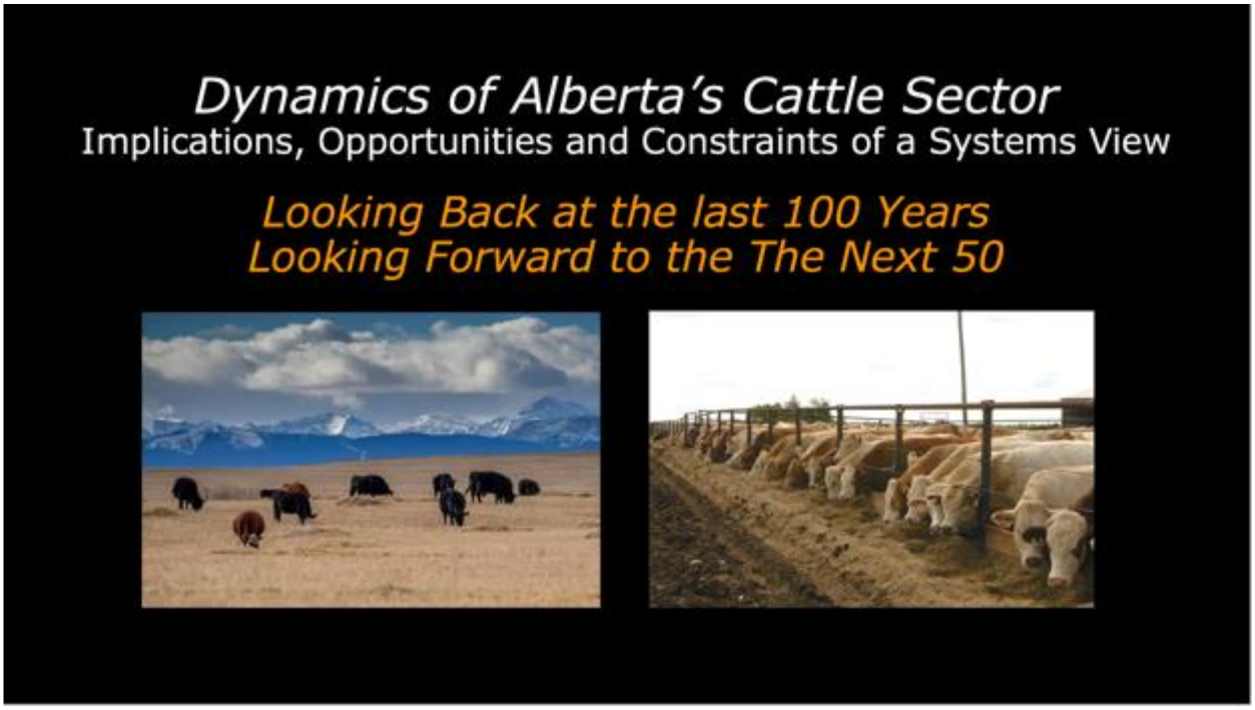

Prepared as a summary to accompany
the Alberta Livestock Alces Online (ALAO) simulator

Prepared for Operation Grassland Community

Prepared by the Alces Group
(www.alces.ca)

November 2016

Abstract

This project was catalyzed by Operation Grassland Community, with a focus on building a dynamic simulator that could track cattle dynamics and explore alternative cattle production strategies in Alberta against a range of economic, social, and environmental factors. This report is a written summary that accompanies the Alberta Livestock Alces Online (ALAO) simulator (www.online.alces) and powerpoint presentation (https://www.dropbox.com/s/g260qpngu0jac9l/Alces%20Online%20and%20Livestock%20Dynamics%20in%20Alberta.ppsx?dl=0).

The cattle sector has a lengthy and nostalgic history in the province of Alberta and is an important component of the larger agricultural land use sector. Currently, Alberta's livestock sector is comprised of ~5 million head, generating an average annual harvest of ~1.5 million head and 0.5 M tonne of meat (Figure 6). This level of commodity production in Alberta is associated with 4.8 million ha of pasture, much of the 8.5 M ha currently in cropland, and 32,000 ha of feedlot.

During the ~14 decades of cattle production in Alberta, temporal trends have occurred in numerous pastoral, husbandry, and genetic descriptors. Key temporal historical patterns include:

- Shift from cattle production supply chains based on mixed farming to greater spatial separation between farms producing young cattle, those that produce cattle forage, and those feedlot properties responsible for finishing cattle
- Increase in body weight, carcass weight fraction, calf survivorship, and reduction in slaughter age.
- Improved cattle genetics caused by selective breeding programs
- Increasing dependence of forage production from irrigated lands.
- Increasing levels of competition for land caused by the expansion of the energy, mining, transportation, urban and rural residential sectors.

Key issues increasingly confronting the livestock sector in Alberta include:

- Increasing competition for livestock landbase from other land use sectors
- Increasing competition for water from other sectors (domestic water demand)
- Reduced biodiversity associated with transformations of native grassland to improved pasture and irrigated lands for forage production.

Alces Online livestock simulations underscore the integrated nature of cattle cow/calf operators, the forage production systems of irrigated and non-irrigated lands, and feedlots for finishing market cattle. As the provincial cattle population has incrementally increased to upwards of 5 million head, so has the overall intensity of land uses that either directly remove livestock landbase, or indirectly reduce the feasibility of conducting livestock activities.

There is a significant signal (correlative) between the extent and intensity of cattle production, and various forms of natural capital including natural grasslands, soil organics, and biodiversity. It is also likely that the persistence of an extensive cattle landbase is responsible for conserving improved grasslands that might have otherwise been converted to other land uses.

Adverse effects of livestock production systems on natural landscapes, water quality, water quantity and biodiversity can be mitigated through adoption of best management practices. The

cattle sector must continue to assess its opportunities and risks as it continues to evolve under the specter of an increasingly discriminating marketplace and stakeholders.

Citation

This citation for this report is: Stelfox, J.B. 2016. *Dynamics of Alberta's Cattle Sector. Implications, Opportunities and Constraints of a Systems View*. Alces Landscape and Land Use Ltd.

Caveat

The information contained in this report is presented in good faith. It is by nature a synoptic overview of the key strategic processes that define cattle production in Alberta. As a synthetic, strategic-level compilation, it is not intended as a replacement of detailed tactical work that examines individual components of the "livestock" system in greater detail.

The organizations and agencies that prepared data that were entered into ALAO are not liable for any implications arising out of the usage of data for any particular purpose.

While caution and effort is practiced for data completeness, those responsible for preparing this report do not accept any responsibility for findings in the document, which are a cumulative effort of primary and secondary research resources. User discretion is recommended for the usage of the data.

Format

This report adopts a format based on a brief written narrative that accompanies the powerpoint presentation. The key deliverable of this project is the ALAO simulator, and this report contains key elements of the methods and findings of the simulator.

Distribution of the ALAO Simulator

As part of project's deliverables, the Alces Group is pleased to make the ALAO simulator available for use by organizations who wish to explore their own unique simulations involving the cattle sector in Alberta. Those wishing to do so should contact Brad Stelfox at bstelfox@alces.ca.

Project Funding

Project funding was generously provided by numerous organization (Figure 1). We appreciate the significant efforts of Kerry Grisley of OGC in securing the funding required to complete the project. Kerry also provided excellent project oversight.

Figure 1. Sources of project funding.

Historical Insight

For several variables relating to historical cattle production, it can be problematic to find published literature. The Alces Group appreciate the historical insights provided by cattle producers (Figure 2).

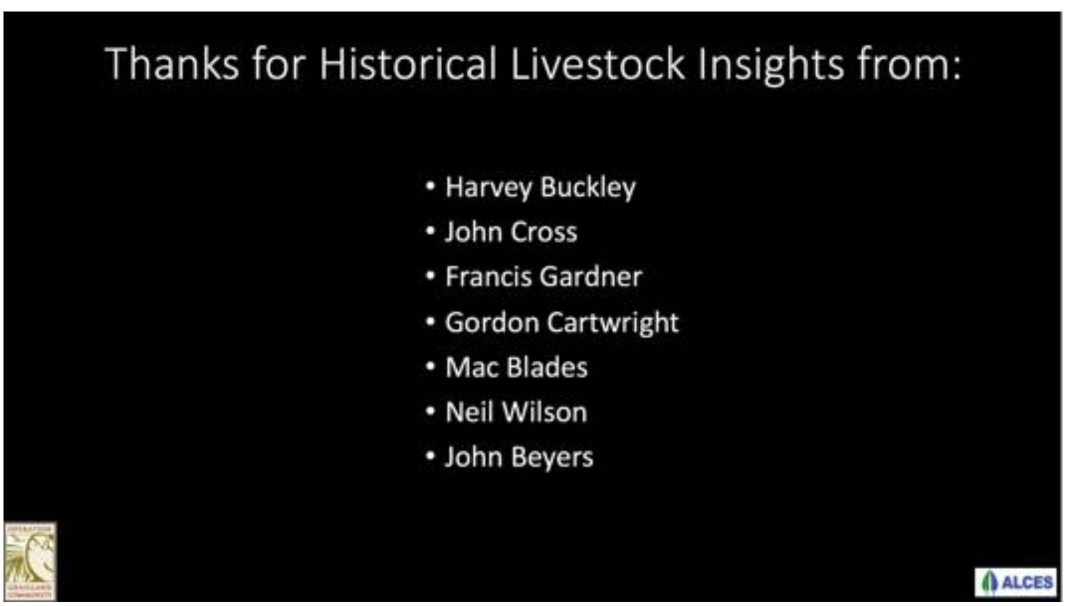

Figure 2. Alberta Ranchers who kindly provided historical insight to the cattle sector in Alberta.

Natural resource sectors are key to fueling global economies and are based on the production of crops, meat, wood fiber, minerals, and hydrocarbons (Figure 3). To maintain public license to operate, these sectors must increasingly demonstrate their commitment to triple bottom line indicators (Figure 4). This project focuses on examining some of the key strategic level drivers of cattle production in Alberta (Figure 5).

Figure 3. The key natural resource sectors.

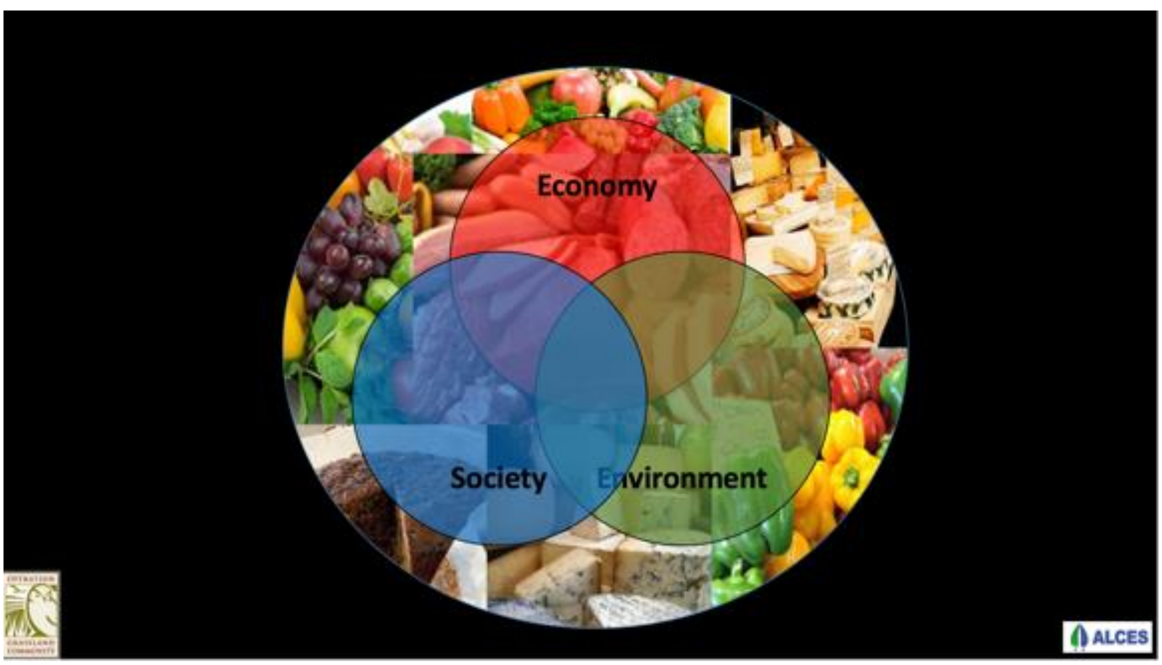

Figure 4. Triple bottom line objectives required to achieve social license.

Figure 5. The focus of this study is the cattle sector in Alberta.

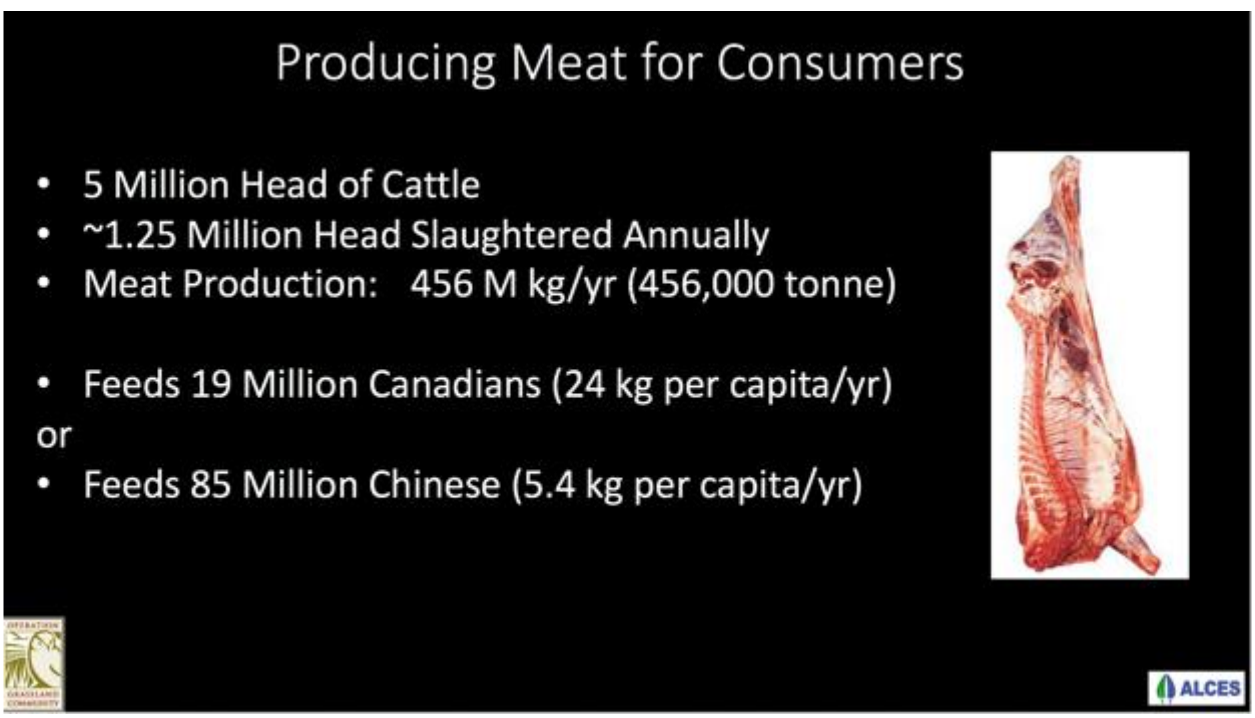

Figure 6. Key production metrics of Alberta's cattle sector.

