Southern Alberta Landscapes:
Meeting the Challenges Ahead

An Examination Of The Effects Of Economic Growth On Landscape Features And Processes In Southern Alberta Using ALCES®
(A Landscape Cumulative Effects Simulator)
2007

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Executive Summary

Regional-scale modelling examined the long-term cumulative effects of land-use, resource demands, and population increases on the landscape of southern Alberta. The results will help inform the project, *Southern Alberta Landscapes: Meeting the Challenges Ahead* (SAL), in addressing the increased use of our environment into the future. SAL was launched in 2002 as a cross-Ministry, inter-governmental, strategic planning initiative to examine sustainable development issues in southern Alberta. A Base Case Scenario, which assumed a continuation of current land use practices and business plans, was developed first as a Baseline for comparison with other scenarios. An alternate scenario was then run to test various “What-if” questions. Both scenarios used 2000 for year zero because this was the most recent year for which most data were available for the region.

The source of change in landscape patterns lies in strong economic growth in the region. The economy is growing at about 5% per year, fueling a population growth rate that is faster than the provincial and national averages. The proportion of the Alberta population in the SAL region has grown from 46% to 50% of the total provincial population over the last decade.

Native vegetation and cropland each currently occupy about half of the total area of SAL. Grassland and forestland make up most of the native vegetation cover. Cereal crops and tame grass dominate cropland. About 18% of cropland is currently irrigated. In addition, the human footprint, comprised of roads, towns, cities, energy infrastructure, industrial and rural residential development, occupies 3.5% of the area of SAL. Most of the footprint is located on land originally occupied by grassland, or grassland that was converted to cropland since the turn of the last century. A relatively small part of SAL (about 5%) is non-vegetated, consisting of rock, water, ice and badlands.

Over the next 50 years, the total human footprint is projected to grow from 3.5% of the SAL area to 5.0% of the SAL area. The overall shift in land cover is expected to be towards increasing anthropogenic landscapes and decreasing native vegetation covers. Overall, cropland area is projected to increase by about 1%, while total native vegetation cover is expected to decrease by about 4%. The projected growth of cropland is offset somewhat by losses due to urban expansion and other land uses. Although all footprints are projected to increase, rural residential, and especially urban footprints are projected to increase the most.

A moderate increase in fragmentation is projected to occur in most cover types, including prairie trees/riparian in the Base Case, hardwood and mixed forest in the What-if Scenario, native grasslands in both scenarios, and all croplands except specialty crops. Fragmentation is projected to increase more under the What-if Scenario mainly because of a more aggressive energy development trajectory. There are small increases projected in the distribution of invasive species in forestland, and moderate increases in grassland.

Non-inhabitable buffers around feedlots are projected to increase, assuming a moderate amount of growth in the livestock population and no changes in technology. Cattle feedlot buffers are projected to double in size, while hog buffers are projected to increase by about 50%.

Modelling also examined the regional economic impacts of population increase and multiple sector growth in the study area. There were short-term declines in economic growth as production levels of conventional oil and gas declined; however the economy recovered as a result of increase in natural gas in coal production and growth in other sectors in the economy.

The possible impacts of climate change were not modeled in the current study, but will be considered in future phases of the SAL project.

1. Introduction

Southern Alberta is currently experiencing rapid economic growth. Economic growth historically is accompanied by landscape change as natural areas give way to settlement, and farmland gives way to urban and industrial expansion. In areas that are geographically diverse, understanding how the landscape is likely to change and what the results might be can be challenging. If possible land or resource conflicts and issues can be identified ahead of time, the impacts of economic growth can be better managed.

To help understand the cumulative effects of economic growth on the southern Alberta landscape, modelling was done to simulate change over a 50-year period using two different scenarios. A Base Case Scenario was developed that contained plausible projections for the main economic drivers of landscape change. A What-if Scenario also was developed that contained a more aggressive economic growth trajectory. This report presents the results of the modelling.

SAL Objectives

The SAL region is about 20% of the province, and includes the Alberta portions of the Grasslands Natural Region, the South Saskatchewan River basin, and the Milk River basin (Figure 1.1).

The focus of SAL is on understanding the complexity of the landscape, and the effects of human activities on environmental quality. The project is looking at the cumulative effects of changes in land use, resource demands, population increases and climate change over the next 50 years, or two generations, and how those changes affect the sustainability of the environment.

To achieve the goal of a continuing high quality of life in a sustainable environment, SAL is looking at social, economic and environmental data for southern Alberta. The data will assist those working on SAL to:

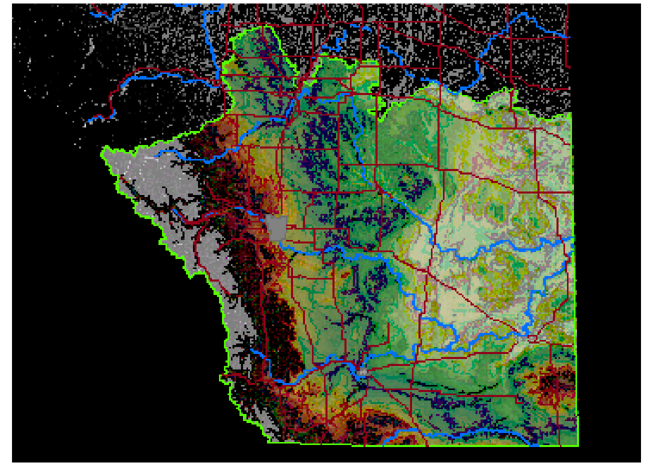


Figure 1.1. SAL Region

- Take stock of the current state of the region's resources,
- Assess the consequences of potential changes over the next two generations,
- Identify issues that need to be addressed to ensure a sustainable future, and
- Address the question of how we can meet our social and economic needs while ensuring environmental quality.

SAL is an opportunity to develop a strategic vision of the future of southern Alberta that provides for all the benefits society wants, while ensuring a sustainable environment.
Out to study cumulative effects, and a Statistics Canada Input-Output model to examine economic impact.

To accomplish this, SAL project staff agreed to:

- Look at the long-term (two generations) cumulative effects of change in land-use, resource demands, population increases and climate change, examine how that change affects sustainability of the environment, and identify opportunities to mitigate effects.

- Gather new information to add to our understanding of the state of the environment of southern Alberta. Develop new analytical tools and build staff capacity to use these tools.
- Initiate partnerships to facilitate sharing of information, increase cooperative understanding and risk management, and educate Albertans about their impacts on the environment.
- Produce a high-level government vision and goals, involving the regulated community, NGOs and the public, for all aspects of the environment in Southern Alberta.
- Achieve a broad social consensus on the key environmental and sustainable development issues, and their priorities, in Southern Alberta.
- Identify impediments to addressing environmental and land use issues.
- Recommend anticipatory, flexible and continuous improvement approaches to inter-departmental policy integration and environmental governance.

Scenarios

Regional-scale modelling examined the long-term cumulative effects of land-use, resource demands, and population increases on landscape features. Cumulative effects were modelled using variables such as total footprint and footprint density by landscape type, river basin water demand, SAL relative water quality index, SAL wildlife abundance index, invasive species abundance and others. Two different scenarios were developed for examining the cumulative effects of economic growth.

A Base Case Scenario, which assumed a continuation of current land use practices and business plans, was done first as a Baseline for comparison with other scenarios. Using 2000 as the base year, simulations were projected 50 years into the future. An alternate What-if Scenario was then run to assess the cumulative effects of a faster growing population and economy. In this scenario, the energy development footprint was increased about 20% over the Base Case Scenario. Medium-term forecasts (20-30 years) from published sources were used to project population growth for both scenarios. A medium rate of population growth was chosen for the Base Case Scenario, while a high population growth rate was chosen for the What-if Scenario.

Neither the Base Case nor the What-if Scenario should be interpreted as forecasts. They are intended to help understand what types of changes and issues might be expected across the landscape given a specific set of assumptions about long-term population and economic growth in southern Alberta.

Report Organization

The first chapter, Methods and Tools, describes the computer modeling tools used for the economic and cumulative effects analysis described in this report. This chapter also explains how footprint and fragmentation were analyzed, and gives an explanation of modelling uncertainty and spatial vs. non-spatial modelling issues relevant to the SAL project. The second chapter, Regional Overview, contains a brief description of the landscape, population and economy of the SAL study area. The third chapter, Modelling Scenarios, describes a Base Case and a What-if Scenario for growing the population and economy 50 years into the future, and the rationale used for developing each Scenario. The remaining chapters describe the results – the projected impacts to the economy, to the landscape, and the impacts associated with each sector. The final chapter presents a summary and conclusions.

2. Methods and Tools

Cumulative Effects

SAL used a computer program called A Landscape Cumulative Effects Simulator (ALCES®) to model the combined effects of land use and development on the region's natural and cultural landscape features, water demand, primary resource outputs, wildlife habitat, and other variables. Outputs are in the form of charts and tables.

ALCES®[1] is built upon STELLA modelling software (HP Systems 1995) that combines spreadsheet-like calculations with a graphics-oriented interface. The user creates an on-screen schematic diagram of virtually any system using icon-based compartments and connectors, while the software automatically writes equations on the diagram that is created. Once populated with numbers, the equations perform the calculations for a user-defined number of time steps. Results can be shown as graphs or tabulated data. Further information about STELLA software can be obtained from ISEE Systems website: http://www.iseesystems.com.

A special version of ALCES® called ALCES®-for-SAL was developed for the SAL project. ALCES®-for-SAL contains several modules for simulating changes to landscape features and processes at a watershed or regional scale relevant to southern Alberta. The program contains the following types of modules: a landscape module to drive changes in the total area of natural landscape and cultural footprint types, and calculate average fragmentation by landscape type; a population module to simulate changes in the total human and livestock population; a meteorology module to simulate regional available water supply, demand and water balance; land use modules to simulate growth or loss of cropland, cultural footprints and commodity production; natural process modules to simulate landscape processes including wildfire, insects and disease, drought, rangeland structural index, and invasive species invasion; and a wildlife module to simulate habitat supply and population abundance indices.

The first step in developing the ALCES-for-SAL program was to define the study area, and then to decide on a practical and meaningful number of landscape categories to represent the landscape. The categories included several natural and cultural landscape types[2] and development footprint types[3]. A Geographic Information System (GIS) was used to assemble spatial landscape data within the defined study area boundary, merge the data into the selected categories, remove overlaps and fill gaps, and then calculate the total area of each category in the study area. These values were then entered into ALCES®-for-SAL, along with non-spatial data including production rates, area growth projections and other key parameters associated with each landscape and footprint type. The year 2000 was used as the starting year simulations because this was the most recent year for which census data were available for the region. The most recent spatial data up to and including the year 2001 were used to parameterize ALCES®-for-SAL The chapter on modelling scenarios contains more information about data sources for this study, and a separate report describes in more detail the process of data collection for SAL[4].

[1] The first version of ALCES® was developed as an independent product over a three-year period by Forem Technologies, and initially parameterized for the Forest Management Agreement landscape of Alberta-Pacific Forest Industries in northeastern Alberta. In 2002-03, Alberta Environment contracted Forem Technologies to develop an ALCES®- for-SAL version that involved the cooperative efforts of government staff, external consultants and independent researchers. The product has undergone several external reviews. The results of these reviews are contained in a separate SAL report.

[2] Landscape type – a category that contains numerical data about natural and agricultural (cropland) land cover (e.g., total area). The data cannot be portrayed on a map. ALCES®-for-SAL contains 19 natural and 5 cropland landscape types.

[3] Footprint type – a category that contains numerical data about human development, such as roads and urban areas. ALCES®-for-SAL contains 18 footprint types.

[4] *Southern Alberta Sustainability Strategy (SAL) Landscape & Footprint GIS Layer Compilation & Statistics Generation.* Alberta Sustainable Resource Development. 2005.

The ALCES®-for-SAL program runs in annual time steps and is driven by changes in the size of stocks and rates of flow between stocks. For example, as urban area, roads and human population increase, the area of cropland and native habitat decrease, fragmentation and area occupied by invasive species increase, while wildlife population indices decrease. The developers of ALCES® refer to the program as a spatially stratified program, meaning that the landscape is divided into multiple strata (groups), and then landuse footprints and natural disturbance regimes are modeled separately within each landscape group. Neither the landscape nor the footprint types in ALCES® have spatial location attributes. In other words, the total area of each landscape type within the study area is simulated, but the program does not contain nor simulate their geographic location or spatial distribution over the landscape.

ALCES®-for-SAL is a non-dynamic simulation program. This means that if a stock such as water becomes limiting or is used up during a simulation, water-using entities such as human populations, settlements, livestock, and crops grow independently of each other and create water demand regardless of how much water is available. Alternatively, threshold targets for various parameters can be identified, and ALCES®-for-SAL will show whether the target has been met or exceeded. Or, the maximum density levels of various individual footprints can be specified, and the simulation will terminate if a maximum level is exceeded.

Generally, no primary data collection was undertaken to parameterize ALCES®-for-SAL; however, feedlot data were gathered to supplement existing data, and sampling methods were used for estimating the average size of farm and non-farm rural residential areas. Model parameters were estimated using data available from the literature, government reports, and expert opinion. An advisory team composed of regional government staff with technical expertise in a variety of environmental and resource areas assisted with data collection and verification, and estimation of unknown parameters. The chapter on modelling scenarios contains more information about data sources used in the Base Case and What-if scenarios.

A separate report contains a more detailed overview of ALCES®-for-SAL[5].

Input Output (IO) Model

SAL also used a Statistics Canada Input-Output (IO) model to compare the economic impact between the Base Case and What-if scenarios. Input-Output (IO) models are generally used to simulate the economic impact of an expenditure on a given basket of goods and services or the output of one of several industries. The results from a simulation shock show the direct and indirect impacts, such as which industries benefit the most, the number of jobs created, rough estimates of indirect taxes and subsidies generated.

Economic growth or decay of a region is a complex of components or a number of changes that occur simultaneously or perhaps sequentially until a new equilibrium is reached. An input-output model is a useful method of estimating secondary impacts of economic development projects. The model is capable of estimating the impacts of either change in the final demand for a product and/or change in the level of output of a sector.

Output from ALCES®, which is in physical units (Table 2-1), first is converted into units recognized by the input-output model. The IO model then estimates the ripple effects created by various economic changes induced by the scenario and calculates total sector sales, regional sales and GDP. Economic changes in the level of economic output of various firms / group of firms (called sectors) then are translated into changes in employment, and subsequent changes in the population of the SAL region.

[5] *Modelling Landscape Effects of Economic Growth in southern Alberta using* ALCES® *(A Landscape Cumulative Effects Simulator).* Draft Report. Prepared by Alberta Environment. 2005.

Table 2-1 ALCES® **Outputs Used in IO Model**

Conventional Oil (m^3)
Natural Gas (m^3)
Natural Gas in Coal (m^3)
Coal (3/yr)
Cereals (tonnes)
Oilseeds & pulses (tonnes)
Specialty (tonnes)
Forage (tonnes)
Tame Pasture (tonnes)
Cattle (individuals)
Pigs (individuals)
Horses (individuals)
Softwood (m^3)
Hardwood (m^3)
Tourism (activity days)

The IO model uses Alberta input-output tables to track and quantify the economic activity generated by changes in consumption or production. The IO tables present one of the most complete and detailed accounting frameworks of the Canadian economy available. Consequently, the model has the greatest potential of all major economic models for capturing the flows of goods and services between industries and consumers at relatively detailed levels.

Provincial coefficients in the transaction matrices for the various sectors were converted to regional coefficients using data on employment and trade flows for various sectors. The input-output model was then linked to an employment model with estimated linkages to regional population impacts (Kulshreshtha & Russell, unpubl. report)[6].

The SAL IO model contains the following important characteristics:

- **Does not forecast. Instead, it estimates the shock to the economy given a set of inputs for a scenario.**
- Technology stays the same for any given scenario (e.g., production efficiency does not change).
- No substitution of inputs from one sector to another.
- Fixed demand-to-import ratios.
- Fixed prices and wages.
- No limits to input supply, and thus no bottlenecks.

Footprint Area and Fragmentation by Cover Type

ALCES® output includes variables that give an indication of the proportion of a cover type that has been consumed/covered by development footprint in a scenario, and also fragmentation (km/km^2). ALCES® uses the total area of each cover type in the study area for calculating these outputs, which results in an average value for each type. In reality however, development typically occurs in some areas of a cover type and not in others. For example, four of the landscape types in SAL have significant portions partly located within parks and protected areas (Table 2-2). This land in reality is protected from most development sectors, especially those sectors that are projected to experience moderate to high growth over the next 50 years. Consequently, an alternate scenario was run in ALCES® that simulated development only on the active parts of the cover types shown in Table 2-2. The results of this scenario are included in this report.

Table 2-2. SAL Landscapes in Parks/Protected Areas

Landscape Type	% in Parks / Protected Areas
Spruce	61
Pine	27
Spruce-fir	20
Parkland	16

Landscape fragmentation can be measured in several ways and at different scales. In ALCES®-for-SAL, the most commonly used measure is total km/km2 by cover type. This measure is computed by adding together the total length of all linear footprints (i.e., roads,

6 *Southern Alberta Sustainability Strategy: Input-Output Model*. Kulshreshtha, S. & Russell, D. 2004.

transmission lines) along with the total "length" of all non-linear footprints associated with a cover type. The total length of a non-linear footprint is calculated by dividing its total area by a user-defined average width.

The impacts of fragmentation can be interpreted in many ways. For example, fragmentation of cropland may be used as an indicator of potential land use conflicts. Or, fragmentation may be used as an indicator of a landscape's susceptibility to invasion by invasive species, or its ability to support wildlife species that are sensitive to roads.

Animal species are affected differently by landscape fragmentation because of their specific range size, dispersal ability, habitat and food requirements and behavior. Moreover, species' abilities to move across a landscape vary depending on the spatial configuration of habitats, the distance separating habitats, and the intervening cover types.[7] Structural connectivity between habitats may be an important factor for maintaining habitat effectiveness.

Modelling Uncertainty

Whenever model predictions are used to support decision making, it is desirable that the uncertainties in these predictions be quantified. When presented as error bounds for individual predictions, estimates of uncertainty allow the user to determine if the model and input data reliably support their particular decision-making process (Johnson & Gillingham 2004)[8]. The magnitude of uncertainty that is tolerable for decision-making will vary depending on the application of the model. For example, owing to the cumulative effects nature of ALCES®-for-SAL, relatively small sources of inaccuracy in parameters can compound, and over a 50-year modelling scenario, can result in an error bound that varies by as much or more than the projected change in an output. Unlike process-based models where simulations can be tested against observed data, ALCES®-for-SAL produces long-term projections. Consequently, the extent of change for each ALCES®-for-SAL output must be carefully weighed in relation to the amount of error it is likely to contain, and what information is desired from the modelling results.

The main source of uncertainty in ALCES®-for-SASS lies in the estimation of unknown parameters. The program contains two groups of parameters: one group estimated from spatial data and a second group estimated from non-spatial data. Spatial data were used for estimating landscape and footprint categories. Accuracy of spatial data from aerial imagery typically is about 80%. Data and information gaps in the spatial databases that appeared during SAL GIS data processing were a source of additional inaccuracy, and overall are probably in the range of 5-10%. Where GIS data were lacking, for cropland for example, assumptions were made to fill in gaps. To check the validity of this approach, the results of the SAL cropland computation were compared with Canada Agricultural Census data. All cropland categories compared favorably with the exception of tame grass (22,000 km^2 compared with 9,100 km^2). This difference was not expected to change the overall results of the modelling scenarios.

Non-spatial data are used in ALCES®-for-SAL for modelling natural processes such as invasive species distribution, and indices specially developed for this study including a wildlife abundance index, a rangeland structure index, and a relative water quality index. Where possible, empirical data were used for estimating model parameters (e.g., the relative water quality index used in this project). In the other models however, expert opinion was used to generate model parameter values because empirical data did not exist. Unfortunately there is no way of estimating uncertainty in any of these models because variation in key model parameters was not estimated or captured.

[7] D'Eon RG, Glenn SM, Parfitt I, Fortin M-J. 2002. Landscape connectivity as a function of scale and organism vagility in a real forested landscape. Conservation Ecology 6: 10.

[8] C.J. Johnson & M. P. Gillingham. Mapping uncertainty: sensitivity of wildlife habitat ratings to expert opinion. *Journal of Applied Ecology* (2004) 41, 1032 –1041.

HSI scores for ALCES®-for-SAL, which give the relative importance of different habitat types to a wildlife species, were estimated through a Delphi (expert consensus) process. Case studies of expert-based habitat suitability models suggest that even simple predictive models can be sensitive to variation in expert opinion[9]. In one study, assumed variation in expert opinion resulted in dramatic decreases in the geographical area of high- and moderately high-quality habitats (85% to 68% decreases respectively). The majority of habitat polygons (85%) could vary by up to one class with smaller percentages varying by up to two classes (9%) or retaining their original rank (7%).

