land-use planning processes is itself a complex subject, although there is a considerable base of knowledge and experience in Alberta and other jurisdictions on which to build. Finally, important research questions regarding the implementation of thresholds or regulatory limits remain to be addressed. The proposed cap-and-trade system for landscape disturbance, for example, is an innovative approach that warrants further attention.

4.4 Inter-Sectoral Integration: Energy and Forestry

As discussed earlier, the management of landscape change associated with energy development and other land uses in Alberta is complicated by the fact that the legal and regulatory regimes that apply to different sectors are not well integrated. For the types of landscape change described earlier in this paper, the lack of integration between energy and forestry sectors is particularly significant. Both sectors share the land base across significant areas of Alberta and both contribute to changes in many of the landscape metrics discussed above in Section 3.2.

To a large extent, resource allocations for these two sectors occur in an incremental, fragmented and uncoordinated way and do not factor in the cumulative impacts of multiple developments on the same land base and the issue of long-term loss and degradation of the productive land base (Ross 2002). Similarly, there are few legal and regulatory mechanisms for achieving inter-sectoral integration when specific projects are reviewed and approved. The environmental assessment (EA) process under Alberta's *Environmental Protection and Enhancement Act* (EPEA), which could serve as an avenue for addressing multiple use and cumulative impacts issues, is seldom used to review oil and gas and forestry projects, most of which are exempted from a full EA. The EUB and the Natural Resources Conservation Board, the two regulatory boards reviewing energy and forestry projects, have separate mandates and do not have the jurisdiction or the ability to conduct full assessments of the cumulative impacts of the activities of both sectors in a specific area.

Integration between the two sectors is complicated by the fact that the tenure systems governing the two industries differ greatly. As pointed out by Fluet and Krogman, the oil and gas industry often operates on a short-term land-based planning horizon (e.g., sometimes only a few months for a given well-site), and on small size tenure areas (one to two sections of land) (Fluet & Krogman 2003, MacKendrick *et at.* 2001). The sector is characterized by a large number of companies of all sizes, with frequent mergers and take-overs. By contrast, the forestry sector operates on a long-term planning horizon (FMAs are allocated for a 20-year period) on very large land bases, and there are only 11 large forest companies holding FMAs in the province. These differences make it difficult for forest companies to coordinate their activities with those of the oil and gas companies. In 2002, one forest company reported having 200 oil and gas companies working in its FMA area (MacKendrick *et al.* 2001).

In recent years, however, the two sectors have taken various initiatives to address both the ecological impacts of their operations and inter-sectoral conflicts. For its part, the provincial government has encouraged and supported various initiatives. The following paragraphs outline some of the options that have been used to promote a more integrated approach to oil and gas and forestry developments, and suggest some others.

To begin with, forestry and oil and gas companies have taken the initiative to cooperate at the operational level to reduce their industrial footprint on the land and to achieve cost savings. One of the first examples of such inter-industry initiatives was the Alberta Pacific Forest Industries (Al-Pac)/Gulf Canada Surmont oil sands project, involving coordinated planning of certain operations (e.g., road access, forest regeneration). Al-Pac has since launched several other projects with other oil sands and conventional oil and gas companies to improve the integration of oil and gas activities in its FMA. It has also encouraged low-impact seismic exploration.

The Alberta Chamber of Resources has supported such efforts with its Integrated Landscape Management (ILM) Program, initiated in 2000. One of the cornerstones of the program has been the integration of infrastructure planning to accomplish reductions in the size, duration and intensity of industrial land use and to minimize cumulative environmental impacts. The program seeks to achieve cost and approval time savings for both industries (Simpson 2005). One of the challenges that the Chamber has identified is the compartmentalization of departmental decision-making processes (the “silo effect”) and it has brought these concerns to the attention of government departments.

The Alberta Joint Energy/Utility and Forest Industry Management Committee, established by the provincial government in 1995, facilitates the coordination of activities of oil and gas and forestry companies working on the same land base. Initially formed to address conflicts over timber damage assessments, the committee now addresses other issues and concerns raised by its members, such as the development of standard land withdrawal and access agreements between the two sectors.

The provincial government has also set up or supported multi-stakeholder initiatives to tackle inter-sectoral conflicts and cumulative effects. One such process is the Cumulative Effects Management Association (CEMA), launched in 1997 as an industry initiative to address cumulative impacts of oil sands development in the Athabasca region. CEMA is a voluntary, multi-stakeholder partnership, composed of representatives from the oil sands industry, other resource developers including forest companies, Aboriginal groups, various levels of government and other interested groups. The mandate of the group is to "develop a regional, formal, multi-stakeholder environmental management system for managing cumulative effects" (Spaling *et al.* 2002:514).