The livestock sector is one of many land uses that have shaped Alberta's economy during the past several decades (Figure 7). Today, the livestock sector is one of many contemporary sectors (Figure 8) that interact in supply chain dynamics and compete for constrained resources of landbase and water.

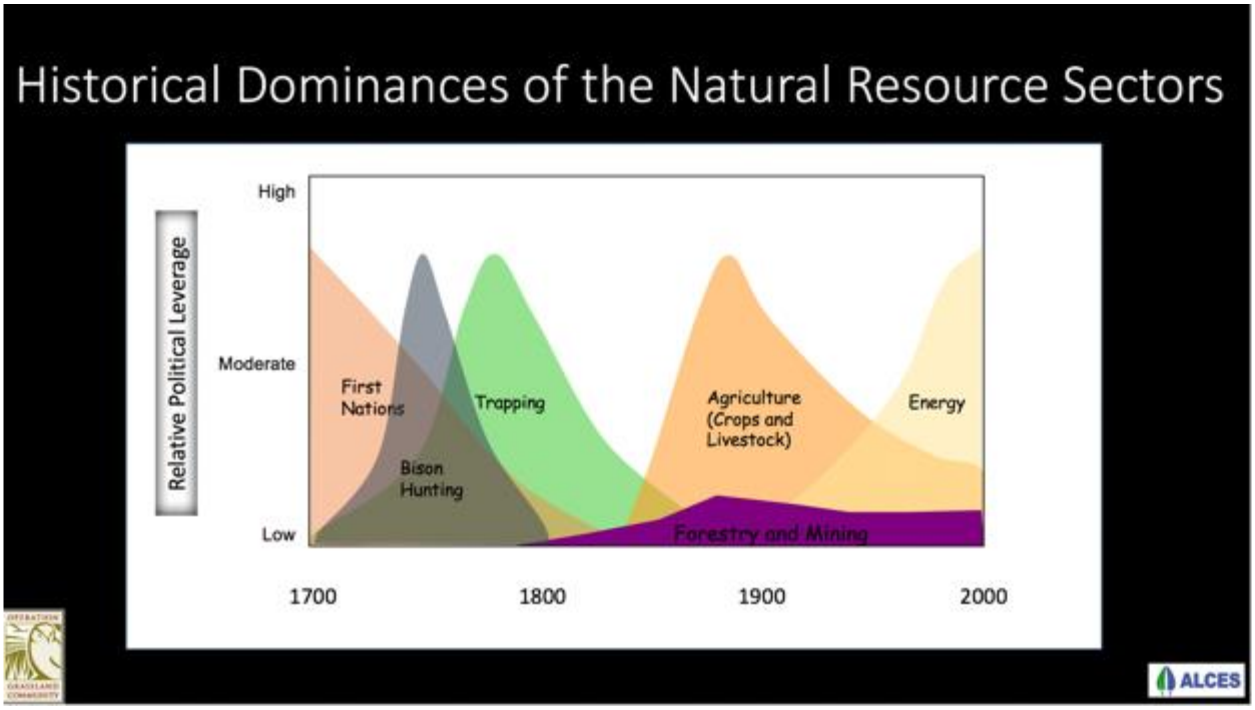

Figure 7. A graphic representation of the history of land use in Alberta.

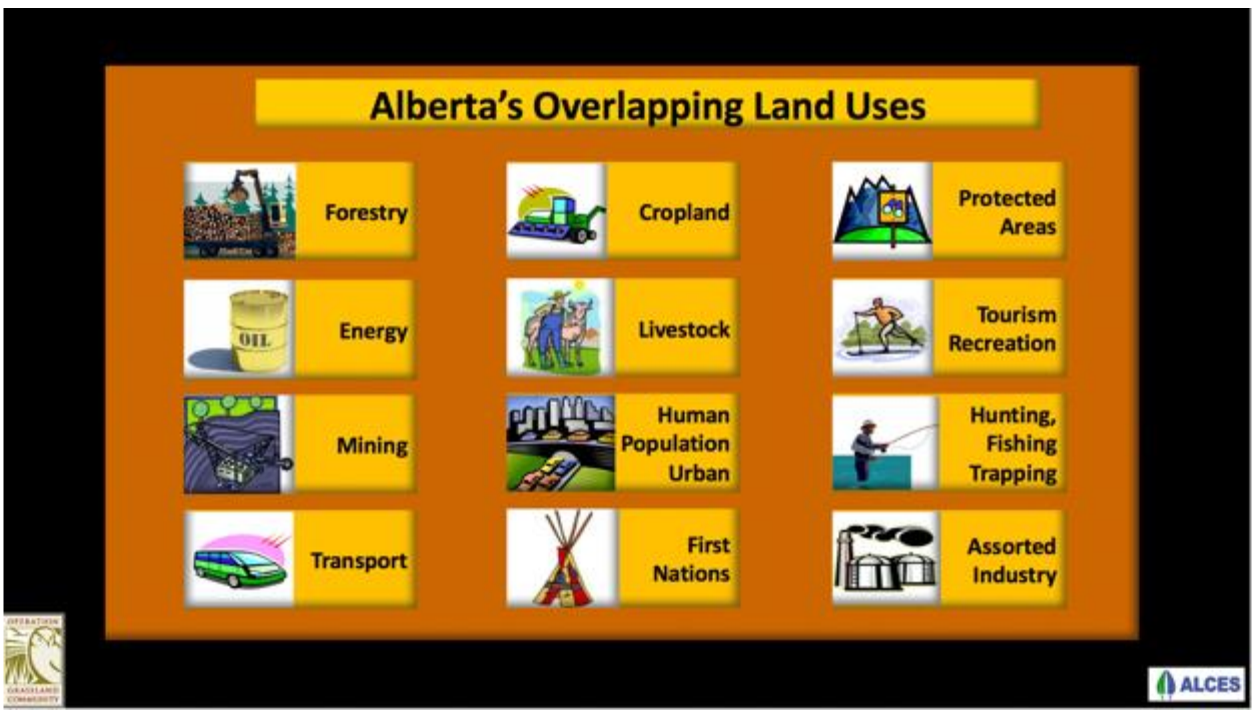

Figure 8. The overlapping land uses of Alberta.

Examples of the level of economic activity of Alberta for an average 8 hour period is illustrated below (Figure 9). The level of cattle production is compared to other key commodities in Alberta (Figure 10).

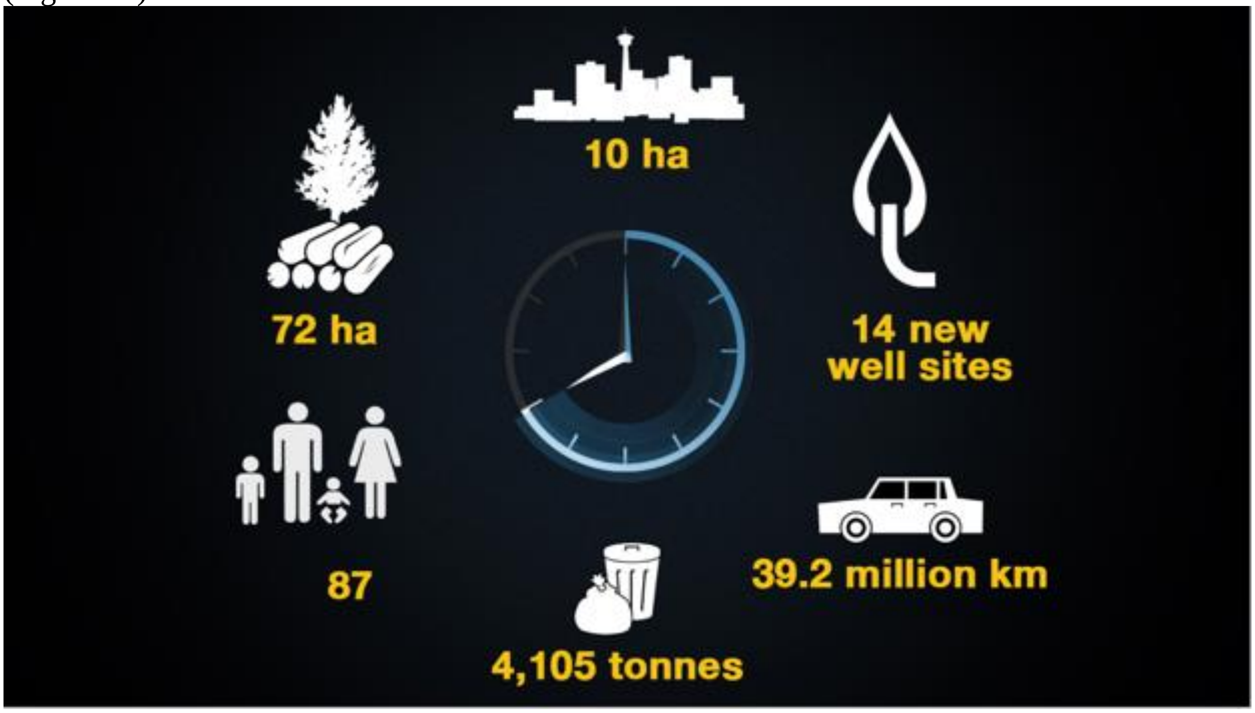

Figure 9. Average change in key land use metrics for every 8 hours in Alberta.

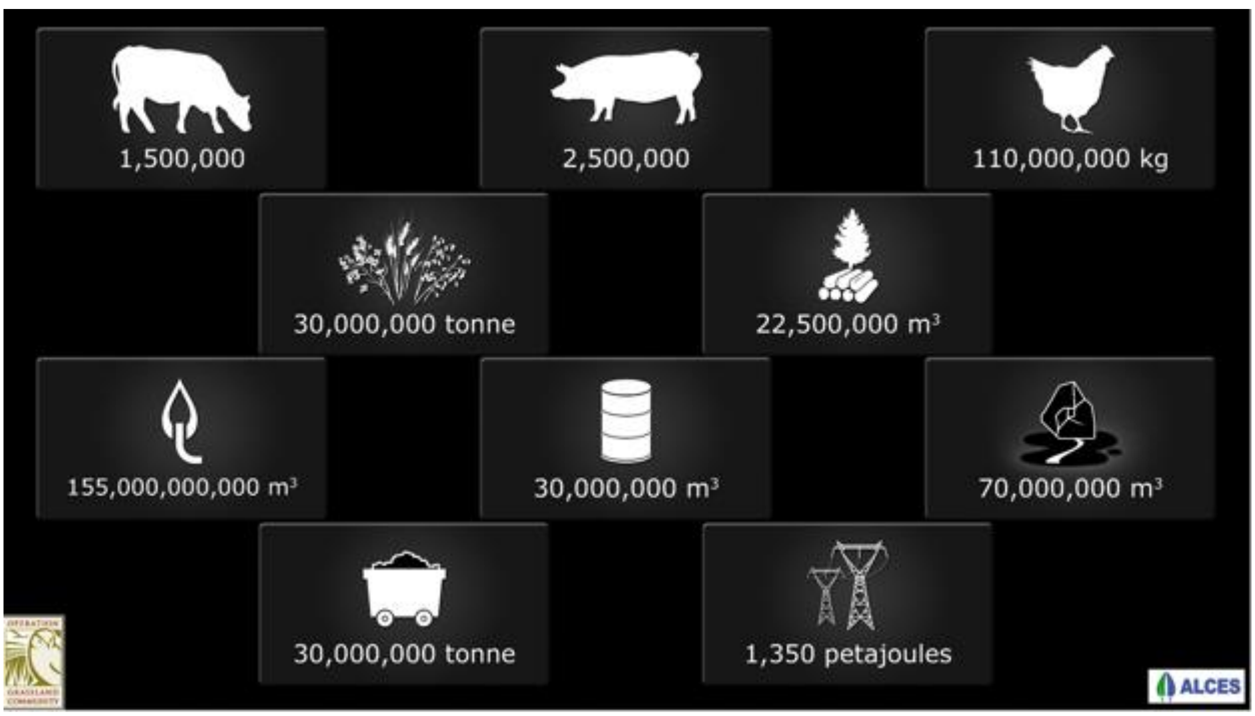

Figure 10. Average annual production values for different commodity types in Alberta.

Beef production in Alberta is related to market demand, dietary preferences (Figure 12, and cattle population size. The size of the provincial herd is also related to the area and quality of pastoral and cropland landbase (Figure 11).

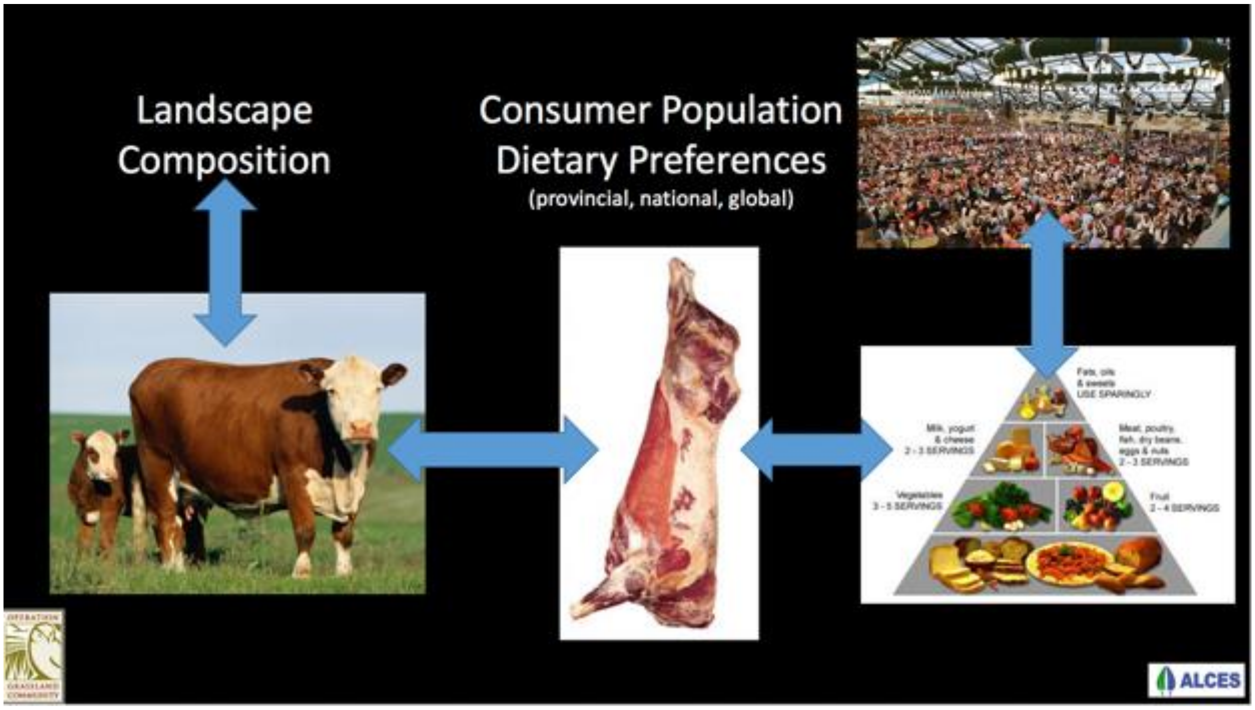

Figure 11. General model design that relates meat production to dietary preferences, market population, the size of Alberta's cattle population, and the composition of Alberta's landscape.