Another source of uncertainty involves the projection of known historical trend data. The most common approach to characterizing this latter type of uncertainty is to present alternate scenarios that assume higher or lower rates than in the medium or central scenario[10]. For example, the results of changing various parameters, such as population growth, projected water consumption rates, tourism growth rates, cropland expansion, and urban expansion can readily be examined using multiple model runs. The main weakness of this approach is that no specific level of uncertainty is associated with the alternatives, and consequently it is not possible for users to interpret the precise meaning of the ranges presented. However, the comparative results of both the Base Case and What-if Scenarios can provide meaningful insights into the cumulative effects of land use change if the effects of modelling uncertainty are kept in mind. This is one of the main uses of ALCES®-for-SAL in the current study.

A separate report[11] contains an uncertainty assessment for ALCES®-for-SAL. The assessment illustrates the effect of spatial data inaccuracy on selected ALCES® outputs, and the effect of changing HSI scores in the wildlife model by a factor of approximately 15-20%. Similar assessments for the rangeland structure, relative water quality index and invasive species models also could be done.

Spatial vs Non-Spatial Modelling Issues

One of the main objectives of SAL is to understand how economic growth may change the landscape at a regional scale over a 50-year time period. ALCES® was chosen because once parameterized, it provides a relatively easy way to examine different scenarios. Spatially oriented issues such as the geographic pattern of urban development on cropland, or the energy footprint on native grassland, were beyond the scope of this study. Spatially explicit tools can be used if answers to these types of questions are desired.

[9] C.J. Johnson & M. P. Gillingham. Mapping uncertainty: sensitivity of wildlife habitat ratings to expert opinion. *Journal of Applied Ecology* (2004) 41, 1032 –1041.

[10] Center for International Earth Science Information Network. www.ciesin.columbia.edu/contact.html

[11] *Modellng Landscape Effects of Economic Growth in southern Alberta using* ALCES®. Draft report Prepared by Alberta Environment. 2005.

3. Regional Overview

This chapter contains a brief overview of the SAL region including its landscape, economy and human population. It also introduces the main landscape features that will be discussed in the remainder of the report.

Interpreting the Figures

Reading the scales on the vertical axes of the figures in this report is essential for understanding the information they contain. Because the region is large (130,000 km^2), different scales are used depending on what types of features are analyzed. For example, figures that depict cropland area generally use a scale of 50,000 km^2, whereas figures that depict development footprint use a scale of only 2500 km^2 or less. For consistency, the report uses as few different scales as possible.

The Landscape

The SAL region comprises all of southern Alberta, or about 20% of the total area of Alberta. It occupies all of the Alberta portions of the Grasslands Natural Region, the South Saskatchewan River Basin, and the Milk River Basin. Urban areas include the cities of Calgary, Red Deer, Airdrie, Lethbridge and Medicine Hat.

Today, about half of this area is cropland and the other half is composed mainly of natural cover types (Figure 3.1.). The natural cover types, composed of native forest, shrub and grasslands, include the scenic landscapes of the Rocky Mountains and foothills, parkland, and the mixed and short grass prairie. About 3% of the region has been developed for residential and industrial purposes, and most of this area is comprised of settlements and roads (Figure 3.2).

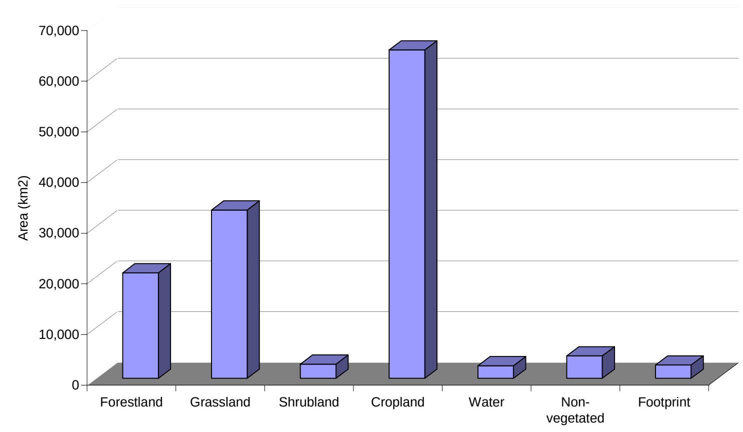


Figure 3.1. SAL Cover Types

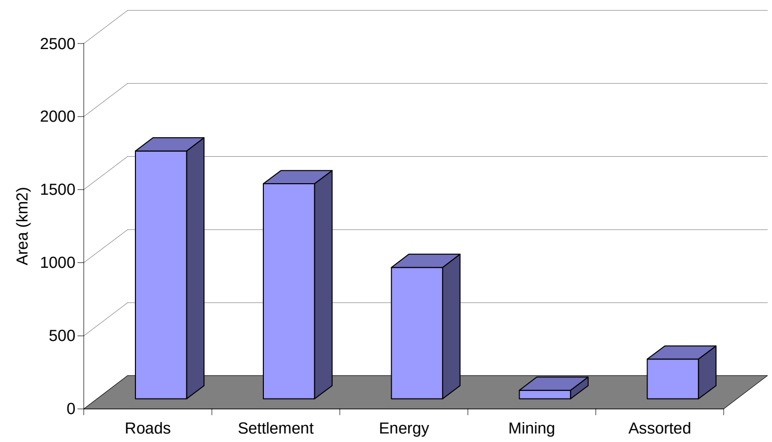


Figure 3.2. SAL Development Footprint (Note change in scale from Fig 3.1)

A more detailed examination of the footprint reveals that most of the road footprint is comprised of minor roads, and about three-quarters of the settlement footprint is comprised of urban area (Figure 3.3).

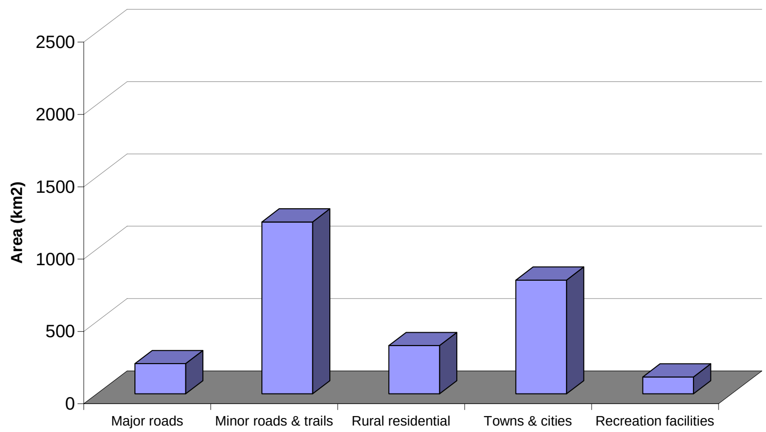


Figure 3.3. Distribution of Selected Footprint Types

The Economy

The SAL region accounts for approximately 46% of Alberta's economic activity.[12] Historically, growth and development of the region was based primarily on agricultural-related activities, which included cattle ranching and other farming operations. More recently, oil and gas development has become a major economic driver. Although the region's economy has weathered cyclical peaks associated with changing world energy prices, the recent trend of higher energy prices has provided considerable economic stimulus to the region. Agriculture, petroleum / petroleum refining and manufacturing are all now major drivers in the economy with each producing approximately 10% of the SAL region's sales. The service related sectors produce 65% of the region's production – indicating a well-developed economy.

The economic performance of southern Alberta has been among the best in Canada. A number of sectors play important roles in the economy, such as:

- 51,000 oil and gas wells produce $7 billion gross gas value and $2 billion gross oil value (2002),
- More than 25,000 farms are located in southern Alberta, of which more than one half are cattle / livestock farms,
- The manufacturing sector contributes $5.4 billion each year to the Calgary area alone,
- Tourism brings in excess of $2.0 billion per year to southern Alberta.

The City of Calgary is southern Alberta's major economic hub with almost 70% of the region's major project spending (Malatest, 2005). Vibrant energy and construction sectors will maintain Calgary's No. 1 growth ranking among Canadian cities in 2005, according to a report by the Conference Board of Canada, an independent, not-for-profit applied research organization (*Metropolitan Outlook – Spring*

[12] SAL: Social/Economic Aspects. Prepared for AENV by Global Training Inc., 2004. Regional and Economic Overview and Outlook for Southern Alberta. Prepared for AENV by R.A Malatest & Associates. 2005

2005). Calgary's real gross domestic product (GDP) is forecast to expand by 4.6 per cent in 2005. This is the strongest growth rate among all the major cities in the country. The Conference Board of Canada expects Calgary to slip to an average third-place position between 2006 and 2009, with an average annual expansion of 3.4 per cent, but retain its No. 1 ranking over the first decade of the century with average growth of 3.8 per cent between 2000 and 2009.

Above average economic growth in the region is not limited to the Calgary region, as most regions in southern Alberta have realized considerable economic expansion. For example:

- The Lethbridge-Medicine Hat Economic Region had the highest labor force growth rate in Alberta over 2003,
- At 4.1%, the Camrose-Drumheller Economic Region had the lowest unemployment rate in the province in 2003, and
- In 2003, the Red Deer Economic Region had a 4.0% labor force growth, largely due to retail center development.

While the southern Alberta region has witnessed strong economic growth during the past ten years, it is expected that this growth will begin to abate during the next five to ten years, assuming a projected decline in world energy prices as well as the gradual improvement in the economies of other Canadian provinces – which is expected to slow net in-migration to the region (Malatest 2005).

Population

The source of change in settlement patterns lies in population growth in the region. Population in the SAL region is growing faster than the provincial and national populations. The proportion of the Alberta population in the SAL region has grown from 46 to 50% of the total provincial population over the last decade.

The human population in SAL is about 1,488,000 (2001). Of this population, 5% (74,400) live on farms, 11% (163,680) live on rural residential, 84% (1,249,920) live in urban areas.

The historic trends illustrate an increasingly urban population (Figure 3.4). The rural population dominated the region until 1950, when urban population outpaced rural. Census Division 6 (Calgary) is 94% urban, and contains two-thirds of the region's population.

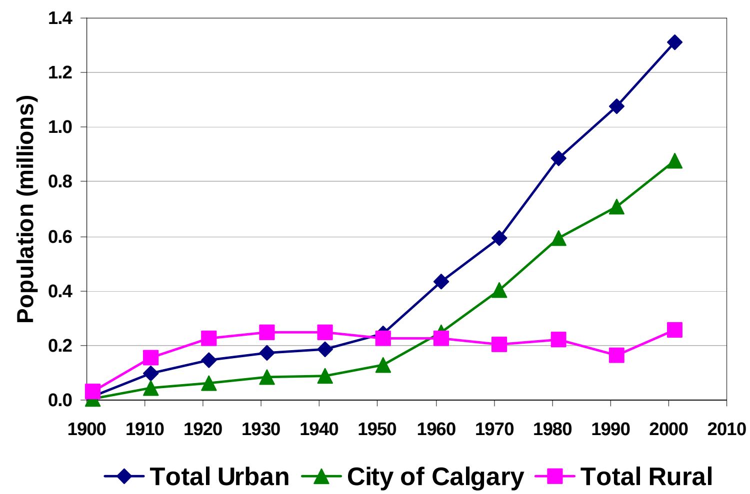


Figure 3.4. SAL Historic Urban/Rural Population Trends

Population growth has not been consistent within the region. There has been a marked population shift within the region to the Calgary area and extending from Calgary into the Calgary Red Deer corridor and into the Calgary mountain corridors. Outside of the Calgary corridors, regional population growth has fallen behind provincial average growth. One census division (Hanna / Oyen) has experienced a negative growth rate (1991-2001) and one census division (Pincher Creek / Oldman) has experienced no recent growth. Calgary's share of the SAL region's population has increased from 62% in 1976 to 68% in 2001.

4. Modelling Scenarios

The following section describes the Base Case and What-if Scenarios, including key projections and assumptions, and explains how each Scenario was developed.

The Base Case Scenario

The Base Case Scenario assumes that growth in the economy of southern Alberta will be a continuation of current trends and business plans. Consequently, many key variables that determine the future size of the development footprint, total resource consumption, and commodity output are held constant. Examples of variables that are held constant include the following:

- Average size of industrial footprints such as road width and well site pads,
- Domestic, industrial and agricultural water consumption rates,
- Irrigation efficiencies,
- Crop production rates,
- Export coefficients for nitrogen, phosphorus and sediment,
- Reclamation rates,
- Natural disturbance rates (fire, insects),
- Invasive species spread rates,
- Feedlot buffer widths.

On the other hand, many variables are expected to change over time, such as growth rates for: the human population, settlement area, crop area, and oil and gas development. Long-term projections for these variables were obtained from a variety of sources including published data and forecasts, consultants' reports, government data and expert opinion. In cases where 50-year projections were not available, best-fit polynomial functions were used to extend the existing forecasts. The remainder of this section provides more information about the Base Case Scenario for each of the main sectors in SAL. Details about population and economic growth in southern Alberta can be found in other SAL reports[13].

Human Population

The SAL Base Case Scenario projects the human population for the region as a whole to grow at a medium rate of about 1.5% into the future. This results in a population of 2.9 million people at Year 50. Growth in the population is projected to unfold as 0% on farms, 17% in rural residential acreages, and 83% in urban areas.

The What-if Scenario projects the human population to grow at the rate of about 1.8% into the future. This results in a population of 3.5 million people at Year 50. Growth in the population is projected to unfold as 0% on farms, 17% in rural residential acreages, and 83% in urban areas.

Several agencies have done medium-term, population forecasts (Table 4-1). Alberta Finance forecasts[14] are by census division from 2003-2026, and if projected for SAL, range from 2 to 3.5 million people by 2050. The "medium" projection is for about 2.7 million people by 2050. This is based on annual growth rates that decline over time, from 1.8% per year initially, to 0.8% per year by 2026.

[13] *Southern Alberta Sustainability Strategy. Social / Economic Aspects*. Prepared by Global Training Inc. March 2004.
Regional Economic Overview and Outlook for Southern Alberta. Southern Alberta Sustainability Strategy. Malatest and Ass. January 2005.
[14] *Alberta Population Projections by Census Divisions 2004-2026.* Alberta Finance - Statistics, Oct 2004.

Table 4-1. Summary of Population Projections-

Source of Projection	Projection to 2050
Alberta Finance (to 2026) for SAL Region	2.0 – 3.5 million people (medium 2.7 million)
Alberta Finance (to 2026) for CD 6 Calgary	1.4 – 2.6 million people (medium 1.8 million)
City of Calgary (to 2033) for Calgary Economic Region	1.5 – 2.2 million people
City of Calgary (to 2033)	1.4 – 1.8 million people
South Saskatchewan River Basin – basin total	2.5 – 3.2 million people (medium 2.9 million)

The forecasts for the City of Calgary for 2003-2033[15] (projected to 2050) suggest populations ranging from 1.4 to 1.8 million people. The forecasts are based on an average annual growth rate of 1.2% over the entire period. When the forecast is separated into 10-year periods, a declining trend emerges. Over the first decade, population growth in the region is expected to grow by 1.7% annually. Population growth is expected to average 1.2% in the second 10-year period, and decline to 0.6% in the last decade of the forecast. This decline occurs largely because of the slowing expected in the natural increase of the population.

The City of Calgary's population is expected to grow at a slightly lower rate than the surrounding region. This is because smaller centres may become more attractiveness as they develop better services. The City of Calgary expects that the proportion of the regional population living within the city will drop to 79% from 83% over the next 30 years.

As part of the SSRB Water Management Plan, population projections were made to support non-irrigation water use forecasts[16]. These projections are for 2.5 to 3.2 million people in the basin by 2046. This population should be slightly lower than the SAL population because of the smaller SSRB area.

Data from the 2001 census were used to parameterize the current human population in ALCES®-for SAL.

Settlement

Southern Alberta's vibrant economy is expected to attract large numbers of workers over the next several years, which will add to the natural growth in the population. As a result, cities in southern Alberta, especially the City of Calgary, are likely to continue to experience above-average growth in the medium term. Rural residential development also is expected to exhibit strong growth, especially within commuting distance of Calgary.

The settlement footprint is projected to grow at the following rates in the Base Case Scenario:

- Farmyards – zero growth
- Rural residential (acreages) - 1.7% per year
- Cities & towns - 1.5% at year 1 and decreasing gradually to 1.0% per year by Year 50.

The rural residential (acreage) growth rate is an estimate using provincial government data. The urban area growth rate was estimated using historical air photos (Prairie Conservation Forum, unpubl. data) and a best-fit polynomial function (Figure 4.1).

Most of the urban area footprint is projected to expand into cereal cropland (32%), tame grass (22%) and fescue parkland (8%) because the City of Calgary is projected to dominate urban area growth as it expands into surrounding cropland.

[15] *Calgary's Shifting Socio-Economic Landscape 2003-2033.* 2003. City of Calgary.

[16] *South Saskatchewan River Basin Non-Irrigation Water Use Forecasts*. March 2001. Prepared by Hydroconsult Ltd. for Alberta Environment.

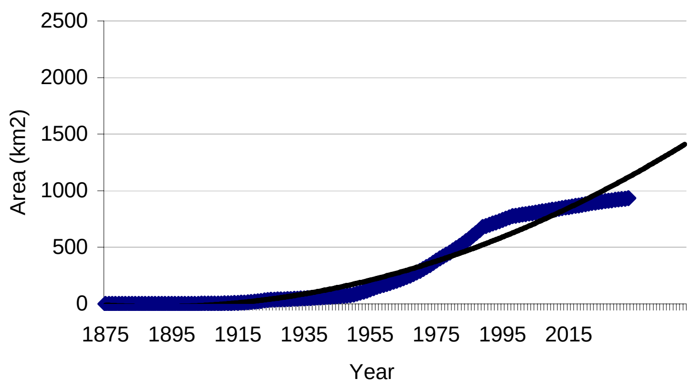


Figure 4.1. Projected SAL Urban Footprint

Under the What-if Scenario, acreages are projected to grow at 3.4% a year over 50 years instead of 1.7%, and the urban footprint is projected to increase twice as much by Year 50 as the Base Case Scenario. The acreage What-if growth rate is purely a speculative rate. The urban What-if growth rate is based on the recent growth rate of some American mid-western cities such as Denver, Colorado and Houston, Texas, whose rapid economic growth is fueled by diverse sectors including high-tech industries and oil and gas.

The total area of acreages in SAL was estimated first by obtaining a representative sample of acreages using air photos, and then using a GIS to calculate their average area. Average area then was multiplied by the total number of acreages in SAL. The total area of the city/town category was estimated through a two-step process. First, total area was calculated in a GIS using provincial Base-features data, which contained administrative boundaries. Then the actual footprint area was estimated by adjusting the administrative area using data derived from air photos (Prairie Conservation Forum, unpubl. data).

Agriculture

Agriculture, and the many industries that support it, are the dominant business in much of southern Alberta. A varied crop mix is grown on a land base that occupies about half of the study area. There is a well-established livestock industry, including pasture and range-fed cattle and confined feeding operations that include pigs and cattle. In addition, heavy investment in transportation infrastructure has provided access to markets. This chapter describes the modelling of SAL agriculture, including crop area and production, irrigation water demand, livestock population, livestock water demand, feedlot footprint, and industrial footprint growth. Data and background information are from Alberta Agriculture, Food and Rural Development, Natural Resource Conservation Board (NRCB), Agriculture and Agri-Food Canada and from Statistics Canada. Estimates of future livestock growth are from Alberta Agriculture, Food and Rural Development and the NRCB.provided background data and information.

Cropland in SAL is classified into five broad categories (Figure 4.2).

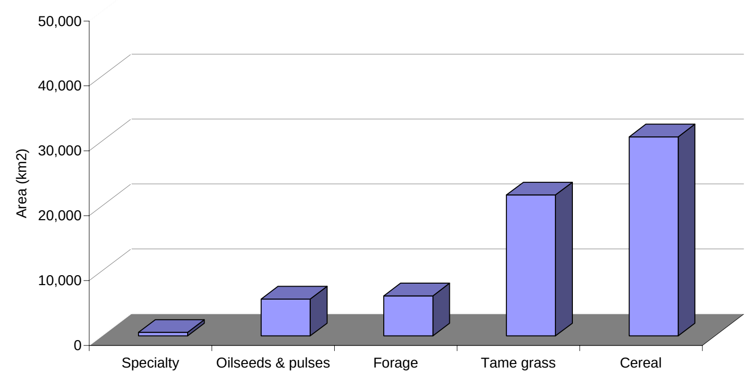


Figure 4.2. SAL Cropland Area (2000).

The current (2000) livestock population in SAL is estimated to be: 4,500,000 cows, 1,500,000 pigs and 100,000 horses. The distribution is estimated to be:

- Cattle: feedlots (38%), native cover types (19%), croplands (43%)
- Pigs: feedlots (100%)
- Horses: rural residential & farms (65%), native (30%), feedlots (5%)

The current number of feedlots and total feedlot buffer area are calculated using an average of 2600 cattle and average buffer width of 2.1 km per feedlot, and an average of 1037 pigs and average buffer width of 0.3 km per feedlot.

The SAL Base Case Scenario reflects Alberta Agriculture, Food and Rural Development's 2004-07 Business Plan, which aims to grow primary agricultural production to $10 billion and value-added industry to $20 billion by 2010[17]. Over the next 50 years, cropland types are expected to shift towards more high value forage and oilseeds/pulses crops. An increase in irrigation of about 10% also is expected. This will allow agricultural production to increase by more than 2 million tonnes per year or 12% over the 50 year time period.