CEMA has achieved progress in setting up a regional database, identifying priority issues and blueprints for action for identified themes, but it has not yet defined regional environmental thresholds. Meanwhile, oil sands projects continue to be approved at a rapid pace, without the benefit of a regional management approach to cumulative impacts. The EUB has expressed concern that regional multi-stakeholders initiatives, such as CEMA, that are designed to address issues of cumulative environmental effects are not progressing fast enough given the pace and intensity of industrial development. The two most fundamental limitations of this type of voluntary, multi-stakeholder initiative are the policy vacuum within which it operates and the uncertainty that surrounds the implementation of its recommendations.

Some efforts have been made by government and industry to minimize the impact of seismic lines (e.g., a 50 percent rebate on timber damage compensation is offered to companies using low-impact seismic techniques). Often, however, government prefers to encourage companies to coordinate and integrate their efforts, rather than imposing legal requirements.[4]

In addition to integration efforts at the operational level, the provincial government needs to address issues of cumulative impacts, as well as the fundamental tenure issues mentioned above. Land-use planning and the establishment of landscape scale objectives (e.g., thresholds) for disturbance levels of oil and gas and forest companies are tools that may be considered to address the negative impacts of rapid development. Kennett has identified the necessary components of an integrated resource management system as follows: 1) an overarching policy framework that reflects a commitment to principles of integration and ecosystem management; 2) comprehensive land-use planning; and 3) legal mechanisms for integration at the resource allocation and management stages (Kennett 1998).

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[4]For instance, there is no legislation governing the use of access roads: the *Alberta Timber Harvest Planning and Operating Ground Rules* simply state that timber operators *should* cooperate with other industrial operators to coordinate and integrate their road planning and construction (Alberta Environment 1994).

Adjustments to the tenure system for both oil and gas and the forest sectors are another option (Fluet & Krogman. 2003). For instance, larger areas could be allocated to oil and gas companies, which would then be held accountable for the impacts of their operations on these areas. Government could also extend the planning horizon of the oil and gas industry. The EUB allows companies that have several developments planned for an area in one season to submit an Area Operating Agreement (AOA), allowing all proposed developments to be approved all together. Other options could be explored to mitigate some of the negative impacts of the current tenure system. These could include both regulatory and fiscal tools (Farr *et al.* 2004).

4.5 Impact Management Toolkit

The discussion to this point has focused primarily on the 'big picture' issues for managing energy futures and landscape change in Alberta: institutional architecture for integrated landscape management, integrating science and policy, and designing regimes for regional land-use planning and rights disposition that set landscape-scale objectives and incorporate a broad range of values and perspectives regarding the future of Alberta's landscapes and the trade-offs that should be made among competing ecological, social, cultural and economic objectives.

The management of landscape change also requires attention to the specific tools that decision-makers can use to prevent and mitigate the impacts from oil and gas development and other land uses. Once again, only a selective and cursory examination of this important topic can be included in this paper. The following section considers options for reducing linear disturbance density and managing public access. The discussion then turns to reclamation as a means of managing cumulative disturbance.

4.5.1 Reducing Linear Disturbance Density and Managing Public Access[5]

Options for limiting the energy sector's footprint and reducing the resulting impacts on ecological and other values include constraining the proliferation of linear disturbances and managing public access to the seismic lines, roads and pipeline rights-of-way that are created. Several management tools are available to achieve these objectives. One of these tools, the reclamation of disturbances once they are no longer needed for energy development, is discussed in the following section. Six others are briefly examined here.

The first option is to establish optimal transportation grids for areas that may be subject to cumulative impacts from energy development and other land uses. Implementing this option would require the establishment by government of a planning process involving the major industrial players, government land managers and regulatory agencies, and other parties with an interest in the social, economic and environmental implications of transportation infrastructure. Elements of this process could include: (1) planning the location and construction timetable for transportation corridors in order to

[5]This section is adapted from Farr *et al.* 2004: Section 2, 38-44.

minimize impacts and costs while meeting the needs of the various interested parties; (2) specifying the design and maintenance standards that are appropriate for all users of the infrastructure; (3) allocating some or all of the construction and maintenance costs among present and future users; and (4) creating incentives or requirements so that industry will, to the extent possible, adapt its operational planning in order to make use of common transportation corridors.

One challenge for this option is the lack of full information on some determinants of future land uses, notably the location and extent of oil and gas reserves. Some reserves have yet to be discovered or fully delineated and technological advances may increase the recovery potential from known reserves. Furthermore, coordinated access planning for the energy sector is complicated by features of the tenure regime, discussed above in Section 4.1.3. In particular, coordination and planning are difficult given multiple and overlapping tenures, the short time frames for development resulting from the ‘use it or lose it’ component of mineral leases, and a competitive business environment that includes incentives to keep information and plans confidential.

