CUMULATIVE EFFECTS

Slide 1 Overview Cumulative Effects is the fifth of a six part series dealing with environmental resource challenges in Prairie Alberta.

Slide 2 Cumulative Effects The purpose of the Cumulative Effects presentation is to demonstrate that cumulative effects are real and to introduce a simulation model that can help decision-makers and the general public understand how the combined effects of human activity will affect the prairie ecosystem in the future. The land base is finite, but our appetite for growth in multiple sectors of the human economy is not. We will look specifically at human influences on the prairies and identify what the potential impact of these influences might be over time.

Slide 3 Alberta's Grassland Natural Region This presentation deals with the Grassland Natural Region, explaining where we have come from, where we are now and where we might be going in the future.

Slide 4 Steering and Technical Committee A committee, comprised of technical experts from within government and the private sector, was struck to steer the process of assessing the cumulative effects of human activity within the Grassland Natural Region, and to critique/test ideas, facts, and assumptions.

Slide 5 Special Thanks Thanks to those who donated photographs.

Slide 6 The Grassland Natural Region The Grassland Natural Region encompasses almost 10 million ha, or about 1000 townships of land, in southern Alberta.

Slide 7 Fire as a Disturbance Regime The Grassland Natural Region was glaciated for an extended period of time. After the glaciers retreated about 10,000 years ago, the area was colonized by a predominantly herbaceous plant community. This community has been repeatedly influenced by natural disturbance regimes such as fire.

Fire has shaped the grasslands community and has assisted the grasses by giving them a competitive advantage over encroaching trees. Fire is instrumental in altering the composition and structure of a plant community.

Slide 8 Flooding as a Disturbance Regime Flooding is another important natural disturbance regime that maintains grassland riparian communities by fostering the establishment of new vegetation on flood plains.

Slide 9 Native Ungulates as a Disturbance Regime Native wildlife species that depend on prairie plants and grasses, such as bison and pronghorn antelope, also create natural disturbances. These species play an important role in moving nutrients through the nutrient cycle.

Slide 10 First Nations People as Landscape Modifers The Grasslands were dominated by the Plains Indian Culture prior to European contact and subject to significant human influence.

Slide 11 Alberta Prairie Ecosystems Many people who are unfamiliar with the prairies view the prairies as a monotonous landscape. In reality, the prairie is anything but monotonous. A tremendous variety of life is associated with a grasslands environment. Biotic richness is found among arthropods, vertebrates, vascular plants and non-vascular plants that are found within the prairie ecosystem. There is in fact amazing diversity within the prairie landscape.

<u>Slide 12 Modified Disturbances Regimes</u> Today, natural disturbance regimes still operate but have been modified by human changes to the landscape. Because they have been altered, they no longer have the effect on the prairie ecosystem that they once had.

Fire remains an active process on the prairies, but for the most part it is feared and controlled. Fires are the exception, not the rule. When fire breaks out it is fought. As a result, fire today operates under a modified regime.

Water remains an integral part of the landscape. Its spatial distribution and its phenology is not what it was 100 years ago. Humans have taken decisive action to manage the distribution and to regulate the flow of water. As we actively manage water we alter natural water regimes, which has the effect of changing, among other things, water flows and water temperature. This in turn has implications for life forms that are dependent on water and for natural processes that are driven by water.

Humans have been very enterprising in capturing, storing and moving water. This has allowed the development of Canada's largest and most productive irrigated agricultural area in southern Alberta. This benefit has necessitated some trade-offs because water plays a vital role within the ongoing functioning of the larger ecosystem.

In terms of biomass consumed, it is estimated that domestic livestock have replaced more than 95% of the native ungulates that were once found on the prairies. There are still abundant native ungulates present in the Grasslands Natural Region, however, cattle have become the predominant grazers. We have significantly modified the herbivorous system that once operated on the prairie landscape.

<u>Slide 13 Untitled (Landscape slide)</u> The human presence that is so apparent on the prairies is also quite evident in the headwaters of prairie rivers – the foothills and mountains. It is important for us to understand what is happening in the headwaters region because land uses and human activities there have downstream effects.

Human land use practices have transformed the landscape over the last century. A significant land use in southern Alberta is conventional agriculture. Agricultural production results in landscape conversion. Much of the area in southern Alberta that was once native grassland is now cropland. Native grassland communities, ranging from short grass to tall grass prairie, have been converted to a diverse spectrum of agriculture uses. Intensive agricultural production has occurred not only in the Grassland Natural Region but also within headwater regions.

Other significant human footprints are evident in the Grassland Natural Region, including the following:

Farms and country residences. Human settlement on rural agricultural lands around major population centres is a rapidly growing phenomenon. Statistics Canada information for the Grassland Natural Region shows startling rates of growth for rural residential development within the urban fringe.

Linear corridors. There is a dense matrix of highways, roads, trails, and rail lines within the Grasslands Natural Region which are critically important for moving people and commodities.