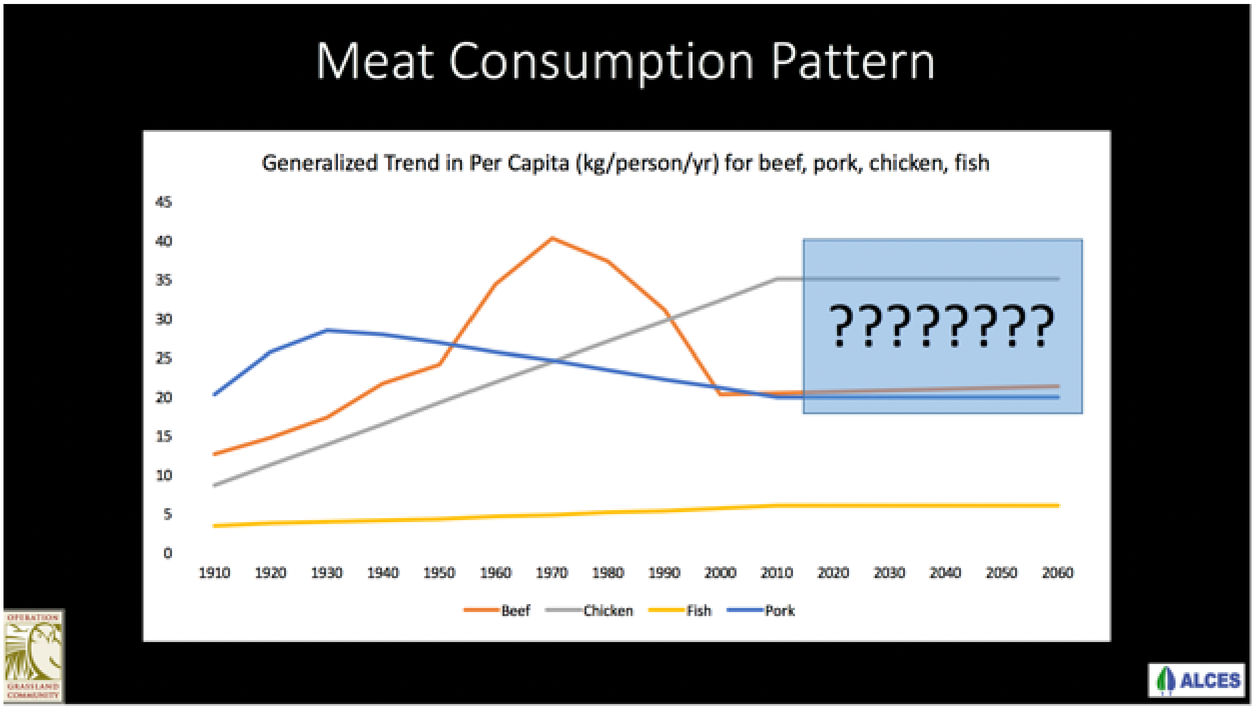

Figure 12. Historical change in per capita meat consumption by each meat type.

Key to livestock forage production is the area and quality of native prairie, improved pasture, forage croplands and cereal croplands. Each of these, in turn, are affected by area of other land uses and climate change (Figure 13). Key competitive land uses include urban sprawl, rural residential, and the landbase associated with the hydrocarbon and transportation sector (Figure 14).

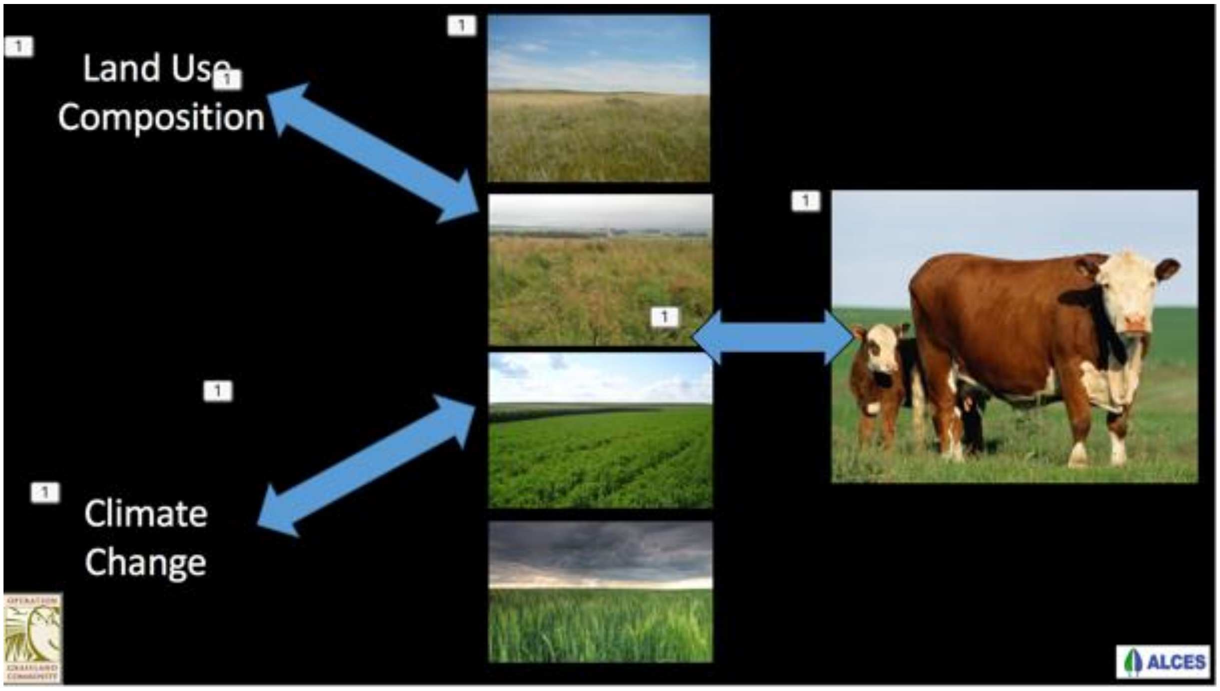

Figure 13. Key dynamics between cattle production, forage production, land use composition, and climate change.

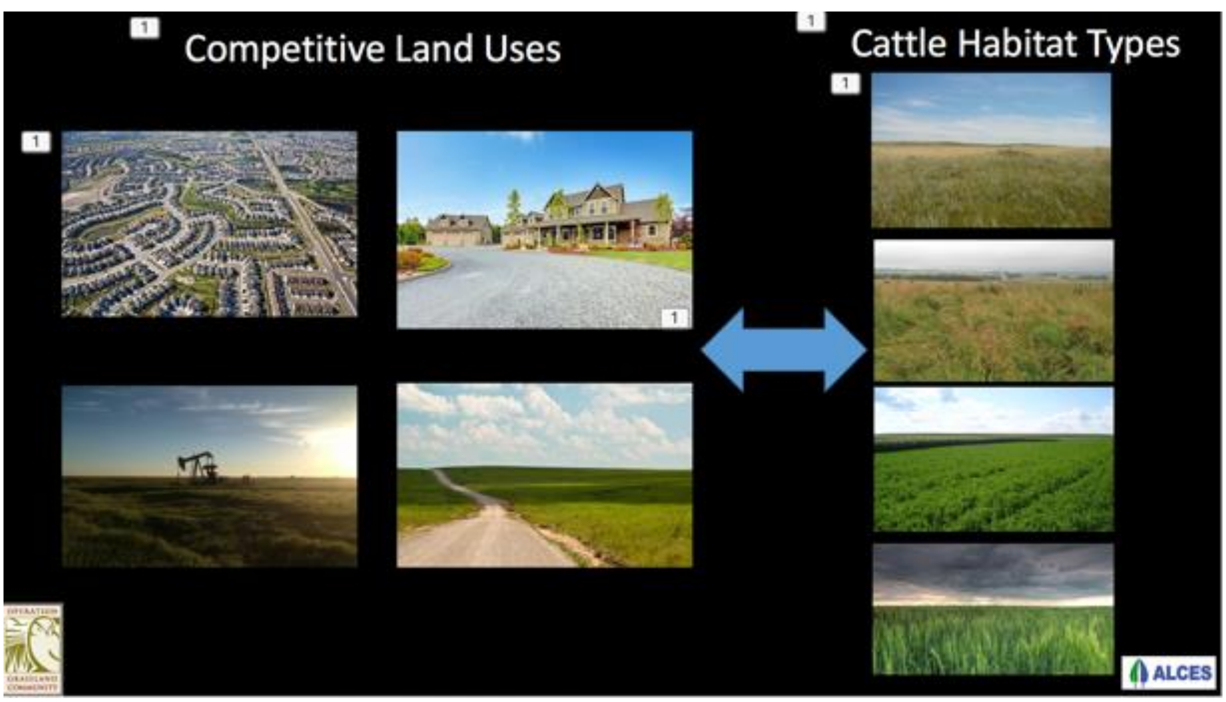

Figure 14. Expanding land uses that can reduce the area of livestock land base.

Key livestock inputs tracked in ALAO include water, forage and concentrate, whereas key outputs include methane, urine and manure (Figure 15). ALAO has been customized to allow users to explore relationships between climate change and the area and quality of plant communities (Figure 16).

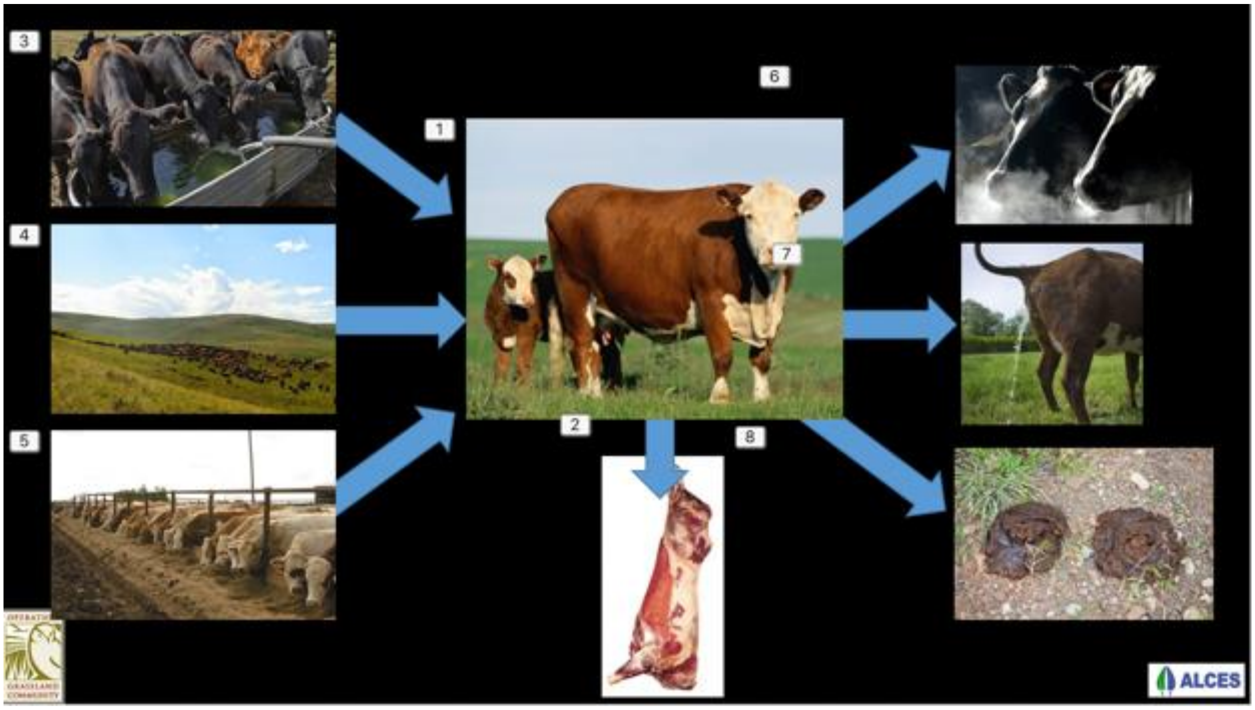

Figure 15. Key inputs and outputs for the cattle sector in Alberta.

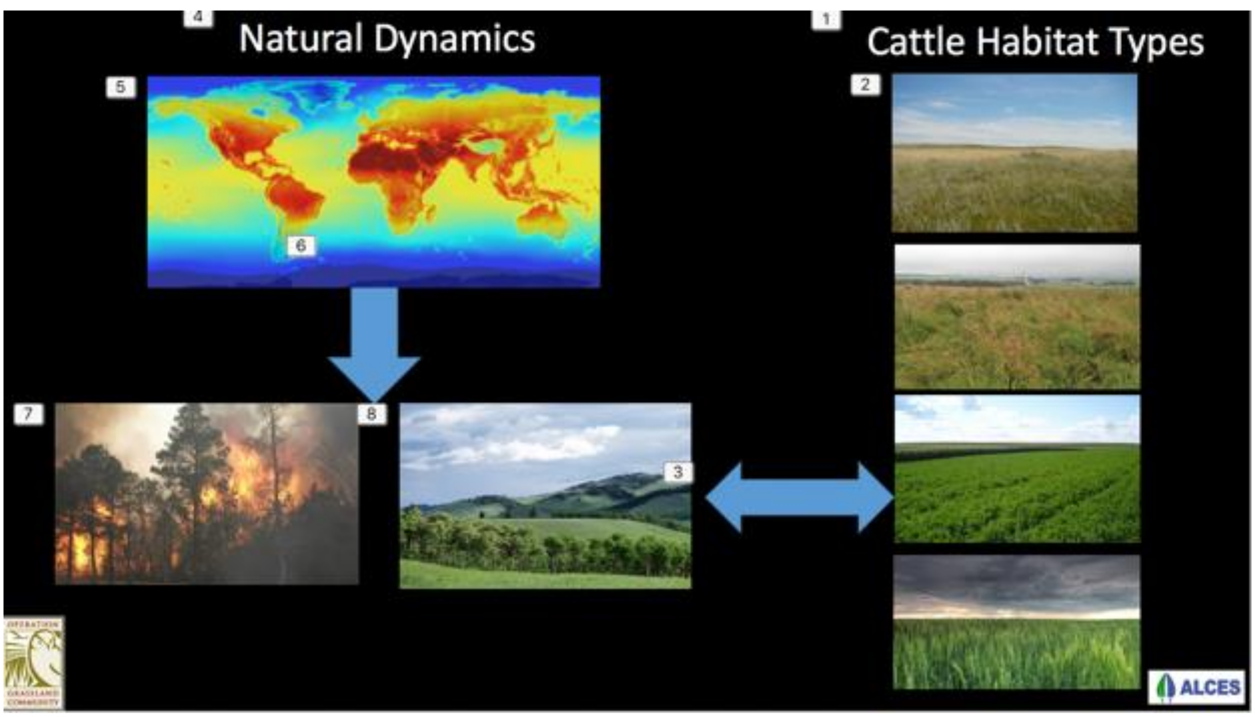

Figure 16. Using the AO simulator to explore the fire regime and forest/grassland dynamics.