A second option is to establish regulatory requirements that companies operating on the same land base coordinate operational planning and share infrastructure. A precedent for this type of regulation is the scrutiny of gas plant applications by the Alberta Energy and Utilities Board in order to prevent the proliferation of facilities (ERCB 1991, EUB 2004c). Applicants are required to demonstrate that their gas processing needs cannot be met by existing facilities before new gas plants will be approved. The Board also has the power to order owners of existing facilities to process gas from other companies. A similar approach could be adopted when considering applications for new roads, pipeline rights-of-way and similar linear disturbances. Implementing this option would require aligning, to the extent possible, the planning time frames of different companies and approval processes. This issue illustrates again the need for integrated planning and the modification of incentives and requirements embedded in tenure regimes.

A third option, that could include both fiscal and regulatory components, would be to establish stronger incentives or specific requirements to adopt ‘best practices’ when creating linear disturbances. For example, a combination of incentives and regulations could promote the shift to low- or no-impact seismic operations in oil and gas exploration. A strict regulatory requirement could be imposed or operators could be required to meet specified low impact standards if they can demonstrate that these techniques are infeasible or would not yield any significant environmental benefit. It should be noted, however, that the pace and intensity of development may be such that the adoption of ‘best practices’ may not, by itself, be sufficient to maintain cumulative effects within landscape objectives.

A fourth option is a policy of ‘no net increase’ in linear disturbance density within specified areas. Setting thresholds or limits of this type was discussed above in Section 4.3. As noted in that section, this policy could be implemented by regulatory limits on new disturbances or through a cap-and-trade allowance system. Additional flexibility could be provided by allowing companies to gain credit for reclaiming existing disturbances. Offset or mitigation banking could also used to complement this approach. This technique would allow government, industry or other land stewards to establish reclamation projects that would then be available through an intermediary (the reclamation bank) to companies in need of offsets for their proposed linear disturbances.

A fifth option is the adoption of a 'roadless areas policy' that would identify areas with few or no roads or other access corridors and explicitly recognize the ecological value of these areas when making land-use decisions. A roadless areas policy could be linked to protected areas designation or accommodated through the creation of 'benchmark' ecological reserves on the working landscape. Roadless areas are also compatible with development if activity is planned over a sufficiently long time frame. Although transportation corridors are inevitable on working landscapes, integrated planning could direct resource development to particular areas for given periods of time and provide for the progressive reclamation of roads and other linear disturbances as the geographic focus of industrial activity shifts. This approach could be used to establish 'floating' roadless areas (or areas with limited road access) that could be moved over time across large landscapes.

The sixth and final option is to manage the human use of industrial access corridors once they have been created. Restricting the recreational and industrial use of linear disturbances through access management mechanisms other than complete reclamation could address some, but not all, of the adverse effects on natural capital from this type of development. For example, it would address impacts directly related to off-highway vehicle use (e.g., erosion, soil compaction), hunting and fishing (e.g., pressure on sensitive populations) and increased human presence in environmentally sensitive areas (e.g., poaching, displacement of animals from breeding habitat). However, human access management would obviously not address certain other effects of linear disturbances, such as pressure on caribou populations linked to the use of these corridors by wolves. Furthermore, access management policies and practices are unlikely to be completely effective in the face of determined efforts by some people to make use of existing linear disturbances, especially given the limited resources that government currently allocates to monitoring and enforcement.

Access management is a politically contentious issue in Alberta due to pressure from certain segments of the public (e.g., the off-highway vehicle lobby) to maintain and expand access using industrial corridors. However, managing recreational access may be attractive from an economic perspective if it reduces negative impacts on natural capital without unduly impeding the creation of corridors for industrial use.

A review of Alberta's legal and policy regime for access management is beyond the scope of this paper, but reference can be made to a recent study by Wenig and Kennett (2004). This study shows that government land managers have a variety of tools for managing public access associated with industrial development. For example, access restrictions can be specified for individual industrial dispositions on public land (e.g., licences of occupation for roads under the *Public Lands Act*) and in approvals issued by the Energy and Utilities Board. There is also a provision under the *Forests Act* for establishing Forest Land Use Zones, within which public access is permitted only along designated routes. Reclamation requirements, fish and wildlife regulations and other regulatory tools could also support access management in some circumstances.