Key assumptions for projecting changes in the crop sector are as follows:

- Input rates for water and fertilizer are based on weighted regional averages,
- Fertilizer application rates and crop production rates are held constant (Table 4-2, Table 4-3),
- Cropland expansion into native communities is based on estimates agricultural potential (Table 4-4),
- Disturbance on croplands (through oil and gas or other land use activities) are immediately reclaimed & the land is placed back into the cropland base,
- Crops are not rotated (not needed in this type of modelling).

[17] http://www.finance.gov.ab.ca/publications/budget/budget2004/agric.html#4

There currently is no What-if agricultural scenario being modeled for SAL. A climate change scenario was considered beyond the scope of this study.

Table 4-2. Fertilizer Annual Application Rates

Crop Type	Nitrogen (Kg/ha/yr)
Cereal crops	75
Oilseeds & pulses	9
Specialty crops	15
Forage	55
Tame Grass	5

Crop Type	Phosphorus (Kg/ha/yr)
Cereal crops	3.0
Oilseeds & pulses	2.5
Specialty crops	3.0
Forage	2.5
Tame Grass	2.0

Table 4-3. Annual Crop Production Rates

Crop Production Rates	Tonnes/ha/yr
Cereal crops	2.5
Oilseeds & pulses	1.6
Specialty crops	29.0
Forage	3.6
Tame Grass	2.3

Crop type	Expansion (ha)	Expands into
Cereal crops	132,000	Grasslands
Oilseeds & pulses	354,180	Cereal
Specialty crops	34,250	Cereal
Forage	386,950	Cereal
Tame Grass	0	n/a

Table 4-4. Cropland Expansion (50-Year Projection)

Cattle and pig populations are projected to grow 0.9% per year, while the horse population is projected to grow 2.5% per year. Seventy-five percent of the cattle growth will occur in feedlots, while 25% will occur on forage crops. All growth in pig populations will occur in feedlots. Feedlot area is projected to grow 1.5% per year, while the projected total area of non-inhabitable buffer is dependent on the number of feedlots, which in turn depends on the size of the cattle and pig populations.

Other key assumptions in the SAL livestock sector include:

- Average number of animals per feedlot remains constant (2600 cattle per feedlot; 1037 pigs per feedlot),
- Average feedlot buffer widths are based on current government regulations (2.1 km per cattle feedlot; 2.3 km per pigs feedlot),
- Stocking rates on native grasslands are held constant.

Energy and Mining

Energy development occurs throughout the SAL study area with the exception of the mountain parks. Aggregate mining is concentrated in the Bow Corridor west of Calgary, and there is one active coal mine near Sheerness for the production of electricity. Current development in the study area includes:

- About 51,000 producing oil and gas wells,
- 184 sweet gas plants,
- 124 sour gas plants,
- 1 oil refinery (Bowden),
- About 116,860 km of pipelines,
- 1 active coal mine and one proposed,
- 1 coal-fired power plant (and one proposed),
- 1 gas-fired electrical generation utility,
- 4 gas fired non-utilities,
- Wind generated power (two projects and four proposed),
- Petrochemical & chemical industry (12 major facilities),
- About 2,500 natural gas in coal (coal bed methane) wells.

A simplified approach is used in ALCES®-for-SAL to generate conventional oil and gas activity, adapted from a model first described by R. Naill for the life cycle of natural gas production in the USA based on previous work by M.K. Hubbert.[18] (Figure 4.3, Figure 4.4). A brief description of the approach is contained in a separate SAL report. Conventional oil and natural gas development are projected to occur using the Hubbert-Naill approach and based on exploitation of EUB potential reserve estimates for SAL (Alberta Energy, unpubl. 2005).

[18] Naill, R. F. 1973. "*The Discovery Life Cycle of a Finite Resource: A Case Study of U.S. Natural Gas.*" pp. 213-256. In: D. H. Meadows and D. L. Meadows, eds. Toward Global Equilibrium: Collected Papers. Cambridge, MA: Wright-Allen Press.

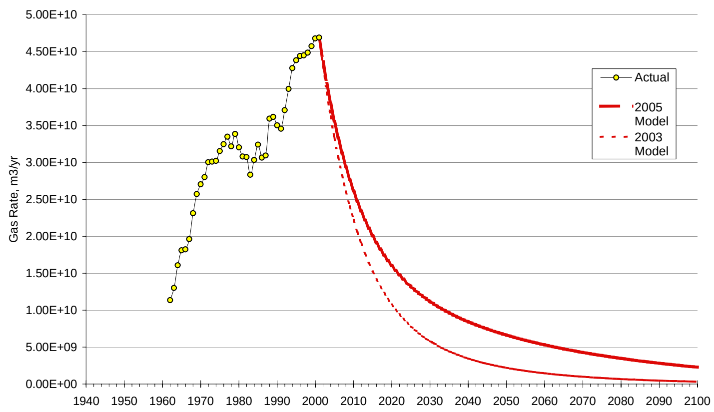


Figure 4.3. Estimate of SAL Oil Production Rate.

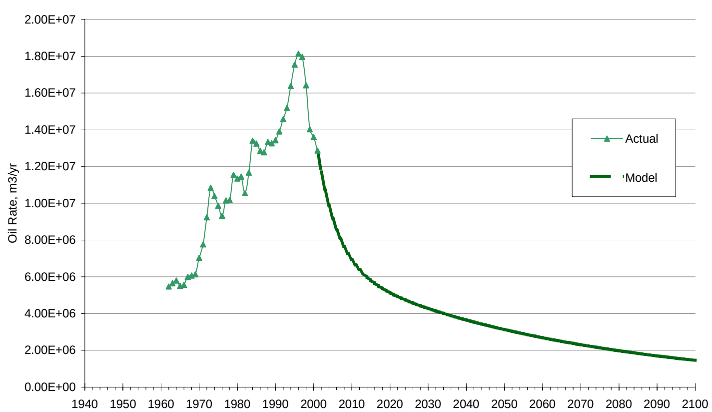


Figure 4.4. Estimate of SAL Gas Production Rate

Conventional oil and gas production is expected to decline over the next 50 years (Figs 1 & 2). Natural gas in coal (NGC) production, in contrast, is expected to increase to a peak in 20 or 25 years. The future distribution of the energy footprint across landscape types is assumed to be the same as the distribution of the initial footprint. Well sites are projected to expand mostly into dry mixed grass (32%) and croplands (31%), and pipelines are projected to expand into dry mixed grass (48%) and cropland (9%).

Development of natural gas in coal (NGC), or coal bed methane, is projected to be consistent with Alberta Geological Survey estimates of reserves in southern Alberta, and to reflect historical trajectories from the United States. The rate of exploitation of SAL conventional gas rates also was considered in developing the NGC rate. Consequently the rates are slightly higher than USA historical, but lower than SAL conventional. Seismic exploration is not needed for NGC.

Life spans in the Base Case Scenario are: well pads (35 years), roads (30 years), and pipelines (permanent). Once the lifespan of each well pad and well site road is reached, the features are reclaimed to a cover type defined by the user. In SAL, all features are reclaimed to their original cover type, except that grassland cover types become occupied by invasive species. The total SAL mining footprint is projected to grow from about 60 km^2 to 240 km^2; however, mine production is not being modeled in ALCES®-for-SAL. The lifespan of coal mines in the Base Case is 25 years.

The modelling approach does not include or consider:

- Multiple discovery and production cycles,
- Oil, gas production response to fiscal regimes (taxes, royalty, regulation, etc.),
- Overall economic cycles or commodity prices,
- Effects of improved technologies, energy substitutions or regulatory changes.

A SAL What-if energy scenario includes the following:

- A 20% increase in conventional natural gas footprint,
- A 20% increase in the natural gas in coal footprint.

Tourism

Tourism remains a growth industry. The World Tourism Organization reported in January 2003 that the number of international tourist arrivals around the world topped 700 million for the first time. The result was an overall increase of 3.1%. While the increase is less than the 4% norm, it is a strong indication that tourism has remained a global force despite recent terrorist attacks. North America registered a 2.4% growth rate. The levels of 4% growth per year can be expected to return in the future. In Alberta, this recovery will be aided through increased marketing and an increased focus on travelers who arrive by car. Southern Alberta is a key destination for this market.

As part of the SAL data collection, an inventory of existing (2003) campgrounds, golf courses, and ski hills was done, and area of footprints estimated. The results of the inventory are:

- Total footprint: 130 km^2 (0.1% of the SAL region),
- 174 campgrounds: 48 km^2 (avg. = 0.28 km^2),
- 90 golf courses: 44 km^2 (avg.9-hole = 0.32 km^2, 18-hole = 0.65 km^2),
- 12 ski hills: 40 km^2 (avg. = 3.33 km^2).

Backcountry trails, random camping areas and hunting camps were not modeled because of their relatively small footprint at a regional scale. The economic impact of tourist activity days was modeled using the SAL Input Output (IO) model.

The recreational facilities total footprint is projected to grow in the Base Case Scenario at a rate of 2% per annum, based on Alberta Economic Development estimates. Growing the facilities at 2% a year is roughly equal to adding about four campgrounds and one golf course a year at the start of the 50-year modelling period, but then increases to about one ski hill, four campgrounds and four 18-hole golf courses a year by the end of the 5th decade.

Assumptions for the growth of tourism:

- o Travel within Alberta and around the world will return to a 4% increase per annum.
- o Increased levels of marketing both within the province and to external markets will attract a growing clientele.
- o The growing Alberta population will dramatically increase the demand for tourism opportunities. This will be especially true for the Calgary area. As the population of the province increases, so will the number of Albertans traveling within Alberta.

In the What-if Scenario, recreational facilities total footprint is projected to grow at the rate of 2.4% per year instead of 2%. This growth would be equivalent to adding about eight 18-hole golf courses or about 5 ski hills a year.

Forests and Forestry

Approximately 16% of the SAL region is classified as forest, including the closed coniferous forests of the foothills, mountains and Cypress Hills, and the hardwood forests that grow in the Parkland Natural Region and in moister locations on the plains. The diverse forest cover of the region was classified into six cover types and the total area of each type calculated for modelling at the regional scale (Figure 4.5).

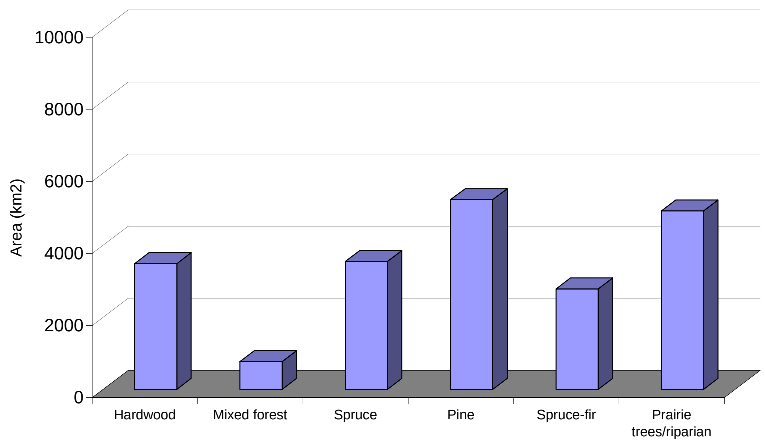


Figure 4.5. ALCES**®-for-SAL Forest Cover Categories** (Note change in scale from Fig 4.2)

In ALCES®-for-SAL, about 37% of the total forest area is classified as “active” forestland, meaning that it can be harvested in a modelling scenario. The remainder is either: 1) prairie trees/riparian representing freehold land that is located in the lower foothills and plains portions of the study area, or 2) located within national and provincial parks, land zoned as Prime Protection (Eastern Slopes Policy) or is withdrawn from the active land base because of proximity to waterbodies, steep slopes and other constraints. Consequently, varying proportions of SAL forest cover types are classified as protected or passive forestland (Figure 4.6). This information is used for calculating fragmentation indices, which are included later in this report.

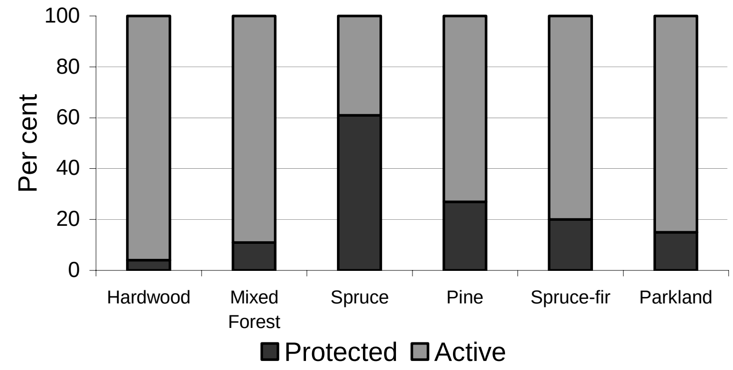


Figure 4.6. Proportion of each SAL Forest Cover Type that Cannot be Harvested

The six cover types were classified as follows:

- **White spruce:** pure conifer types (80% or greater) that have white spruce, Engelmann spruce, black spruce or balsam fir as the leading species,
- **Pine:** pure conifer stands with lodgepole pine as the leading species,
- **Spruce/Fir:** conifer stands with 20% or more Douglas fir, other spruce-fir types that are representative of higher elevation, non-pine dominant, and pure conifer types,
- **Hardwood:** aspen, balsam poplar, birch, predominately deciduous stands (80% or greater),
- **Mixed forest:** predominately coniferous mixed forest stands or predominately deciduous mixed forest stands (no species greater then 80%),

- **Prairie trees & riparian:** riparian cottonwood complexes, wooded escarpments & depressions, wetlands.

Long run sustained yield in SAL for softwood is 550,000 m^3, and hardwood is 38,000 m^3. These volumes are the target harvest volumes in all modelling scenarios. The SAL Base Case Scenario includes the following assumptions:

- The oldest age class within each cover type is harvested first, providing age and volume criteria are met,
- If a forest fire occurs, about 25% of burned area is salvaged and of this, 50% of the original volume is maintained,
- Growth trajectories remain the same over the modelling period and are based on provincial government data,
- Inblock roads have a user-defined lifespan (20 years) and occupy 4% of cutover area,
- Insect outbreaks affect only the pine type (1.5% a year by area),
- Size distribution of cutovers is held constant,
- Harvest levels are not recalculated after wildfire,
- Invasive species spread rates set by cover type (Table 4-5).

Table 4-5. Rate of Spread of Invasive Species into Forest Cover Types

Native Landscape Type	Spread Rate (meters/yr)
Hardwood	0.15
Mixedwood	0.14
Whitespruce	0.06
Pine	0.06
Spruce/Fir	0.22
Prairie Treed & Riparian	0.76

The forestry sector in SAL is projected to exhibit zero growth, even though value-added production has been adding to GDP growth in the region. This is because the forest resource is fully allocated, and consequently there would be no increase in the annual area harvested or footprint associated with harvesting.

Currently there is no What-if Scenario specific to the forest industry being modeled in SAL, however the cumulative effects of other What-if Scenarios on forest cover are analyzed in this report.

Roads and Utility Corridors

Roads and utility corridor features in ALCES®-for-SAL includes highways (major roads), minor roads & trails, forestry inblock roads, railways, canals and transmission lines. ALCES® contains the total length (km) and area (ha) of each category in the study area, and grows them at user-defined rates, displacing native or cropland cover types as specified by the user. Some of the categories, such as forestry inblock roads, can be reclaimed to a user-defined cover type.

The minor roads and trails category contains four subcategories of roads: the municipal road grid, well site roads, agricultural residence roads, and acreage roads. The growth of minor roads and trails is set at a base default value to reflect expected growth in the municipal road grid. Growth of well site roads and residential driveways are set independently. The energy and settlement chapters in this report contain more information about these types of roads. Pipelines and seismic lines are dealt with exclusively in the energy chapter.

Forestry inblock roads are treated and reported separately from the other road categories. A percentage of each cutblock is assumed to be occupied by forestry roads, so the area of inblock roads vary in area as a proportion of area harvested. They have a lifespan that is defined by the user.

Average widths and lifespans for roads and utility corridors for the Base Case Scenario were determined from GIS analysis and consultation with experts (Table 4-6). Roads and trails, with the exception of forestry inblock roads and well site roads, are considered to be permanent footprints on the landscape.

Table 4-6 Road and Utility Corridor Dimensions

Category	Width (10m)	Life span (yrs)
Highways	10	Permanent
Minor roads & trails	10	Permanent (default)
Well site roads	10	30
Transmission lines	20	Permanent
Acreage roads	10 (90 length)	Permanent
Railways	15	Permanent
Canals	47 main 20 lateral	Projected overall decline due to conversion to pipe
Inblock roads	4% of cutover	20

A projected growth rate for highways was obtained from Alberta Transportation, whereas the growth rate of forestry in-block roads was a function of the average area harvested per year (Alberta Sustainable Resource Development). Similarly, the growth rate of acreage roads was a function of the projected growth in acreages, and the growth of well site roads was related to the energy development curve (Table 4-7). Projected growth rates for the municipal road grid were estimated by interviewing several municipal public works managers within the SAL region. Most of the minor roads and trails footprint is projected to expand according to its current distribution on the landscape: 33% cereal cropland, 18% tame grass, 8% forage and 8% dry mixed grass.

Table 4-7 Base Case Projections – Roads and Utility Corridors

Category	Growth Rate
Highways (major roads)	40 km/year declining to 0 km/yr at Year 50.
Minor roads & trails	150 km/yr declining to 50 km/yr at Year 50 (Base default).
Acreage & wellsite roads	tied to sector development.
Transmission lines	210 km/yr, increasing to 300 km/yr at Year 10, declining to 0 km/yr at Year 50.
Railways	0 growth.
Canals	0 growth.
Inblock roads	4% of cutover area.

What-if Scenarios for energy and acreage growth change the growth rate for minor roads and trails compared to the Base Case. No change in growth rate for the municipal road grid from the Base Case is being modeled.

Roads and utility corridors are projected to show small to moderate growth over the next 50 years. Southern Alberta's highway and municipal road system have been developed extensively and consequently, only a few kilometers of new road are expected to be built per year. Some growth in transmission lines is projected as new sources of energy are developed and additional transmission capacity is added. Most of the growth in the roads and utility corridor category is associated with development of natural gas well site access roads and rural residential driveways.

General Industry and Electrical

The general industry and electrical category contains all footprints not included with the forestry, energy, transportation and agricultural categories, and includes landfills, electrical generation plants, water treatment plants, compressor stations and processing plants. Only those developments that are located outside urban areas are included within this category; otherwise they are considered part of the urban area footprint.

The general and electrical industry footprint is projected to grow in the Base Case Scenario at the annual rate of 55 ha/year at Year 1, and gradually increase to 145 ha/yr by Year 50. Most of the growth is projected to occur on cereals (27%), forage (16%) and tame grass (14%) because most of the growth is expected to occur near cities and in the main transportation corridors of southern Alberta.

Rangelands

Much of the native grassland in southern Alberta was converted to cropland during European settlement of the West in the early 1900s. However, native grasslands still occupy about 25% of the SAL study area. Although hundreds of plant community categories have been identified in the study area, Natural Regions and existing inventories were used for defining six cover types for modelling at a regional scale (Figure 4.7). Three of the cover types belong to the Dry Mixedgrass Natural Region (dmg), and represent plant communities found on loamy soils (needle & thread), sands (needle & thread – sand grass) and blowout (northern wheat grass).

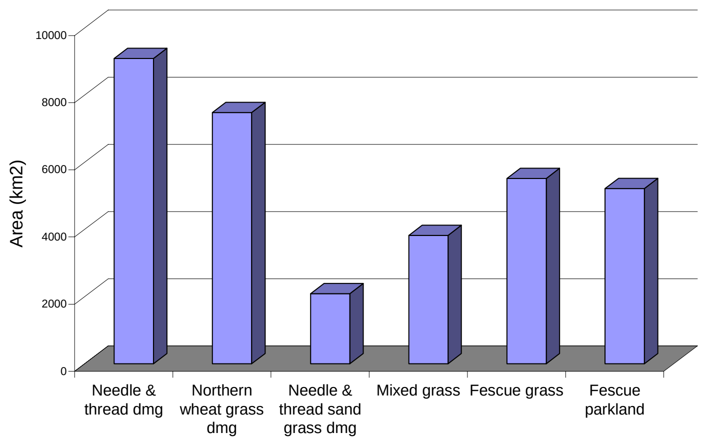


Figure 4.7. SAL Rangeland Cover Types

Rangeland plant communities are projected to decrease in area and increase in fragmentation index over the next 50 years as cropland and anthropogenic footprints grow. Area occupied by invasive species also is expected to increase. Average plant community structure, modeled in ALCES®-for-SAL using an index, is projected to respond to inter-annual variation in rainfall and natural disturbance (wildfire) around long-term means. However, climate change scenarios would cause shifts in the index. Current cattle stocking rates on native rangelands (Base Case) are assumed to maintain the rangeland index at an optimum level (maximum species and structural diversity), assuming average annual rainfall and natural disturbance.