Specific mechanisms in ALAO addressing climate change are shown in Figure 17 and historic changes (decadal; historical for 1980 to 2010; no future climate change) in precipitation are shown in Figure 18.

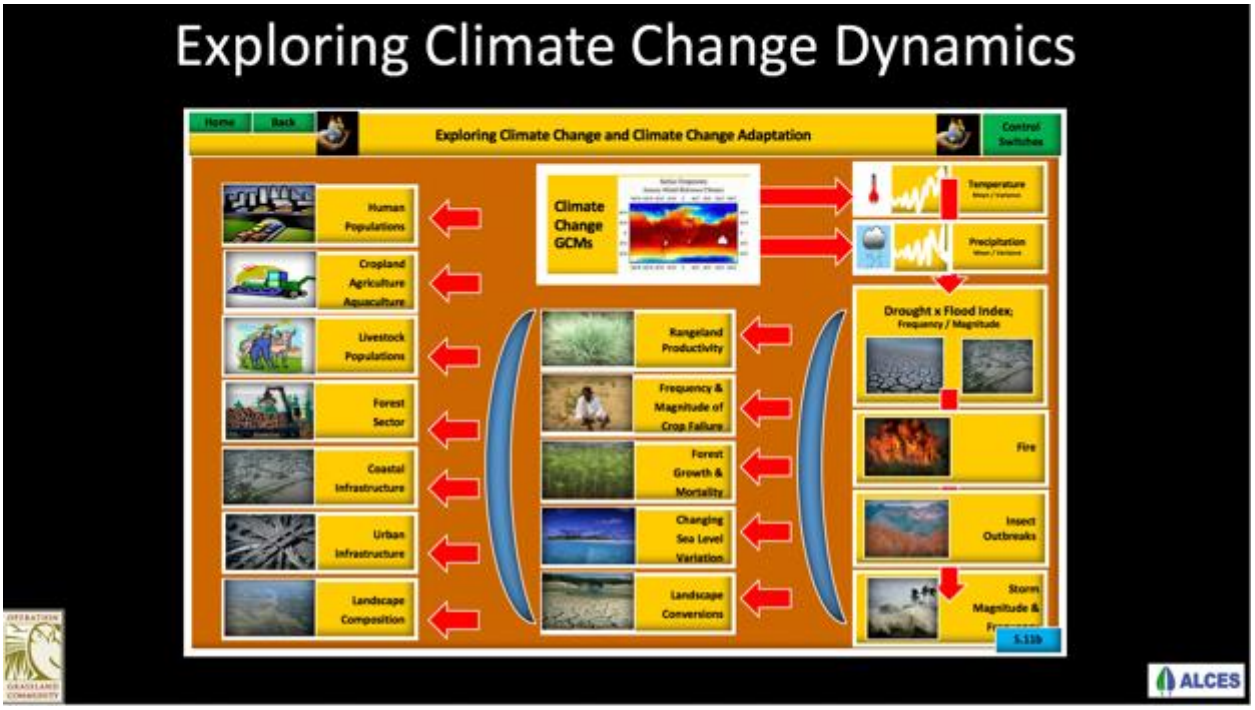

Figure 17. Key mechanisms in ALAO relating to cliamte change.

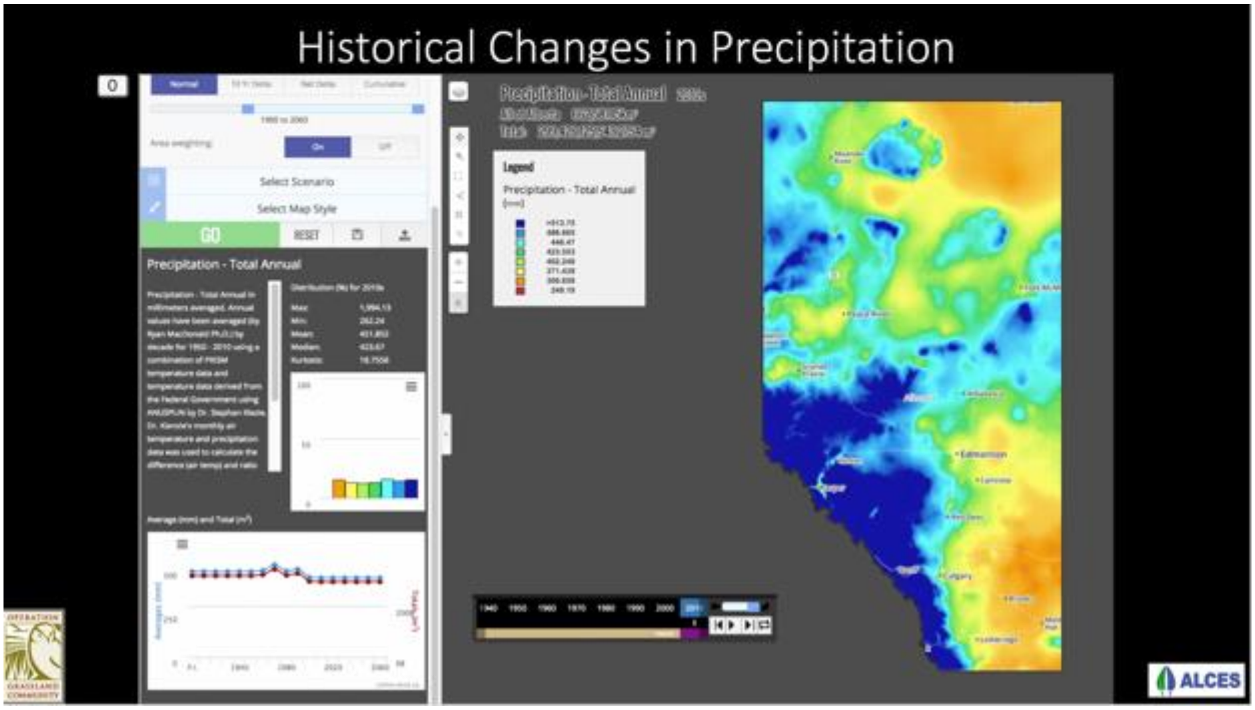

Figure 18. Decadal changes in average precipitation (1960-2010) in ALAO.

Simulated geographic changes in plant communities or cropland types is instructive to discussions on potential changes in the beef cattle supply change in Alberta.

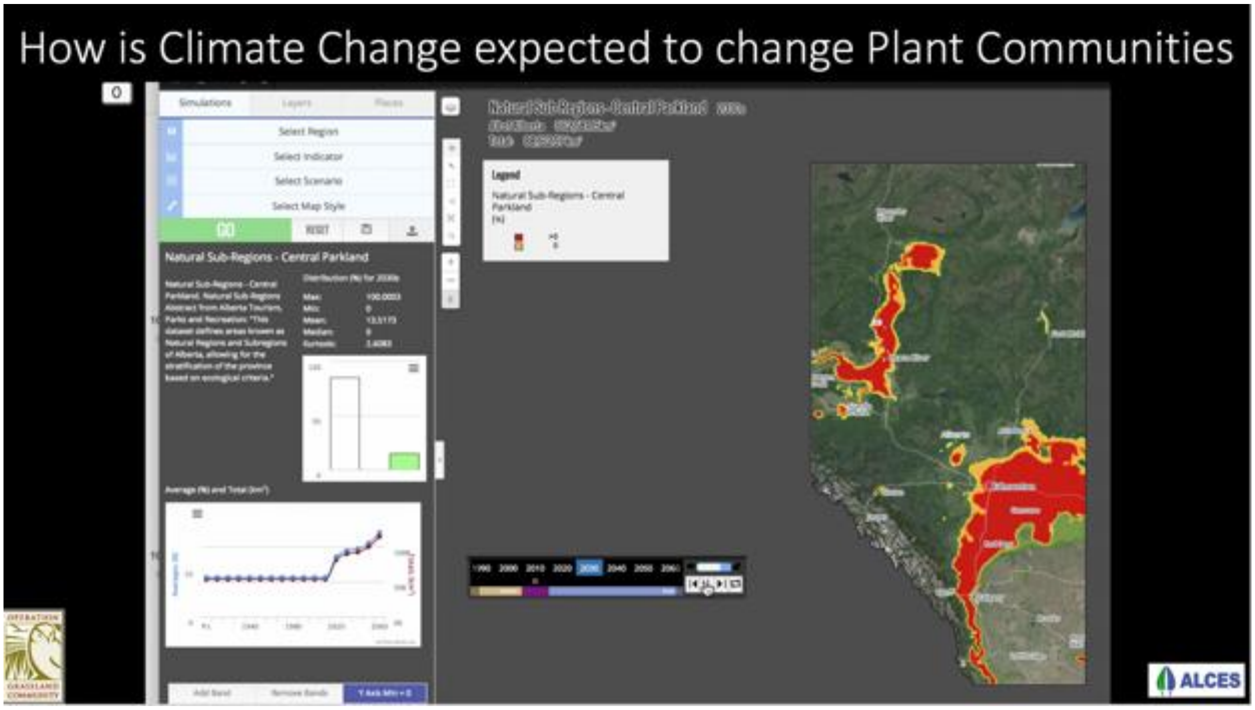

Figure 19. Example of climate change-induced change in distribution of plant communities in Alberta.

The cattle sector has experienced significant temporal trends in Alberta (Figure 20), including population (Figure 21), ration to human population (Figure 22). To date, ~150 million head of cattle have been produced in the province (Figure 23). Cumulative production trajectories incorporate temporal trends in cattle lifespan and supply chain dynamics.

Figure 20. How has Alberta's cattle sector changed (population, morphometrics, husbandry)

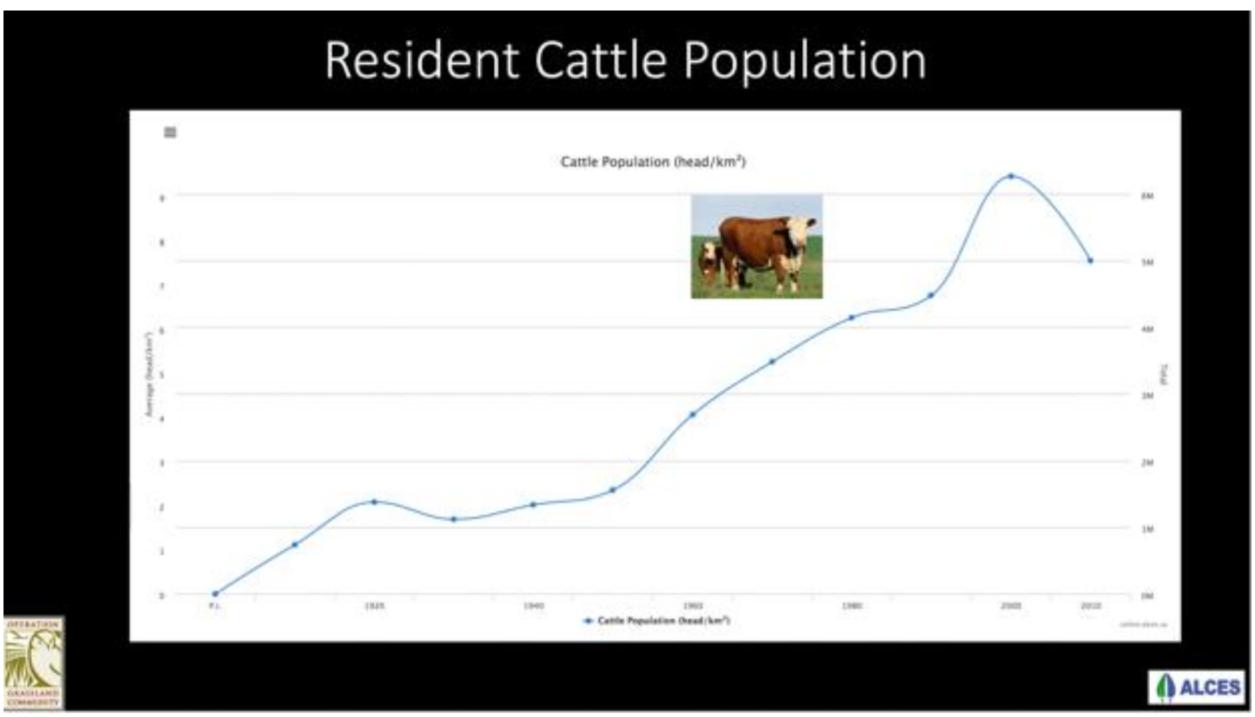

Figure 21. Historical pattern of Alberta cattle population.

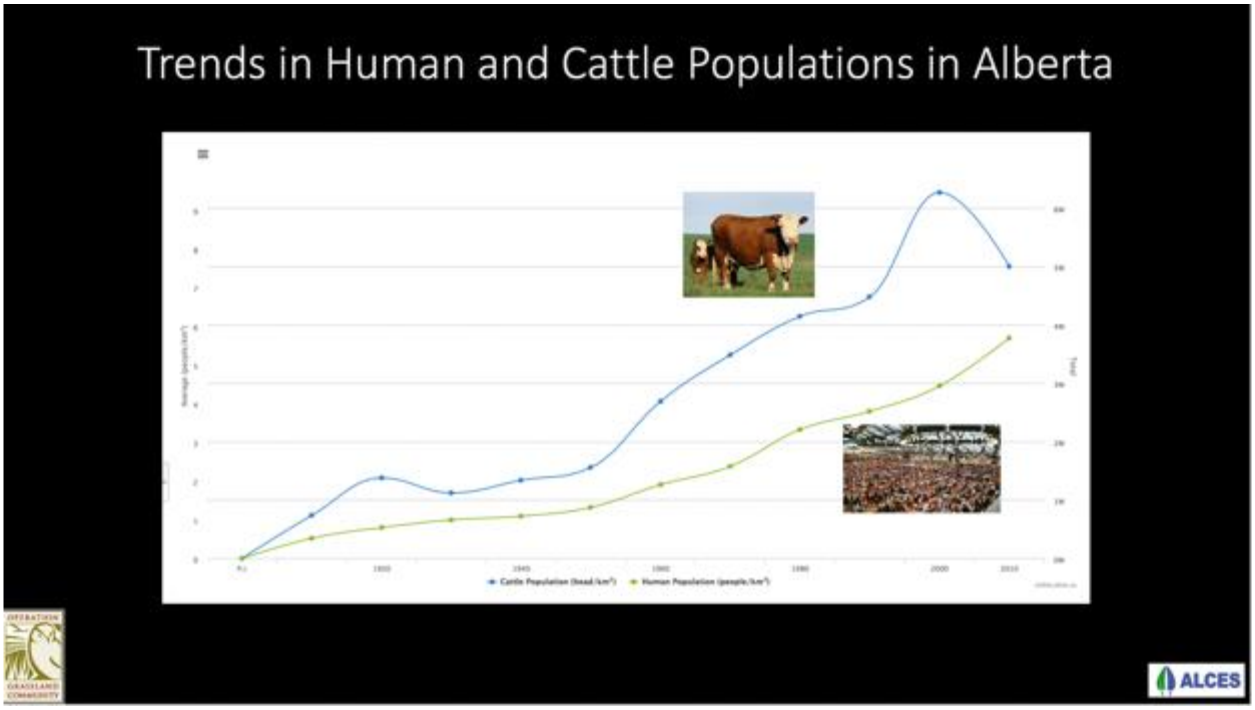

Figure 22. Histgorical pattern in Alberta's human and cattle populations.