Nonetheless, effective access management has been difficult to achieve in Alberta for several reasons. Strong lobbies in support of the public's 'right' of access to public land have limited the use of regulatory mechanisms. Furthermore, once 'traditional' access has been established – meaning access along any corridor that is not closed from the time of its development – the Alberta government's policy is to maintain access unless there are exceptional circumstances (Government of Alberta 1993). From industry's perspective, options are limited because companies that create linear disturbances are in most circumstances unable to restrict the use of these corridors by recreational users, even when these companies are under pressure from regulators and stakeholders to reduce the direct and indirect impacts of their activities. These obstacles have contributed to a perception that the Government of Alberta lacks the regulatory tools and the 'political will' to implement effective access management (Farr *et al.* 2004)

Options for improving access management could take either regional or activity-specific approaches. The most obvious way to balance competing values and manage cumulative effects on a regional basis is access management planning. Alternatively, access issues could be addressed on a disposition-by-disposition basis through direct regulation or by granting resource companies greater authority to manage access on the access corridors that they create. As noted above, however, fragmented and incremental decision-making is the principal challenge for cumulative effects management; achieving landscape-scale objectives in areas of increasingly intense activity will likely require a broader planning framework in addition to improved management of individual corridors. Furthermore, a greater role for private companies in managing access to industrial corridors may require more protection from liability in the event that people using these corridors are injured or suffer property damage as a result of collision with physical access barriers. Finally, government action in support of access management could include public education and enhanced enforcement of access restrictions.

4.5.2 Mitigation of Impacts through Abandonment and Reclamation

There is no way to carry out oil and gas development without some impacts to land. Although these impacts can be minimized, oil and gas operations will by their very nature always require some clean-up once production ends. To return the land base to a productive pre-industrial state, the abandonment of wells and facilities, and the reclamation and remediation of well and facility sites must take place.[6] Although

[6]Generally, abandonment means the permanent dismantlement of a well or facility to ensure that it is left in a permanently safe and secure condition (*Oil and Gas Conservation Act*, s. 1). Reclamation refers to the return of land to an equivalent, but not identical, land capability and includes the removal of all equipment and buildings, the decontamination of land and water, and the stabilization or reconstruction of the surface of land (*Environmental Protection and Enhancement Act*, s. 1). In the case of oil and gas

Alberta's abandonment and reclamation regime has been strengthened over time, issues about its effectiveness remain.

Alberta's regulatory framework for the abandonment and reclamation of oil and gas operations has developed slowly and incrementally over the past three decades (Brezina & Gilmour 2003, Vlavianos 2002, Cook 2004). It has been added to and modified on an as-needed basis, and has been fine-tuned as new issues have arisen. Especially over the last five years, numerous amendments have occurred. These have included amendments intended to clarify a number of issues, including who is liable to carry out abandonment and reclamation, who is liable to pay the costs, when abandonment and reclamation must be carried out, and for how long future liability will be imposed. Provisions have also recently been passed to establish what is now an expanded orphan fund that is available to pay the costs where a licensee or working interest owner becomes insolvent or defunct. Finally, a number of procedures are now in place to try to protect this fund through the payment of security deposits by licensees who may have difficulty meeting their abandonment and reclamation liabilities in the long run.

The sheer number of recent changes to the abandonment and reclamation regime has led to concerns about the complexity of the system. In particular, there are concerns about a lack of clarity in terms of who exactly is liable for clean-up costs. Recently, a number of farmers revealed that banks are refusing to advance funds by way of mortgage on farm property with oil and gas operations because of a concern about with present and future contamination liability (Gregory 2006). The banks are concerned about possible surface landowner liability, even though the industry has said it is primarily liable.

There are also concerns about a lack of integration among the responsible government departments and the adequacy of available resources. While abandonment is within EUB jurisdiction, reclamation is the jurisdiction of Alberta Environment in the case of private lands and the responsibility of Alberta Sustainable Resource Development for public lands. In many cases abandonment of a well or facility has occurred, but the site awaits reclamation. In June 2005, the EUB calculated that out of 117, 841 abandoned wells covered by the orphan program, 33,207 sites had yet to be reclaimed (EUB 2005b). Data on Alberta's growing population of abandoned but un-reclaimed wells was provided above in Section 3.1 (Figure 10).

There are indications that both the EUB and Alberta Environment lack the resources necessary to ensure effective and timely abandonment and reclamation. Recently, the EUB has acknowledged the need for more staff to deal with the backlog of cases relating to inactive wells and other abandonment issues (EnviroLine 2005). Alberta Environment has also moved recently from a system of carrying out site inspections prior to the issuance of reclamation certificates to a system whereby companies applying for certificates file environmental site assessment reports produced by independent consultants. This move was in direct response to the backlog of cases waiting for Alberta

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sites, reclamation includes remediation (*i.e.,* the removal or neutralization) of any contaminants on the site: see Alberta Environment (2006).

Environment inspectors. The new system now requires approximately 15 percent of sites that have been issued reclamation certificates to undergo random field audits. Numerous commentators have raised concerns about the effectiveness of such an enforcement system (Gregory 2006).