Energy development. The activities associated with the energy sector (hydro-carbon exploration, development, processing, and transportation), including seismic lines, trails, well sites and pipelines, leave a significant footprint on the landscape.

There is no denying that these human footprints exist. Human activity is transforming and remaking the landscape. Land use conversion is inevitable as the human population grows. Are we fully aware of the implications of a growing human footprint on the landscape?

Slide 14 Has the Landscape Actually Changed? To what extent has the landscape actually changed with passing time?

Slides 15 through 20 Manyberries 1949 A series of time-sequenced aerial photographs identify landscape change in the Manyberries area in south-eastern Alberta. This site provides a good example of the changing energy sector footprint. This image was acquired in 1949. The blue dots are geographic markers – reference points in the image that will also appear in subsequent images. Anthropomorphic features (roads, trails, well-sites, buildings, and pipelines) which are visible on the image have been highlighted to scale.

This image shows the same area in 1962 . . .

in 1970 . . .

in 1982. Some well sites and access roads are visible in this photo.

This image shows the same area in 1991 . . .

and in 1998. This is not a random site. The Manyberries site was selected because it has been subjected to significant land use change over the last few decades.

Slides 21 through 26 Forks Area Another example of this type of land use is the Forks Area at the confluence of the Oldman River and the Bow River. In 1949 (at the top and bottom to the left) we have a couple of water bodies that have been connected by canals (blue lines).

By 1962, these canals were consolidated into a single, more pronounced channel. Roads are also beginning to appear.

By 1970, well sites and more access roads are beginning to appear.

More land use change is apparent in 1977 . . .

and in 1985 . . .

and in 1998. Hundreds and hundreds of these chrono-sequences can be used to depict land use change. Many sites are experiencing 1-2% change annually. These changes are largely imperceptible to us because they are so gradual. It is hard for us to see these changes because we are living through them and adapting to them. They have the appearance of being small transformations of the landscape. Time-sequence photographs however provide an effective means for helping people understand the extent of 'minor' landscape change over a 30-50 year time frame. What appears to be imperceptible change on an annual basis becomes quite pronounced when considered over a period of decades.

Slide 27 Charles Darwin Charles Darwin put forward the hypothesis that species adapt to their environment through processes of natural selection. The prairie landscape has changed significantly, and continues to change rapidly in its structure and composition. Therefore one would expect concomitant changes in the structure and composition of biota (life-forms) and biotic communities that are found in a prairie landscape. Darwin would maintain that prairie species have to adapt to the changing prairie environment, an environment where the human footprint is becoming increasingly conspicuous.

Slide 28 What Species might be advantaged/disadvantaged? If that is the case, then there are going to be winners and losers among existing species. Some species will do quite well in (i.e., will adapt to) landscapes that are predominantly agricultural, fragmented, structurally simple, and accessible to humans. Other species can only thrive in a native prairie setting that is fairly intact, continuous, that is structurally complex, and which is relatively inaccessible to humans. Starlings and coyotes are examples of species that will do very well in a highly modified landscape. Other species may be disadvantaged. The Swift Fox and the Burrowing Owl are good examples of species that are disadvantaged in an altered prairie landscape.

Slide 29 Prairie Land Uses A variety of land uses exist within the Grasslands Natural Region. Empirically defined growth projections can be established for each land use. All of these different land uses are occurring (and growing) on a land base that hasn't changed in size. The landscape is finite; it is not expanding in size to accommodate increased human activity.

Significant historical trends are emerging for different land uses. The energy sector is active and growing – currently growing at unprecedented rates given the high market price for hydro-carbon commodities. As a consequence, the energy sector footprint is continuing to grow rather than shrink. The same is true for human settlement. By looking at historical data, we can see that human settlement is experiencing an annual growth rate of 2.8-3%. There is no basis for assuming that human population growth will stop or slow down.

If we ask other sectors and industries too look at where they are today and where they would like to be in the future, it quickly becomes apparent that many have a growth mandate. Growth and expansion are their stated objectives. What this means is that sectoral growth must be accommodated on a finite, fixed landscape.

(Future Landscapes) This raises a series of important questions:

Will the future landscape, increasingly modified to accommodate a growing society, allow us to maintain acceptable levels of biodiversity and species richness?

Can we maintain the ecological integrity that is inherent within natural systems?

Will there be enough clean air, clean water, and other resources available to sustain our society?

Will the modified landscape be able to satisfy society's demand for outdoor recreational pursuits?

We know recreational demand is increasing and that demand for clean air and clean water is increasing from both an ecological and a societal standpoint. There appears to be a growing societal interest in the issue of carbon pool dynamics and greenhouse gases. There are more people who want to see carbon in a biotic form on the landscape rather than in the form of greenhouse gases. Surveys indicate that society values and wants to preserve biodiversity. Can these things be ensured in the future given the multiple demands being placed on the grasslands landscape?