Invasive species are projected to spread in native rangelands at various rates (Table 4-8). The rates were defined at a workshop attended by individuals with expertise in non-native plant species invasion into native vegetation. A separate report describes the results of the workshop [19].

Table 4-8 Invasive Species Rates of Invasion

Land Cover Type	Rates of Invasion (m/yr)
Badlands	0.06
Needle and Thread (DMG)	0.16
Northern wheat (DMG)	0.10
Needle and Thread Sand Grass (DMG)	0.16
Mixed Grass	0.32
Fescue Grassland	0.41
Fescue Parkland & rocky mountain	0.45
Grassland Shrubs	0.21

[19] *Invasion of Non-Native Plant Species Report of Workshop Results*. 2003. Unpubl. Report Prepared by C. Bradley for Alberta Environment.

Wildlife and Fish

The purpose of the SAL wildlife model is to highlight some of the potential changes to wildlife and fish that may be caused by increased human activity and a larger human footprint in the SAL study area. The approach uses "flagship" species and species groups. More than 40 biologists from various governments, universities, and consulting organizations participated in selecting the species and species groups and in developing the models.

Abundance indexes were modeled for each species and species group. The experts involved in developing the models advised that the indexes were most appropriate for reflecting changes on a scale of two-fold or greater. Experts considered the models too general to highlight smaller changes with any level of confidence.

Species and species groups were selected according to the following criteria:

- Are found in all natural regions within SAL,
- Represent a diversity of taxonomic groups,
- Are easily recognized by the general public,
- Are known to have diverse resource needs,
- Are found in habitat types that are expected to be greatly affected by human development,
- A diversity of spatial and temporal scales should be represented,
- Habitat needs must be understood, and
- Could be modeled well in ALCES®.

Modelling Steps – Species (Expert Driven/Delphi Process):

1) <u>Model Habitat Availability</u>
   a) Identify landscape types and footprint types used as wildlife habitat for each wildlife species being modeled.
   b) Estimate the proportion of each landscape type and footprint type that is used as habitat for each wildlife species being modeled, or in other words, what is the probability of each given species occurring in each landscape type and footprint type?
   c) Reduce the level of use as habitat if there is evidence that a portion is unusable because of climate, geography or incompatible land use.

2) <u>Model Habitat Quality and Effectiveness</u>
   a) Identify landscape elements important to habitat quality (e.g., % cultivation, grassland structure, % energy footprint).
   b) Wildlife experts thought that about three or four types of human activities would have the most effect on the habitat qualities for each species. Consequently, they developed discounting factors that were applied to each habitat (Table 4-9). Habitat ratings in the table were multiplied by these discounting factors to arrive at an adjusted rating of the habitat for each species.

Table 4-9. Wildlife Habitat Discount Factors

Species	Discount Factors
Ferruginous hawk	Cultivation, rangeland structure, energy
Sharp-tailed grouse	Cultivation, rangeland structure, road density, human density
Prairie rattlesnake	Cultivation, road density, human density

Modelling Steps – Grizzly Bear (Data Driven):

Three data driven models were developed for grizzly bears in the SAL study area: 1) a "habitat selection" model based on the comparison of radio-telemetry data of known grizzly bear "use" locations versus random points, 2) a "mortality risk" model based on known mortality locations in relation to random points, and 3) an "exposure risk" model based on the co-occurrence of habitat use (radio-telemetry locations) and mortality locations for grizzly bears. Each model uses a habitat coefficient or resource selection function that is determined for each habitat type from the telemetry data.

Modelling Steps – Species Groups:

1. The number of species for each species group that are believed to be associated with each landscape type and footprint type are identified.
2. For each species, each of the habitats in SAL are rated from no value to very high value.
3. The variables that will be used to discount habitat quality are identified.
4. Habitat ratings are multiplied by the discounting factor to arrive at an adjusted rating for each habitat.
5. Adjusted ratings were then multiplied by the area of the habitat within the SAL study area, and summed across all habitats for the species.
6. The ratings were then summed across all grassland specialists to obtain an index for the total group.
7. The abundance indices were standardized so that they had a value of 1.0 at the beginning of the modelling period.

Both terrestrial species groups use the following discounting factors;

- Proportion of SAL that is cultivated,
- Increases in population density,
- Increases in road density,
- Average grassland structure.

For each discounting factor, the proportion of the total group that has a positive, negative, neutral or unimodal response is calculated.

The classic prairie fish group uses the following discounting factors;

- % of river water volume remaining,
- Sediment load in rivers,
- Total road density.

Modelling Steps – Coarse filter analysis:

Coarse filter analysis was used to evaluate changes in wildlife habitat. A wide variety of coarse filter metrics was available, but only a few of these were identified as most important for SAL. ALCES® was used to model how the amount and/or quality of these key coarse filter metrics changed between pre-European settlement (approximately 1700) and the present (2000). During this period agriculture, forestry, energy, transportation, and tourism converted some of the native cover types into “anthropogenic” cover types. In addition, human activities associated with population growth and resource use affected the quality of the remaining native habitats.

Water Quantity

More than one million people live in southern Alberta and rely on water from the South Saskatchewan River Basin (SSRB) for irrigation, industrial and domestic use. The basin also supports important recreational and tourism opportunities, and diverse aquatic and riparian environments that provide habitat for many species of plants and animals. Most of the water (80%) originates in the Rocky Mountains. Increasing population and industrial use in the region are placing increased demands on the water resource, which is almost fully allocated for human use and is in insufficient supply in drier years.

ALCES®-for-SAL simulates over 50-year periods annual regional basin flow, storage, domestic and industrial water demand, natural losses, and then calculates net human consumption, net flow and other variables. Natural historical variation in flow is incorporated into the simulations.

A volume parameter that represents total estimated annual natural flow for the region is placed into a lotic (moving water) stock for each year of a simulation. This volume is calculated using the mean and standard deviation from recorded flows over a 68-year period. The total estimated natural flow varies considerably because of inter-annual variation in precipitation and also because of glacial recession, and this variation is used in projecting regional annual flows over a 50-year period.

Total estimated natural flow for the Base Case Scenario is 9.46 x 10^6 dam^3 at Year 1. This includes an estimated 18.3 x 10^6 m^3 from glacial melting, which is expected to decline over time. Regional reservoir capacity is 1.5 x 10^6 dam^3 or about 16% of annual flow. The remaining total water is held within the river and canals. Five percent of the water held within reservoirs or canals per year is lost due to evaporation or leakage.

Water demand volumes for individual sectors were used for calculating total water demand, evaporative losses and return flow volumes (Table 4-10). Average regional crop irrigation requirements

Table 4-10. River Water Demand by Use

Category	Volume (m^3\yr)
Cereals	2,650 per ha
Oilseeds & pulses	2,900 per ha
Specialty	3,350 per ha
Forage	4,500 per ha
Tame Grass	2,900 per ha
Recreational Facilities	5,000 per ha
Industrial/commercial	209,000 in Year 1 increasing to 320,000 in Year 50
Conventional oil	1.0 per m^3 oil produced
Domestic	205 per person
Cattle	25 per animal
Swine	6 per animal
Horses	25 per animal

and irrigation return flows were compiled using provincial government data[20]. Alberta Agriculture, Food & Rural Development (AAFRD) provided forecasts for changes in irrigated acreages by crop type, and the percent of each type that gets irrigated. Crop irrigation water requirements are based on weighted regional averages.

Non-irrigation water demands, including municipal, domestic, industrial and livestock sectors were compiled using existing data, expert opinion on population and economic development, interviews with public sector officials, and questionnaires sent out to 128 jurisdictions in the study area.[21].

[20] ALCES® *Water Component Input Parameters and an Examination of the* ALCES® *Hydrological Engine.* 2003. Prepared by AMEC Earth & Environmental Ltd. for Alberta Environment.
[21] *South Saskatchewan River Basin Non-Irrigation Water Use Forecasts*. March 2001. Prepared by Hydroconsult Ltd. for Alberta Environment.

With the exception of industrial/commercial water demand, which is modeled independently from the total area of the footprint, both irrigation rates (m^3/ha) and non-irrigation use parameters were assumed to remain constant during all scenarios. Irrigation efficiencies are also assumed to remain constant. Consequently, the only parameter that causes a change in total non-irrigation water demand in ALCES®-for-SAL is footprint area. Three parameters in ALCES®-for-SAL can change irrigation water demand: total annual rainfall, crop type area and percent of crop type irrigated.

Regional water irrigation demand volume is simulated using average crop irrigation water requirements, the modeled annual to mean rainfall ratio, and expected losses due to inefficiencies. The total area of crop land under irrigation is projected to increase at the rate of 0.5% per year over the next 20 years and then 0.2% per year over the subsequent 20 years. Open channel canals are projected to diminish in length at a rate of 0.25% per year.

Irrigation accounts for most of the water use in the study area. Irrigated area varies considerably by crop type (Table 4-11).

Table 4-11. Irrigated Areas by Crop Type

Crop Type	Total Area (km^2)	Total Area Irrigated (km^2)	% of Crop Type Irrigated	% of Total Irrigated Area
Cereal	30,700	2,118	6.9	17.0
Oilseeds & Pulses	5,681	301	5.3	2.4
Specialty	540	497	92.0	4.0
Forage	6,169	2,591	42.0	20.8
Tame Pasture	21,727	6,953	3.2	55.8
TOTAL	**64,817**	**12,460**		

Water Quality

Surface runoff is associated with the movement of nitrogen, phosphorus and sediment into streams. Literature-based export coefficients are used for simulating total stream loading in SAL. Export coefficients are considered to be a scientifically defensible way of inferring relative changes in water quality from changes in land use patterns and activities. On the other hand, the modelling of export coefficients would not assess the actual impacts of any land use scenario on water quality, because water quality would depend on factors such as the timing of runoff in relation to the volume of water in streams.

ALCES® simulates the total area of individual landscape and footprint types for each year of a simulation. Using these data and a separate runoff coefficient for each cover and footprint type, ALCES® calculates the total amount of sediment, nitrogen and phosphorus that runs off in the region in kg/ha/yr. The model then uses the net volume of water in the river basin to derive a relative water quality index. As the total areas of landscape type or footprint change, so does the relative index for each component.

Run-off coefficients for nitrogen, phosphorus, and sediment for various landscape and footprint types were adapted from a review of published and unpublished literature, mainly from the United States because of the lack of information on the Canadian prairies[22] (Appendix 2). Alberta government water quality specialists reviewed the data and determined which values to use. Data from Alberta studies were used where possible.

The percent of each landcover type experiencing a given runoff coefficient is held constant. Each landscape or footprint type contributes the same average runoff to the river.

[22] *AENV. Export Coefficients for Total Phosphorus, Total Nitrogen and Total Suspended Solids in the Southern Alberta Region: A Review of Literature* (Unpubl.)

Natural Disturbance

Disturbance by fire and insects is a natural process that has a major role in shaping the age and structure of plant communities. In southern Alberta, both forests and prairie landscapes are regularly subjected to these disturbances. The purpose of modelling fire and insect outbreaks in SAL is to simulate the area of forest, native grassland and crops that are disturbed by fire and insects each year, and to model the impact of the disturbances on other elements such as timber supply, rangeland structure, crop production, and wildlife habitat.

ALCES® can burn the landscape at a constant rate (the same proportion of a landscape type burns each year) or randomly (the proportion of a landscape type that burns in any one year is determined by a random "draw" from an exponential or lognormal distribution whose mean is estimated from historical data). In both the constant and random fire alternatives, the average burn rate for each cover type can be set individually.

Insect outbreaks occur both in pine forest and agricultural crops, resulting in user-defined average annual losses to production within each cover type.

All projections for natural disturbance are the same for both the Base Case and the What-if Scenarios. Average annual area burned for each cover type was calculated from provincial forestry data (Table 4-12)(Stelfox unpubl.).

Table 4-12. Average Forest Area Burned

Forest Cover Type	Area Burned / Year (%)
Hardwood forest	1.4
Mixed forest	1.3
White spruce forest	1.0
Riparian forest	1.0
Pine forest	1.4
Spruce fir forest	1.4
Prairie community types	0.5

Insect mortality rate for pine forest is 1.4% per year (due to bark beetles). Mortality rate for other forest cover types and native prairie communities is zero.

Mortality rate for crops is 6% by area due to insects; and production for affected areas is halved.

The What-if Scenario

In the What-if Scenario, the population and economy are allowed to expand at a much more aggressive rate. Population is grown using a high rate projection (Alberta Finance-Statistics, 2004), resulting in a SAL population of about 3.5 million at Year 50. Urban settlement expands at a rate similar to large urban centres in the Midwest USA, i.e. almost tripling in size over 50 years; and acreage growth rate that is double the Base Case Scenario. Tourism facility area is allowed to increase by 20% over the Base Case. Production of conventional natural gas, natural gas in coal, and tourism are increased by about 20% over the Base Case Scenario. Agriculture and forestry production are held the same as in the Base Case because there is no information to suggest that land bases and technology will increase significantly beyond what is assumed in the Base Case Scenario.

5. Results: Economic Outputs

In the Base Case Scenario, the SAL regional economy shows a small decline in overall output over the next 25 years as conventional oil and natural gas production decrease, and then recovers as natural gas in coal production and increase in the tourism sector cause an overall increase in economic performance by 2050 (Figure 5.1). Also, regional demand for petroleum almost overtakes regional output (Figure 5.2) in the Base Case Scenario. Although regional sales are projected to show a 6% increase reflecting increased economic activity in the region, GDP is projected to stay flat, suggesting no net growth in the economy of the region.

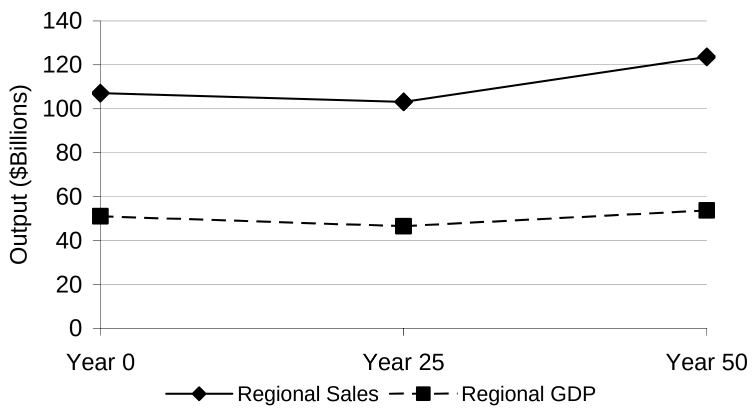


Figure 5.1. SAL Regional Output, Base Case Scenario

The lines in the graphs are straight along 25-year intervals because only three reference years were computed in the IO model: years 1, 25 and 50.

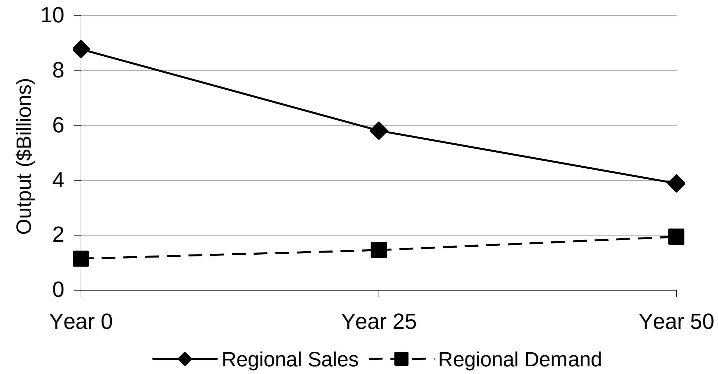


Figure 5.2. SAL Petroleum Output, Base Case Scenario

In the What-if Scenario, a slower decline in both conventional natural gas and natural gas in coal prevent the decline in regional output as seen in the Base Case (Figure 5.3). Both sales and GDP are about 10% higher at year 50 than in the Base Case Scenario.

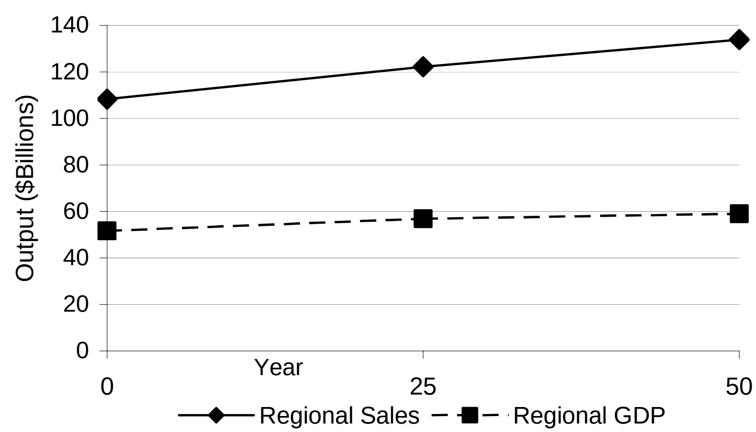


Figure 5.3. SAL Regional Output, What-if Scenario

In the What-if Scenario, regional petroleum output remains much larger than regional demand (Figure 5.4).

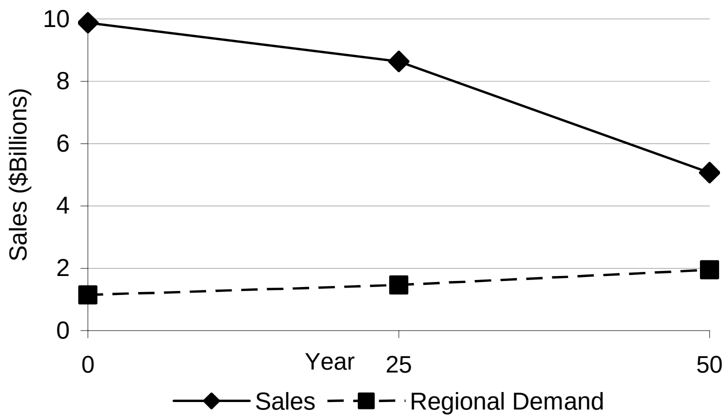


Figure 5.4. SAL Petroleum Output, What-if Scenario

6. Results: Impacts on Landscape Features - Overview

This chapter contains a general description of how landscape features in southern Alberta are projected to change under the Base Case and What-if Scenarios. The remaining chapters in this report contain a more detailed analysis of the impacts associated with individual sectors in the study area.

Interpreting the Figures

All figures in the results sections contain three bars:

- Red bar: is year 2000,
- Blue bar: is the 50 year projection in the Base Case Scenario,
- Pale yellow bar: is the 50-year projection in the What-if Scenario.

Projections & Key Assumptions

The landscape of southern Alberta is projected to undergo several changes over the next 50 years as the population and economy grow. First, there is likely to be a shift in land cover as parcels of native vegetation are ploughed and converted to crops. Second, agricultural land and some native land cover is expected to be lost with ongoing settlement and energy development. Third, parts of the landscape are likely to become more fragmented as more transmission lines, roads, well sites, pipelines and other infrastructure are built. Fourth, invasive species are projected to become more widespread as the landscape becomes more developed and fragmented. As a result of changes to the landscape, the abundance of wildlife is likely to be reduced. Finally, if current trends continue, there will be less net flow in the basin and water quality may be reduced.

The main drivers of landscape change in southern Alberta are projected to be urban growth and energy. This will occur mostly at the expense of cropland and dry mixed grass cover types. Agricultural land also is expected to expand mostly at the expense of dry mixed grass. Key assumptions behind economic growth and development in southern Alberta are explained in respective sections of this report.

Native and Agricultural Land Covers

Over the next 50 years, a relatively small overall loss (4%) of native landscape is projected in the region as cropland expands and the development footprint grows (Figure 6.1). Overall, cropland area is expected to remain static, however, because losses to urban growth and energy development offset projected agricultural expansion into native grasslands.

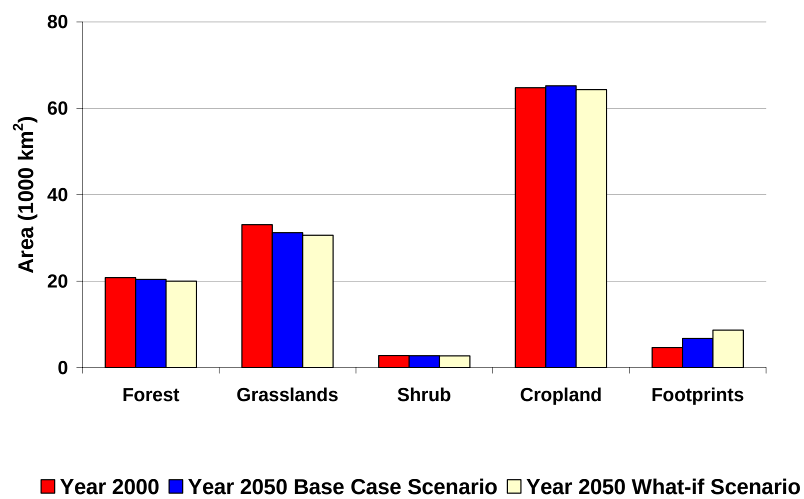


Figure 6.1. SAL Landscape Composition

In the Base Case Scenario, grasslands will decrease in area by 6%, and forests by 2%. In the What-if Scenario grasslands will decrease by 8e, and forests by 5%.