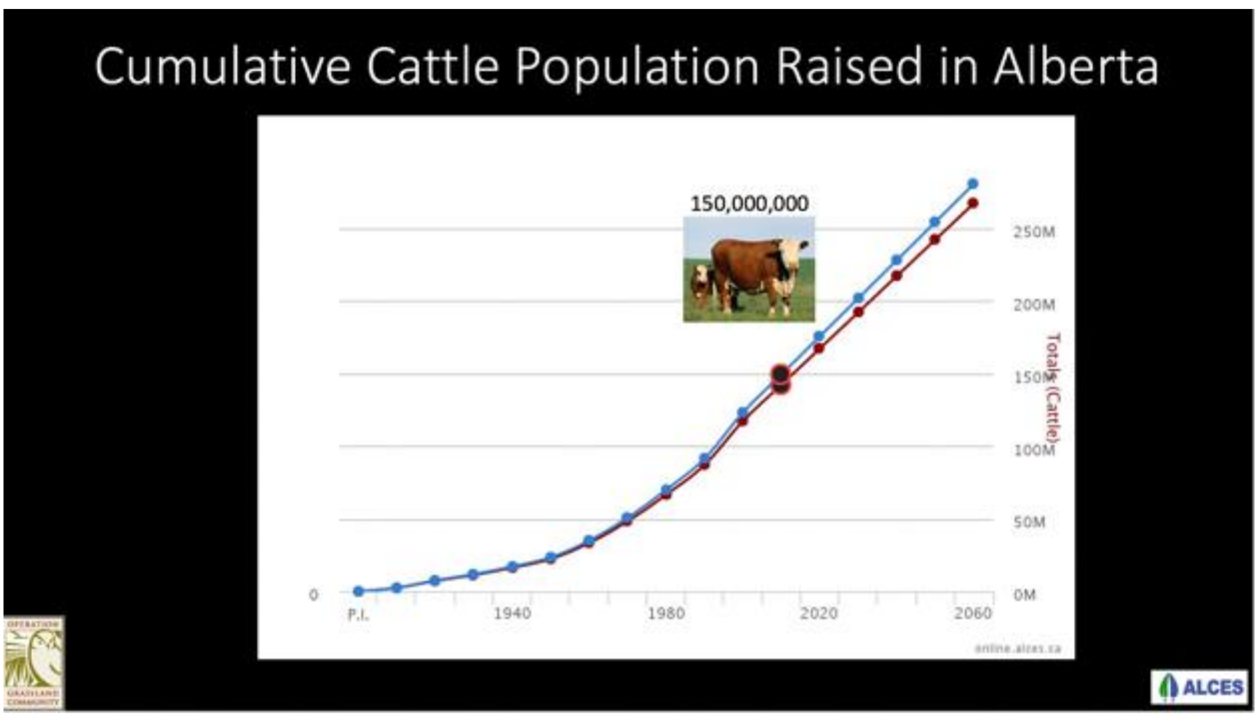

Figure 23. Cumulative cattle population raised in Alberta.

A historical reconstruction of Alberta's cattle population has been completed in ALAO (Figure 24), and can be readily revised as new information emerges. During recent decades, the fraction of the provincial population that is harvested annually has been ~24-25% (Figure 25).

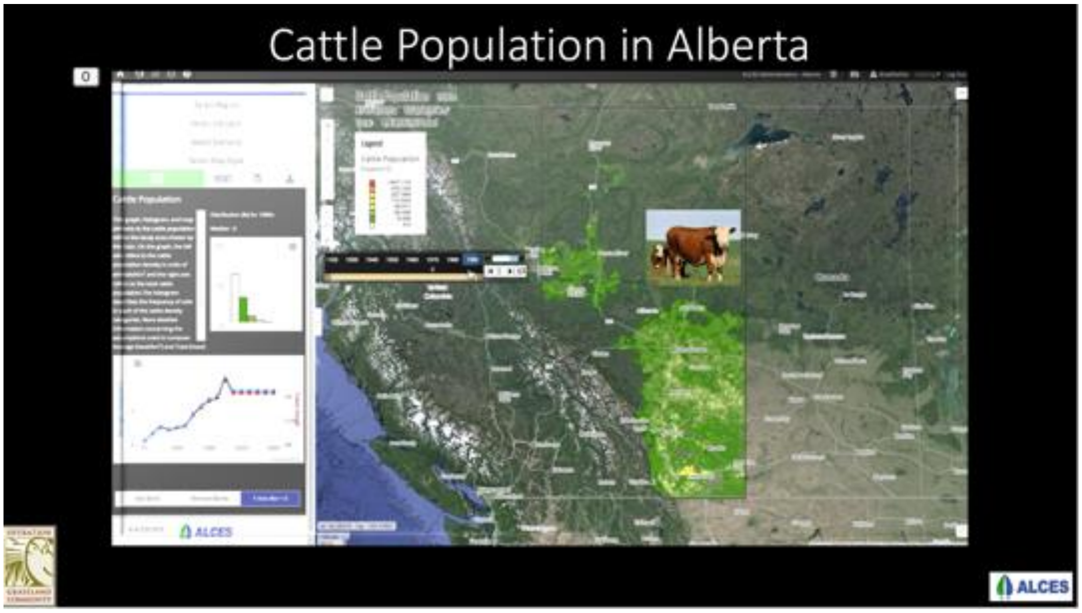

Figure 24. Temporal reconstruction of Alberta's cattle population.

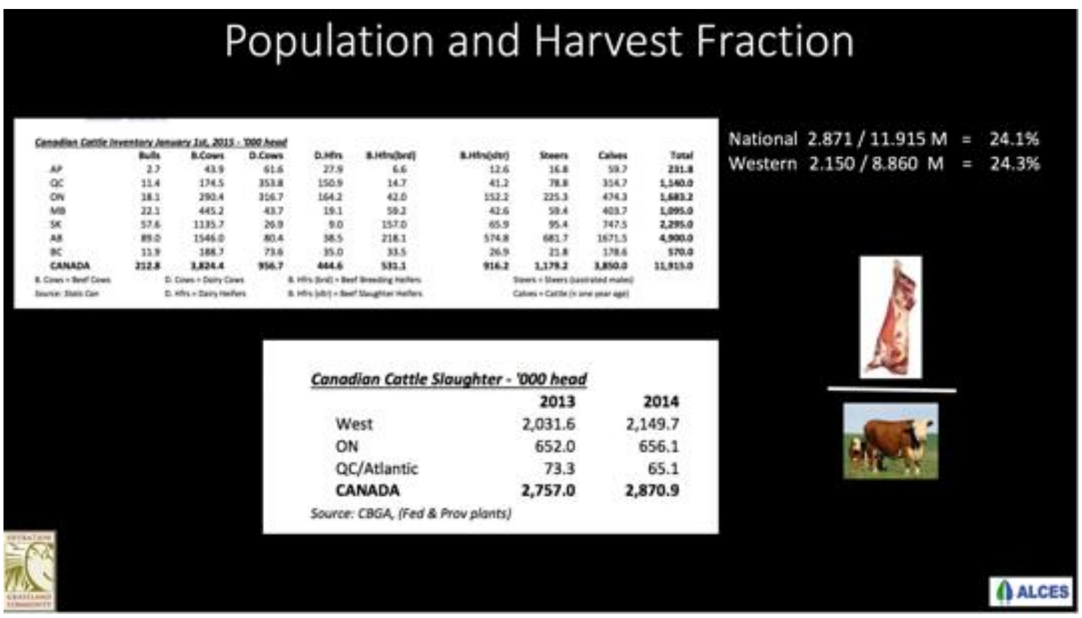

Figure 25. Computing average fraction of beef population that is harvested annually.

Published and anecdotal data (based on interviews with old ranchers), indicates that increases in inventory slaughter fraction (Figure 26), average liveweight (Figure 27) and carcass weight (Figure 28) have occurred in the past several decades. During the same period, the average age of cattle at slaughter has decline (Figure 29). The distribution of cattle on rangeland/improved pasture, backgrounding, and feedlots is shown in Figure 30.

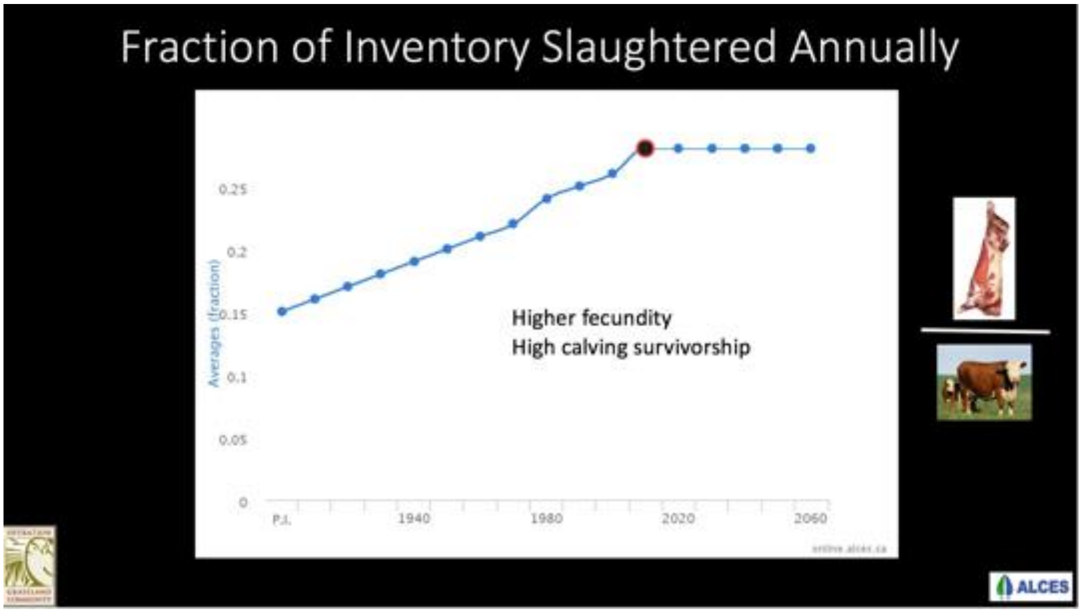

Figure 26. Simulated change in fraction of population that is harvested annually.

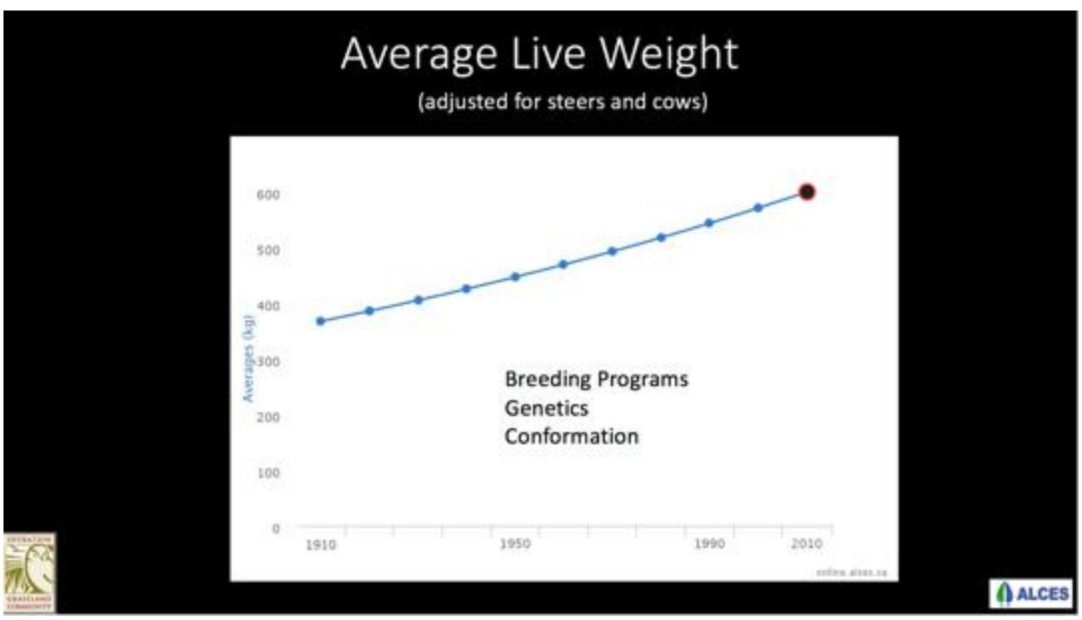

Figure 27. Simulated change in historical liveweight of beef cattle in Alberta.

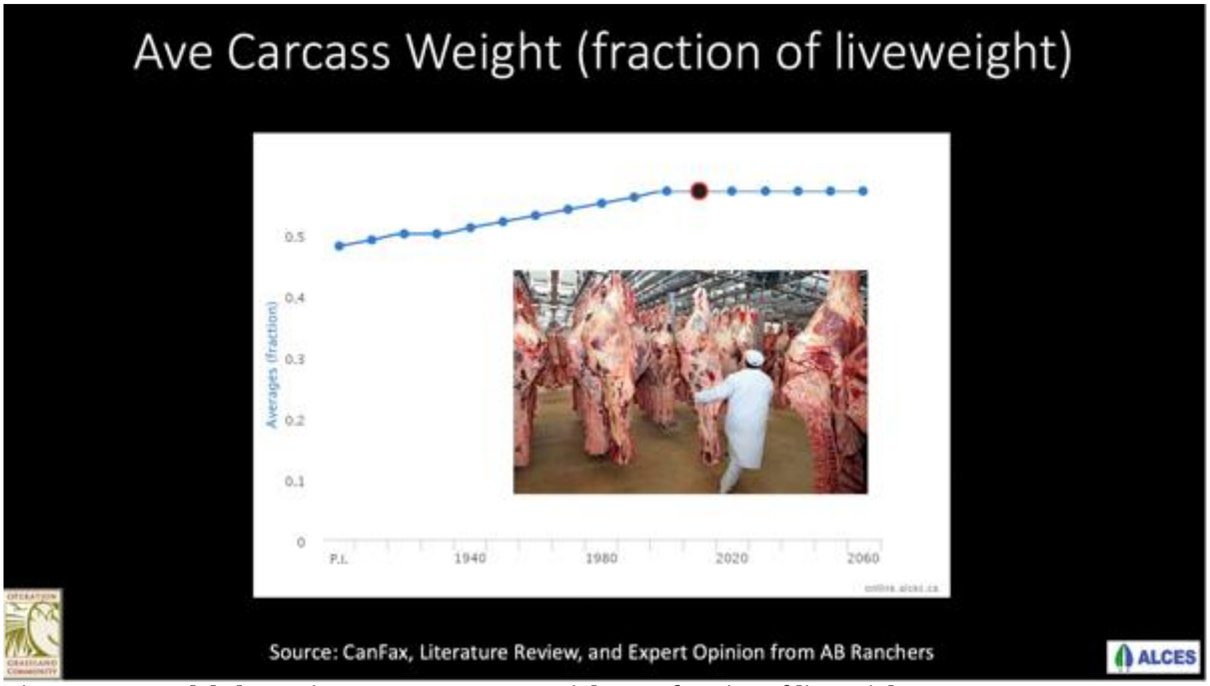

Figure 28. Decadal change in average caracass weight as a fraction of liveweight.