Slide 30 Wildland Recreation People are engaged in a variety of different outdoors recreational activities within the Grassland Natural Region. Some are consumptive, others are non-consumptive. All require a land base on which to occur, which has implications for other land uses.

Slide 31 Recreation Requiring a Modified Landscape Some of these recreational pursuits do not involve natural systems. They are recreational pursuits that involve modified or man-altered landscapes. Examples are hunting for exotic wildlife species, golf, and the use off-road vehicles (in abandoned gravel pits for example). These are important recreational activities to certain individuals. Conflict sometimes emerges between those recreational pursuits that are dependent on the natural environment and those that require a modified, or highly modified, environment.

Slide 32 Where do disturbances occur? It is useful to know where human footprints appear on the landscape. Some sectoral footprints are present everywhere, some are confined to specific geographic areas. Livestock grazing, oil and gas development, and recreational use occur across the spectrum of different landscape types, while other land uses are confined to specific regions (e.g., forestry operations are located in the foothills and mountains). Spatial data has been acquired to determine the extent of each human activity within the Grassland Natural Region. At present, intensive agriculture and human settlement are predominantly located in the western part of the Grassland Natural Region. Oil and gas development and roads occur throughout the landscape. Rangelands dominated the eastern portion.

Slide 33 How long do landscape deletions persist on the landscape? The landscape does not become smaller as it submits to unrelenting human encroachment; rather, its composition changes. We presently have land tied up in expanded cities and settlements, confined feeding operations (CFOs), crop production, roads, well sites, irrigation reservoirs, etc. It is comparatively easy to document the spatial extent of these land uses. What we don't always have a good handle on are recovery rates. If an access road is built to a well site, does it remain in use for 2, 5 or 10 years? Estimated recovery rates for particular activities will influence outcomes in the simulation model. Some things, like highways, are permanent features. Well site access roads and pipeline disturbances are however a temporary land use. Whether such a temporary land use exists for 3 or 7 years makes a big difference with respect to the model.

Slide 34 Using ALCES A model, known as 'A Landscape Cumulative Effects Simulator' (ALCES), is being used to try to simulate future states for the Grassland Natural Region. The model is dependent on data. Spatial data has been obtained on the human infrastructure and the bio-physical resources found in the Grassland Natural Region. Information has also been acquired for a number of sectors: energy, agriculture, transportation, settlement, etc., to try and put together a reasonable projection of what the future might look like in the Grassland Natural Region.

Spatial data has been collected to quantify the extent of the existing human footprint within the Grassland Natural Region. This data has been incorporated within a simulation model. Using the simulation model, and a series of assumptions on future human activity, it is possible to extrapolate how the human footprint may increase on the landscape over the next 10, 20, 30, 50 and 100 years. The model identifies what the landscape might look like based on sectoral trend analysis, growth projections, the use of existing and new technologies, etc. By anticipating how the human footprint will affect the landscape in the future, we can anticipate the issues and consequences that are associated with human activity and economic growth.

Will we lose too much agricultural land?

Will sufficient water exist to meet growing demands?

Will habitat exist for different plant and animal species?

What resources will be used up or are recoverable using conventional technologies?

How is the nutrient cycle being altered?

Where will human settlement occur?

The simulation model provides a means for us to raise these and other relevant questions by projecting human activity into the future.

Slide 35 ALCES Wizard for Trainees To operationalize ALCES, we needed to complete the following steps.

The Grassland Natural Region was geographically defined.

The Grassland Natural Region was then stratified into a series of landscape composition classes.

Spatial data was acquired to tell us what the landscape looks like today.

Information on natural disturbance regimes was obtained (e.g., fire, hydrological cycles).

It was determined that agriculture, energy development, and settlements were the dominant land use that occurred in the region.

Key people were consulted to speculate on the future of the different land use practices.

Experts were consulted to determine how wildlife habitat quality may change through time.

Acceptable landscape threshold levels and targets were determined.

A variety of land use options were looked at and how different growth rates affect the landscape.

Issues affecting the landscape and mitigation strategies were identified.

Slide 36 Initial Landscape Composition The constituent elements of the landscape were identified based on remote-sensed data and other data sources. The landscape is stratified—that is, separated into identifiable components—land that is vegetated and land that is not, and the various natural and human land use categories in each. The simulation model tracks movements between these land use categories over time.

Slide 37 Plant Community Dynamics The model incorporates various sub-models to track changes occurring on natural landscapes because these are not static system, but experience dynamic change over time.

(Energy Sector Trajectories) ALCES projects growth trajectories for various sectors within the landscape. These curves describe the sector experts' best estimates as to likely future scenarios.

(Using ALCES) ALCES can be used to simulate timber supply, the human footprint on the landscape, wildlife habitat and population dynamics and carbon pool dynamics. More importantly, it can also be used to explore mitigation strategies.