Development Footprint

The development footprint is projected to grow in the Base Case by about 60% over 50 years (Figure 6.1). The What-if Scenario shows a moderate increase in the footprint. Although all footprints will increase, settlement, minor roads & trails, and energy footprints are projected to grow and contribute the most to the overall footprint (Figure 6.2). Some cover types are projected to be consumed relatively more than others under both scenarios (Figure 6.3).

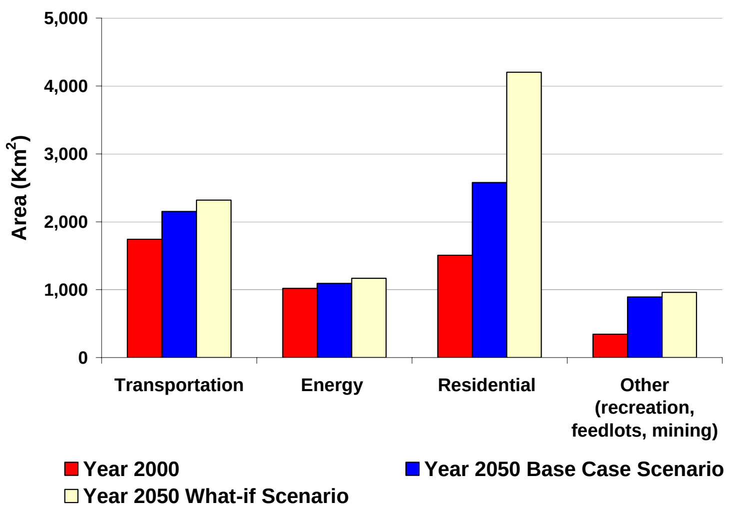


Figure 6.2. SAL Development Footprint

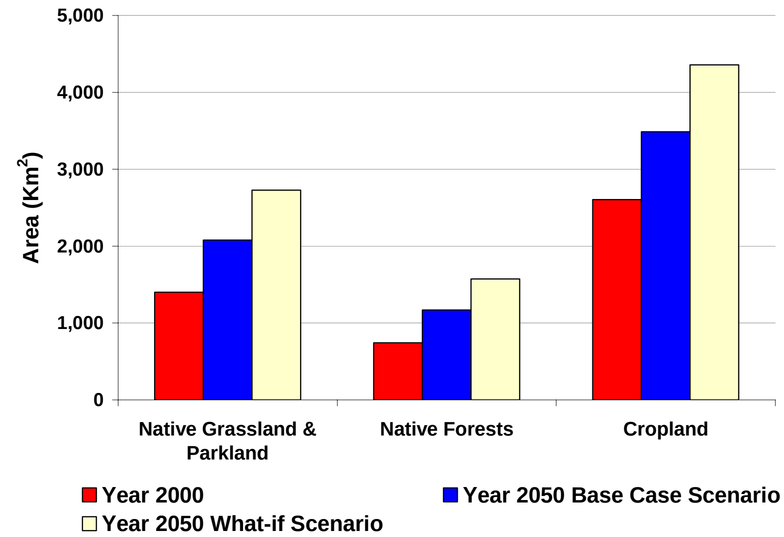


Figure 6.3. Area of Cover Group Consumed by Footprint

Fragmentation

Regional fragmentation, that is the combined linear density of all development footprints within the entire study area, is projected to increase about 50% in the Base Case Scenario (Figure 6.4). In this Scenario, small increases in fragmentation are projected to occur in forestlands, and increases of 50% or more in grasslands and croplands. Small additional increases in fragmentation are expected to occur across cover types in the What-if Scenario.

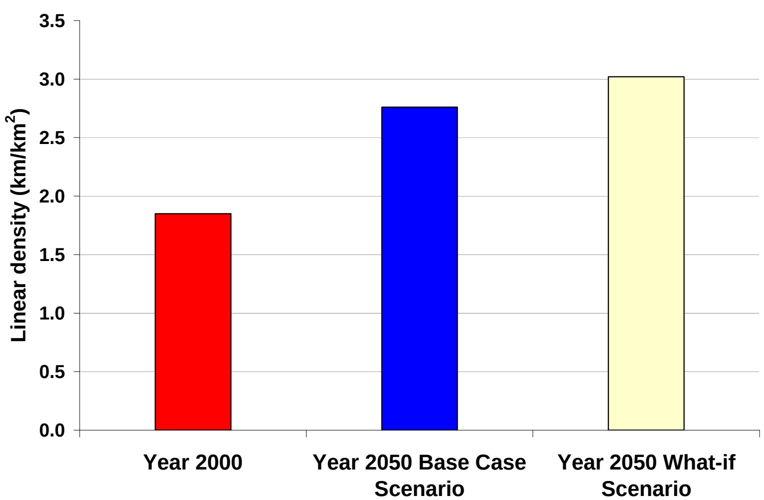


Figure 6.4. Regional Fragmentation

Fragmentation of forest types is larger in the Base Case Scenario when protected area land is excluded from the analysis (Figure 6.5). For example, fragmentation of spruce is 3 km/km^2 instead of 1.3 km/km^2, pine is 2.3 km/km^2 instead of 1.8 km/km^2, and spruce-fir is 2.5 km/km^2 instead of 2 km/km^2.

Fragmentation can have various effects on the landscape. Habitat fragmentation occurs when wildlife habitat is divided and/or when movement corridors are blocked. Roads, power lines and settlement may disrupt natural scenery. Roads and other corridors may act as conduits for invasive species and unwanted vehicular access.

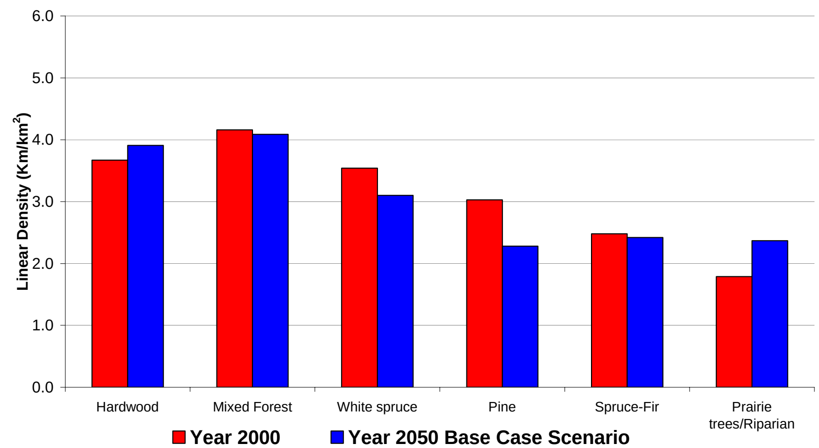


Figure 6.5. Fragmentation of Forest Cover Types, Excluding Protected Areas

Later chapters in this report contain more results on fragmentation.

Invasive Species

There are small increases projected in the distribution of invasive species in both the Base Case and What-if Scenarios (Figure 6.6).

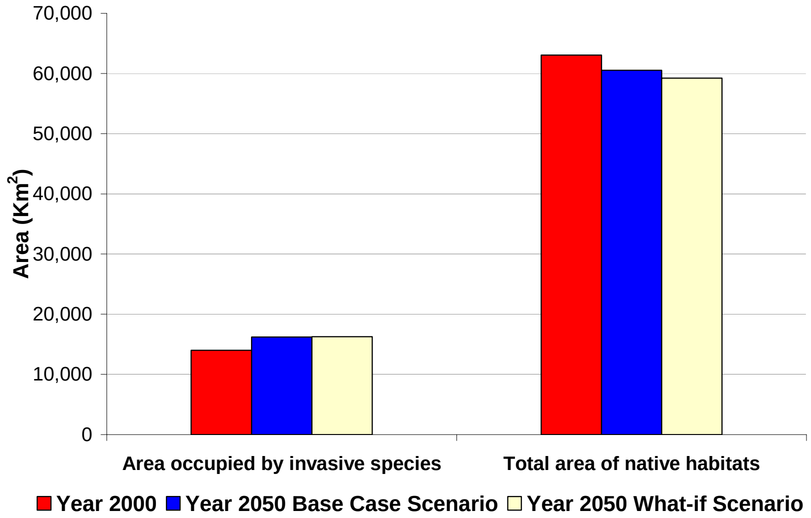


Figure 6.6. Area of Native Land Occupied by Invasive Species

Fish & Wildlife Habitat

There are moderate decreases projected in the effectiveness of wildlife habitat in both the Base Case and What-if scenarios (Figure 6.7). The largest declines are in the area of effective habitat for sharp-tailed grouse (37% Base Case, 47% What-if) and rattlesnake (60% Base Case, 81% What-if). Effective habitat for ferruginous hawk decreases by 15% for the Base Case and somewhat less in the What-if scenario. The wildlife chapter in this report contains more results of the cumulative effects of population growth and development on wildlife habitat.

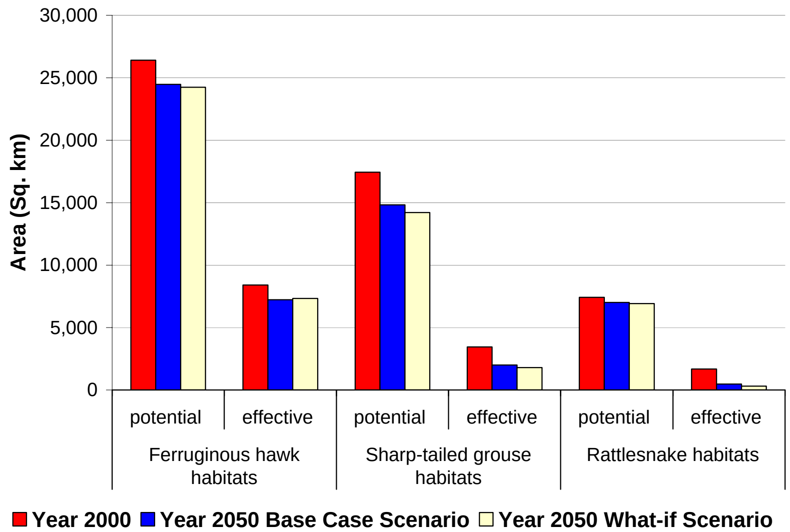


Figure 6.7. Wildlife Habitat Area of 3 SAL Flagship Species

7. Results: Effects by Sector

Settlement

Settlement growth is projected to outstrip all other footprint categories in the Base Case Scenario over the next 50 years (Figure 7.1). Settlement growth will spur additional minor roads and trails footprint because new access will be built along with acreages. Changing acreage growth from 1.7% to 3.4% in the What-if Scenario resulted in a large increase in the rural residential footprint.

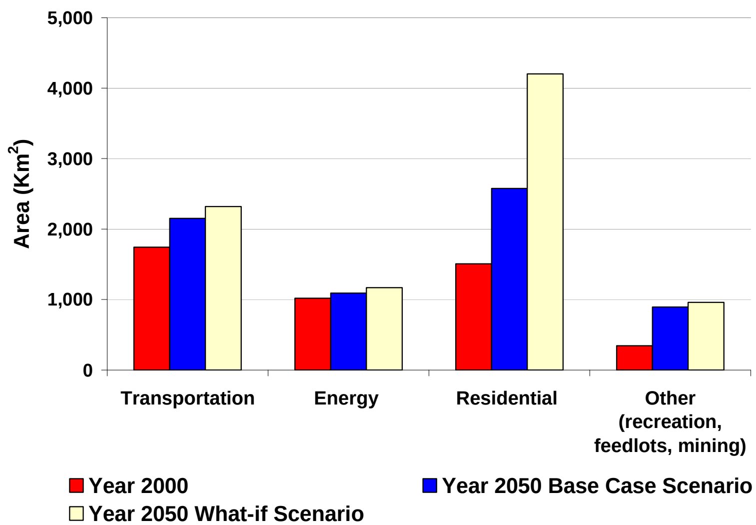


Figure 7.1. Projected SAL Development Footprint[23]

Much of the growth of the urban footprint in the Base Case Scenario is projected to occur on croplands (Figure 7.2). Cereal and tame

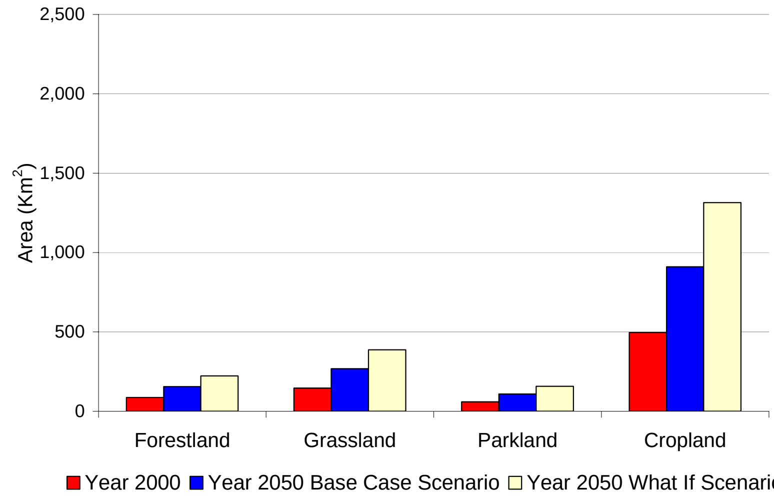


Figure 7.2. Projected Urban Footprint by Landscape Group

grass cover types are projected to absorb about 60% of this growth. The What-if Scenario has a small effect on croplands.

In contrast, relatively smaller areas of native cover types are projected to be lost to settlement. For example, urban growth is projected to consume about 80 km^2 of fescue parkland in the Base Case Scenario over the next 50 years, the most of any native cover type. This reflects the projected growth of the City of Calgary into areas where fescue parkland is found.

The impact of urban area growth on forestland is projected to be relatively small. More hardwood will be consumed than other categories. This is because urban growth is expected to grow into the aspen parkland more than into closed forest categories.

Most of the growth in the rural residential footprint is projected to occur in grassland and cropland (Figure 7.3). This reflects the current trend in the rapid growth of acreages into fescue parkland near Calgary.

[23] The assorted category includes mining, recreational, feedlots & industrial plants, and a minor amount of landfills and water treatment plants.

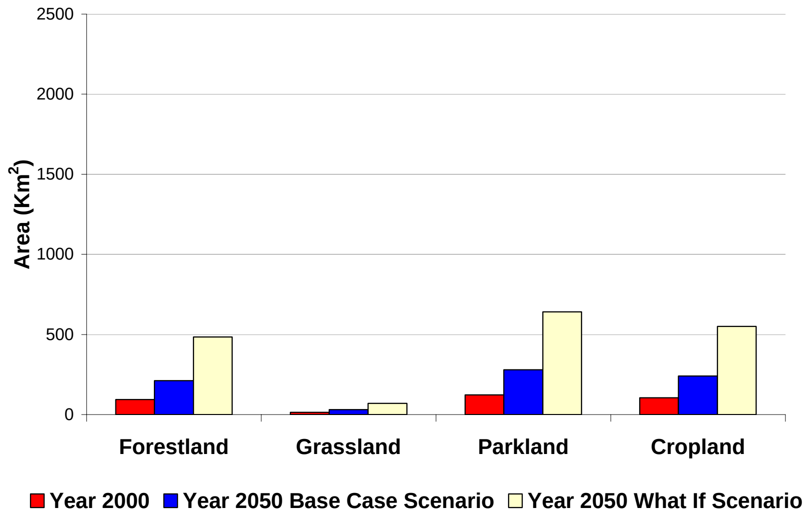


Figure 7.3. Projected Rural Residential Footprint by Landscape Group

Agriculture

Changes in cropland areas reflect the shift to higher-value crops in the Base Case Scenario (Figure 7.4). Overall, about 1,320 km^2 of native vegetation is projected to be transformed to cropland over the next 50 years, however a net increase of only 434 km^2 of cropland is projected because of losses to growing urban areas.

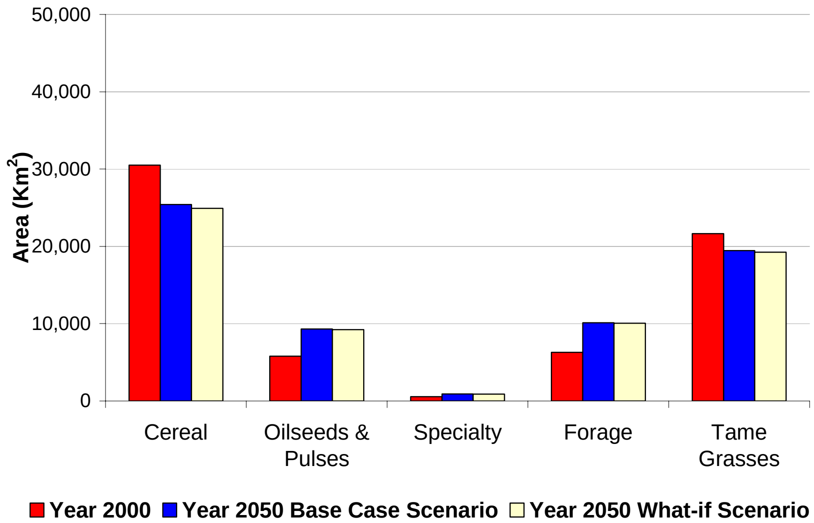


Figure 7.4. Projected Cropland Area

Crop production in the Base Case Scenario shifts in proportion to this projection (Figure 7.5). Loss of cropland to urban development and a drought in the What-if Scenario reduce production.

There is a medium increase projected in the development footprint and fragmentation on croplands, especially on cereals (Figure 7.6, Figure 7.7). This is caused mostly by an increase in urban area and minor roads and trails (see Settlement Chapter).

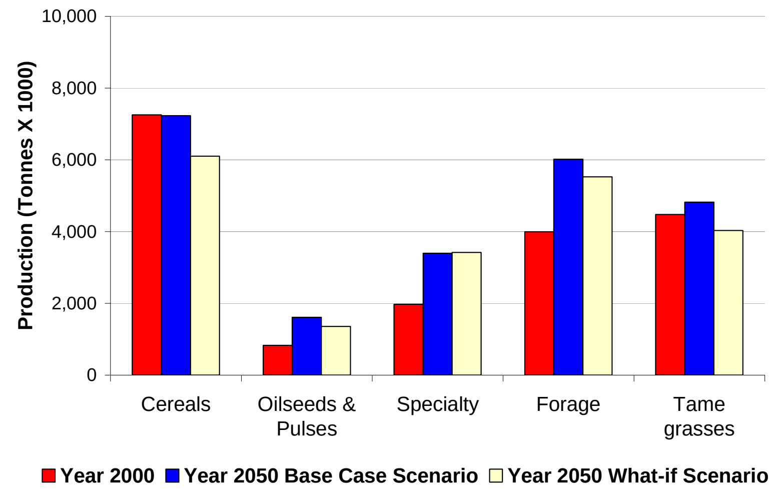


Figure 7.5. Projected Crop Production

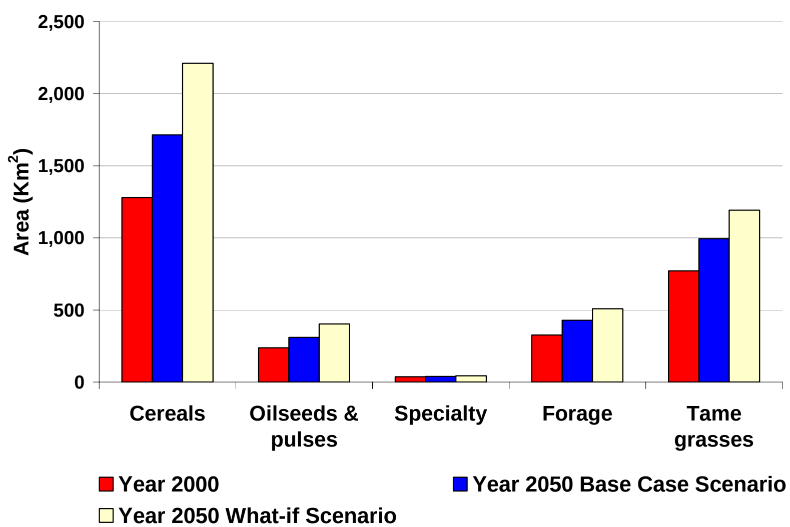


Figure 7.6. Projected Footprint on Cropland (Note change in scale from Figure 7.4).

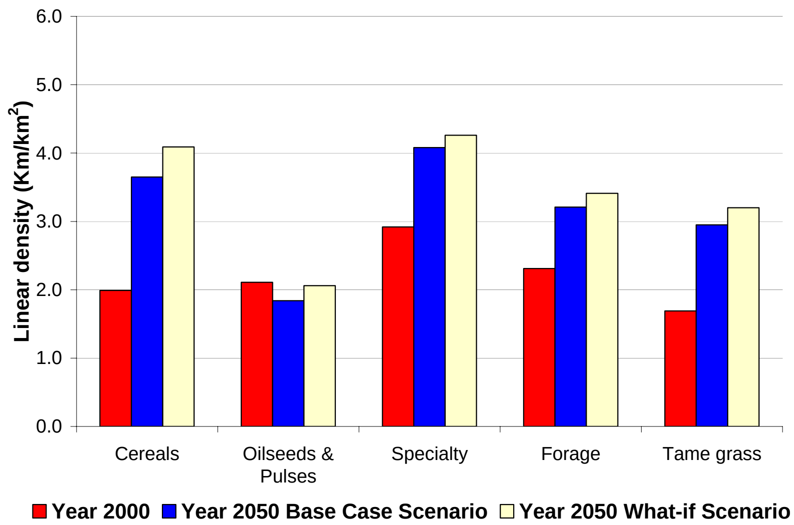


Figure 7.7. Projected Fragmentation of Cropland

A small increase in irrigation water demand is projected in the Base Case Scenario; however a larger increase is projected in the What-if Scenario (Figure 7.8). A drought introduced in the What-if Scenario causes the increase

The Water Quantity chapter of this report contains more information about the cumulative effects of economic growth on water quantity in SAL.