Another possible reason for the lack of timely response by industry in the case of reclamation is the lack of clear timelines for beginning and completing reclamation. In the case of abandonment, the EUB recently addressed this issue through a detailed directive that requires companies to properly abandon their wells – many of which had remained inactive for more than 25 years – within certain time frames (EnviroLine 2005). For reclamation, although the general rule is that a site must be reclaimed when it is no longer productive, there are no specific rules prescribing exactly when reclamation must begin. As well, there are no general guidelines regarding timeframes within which reclamation must be completed (Government of Alberta 2005b).

Despite some more detailed rules for well and facility abandonment, issues about abandonment also remain. There is evidence that the number of wells being abandoned is declining as compared with the number of new wells being drilled. In 2001, more than 2,200 wells were abandoned compared with over 15, 000 new wells drilled. But in 2003, only about 1,660 wells were abandoned compared with 18,350 new wells drilled (EnviroLine 2005). The reasons for this decrease are not yet clear.

Furthermore, questions are being raised about the condition of approximately 116,000 wells that have already been approved as abandoned by the EUB. Experts now say that some of the older wells may have been improperly sealed and may therefore be leaking natural gas to the surface or seeping gas downhole, potentially contaminating soil and groundwater (EnviroLine 2005).

Given these and other concerns, the following questions regarding the current abandonment and reclamation regime remain to be addressed in order to ensure that the environmental impacts of energy development in Alberta are mitigated in a timely and effective manner:

- Is the current approach of amending Alberta's abandonment and reclamation regime on an as-needed and piecemeal basis appropriate, or is a wholesale review required to ensure a properly integrated and coordinated approach?

- Is more clarity needed in terms of allocating current and future liability as between the industry and surface landowners?

- What types of regulatory and non-regulatory measures are available to ensure more timely and effective abandonment and reclamation of energy operations?

- Do the EUB and Alberta Environment have the resources necessary to adequately enforce the current abandonment and reclamation regime? What are some other options?

- Are there enough funds available in the orphan fund to cover any future problems with wells and facilities that may have already been abandoned and/or reclaimed but whose owners are now defunct or insolvent?

4.6 Incorporating Landscape Perspectives through Participation in Decision-Making

As noted in the introduction to Section 4, managing landscape change will require decision-making processes that accommodate and respond to a broad range of interests and values that are affected by landscape change. More specifically, these processes must provide meaningful opportunities for the expression of different perspectives regarding the future of Alberta's landscapes and the trade-offs that should be made among competing ecological, social, cultural and economic objectives – and these perspectives must be taken seriously by decision-makers.

This section of the paper considers three ways that a broader range of views regarding landscape change and the associated trade-offs could be incorporated into decisions about energy development and other land uses in Alberta. The first is through the expression of regional land-use preferences by municipalities and regional health authorities. Second, the emerging legal requirements for consultation with Aboriginal people are likely to affect decision making. Finally, public participation could be included in the mineral rights disposition process.

4.6.1 The Role of Municipalities and Regional Health Authorities

An important issue for the management of landscape change in Alberta is the extent to which regional preferences regarding alternative energy and landscape futures are reflected in decision-making. This issue, in turn, raises important questions regarding the potential to involve entities such as municipalities and regional health authorities in planning, rights disposition and project review processes. As noted above, there are currently institutional and legal impediments to this type of involvement. Nonetheless, the situation is far from static.

Throughout Alberta, municipalities are the political and legal entities for land use planning and development on a regional basis. Part 17 of the *Municipal Government Act* (MGA 2000) grants considerable powers to Alberta municipalities to regulate land use and development within their borders. With respect to energy development, however, the MGA significantly restricts the ability of municipalities to approve or disapprove of a particular development. Rather, it is the EUB that has ultimate authority over the granting of a well or facility licence or approval. Consequently, energy development can proceed in a municipality even where it does not accord with the regional planning objectives of that municipality.

Two provisions of the MGA are responsible for this result. First, according to section 618, Part 17 of the Act (and the regulations and bylaws under it) do not apply when a development or subdivision is effected only for the purpose of an oil and gas well, battery or pipeline. Second, section 619 states that any license or approval granted by the EUB prevails over any municipal statutory plan, land use bylaw, subdivision or development decision. The legislation requires municipalities to approve a subdivision or development permit application to the extent that it complies with the EUB's approval.

The effect of section 619 has been considered in a number of decisions. The EUB has said that, although land use planning generally remains within municipal jurisdiction, the ultimate decision of whether a proposed energy development is or is not in the public interest is within the EUB's jurisdiction (EUB 2000d). In the Board's view, section 619 of the MGA means that the Board does not have to give effect to municipal land use plans and instruments in determining applications before it. Approval or rejection of an application is based solely on the criteria contained in the Board's legislation and not on municipal plans or by-laws. Finally, the Board has said that it is not required to defer its consideration of an application until the municipal development permit process is completed (EUB 2001b).