Slide 38 Topography This slide identifies the topographic variability with the Grasslands Natural Region. The prairies are not a flat, homogenous landscape.

Slide 39 Water and its Distribution The next series of slides will display how water is distributed throughout the Grasslands Natural Region.

Slide 40 Hydrology Water is not uniformly distributed over the landscape. Topography significantly influences the spatial distribution of water. The construction of water conveyance and impoundment structures has had the effect of re-distributing water over much of the Grasslands Natural Region during the last several decades.

Slide 41 River Mainstems This slide shows the main-stem of river (lotic) systems and their tributaries.

Slide 42 Major Lakes This slide shows the major lakes and reservoirs (lentic systems) in the Grassland Natural Region.

Slide 43 Irrigation Water has been significantly re-distributed through the region, primarily to assist in agricultural production.

Slide 44 Water Distribution and Impoundments Irrigation development has resulted in a significant transformation of the landscape over the last 100 years through the development of an extensive water delivery and storage system.

Slide 45 Irrigation Infrastructure Among other reasons, the Oldman River Dam was built to manage water supplies for the agricultural industry.

Slide 46 Irrigation Infrastructure This slide shows the extensive irrigation infrastructure that exists to convey water to croplands.

Slide 47 Lotic Water Volume and Demand Here the ALCES model has been used to simulate the hydrologic cycle. This slide shows the amount of water remaining in the mainstem of rivers after water has been removed for various human uses; it is assumed that all land use sectors are using water. The model is projecting that precipitation will be constant over time with no annual variations (if precipitation is not pictured as a constant, water volume levels would fluctuate up and down even more throughout the years). The model projects that the total amount of water within the main stem of rivers is on a downward trend. At the same time, the demand for water is increasing on an annual basis.

This slide would indicate that if our goal was to withdraw water to satisfy human consumptive needs, we really won't have any conflicts for next 80 years. That, however, assumes that we are **not** concerned about leaving water in the rivers for other purposes (e.g., to sustain fish and other aquatic life forms).

Hydrologic systems are anything but constant. One must always be cautious or pessimistic when someone presents a graph where a natural disturbance regime is said to be constant. The variance in precipitation from year to year is very important and must be included in the model. The demand side for water may be relatively constant but is, in part, dependent on precipitation levels. One could argue that during a really wet year less water is needed for irrigation. If one starts plotting all of these temporal variances in the hydrologic system, they become considerable.

Slide 48 Human Population and Urban Expansion The next series of slides pertain to human populations and urban growth within the Grassland Natural Region.

Slide 49 Human Communities The eastern part of Calgary falls within the Grassland Natural Region. Calgary is one of the fastest growing communities in North America. In the last five years, the City of Calgary has had a growth rate in excess of 3%. This may seem small for a single year, but over a period of time, such as 10 years, this rate of growth can have a dramatic affect on the landscape.

Slide 50 Human Settlements Human settlements range from small to large in the Grassland Natural Region. These are the largest urban communities.

These are the smaller communities. It is important to note that there has been a radical re-distribution of people within the region during the past 4-5 decades.

Slide 51 Aboriginal Reserves There are also sizeable aboriginal reserves within the Grassland Natural Region.

Slide 52 Human Population Growth About 1.6 million people are currently living in Southern Alberta. This slide shows population growth projections at 1, 2, 3, and 4%. StatsCanada census data indicate that the population growth rate for urban subdivisions in the Grassland Natural Region ranges from 2.8-3.5%. If the regional population grows at a rate of 3%, there will be 25 million people living in the region in 90 years time. Similar growth patterns are found in comparable areas within North America. If the growth rate were to drop to 2.5%, there would be 13 million people in the region in 80 years. That is 8 times as many people as are in the region today. These people will have to live somewhere, so communities will need to expand and the number of acreages will continue to grow – resulting in increased competition with agriculture. Assuming these growth projections, the model can tell us how much natural gas the expanded population will need, how much water will be consumed, what road networks will be needed for transportation, etc.

Slide 53 Urban Expansion and Acreage Development While urban centers are expanding at a rate of 1-2% on an annual basis, country residential development is expanding at a rate of about 4% annually. The implications of acreage development on the landscape will be tremendous if these trends are maintained into the future.

Slide 54 Human Settlement Footprint Communities have two ways of expanding, either by growing up or by growing out. They usually do both. In the Grassland Natural Region urban communities tend to grow outward. Currently, about 92,000 ha of land is taken up in settlements. In this slide city grow rates are projected at 0, 1.5, and 3%. We can anticipate far greater land areas being occupied by human settlements in the future, whether they are towns, cities, or acreages.

Slides 55 through 60 Lethbridge The growth rate of the three major communities in the region, Lethbridge, Medicine Hat and Calgary, can be shown through time sequenced aerial photographs. The area figures given are in square miles and are accurate to about 10%. In 1950, Lethbridge was 3 square miles in size.