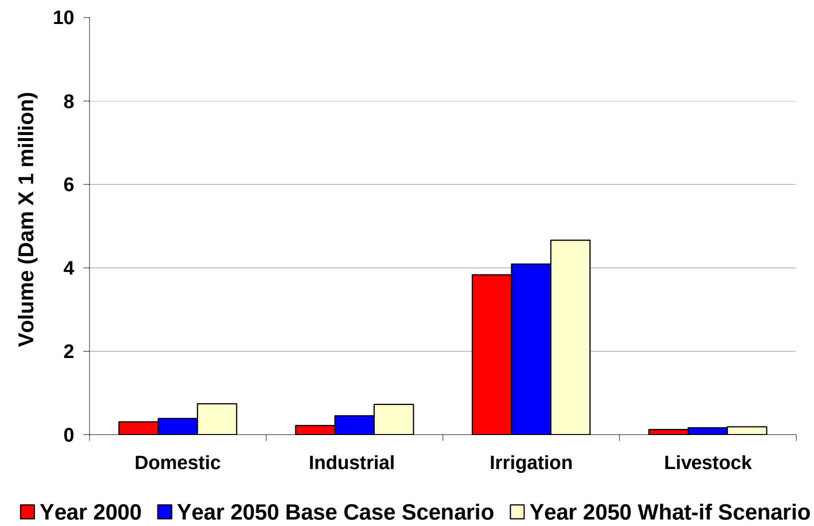


Figure 7.8. Projected Gross River Water Demand

The projected growth in area of the feedlot footprint is small compared to non-inhabitable area (Figure 7.9). Non-inhabitable area is projected to be about 34% of the total SAL area by 2050.

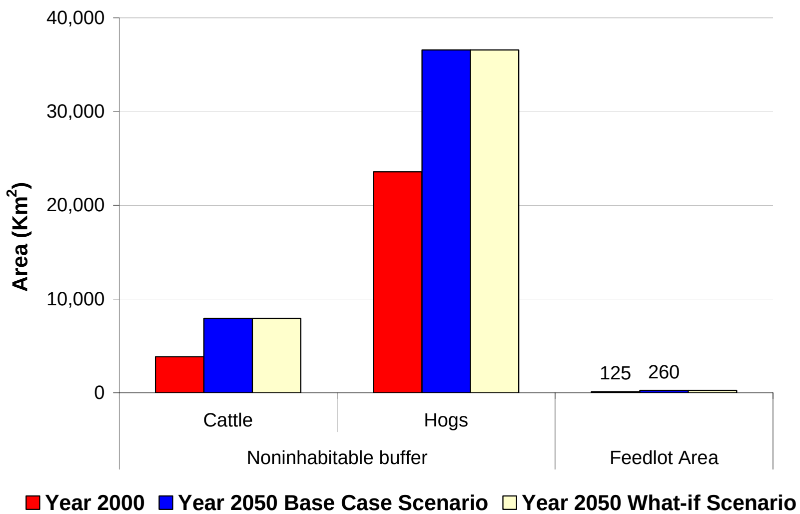


Figure 7.9. Projected Footprints for Feedlots and Non-Inhabitable Area

Non-inhabitable area for cattle feedlots is projected to increase proportionally more than for hogs because of a greater projected increase in the number of cattle. However the actual non-inhabitable area is much larger for hogs because of the greater number of hog feedlots. The projections for the What-if Scenario are the same as for the Base Case Scenario because agricultural production was not changed in the What-if Scenario.

Energy

The projected decline in conventional oil and gas production, and continued reclamation efforts, result in a small increase in the energy footprint in the Base Case Scenario over the next 50 years (Figure 7.10). The overall change in the energy footprint will be relatively small compared to some of the other footprints. The energy footprint in the What-if Scenario is projected to have about a 7% larger footprint over 50 years than the Base Case Scenario.

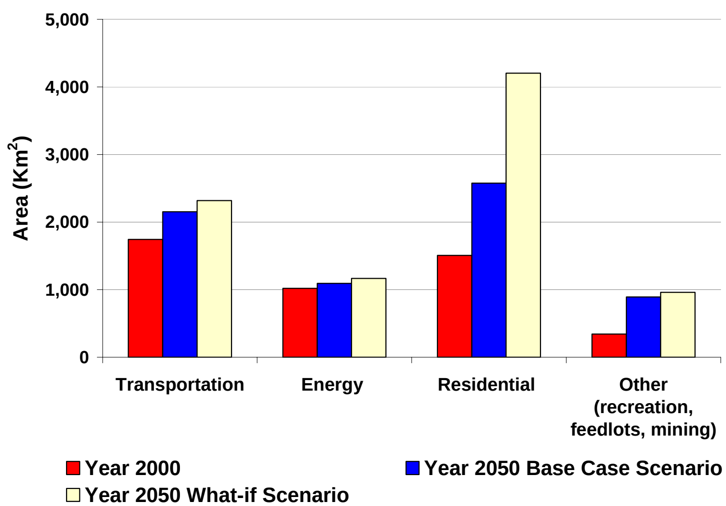


Figure 7.10. Projected Energy Footprint Relative to Other Footprints

Most of the wellsites footprint is projected to occur on croplands, and to a lesser extent on native grasslands (Figure 7.11). In cropland, most of the well sites footprint is projected to occur on cereals and tame grass

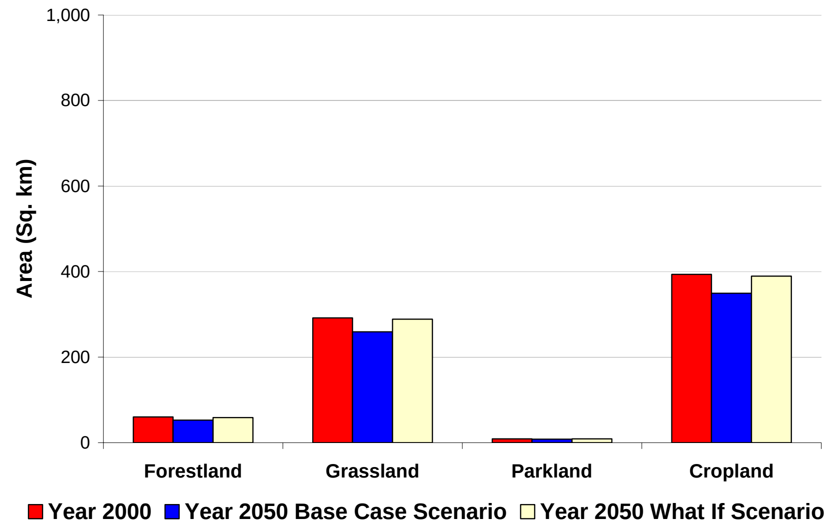


Figure 7.11. Projected Well Sites Footprint by Landscape Group (Note change in scale from Figure 7.10).

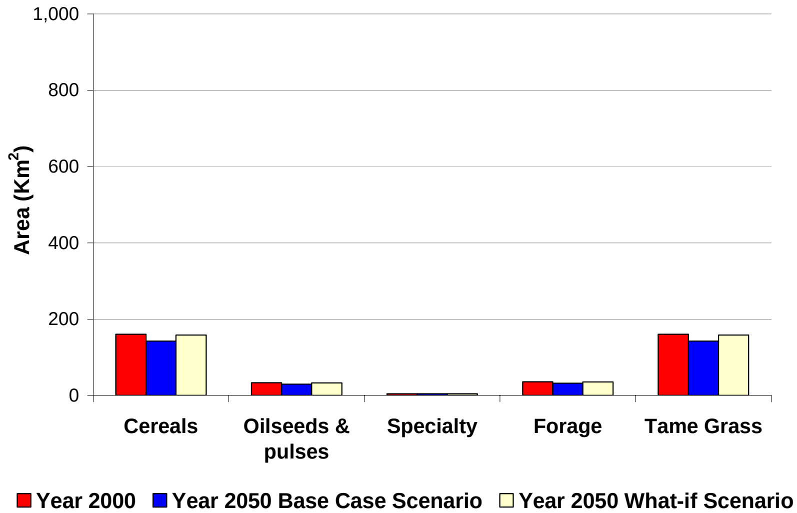


Figure 7.12. Projected Well Sites Footprint in Cropland

Although the well site footprint declines in the Base Case and does not change in the What-if Scenario as a result of well pad reclamation, the pipeline footprint continues to increase, reflecting a longer lifespan on the landscape before reclamation (Figure 7.13).

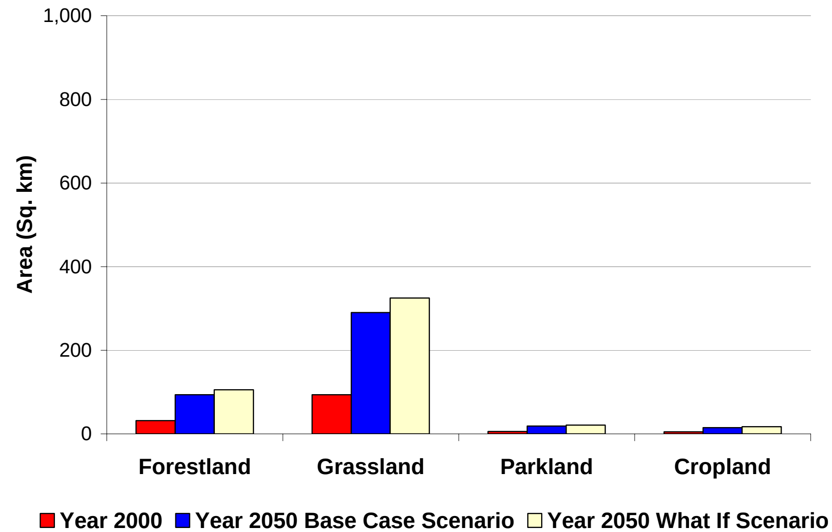


Figure 7.13. Projected Pipeline Footprint by Landscape Group

Wellsite fragmentation on cropland is projected to be less than 1.0 km/km^2 (no figure shown). Pipeline fragmentation on native cover types is projected to be in the range of 0.5 to 1.5 km/km^2 (Figure 7.14).

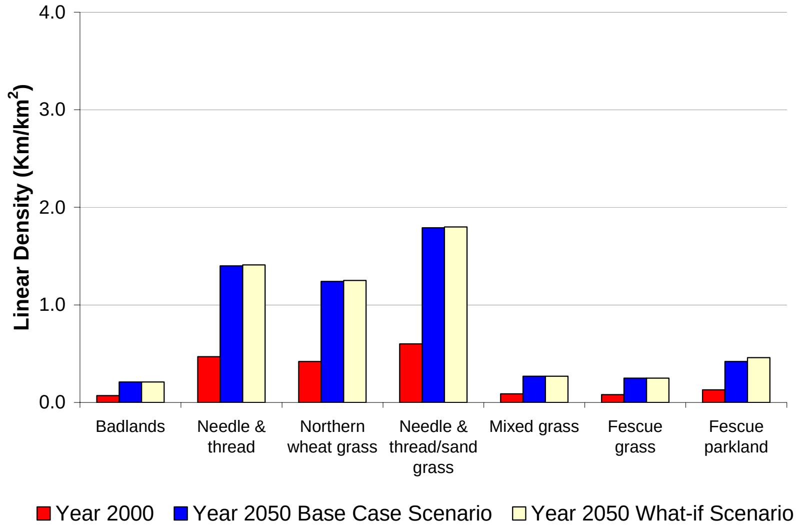


Figure 7.14. Pipeline Fragmentation on Native Grassland

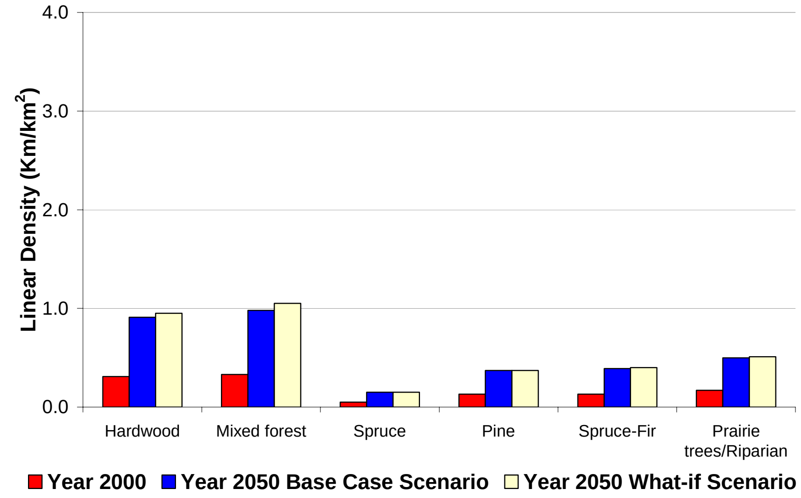


Figure 7.15. Pipeline Fragmentation on Forestland

Pipeline fragmentation on forestland is projected to be in the same range as grassland (Figure 7.15).

Fragmentation by minor roads & trails in native prairie is projected to be in the range of 1.0 km/km^2 (Figure 7.16). Well site access roads are the main cause of this fragmentation because the Base Case and What-if Scenarios assume that growth in other types of minor road categories is minimal. Fragmentation by minor roads and trails in forest is projected to be about the same as in native prairie (no figure shown).

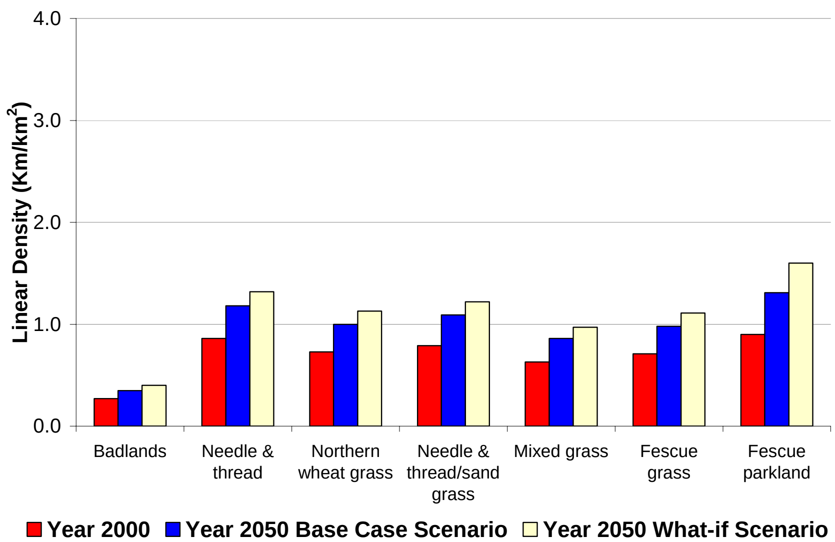
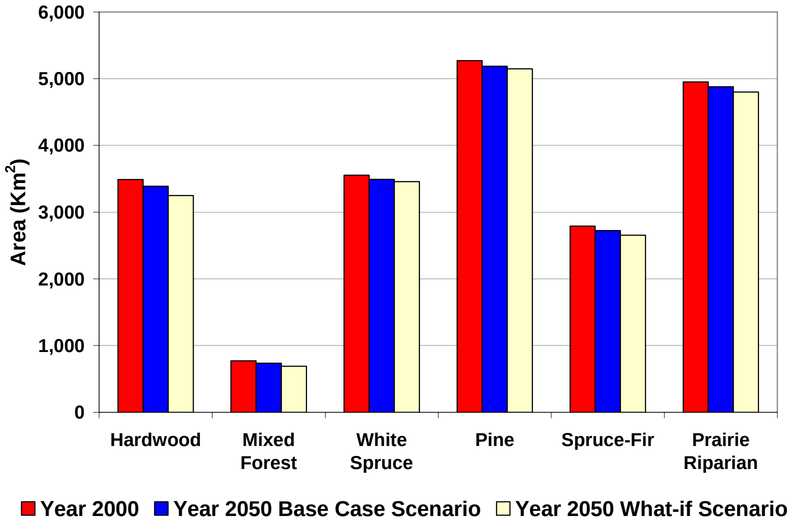


Figure 7.16. Minor Roads and Trails Fragmentation in Native Grasslands

Forests & Forestry

In 50 years, the area of each forest cover type is projected to decline slightly in the Base Case Scenario as a result of projected growth in cities/towns, recreation, energy, and roads and trails (Figure 7.17).



The What-if Scenario shows a continuation of these projections.

Figure 7.17. SAL Forest Cover Projection

Much of the footprint is projected to occur in hardwood and prairie treed/riparian forest types (Figure 7.18). This is caused mainly by the growth of residential development. The chapter on settlement contains more information about the impact of settlement on forestland in SAL.

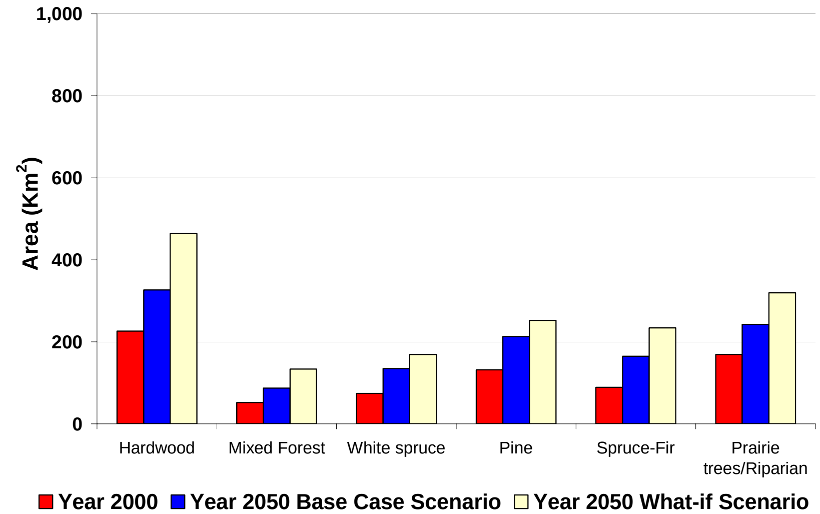


Figure 7.18. Projected Footprint Across Forest Types

Fragmentation is projected to decline in some forest types and shows a small increase in others (Figure 7.19)

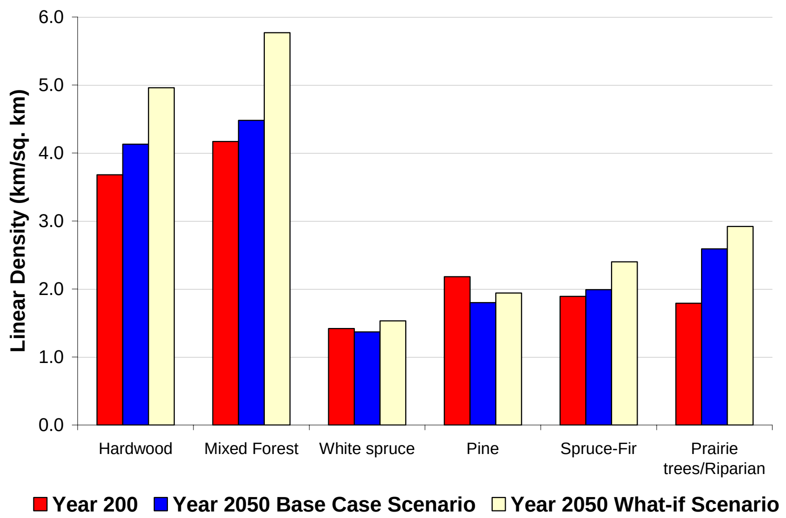


Figure 7.19. Projected Fragmentation Across Forest Types

If current trends continue, most of the future development footprint in southern Alberta likely will occur outside parks, which are off-limits to industrial land use and new settlement. To show the result of calculating fragmentation only on the active part of the forestland base instead of averaging it, a modified version of the Base Case Scenario was used in which the areas of forest types were adjusted (Figure 7.20). A modified version of the What-if Scenario was not tested.