Historically, Alberta municipalities have, for the most part, deferred to energy development decisions made by the province. There are signs, however, that municipalities are pushing for more involvement in the face of significant landscape change and the resulting land-use conflicts. One example of an increasingly proactive municipality is Strathcona County, east of Edmonton. In 2003, the County formed a committee to develop recommendations on how to deal with oil and gas development. Although a bylaw was ultimately not passed, the committee developed a protocol that it has asked the EUB to implement. The protocol's stated purpose is to have oil and gas development occur with the least possible impact on the environment, health, safety and quality of life of the County's residents. It adds to provincial requirements for public notification and consultation, and requires oil and gas operators to comply with the County's standards for emergency preparedness, land reclamation, environmental and habitat protection, flaring, and noise and light restrictions (Strathcona County 2004).

Given municipalities' general bylaw-making powers in relation to public health and safety, Strathcona County's reaction to increasing oil and gas development within its borders is perhaps not surprising. Along with planning powers, the MGA grants municipalities the power to pass bylaws in relation to "the safety, health and welfare of people and the protection of people and property" (MGA 2000:s. 7(a)). They are also authorized to pass bylaws to deal with nuisances, including noise, dust, and odors (MGA 2000:s. 7(c)). In a seminal case on the use of pesticides, the Supreme Court of Canada has acknowledged the important role of municipalities in protecting health and quality of life in the context of adverse environmental impacts. In the Court's view, environmental regulation and implementation are often best achieved at a level of government that is "… closest to the citizens affected and thus most responsive to their needs, to local distinctiveness, and to population diversity" (*114957 Canada Ltee* 2001). This level of government is also likely to be sensitive to the implications of landscape change for those who are closest to the landscape in question.

Another regional legal and political entity with an interest in energy development in Alberta is the regional health authority. Each health region in the province is administered by a regional health authority pursuant to the *Regional Health Authorities Act* (2000). The responsibilities of a regional health authority include promoting and protecting the health of the population in the health region and working towards the prevention of disease and injury. Regional health authorities are also required to assess on an ongoing basis the health needs of the health region under its administration. Section 5(1)(b) of the Act grants the regional health authority the "final authority" in the health region in respect of these matters.

Despite its broad mandate over health, the legal situation of a regional health authority in the context of energy development is more restrained. Before the EUB, the opinions of a regional health authority about health matters relating to energy development carry no greater weight than those of any other intervenor. Courts have held that the EUB's mandate to consider whether a proposed project is in the public interest makes it the ultimate decision-maker, even in relation to health risks and impacts (*Calgary North H_2S Action Committee* 1999).

Undoubtedly, such a legislative result has the potential to cause significant frustration for regional health authorities. Most recently, the potential for conflict between a regional health authority and the EUB was played out in the context of Compton Petroleum Corp.'s application to drill six critical sour gas wells just east of Calgary. Despite strong opposition from the Calgary Regional Health Authority (CRHA), the EUB approved Compton's application subject to a number of conditions. In response, the CRHA filed an appeal of the decision arguing that the EUB had failed to assess adequately the health risks for city residents and for patients of a new hospital to be built near the proposed wells.

As this brief review demonstrates, both with respect to municipalities and regional health authorities, the effect of current legislation is to subordinate their roles in the context of energy development to that of the EUB. But the end result in the Compton case suggests that municipalities and regional health authorities may in fact have more power than appears at first glance. The EUB ultimately closed Compton's application because the company was unable to reach an agreement within a specified time with the municipalities involved and with the CRHA on an appropriate emergency response plan (EUB 2006). Support from municipalities and from regional health authorities is of course critical to a proper emergency response plan for oil and gas facilities.

In sum, despite their mandates, the actual and potential role and powers of municipalities and regional health authorities in the context of energy development is unclear. The interrelationship between these entities and their respective mandates is also unclear. Recognizing this problem, a multi-stakeholder committee investigating public safety and sour gas development in 2000 recommended that the EUB increase and improve coordination between itself and municipalities and regional health authorities. The committee recommended that the EUB develop a system to provide for the involvement of these entities in relevant EUB policy-making, and for their early, efficient and effective involvement in the review of applications dealing with sour gas and public health and safety. In May 2005, the EUB responded by adopting two draft protocols to be implemented on a two-year trial basis (EUB 2003b, EUB 2002a, EUB 2005a).