In 1961, it grew to 6 square miles.

In 1974, to 9 square miles.

In 1985, the city expanded to 12 square miles.

In 1991, to 15 square miles.

In 1999 to approximately 20 square miles.

Slide 61 A Time Series of Lethbridge Lethbridge is now 7 times bigger than it was 50 years ago.

Slide 62 through 68 Medicine Hat Medicine Hat covered an area of 5 square miles in 1949.

In 1962, it grew to 7.5 square miles.

In 1974 to 10 square miles.

In 1980, to 12 square miles.

In 1985, to 17.5 square miles.

In 1991, to 9 square miles.

In 1998, to 20 square miles.

Slide 69 A Time Series of Medicine Hat Medicine Hat has doubled in size twice during the last 50 years.

Slide 70 through 76 Calgary Calgary covered an area of 7 square miles in 1924.

15 square miles in 1949.

30 square miles in 1957.

55 square miles in 1969.

80 square miles in 1976.

135 square miles in 1989.

154 square miles in 1998.

Slide 77 A Time Series of Calgary The growth of the city of Calgary has been spectacular over the last 75 year period.

Slide 78 Transportation Let's examine the transportation infrastructure in the region.

Slide 79 Road Network The road network in the Grassland Natural Region ranges from small trails (leading to well sites) to major highways. These roads form an extensive grid throughout the region.

Slide 80 Major Highways This slide shows the major highways and numbered secondary roads in the Grassland Natural Region (based on 1985 data). These roads are 1200 km in length and cover approximately 5900 ha.

Slide 81 Minor Roads There are more than 30,000 km of minor roads in the Grassland Natural Region. This figure is based on old data and significantly under-estimates the actual number of minor roads in the region.

Slide 82 Main Rail Lines The main railroad system in the Grassland Natural Region is about 2,500 km in length. Spur lines have not been included in this figure.

Slide 83 Protected Areas Network Recreational demands will increase as the human population increases. Where will all the additional people go to recreate? Many like to visit our parks. Are we going to intensify recreational use within the existing parks system or will new parks be needed to accommodate a growing population? Where would new parks be located? If new parks are established in the region, they will have to displace something else that is already occurring at the chosen location.

Slide 84 Agriculture The next slides will deal with agricultural production in the Grassland Natural Region.

Slide 85 A Diversity of Crop Types There are many different types of crops grown in the region, too numerous to list here.

Slide 86 Density of Crop Types Crop varieties are not uniformly distributed across the Grassland Natural Region. Climate, land productivity, land values, the availability of water and other factors influence where crops are grown and in what densities. These images show varying crop type densities in the Oldman River Basin which encompasses a portion of the south west part of the Grassland Natural Region.

Slides 87 and 88 Area in Agricultural Crop Types The amount of area within the agricultural land base devoted to specific crop types will fluctuate depending on commodity prices, technology, and other factors.

Slide 89 Number of Farms Looking at Alberta wide data, the total number of farms on the landscape has declined over the last three decades. There has been a radical shift in the number of people living on farms as a result of rural economic and social factors. More people are living in urban centres. As a result, the percentage of people that live on farms has declined significantly. Perhaps it has bottomed out, or perhaps it may still continue to drop even further.

Slide 90 Average Size of Farms Again, on an Alberta wide basis the average size of farms has increased significantly. Large farms, it is argued, are necessary to achieve the 'economies of scale' which make farming financially viable. A large land base is needed because of the high cost of capital investments in new technology and farm equipment which are required today. Intensive utilization of farmland has also become common place.

Slide 91 Land Fragmentation Land fragmentation occurs when large, intact land units are broken into smaller parcels as a result of land subdivision, accommodating different land uses, and bisecting intact areas with linear corridors (e.g., roads, irrigation canals). Land fragmentation poses serious problems for various plant and animal species and undermines ecosystem integrity and function.

Slide 92 Cattle Population in Alberta Cattle production continues to grow in southern Alberta. A growing cattle population requires greater quantities of cattle feed (i.e., land dedicated to cattle production). Increased amounts of animal waste material need to managed and disposed of, but where and how?

Slide 93 Pig Population in Alberta The swine population has fluctuated, and is currently in a leveling-off trend. The same issues associated with cattle production on a finite land base also affect hog production.

Slide 94 Horse Population in Alberta This graph clearly shows the shift from horse powered farming to mechanized farming. Horse production seems to be increasing in recent years to accommodate leisure time and recreational activities that involve horses.

Slide 95 1991 Livestock Density in Southern Alberta This graph shows the density of livestock in different rural municipalities in southern Alberta. It accounts for livestock in confinement operations and open pasture operations.

Slide 96 Pasture Fed Livestock Cattle are predominantly bred and raised in open-range situations.