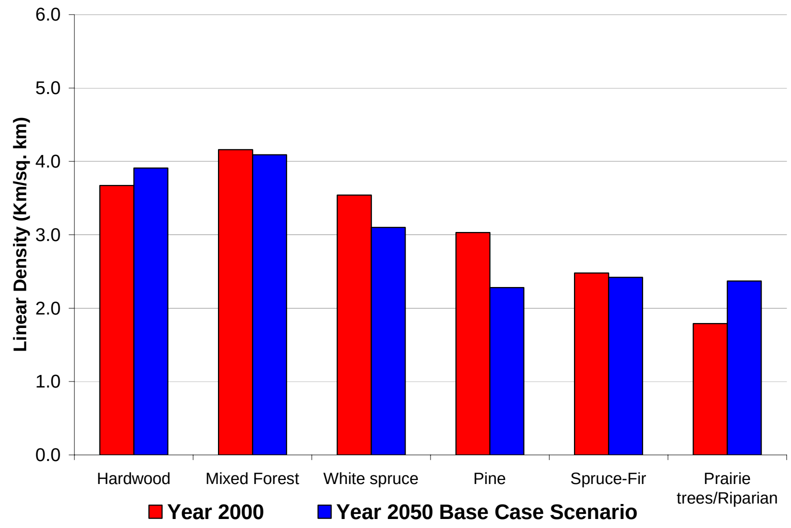


Figure 7.20. Projected Fragmentation Using only the Active Area of Forest Types (Base Case Scenario Only).

Old growth forest, defined as stands 140 years or older, is projected to increase on the protected land base as the forest in the mountain parks grows older (Figure 7.21) On the active forest land base, white spruce is projected to experience a small decrease, and spruce-fir a medium decrease in area of old growth forest, while pine is expected to experience an increase. Projected areas for old growth in the What-if Scenario were the same as in the Base Case Scenario.

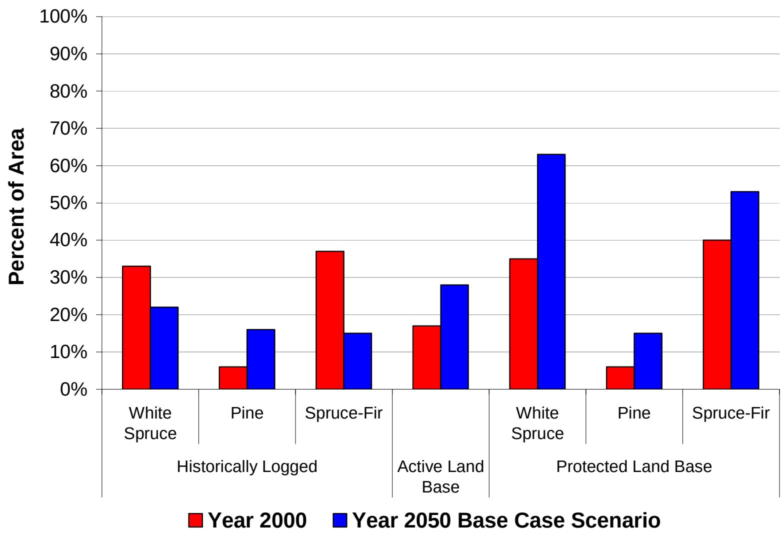


Figure 7.21. Percent of Each Forest Type that is Old Growth Forest (Base Case Scenario Only)

The projected spread of invasive species into forest cover types is projected to be quite small in both Scenarios (
Figure 7.22). The largest increase is projected to occur in Prairie Trees/Riparian in the What-if Scenario, where a 10% increase is projected.

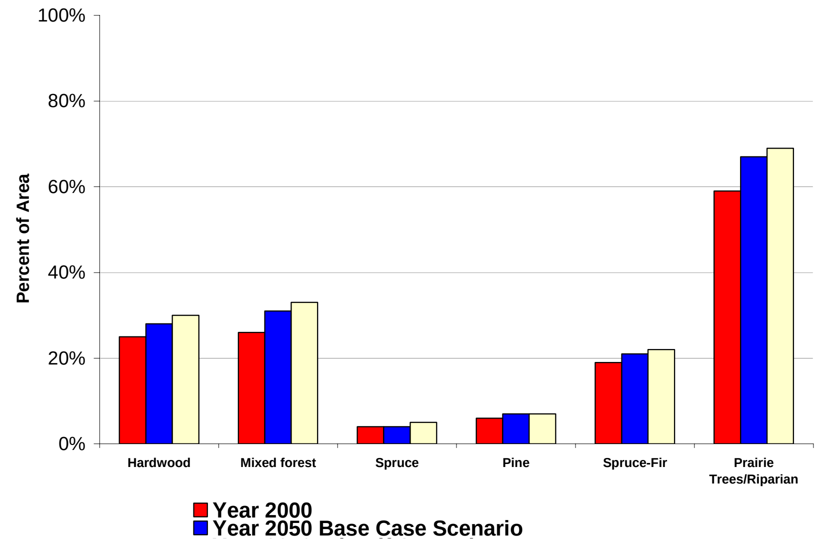


Figure 7.22. Projected Percent of each Forest Type Occupied by Invasive Species.

The Natural Disturbance chapter in this report contains the results of natural disturbance projections on forestland

Tourism and Recreation

Tourism and recreation facilities are projected to occur mainly on forestland, and are projected to more than double in area over the next 50 years in the Base Case Scenario (Figure 7.23). Growing the facilities at 2.4% a year (What-if Scenario) instead of 2% a year shows a proportional increase across cover types.

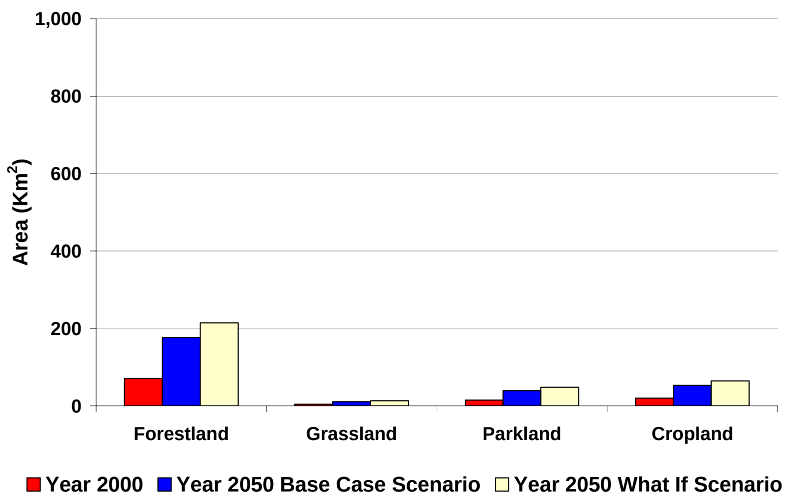


Figure 7.23. Projected Tourism/Recreation Footprint by Landscape Group

On forestland, most development is predicted to occur in spruce and pine cover types (Figure 7.24).

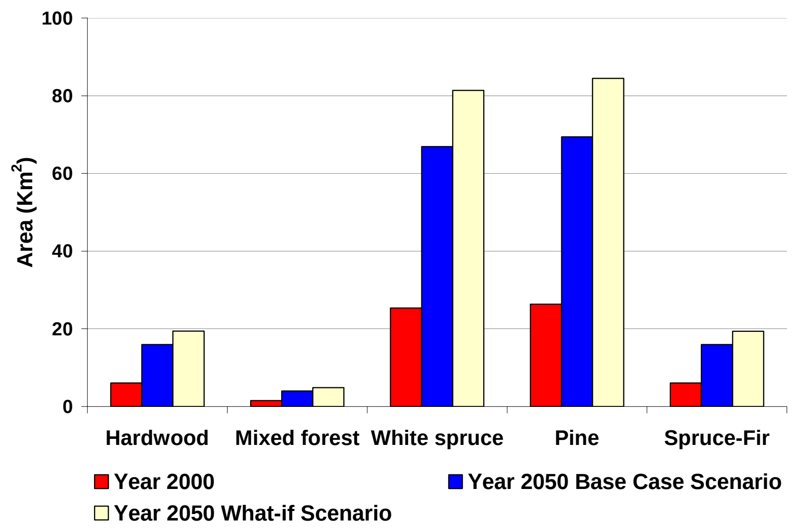


Figure 7.24. Projected Tourism/Recreation Footprint by Forest Type. (Note change in scale from Figure 7.23)

The only other landscape type projected to have any substantive tourism/recreation development is fescue parkland (from 15 km^2 at, year one to 40 km^2 in the Base Case, and to 48 km^2 in the What-if Scenario (no figure shown).

Roads and Utility Corridors

Minor roads and trails, which include the municipal road grid, energy roads and acreage roads, are projected to show small to medium growth in the Base Case Scenario over the next 50 years, and medium growth in the What-if Scenario (Figure 7.25).

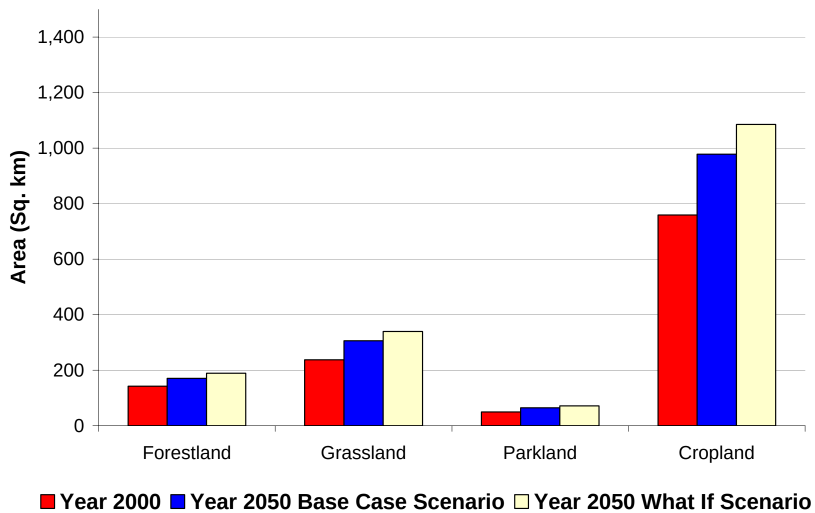


Figure 7.25. Projected Footprint of Minor Roads & Trails by Landscape Group

Most of the growth in minor roads & trails is projected to occur on cropland, especially the cereals cover type as a result of energy development (Figure 7.26). Other roads and utility corridors in SAL are projected to show relatively small overall growth. Projected growth of minor roads & trails in native habitat is relatively small in the Base Case, and medium in the What-if Scenario (Figure 7.27). The largest increase is in needle & thread dry mixed grass (12 km^2 in the Base Case Scenario and 35 km^2 increase in the What-if Scenario). This is consistent with the projected amount of fragmentation reported in the Landscape chapter of this report.

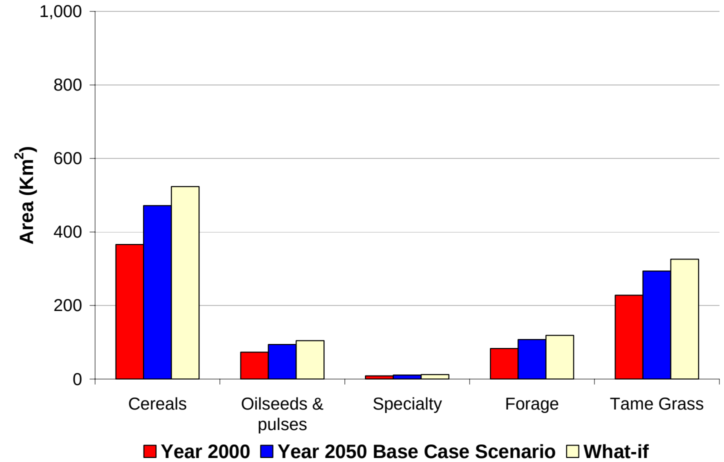


Figure 7.26. Projected Growth of Minor Roads & Trails in Cropland. (Note change in scale from **Figure 7.25**).

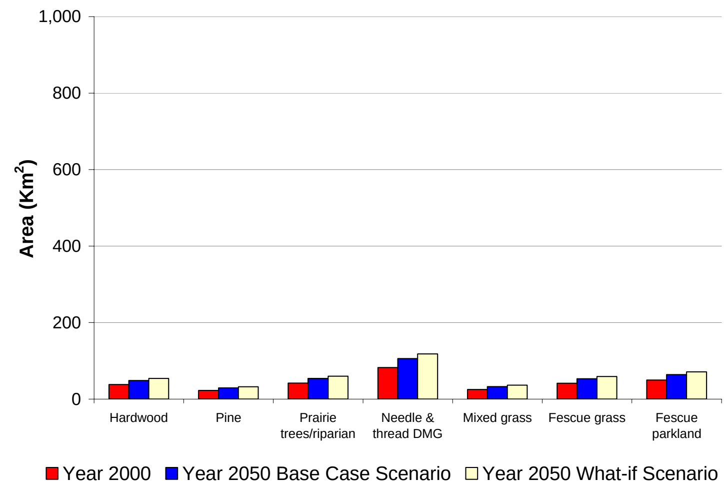


Figure 7.27 Projected Growth of Minor Roads & Trails in Selected Native Landscape Type

Rangeland Plant Communities

Fescue parkland is projected to endure the largest increase in development footprint of any rangeland community type (Figure 7.28). More than one-half of this increase is caused by the growth of acreages, which consume 162 km^2 of parkland in the Base Case Scenario. Energy and urban growth make up most of the rest of the footprint growth on parkland.

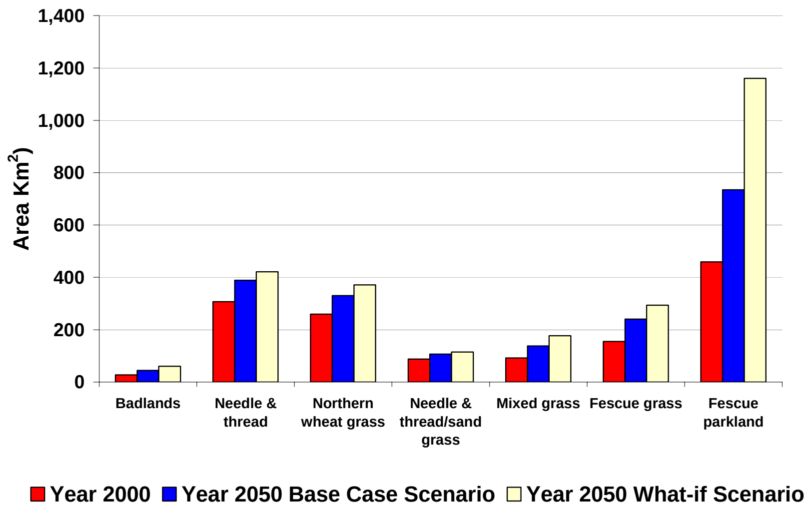


Figure 7.28. Projected Growth of Footprint on Native Rangelands

Overall losses in the area of each rangeland cover type are relatively small. However, added to the losses are increases in both fragmentation and invasive species.

Invasive species are projected to occupy about 30% of fescue grass and more than 90% of fescue parkland by Year 50 in the Bases Case. Fescue parkland is the only cover type that experiences an increase in the What-if Scenario, and it increases to 100% (Figure 7.29).

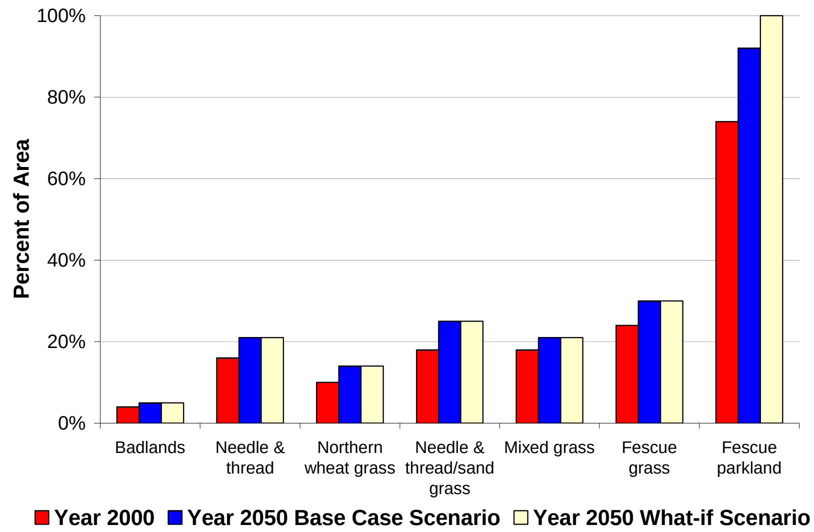


Figure 7.29. Projected Increase in Invasive Species in Rangelands

Fragmentation is projected to show a small increase in all rangeland types, except fescue parkland where about 20% of future rural residential development is projected to grow (Figure 7.30).

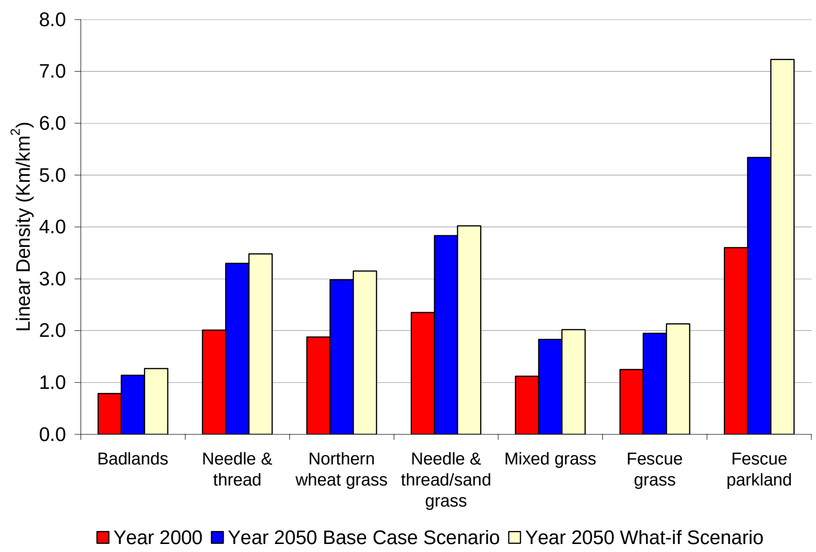


Figure 7.30. Projected Fragmentation of Rangelands

Rangeland structure is projected to vary in the Base Case according to the modeled variation in rainfall and annual area burned by wildfire (Figure 7.31). Spike declines in rangeland structure occur across all rangeland types. Although mixedgrass and fescue cover types recover from these declines and maintain their overall structural index over the 50 years, dry mixedgrass types show a general decline in structure (e.g. lines 1 & 3). These general declines are projected to occur because they are modeled to lose structure faster than the other types, and take a longer time to recover (as long as 9 years as opposed to 3-5 years).

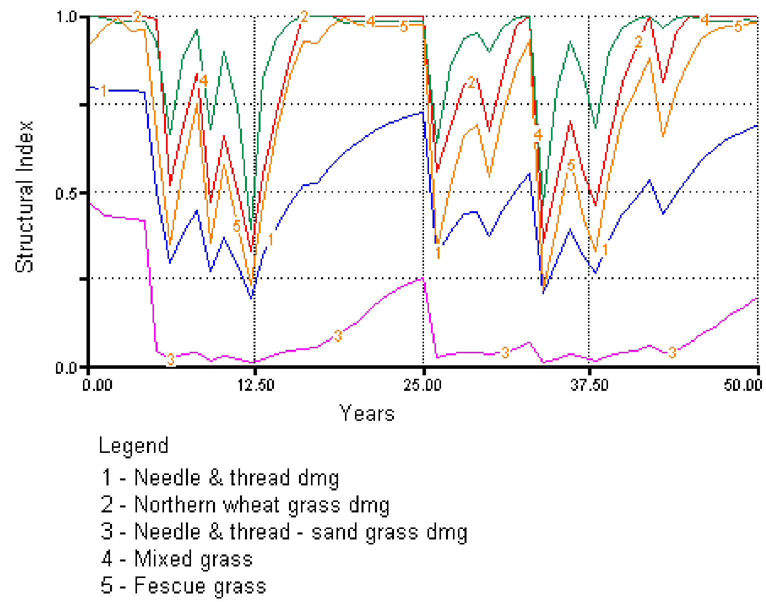


Figure 7.31. Projected Rangeland Structural Index, Base Case Scenario, under a Variable Precipitation and Natural Disturbance Regime

Wildlife and Fish

The species abundance index declines a small to medium amount in the Base Case for ferruginous hawk, sharp-tailed grouse and rattlesnake (Fig 1), but shows only a small decline in the What-if Scenario. The lack of change in the ferruginous hawk index in the What-if Scenario likely is caused by a decline in rangeland structure, which is beneficial to ground squirrels, the main food source for the hawks. This has a compensatory effect on increased energy footprint in this scenario. However, excessive loss of rangeland structure could result in scarce food for ground squirrels and a subsequent decline in the index for ferruginous hawk.