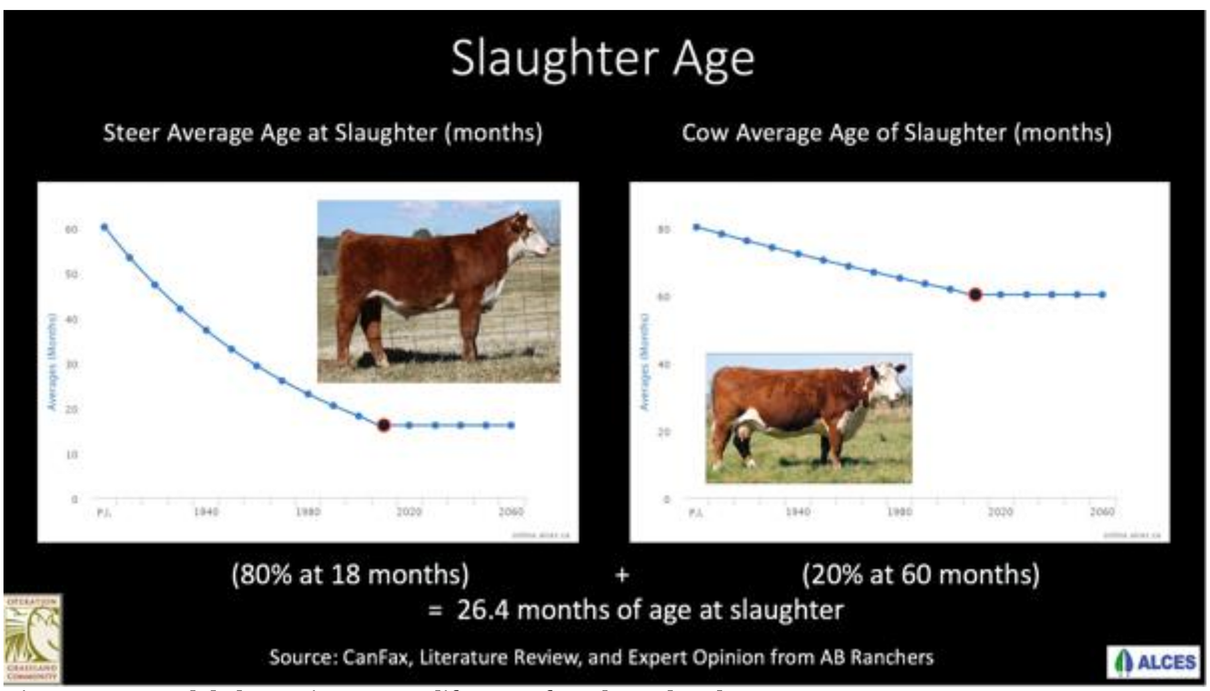

Figure 29. Decadal change in average lifespan of cattle at slaughter.

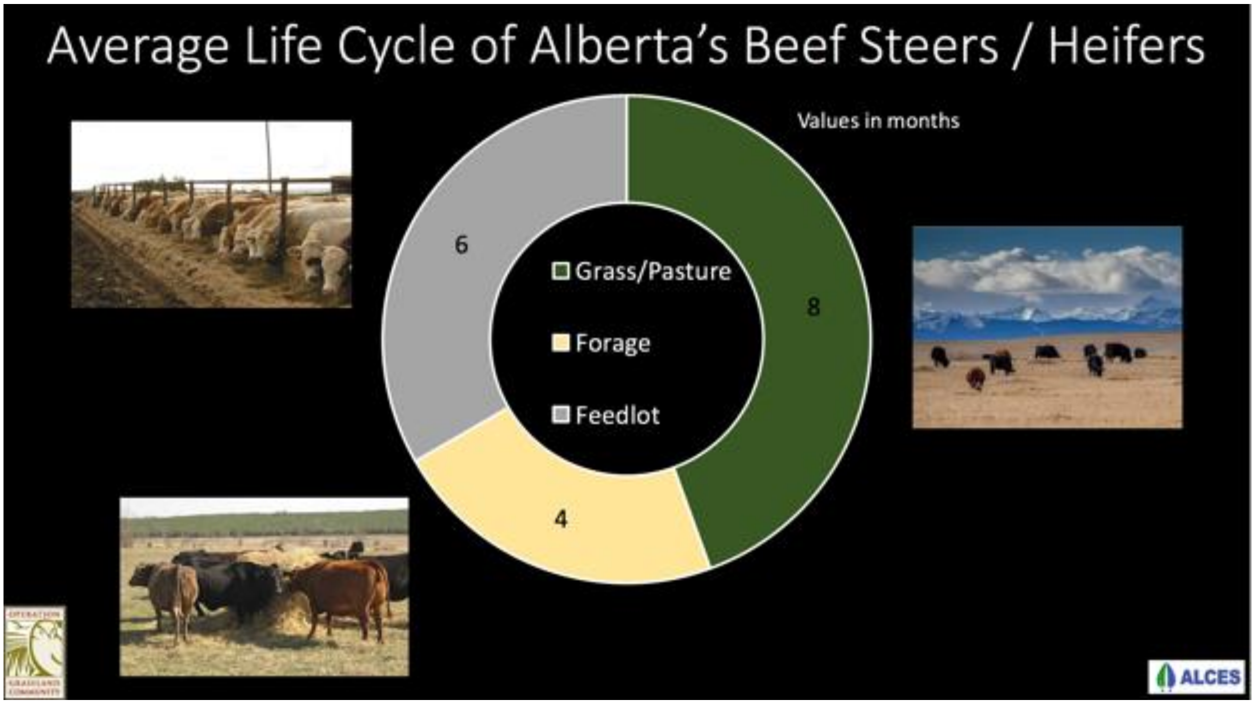

Figure 30. Area weighted average distribution of steer cattle in Alberta. Based on average slaughter age of steers of 18 months.

The cattle sector has experienced significant changes in supply chain dynamics and livestock morphology during the past century (Figure 31). During this period, the area of pastureland, cropland and native pasture has also experienced significant changes (Figure 32, Figure 33, Figure 34).

Figure 31. Key temporal trends in the cattle sector.

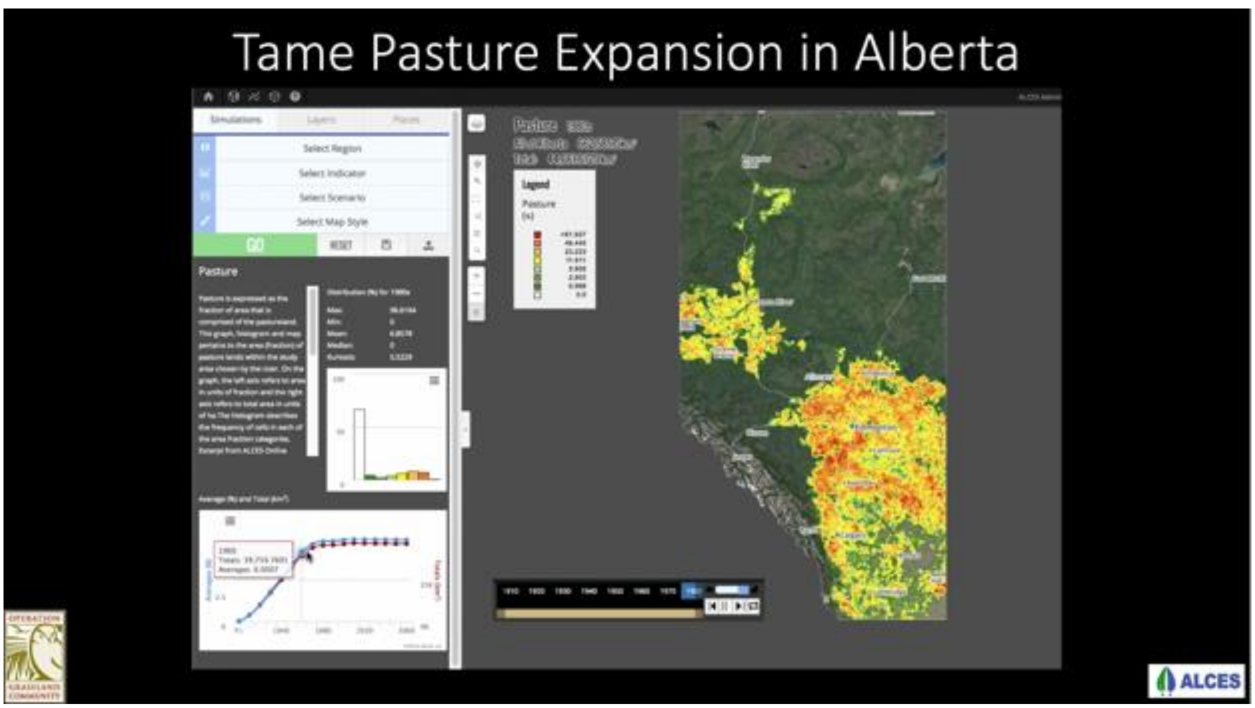

Figure 32. Temporal changes in tame pasture in Alberta.

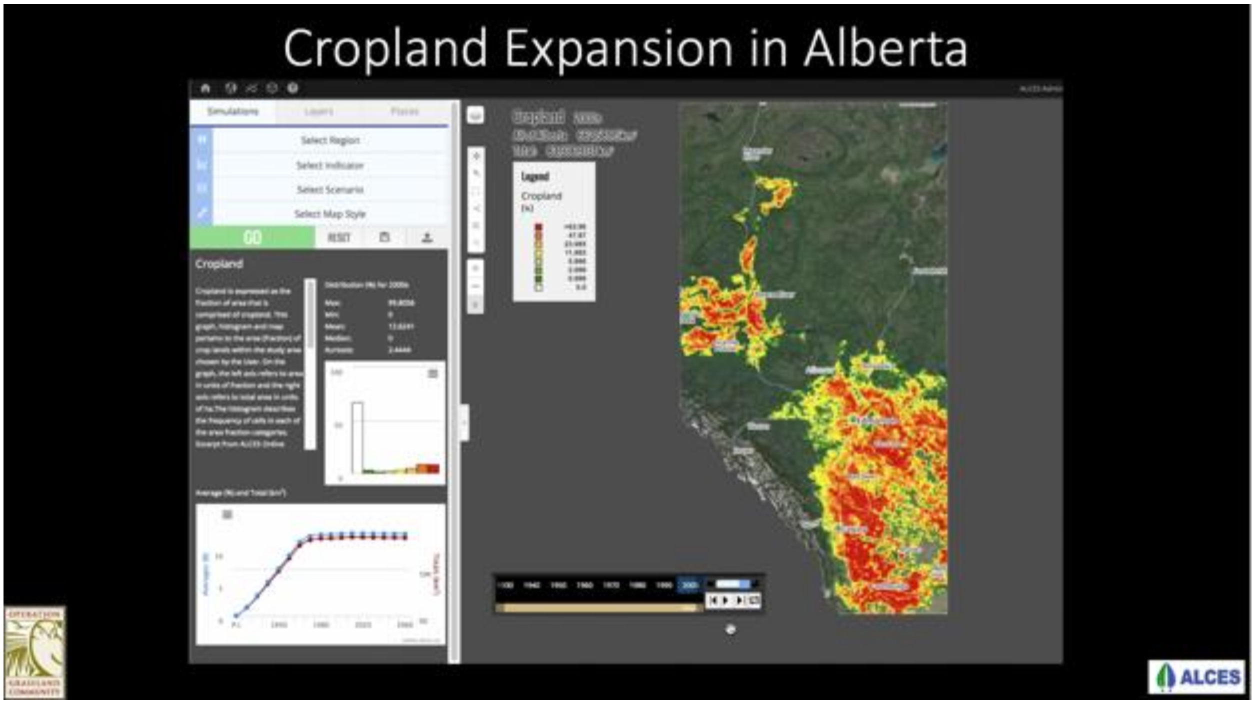

Figure 33. Temporal changes in cropland in Alberta.

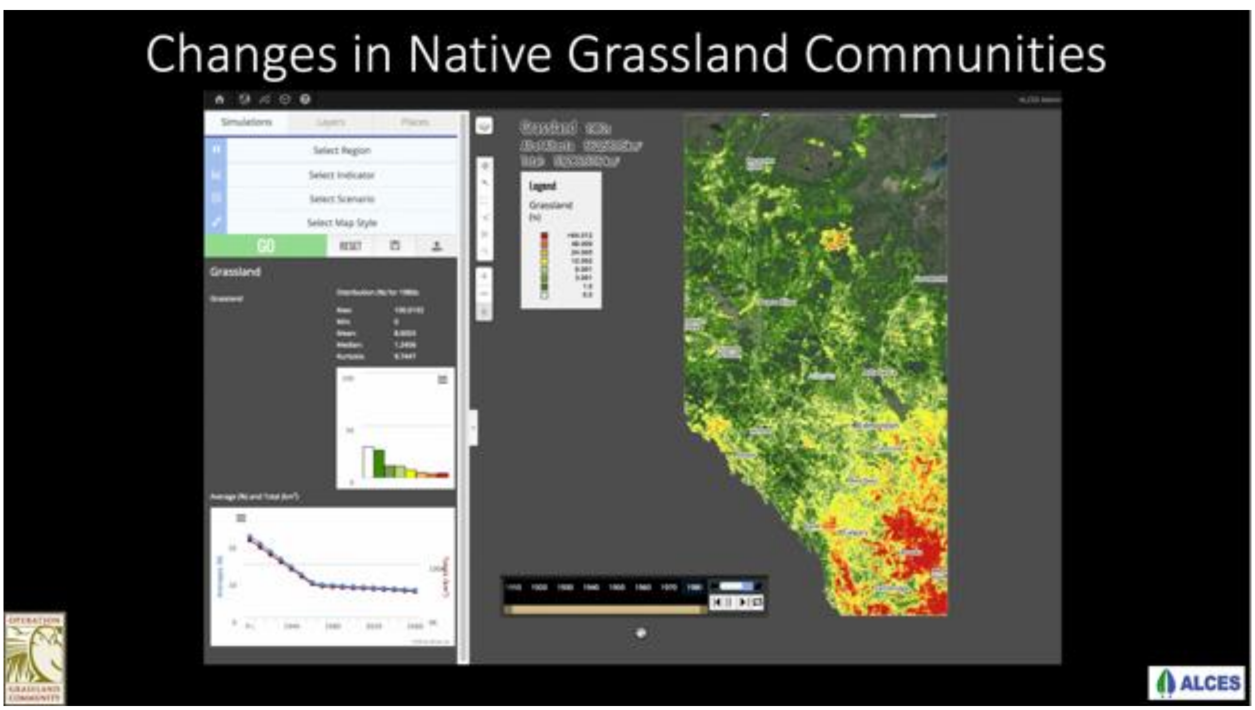

Figure 34. Temporal changes in native pasture in Alberta.

From a supply chain perspective, incremental loss of high quality native grassland, pasture and cropland is a longterm issue to the sustainability of Alberta's cattle sector. As shown below (Figure 35), the black loam region of Alberta is particularly vulnerable because of the high density of people, residential, and infrastructure that exists in this region.