In order to properly assess the role of municipalities and regional health authorities in energy development in Alberta, the following questions require further research and analysis:

- Are municipalities and regional health authorities appropriate entities to represent regional interests in the context of energy development?
- What precisely are their current powers, in law and in practice, in the context of energy development?
- What are the limits and obstacles to their effective involvement in energy matters?
- What are some of the concerns with giving them a greater role and more control?
- How are the EUB's protocols working in practice to better involve municipalities and regional health authorities in energy matters?
- What changes to the current system are required to clarify and possibly enhance the roles of municipalities and regional health authorities in matters of energy development and management?

4.6.2 Aboriginal Consultation and the Accommodation of Aboriginal Rights in Decision Making

As noted above in Section 3.4.3, the impacts of energy developments on Aboriginal peoples and their traditional lands have been significant. Even though they have invoked their treaty rights to defend themselves against charges of illegal hunting, trapping or fishing, Aboriginal peoples have seldom used these rights to oppose resource developments. When they have, their efforts have been for the most part unsuccessful, as has been the case with the Lubicon Cree.

In 1982, the Constitution of Canada was amended and a new section (section 35) was added that specifically protects the Aboriginal and treaty rights of Aboriginal peoples in Canada. This constitutional recognition of Aboriginal and treaty rights has resulted in remarkable judicial developments across the country. In a series of landmark decisions, the courts have determined that governments cannot infringe Aboriginal and treaty rights unless they meet a strict justification test. A judicial doctrine on the government's duty to consult and accommodate Aboriginal and treaty rights has developed, which is beginning to affect the way in which governments allocate and develop natural resources.

The evolution of Aboriginal rights in Canada has potentially important implications for the management of landscape change in Alberta. This complex area of the law will not be examined in more detail here, but the judicial decisions regarding consultation rights and the Alberta Government's response to this newly developed "duty to consult" are examined in another paper prepared for ISEEE's Alberta's Energy Futures Project (Potes *et al.* 2006).

4.6.3 Public Participation in the Disposition of Mineral Rights

The implications of the mineral rights disposition processes and tenure regimes for the management of landscape change were summarized above in Section 4.1.3 and have been examined in more detail by Wenig and Quinn (2004) and two case studies prepared for the National Round Table on the Environment and the Economy (Farr *et al.* 2004, McManus & Salmo 2004). Wenig and Quinn (2004) conclude their paper with a set of proposals that include pre-tenure assessment of surface access needs and impacts, integration of surface access across sectors and land uses (e.g., through a cap-and-trade allocation system, as discussed in Section 4.3), the incorporation of conditions relating to surface access into tenure agreements, the creation of incentives (and removal of disincentives) to reduce total footprint, and the inclusion of public participation and other guarantees of transparency and accountability in the rights disposition process. Similar conclusions and recommendations are found in the NRTEE case studies.

While all of these recommendations warrant further investigation, the following discussion focuses on the incorporation of broader land-use values into the rights disposition process by providing opportunities for public involvement. Looking at rights disposition from this perspective raises important questions of public policy and law.

The broad policy rationale for increased public participation in matters of energy, natural resources and the environment has two elements. Some authors justify public participation as a means to obtain better decisions. Others argue that public participation matters for its own sake, whether or not it improves substantive outcomes of decision-making. According to this view, participation is a democratic imperative; institutions and decisions that are participatory will have greater levels of legitimacy (Barton 2002). Both perspectives support public involvement in the rights disposition decisions that initiate the development process for energy resources.

Along with these policy reasons, increased public participation sometimes occurs because it is required by law. In the context of the disposition of oil and gas rights in Alberta, some type of public consultation at this stage in the development process may be required by principles of administrative law and human rights law.

As regards administrative law, two principles appear most salient. First, courts have said that an abuse of discretion can occur where a statutory delegate (such as Alberta's Minister of Energy) acts on inadequate material, including where there is no evidence, or acts without considering relevant matters. It is arguable that this principle may be violated when the Minister disposes of oil and gas rights without considering the relevant concerns of potentially affected landowners, or of the public at large. Second, the law regarding procedural fairness, or the duty to be fair, may also be relevant in the context of the disposition of oil and gas rights. Courts have said that a duty of procedural fairness lies upon every public authority making an administrative decision that affects the rights, privileges or interests of an individual (*Baker* 1999). Arguably, the surface landowner or occupant, and possibly his or her neighbors, could be recognized as being affected by a mineral rights disposition decision. If so, it may be that the law requires that any such decision be made using a fair and open procedure, which typically includes some opportunity for the person affected by the decision to put forward his or her views and evidence fully and to have them considered by the decision maker.