Slide 97 Livestock Feeding Facilities Market-destined cattle are finish fed in confined feeding operations (CFOs) which vary greatly in size. CFOs occupy about 3,000 hectares of land in the Grassland Natural Region.

Slide 98 Livestock Feeding Facility Locations in the Oldman River Drainage CFOs are not uniformly distributed across the landscape. As this slide of the Oldman River Drainage Basin shows, they are clumped in their distribution, concentrated within an area around Lethbridge, sometimes referred to as 'feedlot alley'.

Slide 99 Cattle on Pasture and Feedlots This is a very conservative projection of how cattle population might grow over the next several decades. It shows that in about 50 years the number of beef cattle in feedlots may well exceed the number of cattle on pasture lands. Pasture/rangelands will initially increase and then be reduced as these lands are taken over by other competitive land uses. If we grow feedlots at a rate of 2% for 5 decades, there will be a significant increase in the number of cattle in the region.

Slide 100 Annual Livestock Wet Waste We can calculate, based on existing data, the average manure rates for an animal unit. Pigs generate a lot of wet waste per metabolic kilogram when compared to cattle. This graph shows the total number of metric tons of wet animal waste that may be generated in the future and which will need to be dealt with.

Slide 101 Livestock Waste Nutrient Production We can also calculate the nutrient composition of animal waste. It doesn't matter if our assumptions are off by 10-15% because the issue the model is trying to help us understand is that we can expect more manure on the landscape, which means more nutrients will need to be absorbed by the landscape in the future.

Slide 102 Nitrogen Production, Requirement and Surplus We can estimate future nitrogen requirements. If our assumptions are correct, we will see a gradual reduction in the total amount of nitrogen that is required by the system in the future. The reason for this reduction is that the total amount of land in agricultural production will decrease in the future. While we are moving towards more intensive cropping practices, there will be less cropland available. Meanwhile the production of nitrogen rises as feedlot wet waste grows and the stockpile of nitrogen will also grow (the model calculates and apportions that amount of nitrogen which can be cost-effectively redistributed in the landscape). Note that even if all the nitrogen produced by livestock could be cost effectively distributed anywhere on the landscape, we would still have a huge nitrogen deficit, even as the productive agricultural land base declines. This is because our cropping systems demand huge amounts of fertilizer, the vast majority of which is supplied as chemically fixed nitrogen from fertilizer plants.

Slide 103 Phosphorus Production Requirements and Surplus We see the same pattern with phosphorus, although the difference between production and quantity is much tighter. If it could be cost effectively distributed, livestock wet waste could potentially meet about half of the agricultural phosphorus requirement.

Slide 104 Livestock Forage Requirements If poultry, hog, and cattle populations grow in the future, there will be an increased demand for livestock forage. Most of this forage will be consumed by cattle. Relative to where we are right now, more of the region's landscape will need to be dedicated to forage production in the future.

Slide 105 Forage Production and Requirements The question is then, where will the new forage production occur? The model, which keeps track of the amount of forage crops being grown and the average productivity of forage crops, indicates that there will be a big discrepancy between forage production and forage demand. Give the model's projections for various land uses in the region in the future, land will not exist for additional forage production. This will necessitate that forage be imported to meet the regional demand of ranchers, farmers, and ILOs, all of which will have insufficient forage to maintain their cattle herds.

Slide 106 Incremental Loss of Agricultural Land base If we start to simulate how the landscape will change in the future to accommodate an expanded transportation network, more energy development, and the growth of human settlements, the model informs us that we will lose about 20% of our agricultural lands over the next century. This will occur because other sectors are expanding and making their presence known on the finite land base. The agricultural land base will decline unless agriculture expands onto the remaining native prairie within the Grassland Natural Region.

Slide 107 Native Grassland Communities How much native prairie do we have left? Where is it found? What's happening to it? What is it likely to happen to it in the future?

Slide 108 Remaining Native Prairie This map of the Grassland Natural Region shows quarter section land parcels where at least 75% of the quarter contains native prairie. We still have a lot of native prairie left in the Grassland Natural Region. About half of what was once there is now gone.

Slide 109 Projected Native Grassland Loss If we factor in future land deletions caused by the expansion of settlements, energy development, agricultural production and transportation networks, we will see a gradual reduction in native prairie through time.

Slide 110 Hypothetical Native Grassland Loss to Expansion of Agriculture If we took existing agricultural land uses and expanded them by very small percentages, these are the losses of native grassland to agriculture that we could expect to see in the future.

Slide 111 Remaining Native Grassland near Lethbridge This loss of native prairie happens in many different ways, not just through the expansion of the agriculture or energy sectors. This map shows the southern portion of the City of Lethbridge. Quarter section land parcels have been shaded different colors to indicate the percentage of native prairie that remains on each quarter. Expanding communities tend to be indiscriminate when annexing adjoining lands to accommodate urban growth.