In simulating crop and meat production and demand for Alberta, ALAO clearly demonstrates (Figure 36) that our province has undergone a transformation from a province whose net export ratio was increasing (late 1800s to 1970/80s) to one whose demands continue to increase but whose capacity is incrementally diminishing (1980s to 2010). This trend is likely to continue, indicating that Alberta is likely to become a net importer in future decades (Figure 37).

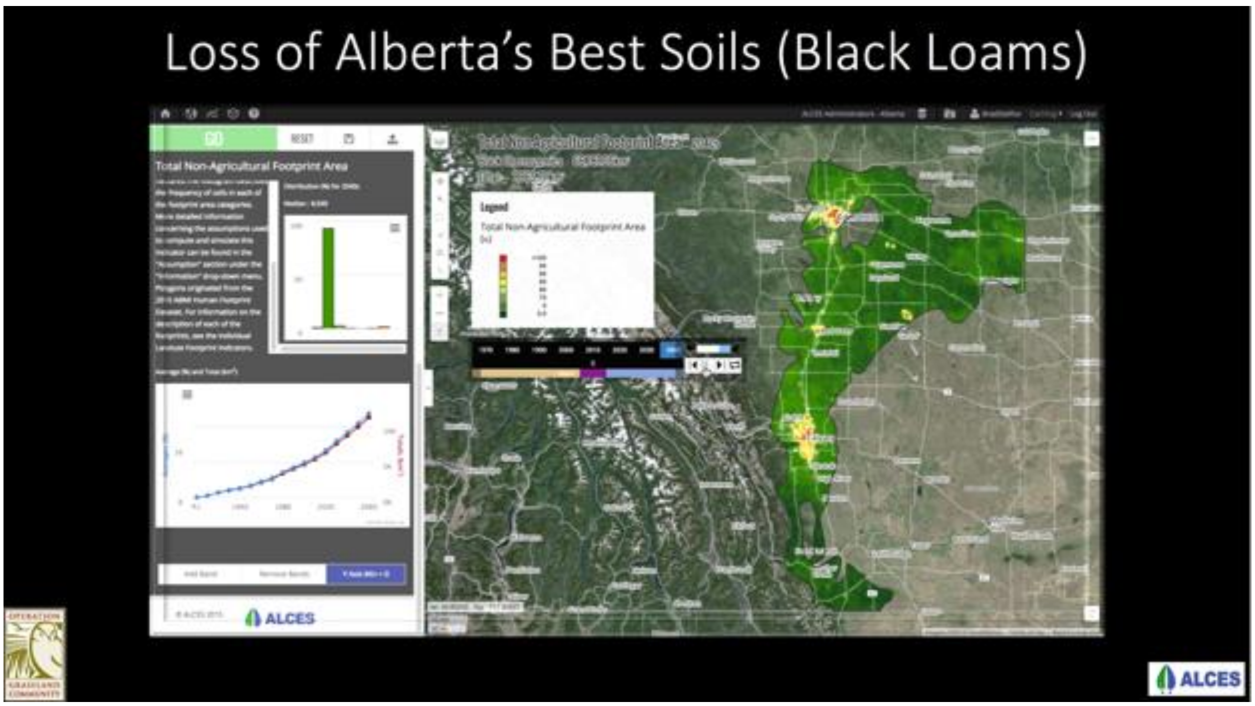

Figure 35. Spatial and temporal patterns in loss of black loam soils in Alberta.

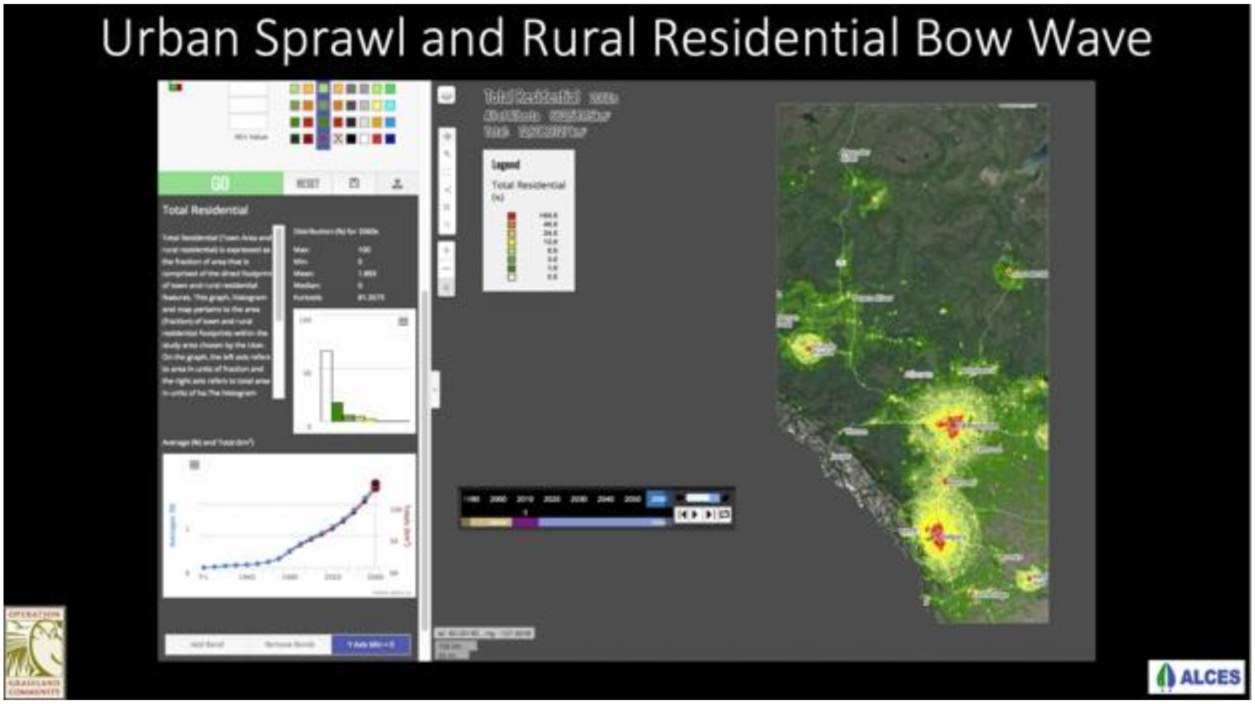

Figure 36. Spatial and temporal pattern in urban and rural sprawl in Alberta.

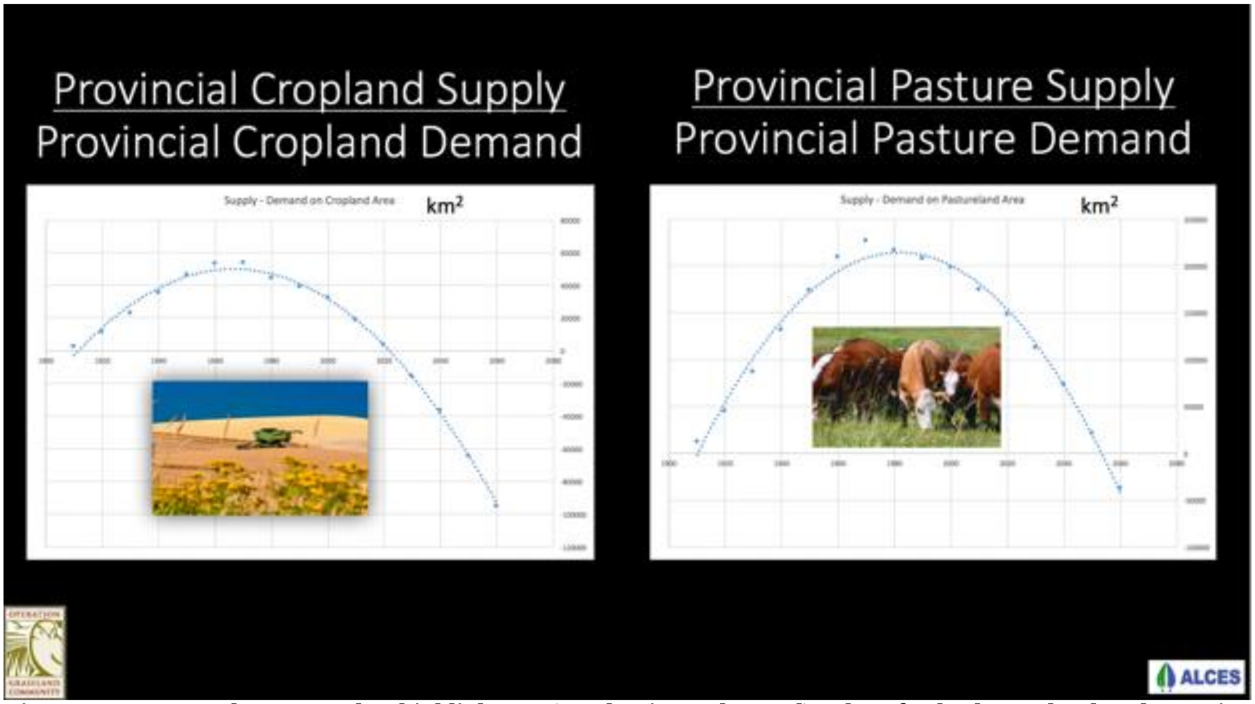

Figure 37. Temporal patterns that highlight net (production – demand) values for both cropland and meat in Alberta.

Given the large provincial cattle herd and their extensive distribution, it is unsurprising that the cattle sector is associated with environmental challenges. Key issues relate to water quality, water quantity, riparian habitat, changes to range health, and loss of biodiversity. The ALAO simulator has been customized to allow users to explore the consequences of various best management practices (BMP). Key best management practices are shown in Figure 38, Figure 39, and Figure 40. Collectively, these practices will be key to maintaining public license to operate (Figure 41).

Figure 38. Examples of best management practices intended to enhance range quality.

Figure 39. Examples of best management practices relating to cattle systems and water quality.

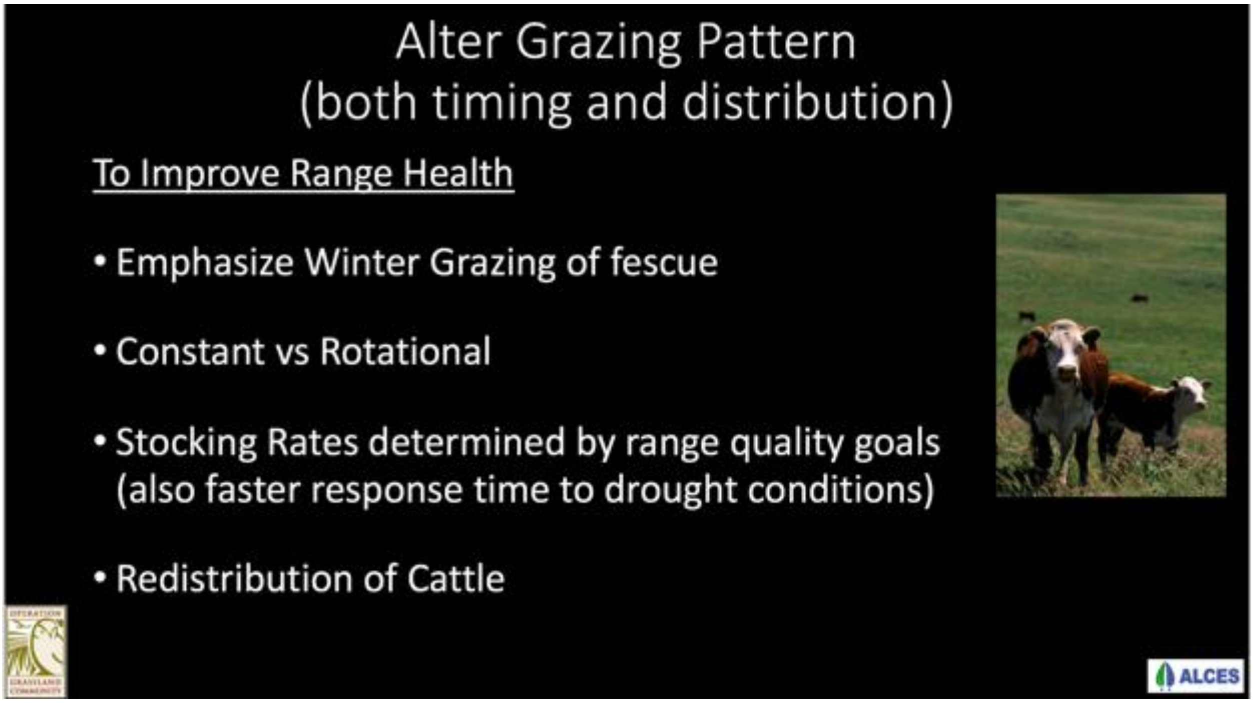

Figure 40. Examples of best management practices relating to grazing systems.

Figure 41. Enhancing market strength of the cattle sector.

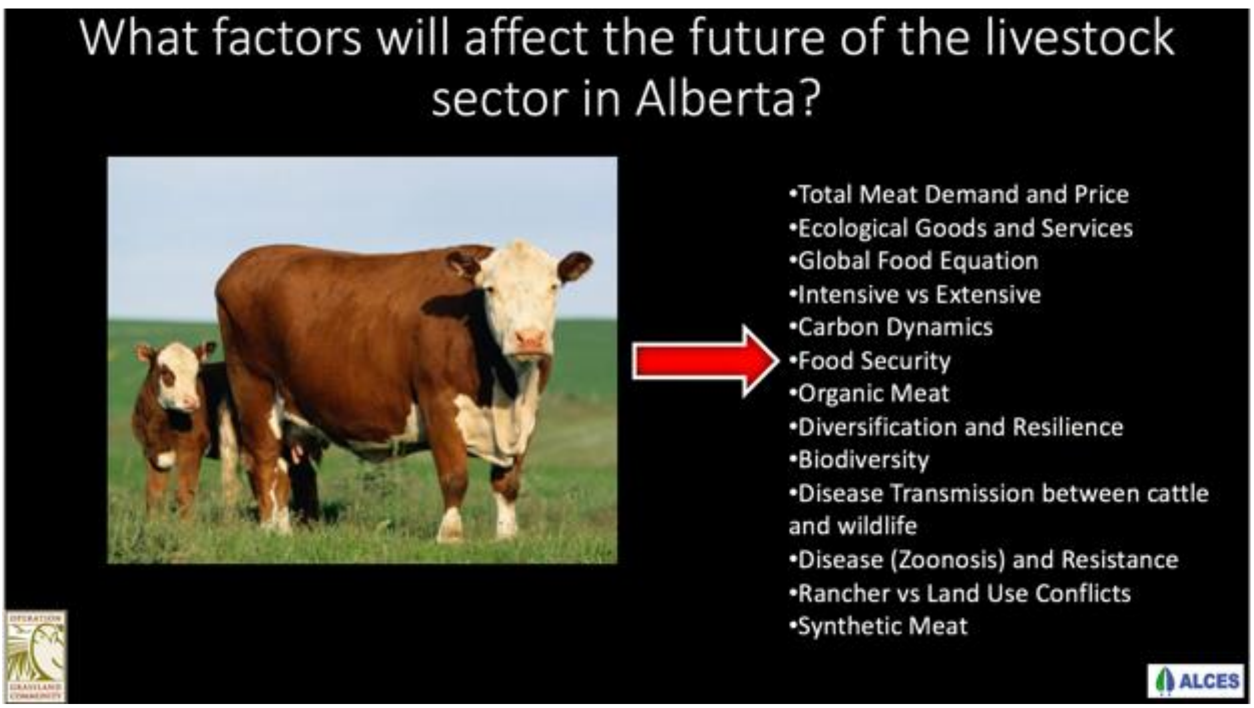

Figure 42. Factors that are likely to affect the livestock sector in the next decade.