As far as human rights law is concerned, two different sources may signal a need for some type of public participation in the context of oil and gas rights disposition. First, section 7 of the *Canadian Charter of Rights and Freedoms* (the *Charter*) grants certain procedural guarantees whenever someone's rights to life, liberty and security of the person are in placed in jeopardy. Although the law is far from settled, there is case law that suggests that health effects or health risks from environmental impacts may be protected by section 7 of the *Charter* (Vlavianos 2003, Gage 2003). There is also some indication that the right to pursue a livelihood or a way of life might be protected (Keeping 2004). If so, and if a potential violation of section 7 could be established in a particular case, the procedural protections in that provision would, at a minimum, require some opportunity to state one's case before a fair and impartial tribunal, acting in good faith.

Also in the context of human rights law, the *Alberta Bill of Rights* (2000) might have some relevance to the process of disposing of oil and gas rights in the province. Section 2 states that every law of Alberta shall (unless it expressly states otherwise) be construed so as not to infringe or authorize an infringement of any of the rights or freedoms the *Bill of Rights* recognizes, including the right to the "enjoyment of property" and the "right not to be deprived thereof except by due process of law". It is at least arguable that this right to "enjoyment of property" might bolster an argument by the surface landowner or occupant (and his or her neighbors) that they are entitled to "due process" before Alberta's Minister of Energy makes a mineral rights disposition decision that might ultimately affect the use to which they can put their lands and the value of those lands. At a minimum "due process" includes a right to effective notice and to some type of opportunity to be heard.

Undoubtedly, these and other legal and policy reasons for requiring public participation in the oil and gas rights disposition process in Alberta will require further research. Issues to be examined include who precisely should be consulted prior to a disposition decision and what type of participation would be sufficient. Research will also be required to assess how a balance could be struck between ensuring fair process and addressing important issues of cost, efficiency and feasibility.

Should a decision be made to move to public consultation in disposition decision-making in the province, creative solutions will be needed to establish the most appropriate regime. Other mineral rights disposition regimes that include consultative processes both within and outside of Canada could be studied. In Alberta, one such regime is the Métis Co-Management Process which establishes a different disposition process for minerals situated beneath Métis Settlements. Although not without its own problems, this regime, along with others, will require careful study to assist in ascertaining the most salient and workable features of a mineral rights disposition system that includes some level of public participation.

5 Conclusion

The data and analysis presented in Section 3 of this paper show clearly that the landscape change attributable to the energy sector and other land uses in Alberta is in large part the result of a multitude of individual activities and projects. Seismic lines, well sites, production and transportation facilities, access roads and pipeline rights-of-way make up the growing footprint of the energy sector, expanding incrementally but steadily across large parts of Alberta. These sources of direct physical disturbance bring with them the significant changes in the landscape metrics described in Section 3.2 and contribute to the range of potential ecological, social, cultural and economic effects described in Sections 3.3 and 3.4. While the impacts of each individual disturbance may be insignificant from a landscape perspective, the ALCES simulations presented in this paper leave no doubt about their substantial cumulative effects.

If Albertans are concerned about the landscape change caused by the energy sector and other land uses and want to exercise some control over the pace, extent and type of change, decision-making processes must be structured so as to yield socially determined outcomes. Achieving this objective requires attention to the legal, institutional and policy framework for decision-making. In particular, managing landscape change requires regional land-use planning, integrated landscape management, and the effective integration of science and policy in decision-making.

An important lesson from the experience in Alberta and elsewhere is that cumulative effects management must involve all stages of decision making. Land-use planning should be used to set objectives, review alternative land-use scenarios, and establish thresholds or limits on the activities that are driving landscape change. This process will necessarily involve difficult trade-offs among competing values, but these trade-offs are inevitable and they are currently being made without explicit consideration by decision-makers and the public at large.

The mineral rights disposition process should also take into account the cumulative impacts of expected development and integration among sectors – notably the energy and forestry sectors – should be improved. Management tools for reducing and mitigating impacts should also be used. Finally, all decision-making regarding land and resource use should involve consideration of the full range of land-use values. Openness and transparency requires, among other things, opportunities for significant public involvement at each stage of decision-making. In particular, decision-makers should hear from the landowners, communities – including Aboriginal communities – and the regional or place-based organizations that are most able to articulate the full range of values and interests affected by landscape change.

Achieving these objectives will require an ongoing commitment to laying the scientific and policy foundations for sound decision-making, fostering interdisciplinary research and communication, and building bridges between the research community, stakeholder groups, government decision-makers and the public at large in order to manage energy futures in a way that reflects the many values associated with Alberta's varied landscapes. Private and public research partnerships on strategic issues and priorities offer a promising model for moving forward in these areas. The information and analysis presented in this paper illustrate how applied interdisciplinary research can contribute to our understanding of the landscape change that will be associated with alternative energy futures in Alberta and to the development of effective strategies for managing that change.

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