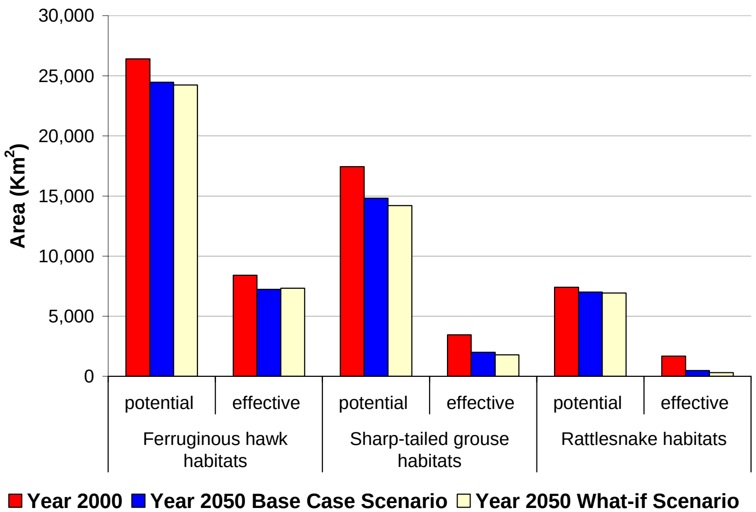


Figure 7.32. Projected Change in Habitat Area, 3 Flagship Species

There is a slight increase in the exposure index and a slight decline in the habitat RSF (resource selection function) index for grizzly bear in both the Base Case and What-if Scenarios (Figure 7.33). Although the projected future trend for both of these indices is negative for grizzly bear, the extent of change likely is inconsequential at a regional scale.

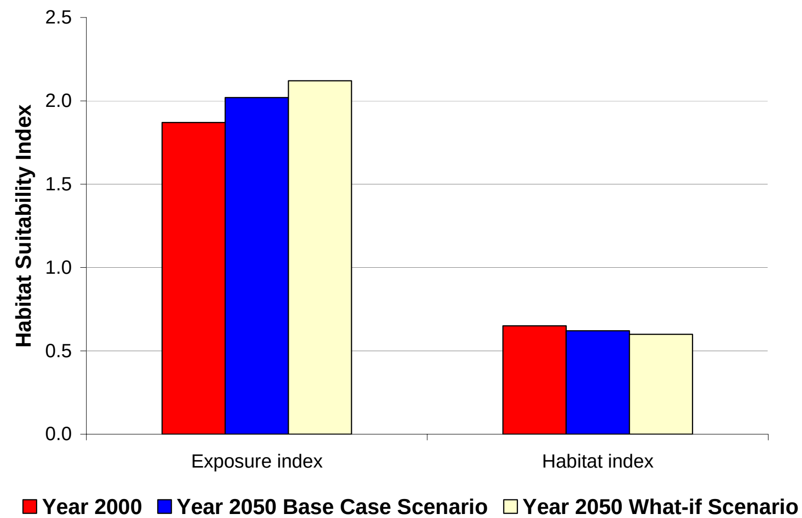


Figure 7.33. Projected Change in Grizzly Bear RSF Index.

The species group indices show varying changes (Figure 7.34). The grassland vertebrate specialist index shows a small decline, anthropogenic generalists show a moderate increase, while the classic prairie river fish index declines to zero. The decline to zero in the classic prairie river fish index occurs at about year 35 (not shown).

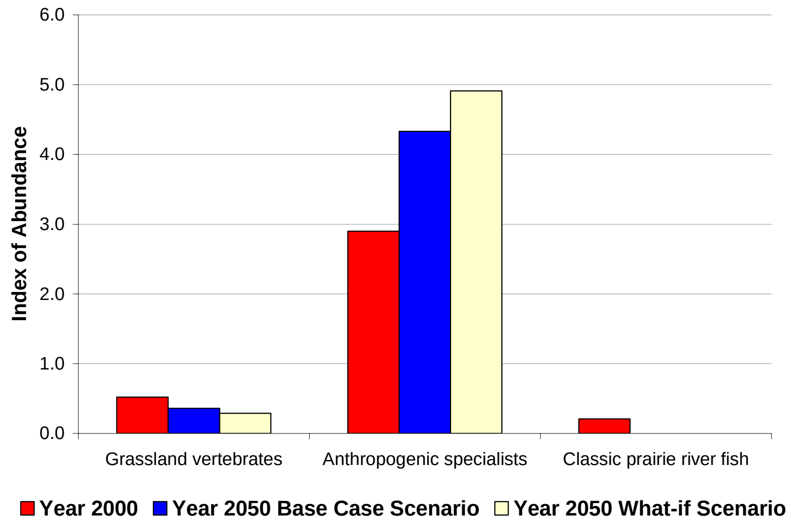


Figure 7.34. Projected Change in Guild Abundance Index

Increased road density and human population are the main causes for the decline in the grassland vertebrate index. The spread of weedy species also contributes to the decline. The same factors contribute to the increase in the anthropogenic generalists index. The decline to zero in the fish index is caused by the cumulative effects of less water in the basin, increased road density and a decline in the relative water quality index.

Because the projections used in this section are based on a Delhi (expert consensus) process, interpretation of the results should place emphasis on the direction of change, and not necessarily on the magnitude of change. Changes greater than a factor of two are likely to be the most important changes (Schieck, 2005)[24].

[24] Schieck, J. 2005. Pers.comm..

Water Quantity

Gross regional water demand is projected to increase in all sectors in both the Base Case and the What-if Scenarios as human population, livestock population and industry grow (Figure 7.35). Livestock population was not increased in the What-if Scenario. Irrigation water demand increases in the Base Case because the areas of specialty crops, forage and oilseeds & pulses, which use more irrigation water than cereals, increase. In the What-if Scenario, however, a severe drought increases crop irrigation demand. The result in the Base Case is that in an average year, there is barely enough water to meet apportionment by Year 50 (Figure 7.36). If natural variation in flow is considered, the frequency and extent to which apportionment would not be met without restrictions increases into the future.

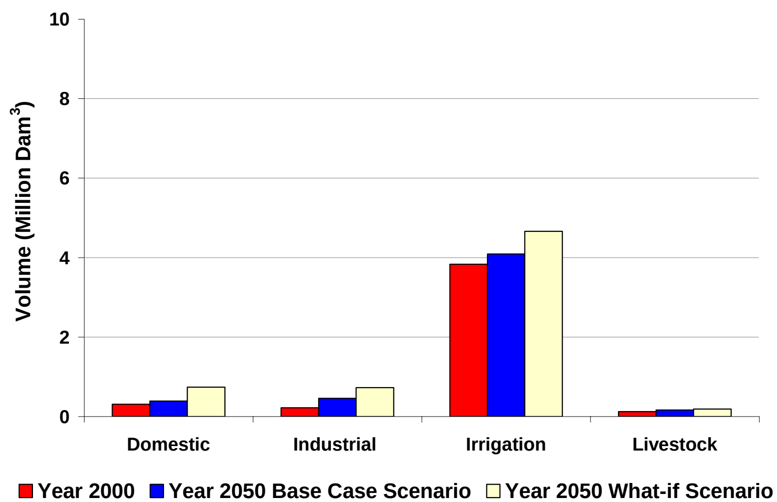


Figure 7.35. Projected Gross Water Demand by Sector

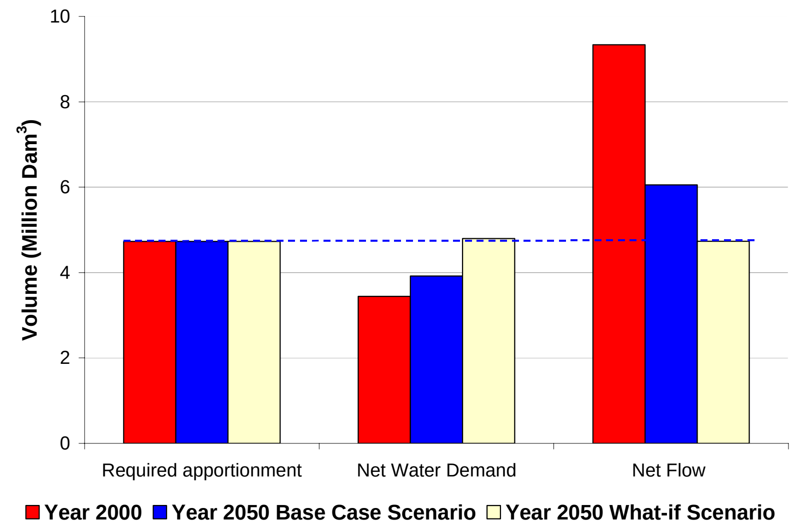


Figure 7.36. Projected Net Flow Relative to Net Demand and Apportionment

Water Quality

Water quality is projected to decline in the Base Case Scenario, with most of the increases in the mass export of nutrients coming from cropland: nitrogen (12% increase), phosporus (9% increase) and sediment (1% increase) (Figure 7.37, Figure 7.38, Figure 7.39). Both nitrogen and phosphorus export from cropland increase in the What-if Scenario, but to a lesser extent. The smaller increase in the What-if Scenario likely is caused by a loss of agicultural land as settlement expands. Settlement also accounts for increased export of nitrogen and phosphorus in both scenarios.

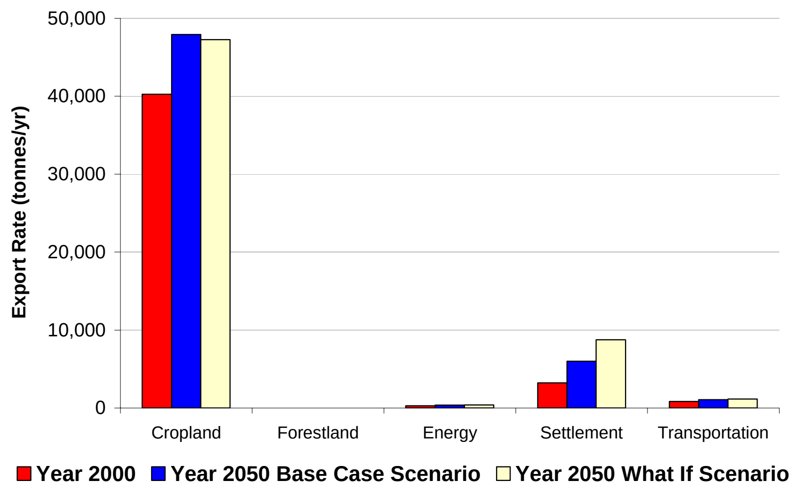


Figure 7.37. Projected Nitrogen Runoff

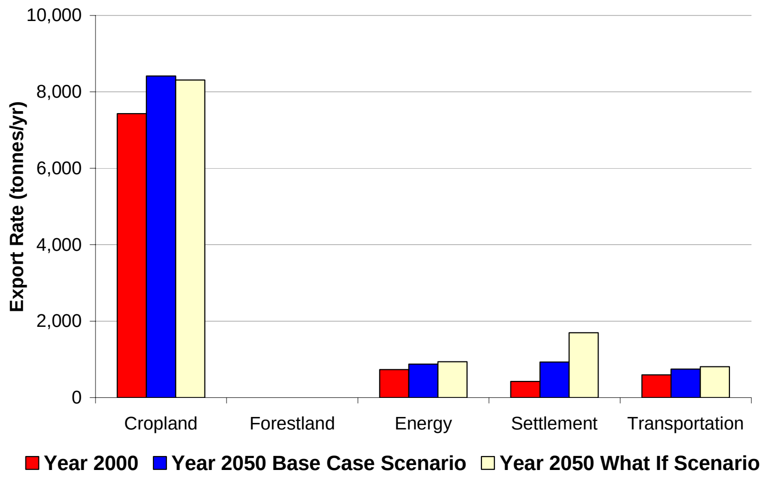


Figure 7.38. Projected Phosphorus Runoff

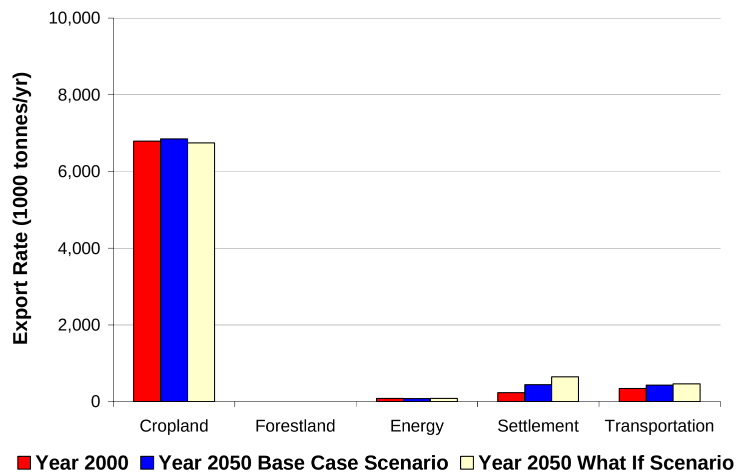


Figure 7.39. Projected Sediment Runoff

The water quality index declines or remains static for all three components (Figure 7.40). This is because the increase in export from the land is accompanied by a decline in the volume of water in the river, resulting in a relative increase in the concentration of each component.

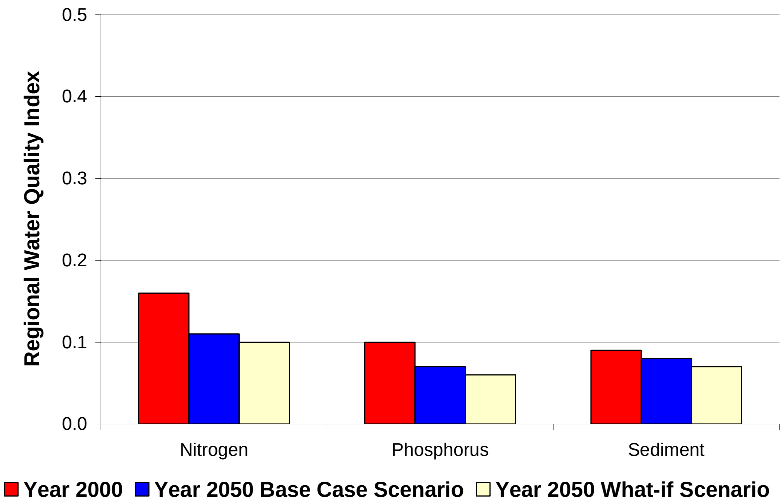


Figure 7.40. Projected Change in Water Quality Index

Natural Disturbances

In ALCES®-for-SAL simulations, the area of forest burned or attacked by insects in any one year is relatively small compared to the active SAL forestland base, which is about 7,600 km^2. Because some of the burned forest is salvaged for timber production, the amount of timber production lost annually to wild fire is very small.

Annual loss to agricultural crop production is on average, 1% of total production. Losses decline in cereal and tame grass, while they increase in other crops, reflecting the shift in total areas of the crop types over the modelling period.

8. Summary and Conclusions

Two simulations were performed to examine the possible cumulative effects of population and economic growth in southern Alberta from 2000 to 2051. A computer program called ALCES®-for-SAL and a Statistics Canada Input-Output model were used to perform the simulations. Understanding the assumptions used to project economic growth and how the human footprint might unfold on the landscape are critical to interpreting the results from this study. A variety of methods were used to project the growth of the economy and the human footprint into the future. These methods included: the use of empirical information to estimate the amount of suitable land available for agricultural development; published models such as the Hubbert-Naill curve for projecting petroleum reserve exploitation; population projections from economic think-tanks and consultants, economic goals contained in government business plans, and expert opinion.

Understanding the limitations of the models used in this study and the inherent uncertainty in model outputs also are important to interpreting its results. For example, the Input-Output model is not used to make economic forecasts; instead it is used to rebalance the regional economy as projected and modeled through ALCES®-for-SAL. In ALCES®, landscape feature outputs are typically a single average value for a landscape feature that in reality is a highly variable patchwork across the landscape. Consequently, the general trend among a suite of variables and how they interact may be as important as the magnitude of change in a single variable over the 50-year modeling period.

Two scenarios were modeled, a Base Case Scenario and a What-if Scenario. The Base Case Scenario assumed a continuation of current trends and reflected government business plans. The What-if Scenario contained a more aggressive growth trajectory in sectors that contain relatively large footprints: urban settlement and energy. Comparing the results of the scenarios may provide insights into what variables are most sensitive to changes in economic growth rate.

The landscape of southern Alberta is projected to undergo several changes over 50 years as the population and economy grow. First, there is likely to be a relatively small conversion of native cover to cropland. Second, cropland and some native land cover are expected to be lost to settlement and energy development. Third, fragmentation will likely increase as more transmission lines, roads, well sites, pipelines and other infrastructure are built. Fourth, invasive species are projected to become more widespread. As a result of changes to the landscape, the abundance of wildlife is likely to be reduced. Finally, more development in the absence of enhanced conservation measures are projected to result in less net flow in the South Saskatchewan River basin, and increase the risk to water quality.

Landscape variables are projected to exhibit a wide range of change. Although overall growth of the land use footprint will have a relatively small impact on the total area of landscape types, the impact on variables such as fragmentation and wildlife abundance is projected to range from small to moderately large. Fragmentation increases more on the active portion of the land base when protected area lands are not included in the model projections.

The main drivers of landscape change in southern Alberta are projected to be urban growth and energy. This will occur mostly at the expense of cropland and dry mixed grass cover types. Cropland also is expected to expand mostly at the expense of dry mixed grass.

Appendix 1

SAL Steering Committee Members

Ian Dyson, Alberta Environment (Chair), Lethbridge
Bill Symonds, Alberta Municipal Affairs, Edmonton
Brent Paterson, Alberta Agriculture, Food & Rural Development, Lethbridge
Dom Ruggieri, Alberta Sustainable Resource Development, Calgary
Holly Mayer, Agriculture & Agri-Food Canada-PFRA, Calgary
Jennifer Steber, Alberta Energy, Edmonton
Loren Winnick, Alberta Economic Development, Edmonton
Bill Dolan, Parks Canada, Waterton Lakes
Pauline Erickson, Environment Canada, Edmonton
Eric Davey, Aboriginal Affairs and Northern Development, Edmonton
Archie Landals, Alberta Community Development, Edmonton
Dug Major, Alberta Municipal Affairs-Special Areas, Hanna

Appendix 2

Export Coefficients – Nitrogen (t/ha)

White spruce	0.0025	Feedlots	1
Pine	0.0025	Urban	0.0401
Spruce/Fir	0.0025	Oilseeds & pulses	0.0123
Prairie Treed & Riparian	0.0025	Specialty Crops	0.0123
Forest Shrubs	0.0025	Agricultural Residential	0.0103
Gravel pit	0.00225	Coal mine	0.0086
Industrial Plants	0.00225	Cereal crops	0.006
Well sites	0.00225	Tame Grass	0.0051
Rural Residential	0.00152	Pipelines	0.0051
Recreational facilities	0.00152	Major road	0.005
Fescue Grassland	0.00124	Minor road	0.005
Needle and Thread (DMG)	0.00106	Rail	0.005
Northern wheat (DMG)	0.00106	Inblock road	0.005
Needle and Thread Sand Grass (DMG)		Transmission line	0.005
	0.00106	Seismic lines	0.005
Mixed Grass	0.00106	Forage	0.004
Fescue Parkland & rocky mountain		Rock/ice	0.00275
	0.00065	Hardwood	0.0025
Grassland Shrubs	0.00065	Mixedwood	0.0025
Badlands	0.000005		

Export Coefficients – Phosphorus (t/ha)

Feedlots	1
Pipelines	0.0051
Industrial Plants	0.00225
Well sites	0.00225
Agricultural Residential	0.0103
Rural Residential	0.00152
Recreational facilities	0.00152
Oilseeds & pulses	0.0123
Specialty Crops	0.0123
Major road	0.005
Minor road	0.005
Rail	0.005
Inblock road	0.005
Transmission line	0.005
Seismic lines	0.005
Urban	0.0401
Coal mine	0.0086
Gravel pit	0.00225
Cereal crops	0.006

Tame Grass	0.0051
Forage	0.004
Fescue Grassland	0.00124
Hardwood	0.0025
Mixed wood	0.0025
White spruce	0.0025
Pine	0.0025
Spruce/Fir	0.0025
Prairie Treed & Riparian	0.0025
Forest Shrubs	0.0025
Needle and Thread (DMG)	0.00106
Northern wheat (DMG)	0.00106
Needle and Thread Sand Grass (DMG)	0.00106
Mixed Grass	0.00106
Fescue Parkland & rocky mountain	0.00065
Grassland Shrubs	0.00065
Badlands	0.000005
Rock/ice	0.00275

Export Coefficients – Sediment (t/ha)

Urban	0.0401
Major road	0.005
Minor road	0.005
Rail	0.005
Inblock road	0.005
Transmission line	0.005
Canal	
Seismic lines	0.005
Feedlots	1
Cereal crops	0.006
Oilseeds & pulses	0.0123
Specialty Crops	0.0123
Coal mine	0.0086
Industrial Plants	0.00225
Well sites	0.00225
Gravel pit	0.00225
Forage	0.004
Tame Grass	0.0051
Pipelines	0.0051
Forest Shrubs	0.0025
Rock/ice	0.00275
Needle and Thread (DMG)	0.00106
Northern wheat (DMG)	0.00106
Needle and Thread Sand Grass (DMG)	0.00106
Mixed Grass	0.00106
Hardwood	0.0025
Mixed wood	0.0025
White spruce	0.0025
Pine	0.0025
Spruce/Fir	0.0025
Prairie Treed & Riparian	0.0025
Agricultural Residential	0.0103
Rural Residential	0.00152
Recreational facilities	0.00152
Badlands	0.000005
Fescue Grassland	0.00124
Fescue Parkland & rocky mountain	0.00065
Grassland Shrubs	0.00065