Slide 112 Where is Agriculture Headed? Alberta Agriculture, Food and Rural Development has stated that a departmental goal is to increase primary production and secondary processing within the agricultural sector in the province. This could well occur through the use of improved technology, more intensive use of the land base, a reliance on forage imports, and through the expansion of crop production onto native prairie.

Slide 113 The Energy Sector An active energy sector is associated with extensive seismic operations and drilling programs, leading to the placement of roads, well sites, batteries, compressor stations, pipelines, flare pits, etc.

Slide 114 Wellsites Numerous well sites currently dot the landscape. More are anticipated in the future.

Slide 115 Well Site Locations There are currently about 15,000 wells in the region. This figure includes wells that are producing and those which are inactive.

Slide 116 Oil Pipelines Pipelines bring raw oil and gas to collecting sites. Pipelines also convey refined products to different markets.

Slide 117 Pipelines About 10,000 km of pipelines exist in the Grassland Natural Region covering upwards of 18,000 hectares. Pipelines are not uniformly distributed. The current pipeline delivery system will need to undergo expansion in the future as the energy sector continues to grow. Current pipeline densities may well perpetuate themselves throughout the whole Grassland Natural Region as high value petroleum products encourages successive waves of hydro-carbon exploration and development.

Slide 118 Gas and Oil Processing Plants Processing plants and refineries will need to grow with a growing industry.

Slide 119 Seismic Lines There are 65,000 hectares and 82,000 km of 'edge effects' due to seismic activity in the region. Most areas disturbed by seismic activity recover relatively quickly. Although these areas quickly 'grow in', it takes some time for disturbed areas to achieve the same plant composition as is found in the surrounding vegetation community.

Slide 120 History of the Energy Sector What has the energy sector achieved to date and where is it going?

Slide 121 The Energy Sector, A Historical Approach This graph shows the number of new wells within the Grassland Natural Region at 5-year intervals. The Alberta Energy and Utilities Board (AEUB) expects that this trend will continue in the future.

Slide 122 Production History Remaining proven reserves of oil and gas are being extracted and known deposits will eventually be depleted. There are, however, abundant coal deposits in the Grassland Natural Region that have yet to be developed.

Slide 123 Annual Energy Sector Footprint The energy sector footprint has been increasing at a rate of about 9,000 hectares per year in the Grassland Natural Region. This trend will reach a peak and then gradually fall off as conventional oil and gas deposits become depleted.

Slide 124 Projected Energy Sector Footprint Based on AEUB data, this slide shows what area of the Grassland Natural Region will be occupied by well sites, pipelines, and seismic lines in the future. This projection is based on current commodity prices and the fact that significant hydrocarbon resources were not exploited in the past because it was not cost-effective to do so. This slide indicates that a second major phase in exploration and extraction will occur as companies locate and recover pools that were overlooked in an earlier phase or which can now be accessed with improved technology.

It is important to note that seismic lines are a short-lived disturbance, that well sites have a life-span, and that reclamation programs can be undertaken which re-vegetate pipeline Rights of Way to former native prairie conditions.

Slide 125 Remaining Proven Reserves A downward trend on remaining, proven reserves of crude oil and gas seems apparent based on AEUB data.

Slide 126 Estimated Depletion There are finite hydro-carbon reserves under ground, whether they are in the form of conventional oil, oil sands resources, or natural gas. Provincial reserves of conventional oil could be depleted as early as 2010 according to some estimates. That date is subject to change based on new resource discoveries and based on commodity prices. Natural gas and conventional oil resources will be eventually be exhausted if our society continues to rely heavily on hydro-carbons to satisfy its energy needs. Oil sand hydro-carbons will be depleted as well, but over a much longer period of time.

Slide 127 Sheerness Coal Mine Abundant coal resources underlie large areas of the province, including the Grassland Natural Region. These have been minimally exploited to date.

Slide 128 Possible Mitigative Solutions for the Energy Sector The ALCES model helps us identify land use issues, but we don't want to stop there. We now want to look at some of the mitigation solutions that could be implemented. For the energy sector, solutions to minimizing the industry's footprint on the landscape includes the following:

Multiple well sites on one drilling pad;

Rapid reclamation of non-producing wells;

Minimal right-of-ways for pipelines;

Reduction in seismic line width;

Re-vegetation of linear features to native flora; and

Maximizing the spatial overlap of features through use of dedicated utility corridors.

Slide 129 Effect of Concentrating Wells on Well Pads This slide shows the total area taken up by well sites through the next hundred years if we have one, two, three, or four well sites per drilling pad. By consolidating well sites in this manner, at the point of greatest area coverage (in about 40 years), 1/3 of the total area of well sites disappears. That would also equate to a 1/3 reduction in the total amount of well site access roads.

Slide 130 Now Reduce Pipelines from 20-10 m By reducing pipeline Right of Way disturbance from a 20 meter width to a 10 meter width, another significant reduction in this land use occurs. This has the effect of incrementally reducing opportunity costs, and from an environmental standpoint, it means doing business differently.

Slide 131 Wildlife Habitat Quantity and Quality What lies in the future with respect to wildlife habitat?

Slide 132 Anthropogenic Edge If we look at the total amount of anthropogenic edge in km/km^2 we can anticipate about 3.6 km of anthropogenic edge per km^2 of development in the energy and transportation sectors in about 35 years time. This is due to the growth trajectories that are being forecast for these sectors. The anthropogenic edge is much more short-lived in the prairies than in Alberta's boreal forests because grassland disturbances have a quicker recovery time in moving to a herbaceous state.

Slide 133 Projected Pronghorn Habitat Availability An attempt was made to anticipate how transforming landscapes will affect wildlife. A few wildlife species, which may be sensitive to transformed landscapes, were selected to determine how they might respond to altered landscapes and to try to project a species habitat availability and habitat quality through time. In this scenario, ALCES is informed which landscape types the pronghorn antelope uses and which it doesn't. Pronghorns live in about 40% of the landscape. The availability of pronghorn habitat is going to decline in the future as grassland habitats used by pronghorns will be converted to other uses. If pronghorn do not adapt to well sites and acreages, then the total available habitat for this species will decrease.

Slide 134 Projected Pronghorn Habitat Quality When we weigh anthropogenic edge as an undesirable feature for pronghorn, the quality of pronghorn habitat will decreases in the future. What this means is that the future grassland landscape will be less and less useful to pronghorn both in terms of habitat availability and quality.

Slide 135 Projected Pronghorn Habitat Value If the assumptions on which ALCES operates are correct, the model suggests that the pronghorns future will be less desirable than is the case today under present conditions.

The same analysis can be completed for other wildlife species. Where are they found? What elements on the landscape constitute their unique habitat? What is their response to landscape change?

Slide 136 Grassland Natural Region Targets and Thresholds This leads us to ALCES's threshold panel. It isn't feasible to consider a vast array of land use options and potential land use scenarios so a subset was designed for the Grassland Natural Region. As well, based on discussions with professional staff, the following attributes were selected and given significant weight in the model:

Minimum amount of remaining native prairie;

Minimum amount of riparian habitat;

Maximum amount of feedlot manure that can be applied to agricultural lands;

Net change in the agricultural land base;

Percentage of total amount of water in the main stem of rivers that has been allocated to land uses; and

Anthropogenic edge.

Using a stakeholder process, targets and thresholds were set for these key attributes. The target level can then be simulated through time to determine what percentage of changes it produces and what percentage of years we are successful in hitting the targets and thresholds. If a threshold is violated, we can then identify what land use practices should occur without violating the threshold. This slide shows an example of what was considered in the model to help people understand tradeoffs and their consequences.

<u>Slide 137 take Home Messages</u> Native prairie has been significantly reduced, and natural disturbance regimes (fire, flooding, bison, aboriginal peoples) have been significantly altered.

Agricultural land use practices now dominate the landscape and are increasing in intensity (intensive livestock operations, high yielding agricultural crops).

Intensive agriculture has lead to increasing dependency on irrigation water, pesticides, and genetically improved plants.

Remnant native prairie systems are threatened over the long term as society places greater emphasis on intensive agriculture and urban expansion.

Increasing surface runoff of livestock waste, herbicides, and fertilizer are likely.

As the regional human population increases, so do the demands on the landscape for recreational opportunities.

Species sensitive to linear disturbances face an uncertain future.

<u>Slide 138 Meeting the Challenge</u> The landbase is finite in size, yet numerous land uses are increasing in size and intensity (e.g., agriculture, forestry, settlements, energy sector, roads, commercial and non-commercial recreation).

Society must become engaged in discussions dealing with “meaningful” space and “meaningful” time. Not all land uses can be accommodated on a finite land base. Tough decisions lie ahead of us.

Important questions are: What is society’s collective vision for the future landscape? Can that vision be achieved with our current approach to land use management?

<u>Slide 139 ‘Ad Hoc’ Approach</u> An ‘ad hoc’, un-coordinated approach, wherein each sector makes land use decisions and resolves land use problems in an independent manner, has proven itself over the years to be ineffective in solving land use issues.

<u>Slide 140 An Integrated and Planned Future Landscape</u> What is needed is an integrated and holistic approach to addressing future land issues.

<u>Slide 141 The End</u> As we enter a new millennium, southern Alberta still has significant native prairie landscapes which provide native flora and fauna, ecological services such as clean air, clean water and carbon storage, and a variety of outdoor recreational opportunities. But the twenty- first century is going to place even greater demands on the Grasslands Natural Region than the twentieth century did. Balancing human consumptive demands to conserve some measure of environmental quality will require considerable ingenuity, foresight and trade-offs. Whatever environmental quality we bequeath to future generations will reflect the extent to which our social and institutional systems can rise to this extraordinary challenge.