A key finding emerging from this study is the integrated nature of the livestock and crop sectors in Alberta. The land, water, and forage links between cropland, pastureland, livestock forage form a system, are complex and integrated.

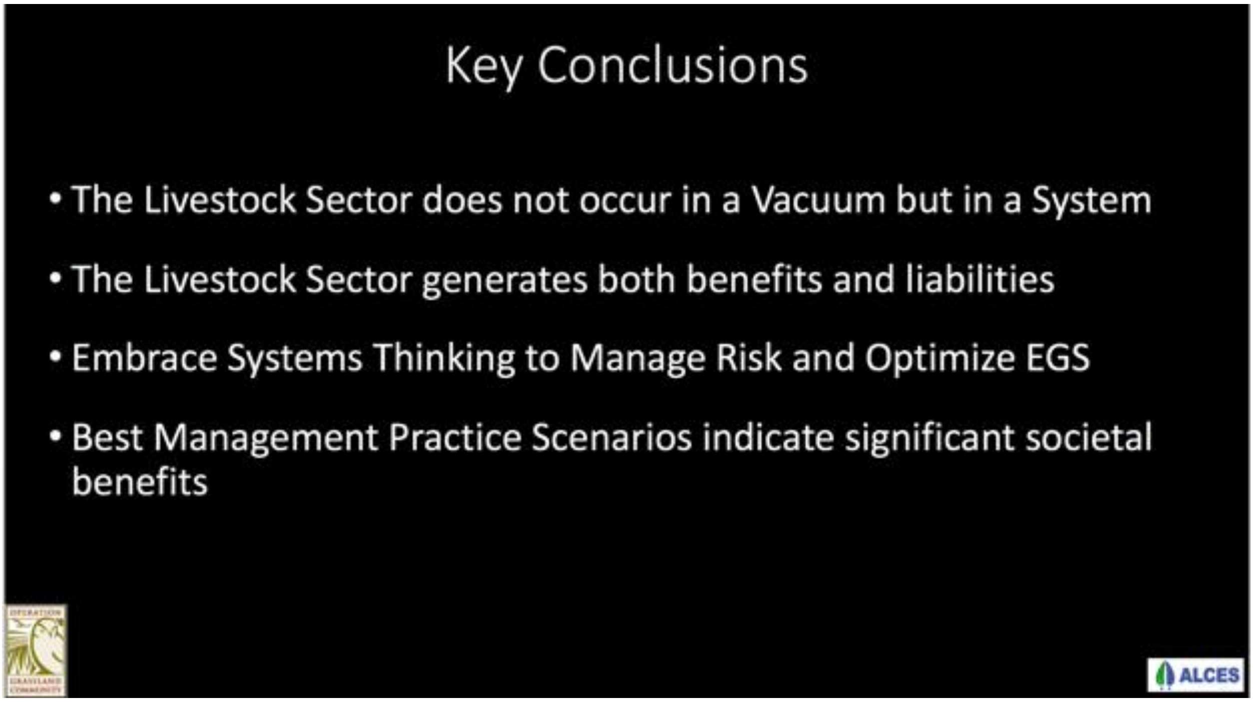

Figure 43. Key findings of the project.

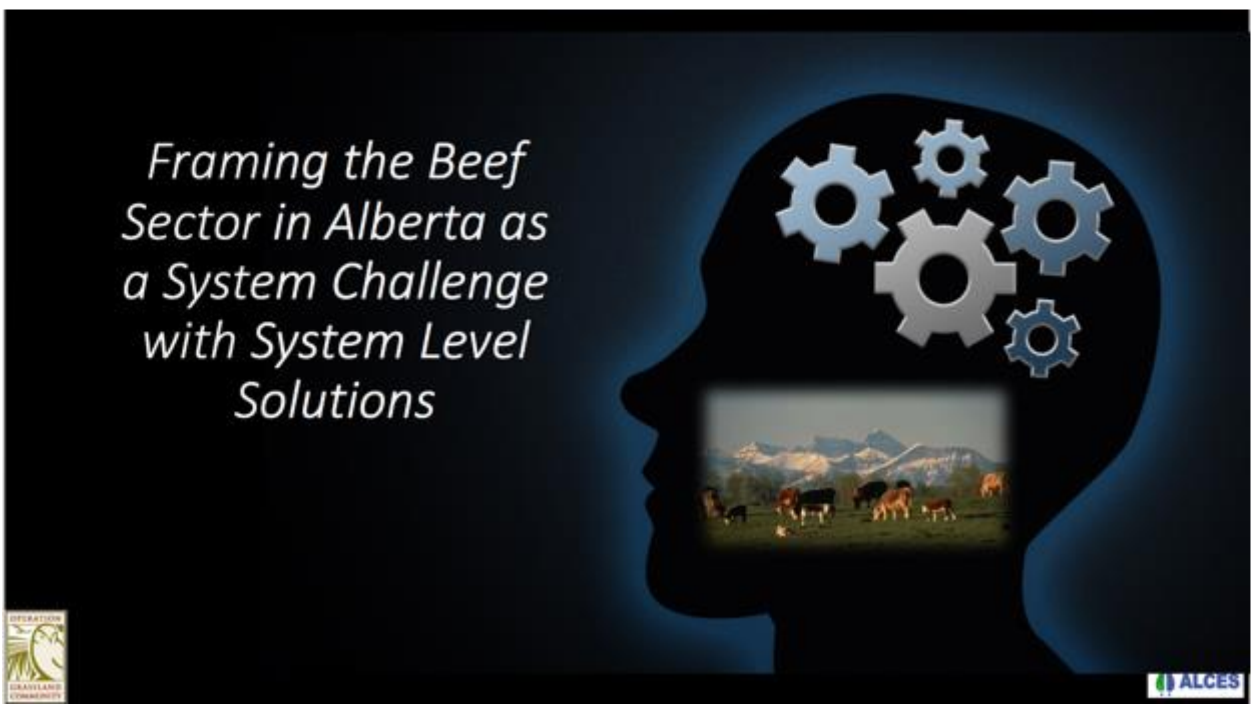

Figure 44. Framing the cattle sector dialogue in Alberta.

Figure 45. Examples of how the ALAO simulator can assist stakeholders.

Building Conceptual Models such as ALAO

In the minds of the stakeholders, whether they be the public, policy analysts, industrial representatives, or scientists, natural and anthropogenic systems can be viewed from many perspectives that include:

- Simple to complex
- Small to large
- Short to long time periods
- Independent to inter-connected
- Deterministic to stochastic

When considering how best to design a project using Alces Online, it is instructive to construct conceptual models (mental constructs, also called Impact Hypothesis Diagrams (IHD)) of the systems we are studying. These models help us clarify and challenge our thoughts, and convey ideas to colleagues and clients for review and adjustment. Properly constructed, conceptual models can help us understand our key uncertainties of how the system works, the kind of knowledge we will need to complete the project, and the level of data that is required to justify our assumptions. Examples of these conceptual models include Figure 46 and Figure 47.

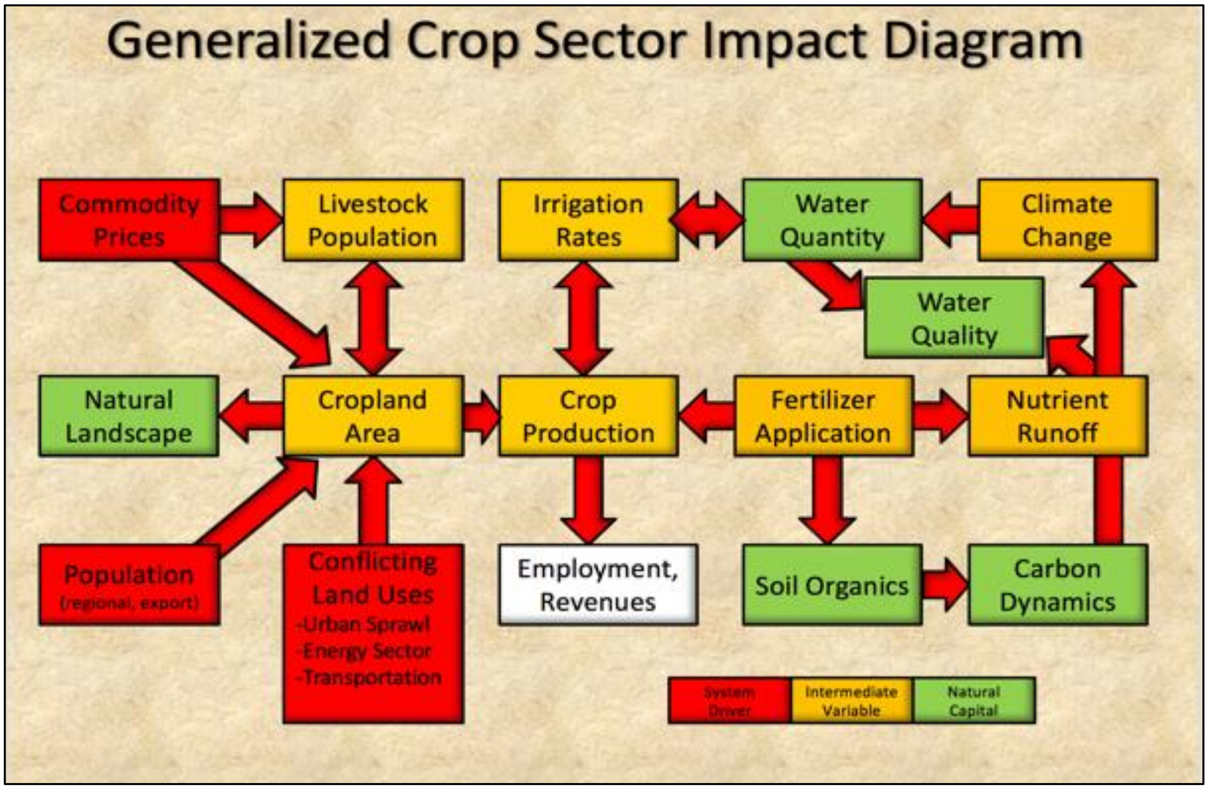

Figure 46. An example of a conceptual model of the key defining relationships of the crop sector.

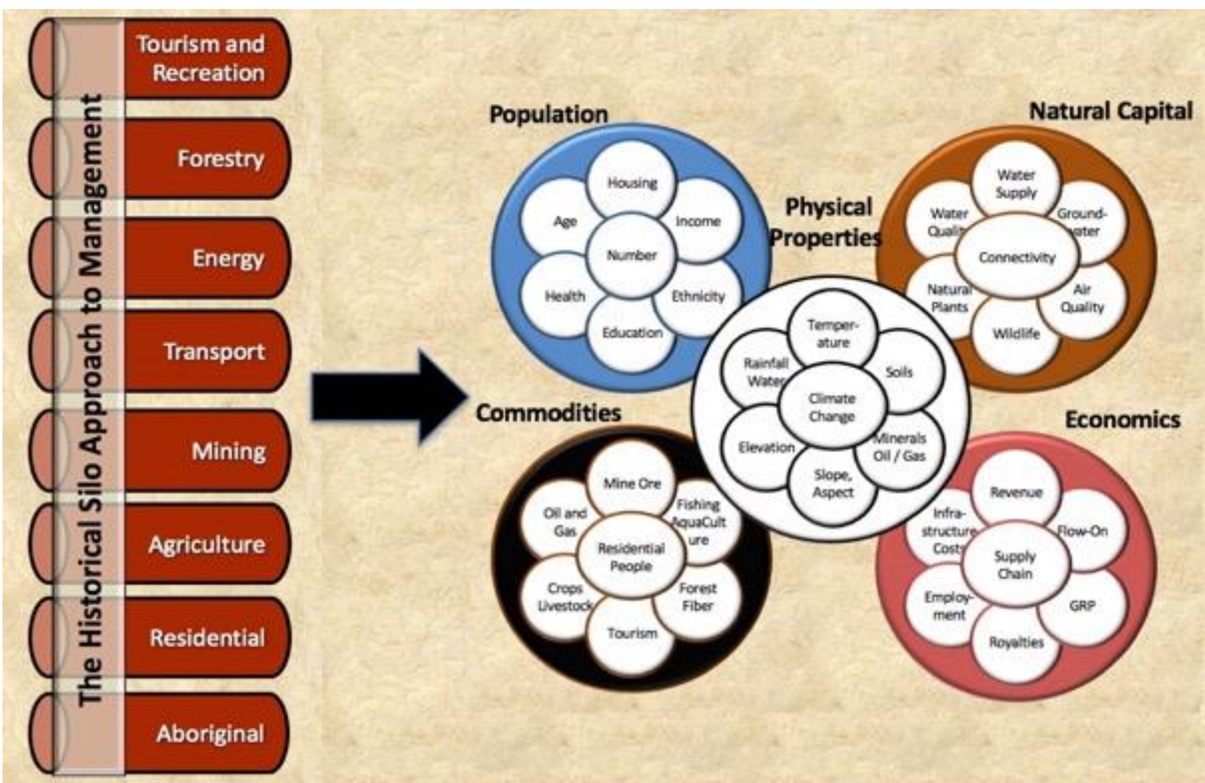

Figure 47. Transitioning from a silo architecture that addresses components independently to an integrated approach that formally recognizes the interactions among the key clusters that comprise the Alberta land use system.

The Argument for a Strategic-Level Simulator

A primary reason for building a customized version AO for Alberta cattle sector is that its core value to managers and planners lies at the strategic end of the management spectrum. Although there is an abundance of tactical (operational) models that address individual land uses and natural dynamics in great mechanistic detail, seldom do stakeholders have access to simulation technologies that can effectively integrate the key 1^{st}-order dynamics and provide planners an understanding of the "larger picture" that attends alternative future land use and landscape trajectories. By definition, strategic level models do not, and should not, contain the same level of detail as tactical models, but they must strive to incorporate the key dynamics of each component of the system, and ensure that their domain breadth is sufficient to capture each of the land uses and natural dynamics that are shaping the socio-economic and environmental performance of Alberta.

While significant attention has been given by the Alces team as to how best to aggregate/disaggregate the Alberta livestock "system", the simulator is structured to allow for ongoing levels of refinement as stakeholders (research community, managers) evolve their thinking on how the Alberta livestock system works or as new data (learnings) emerge.

Systems and Simulators: Depth versus Breadth

One of the main purposes of ALAO Online simulator is to serve as an integrator of key processes (land use, natural dynamics) in Alberta. There is a great diversity of anthropogenic sectors and natural processes in the province. As such, an important challenge for the Alces Group is to devise a level of system dis-aggregation that is likely to capture key 1^{st} order dynamics relevant to stakeholders and can be attributed with available datasets. Another key consideration for model structure is the time required to complete individual simulations, as there is a trade-off between model complexity and simulation speed.

The Alces Group has used interviews with sectoral experts and literature reviews to determine a level of systems stratification that we believe appropriate for the strategic level assessment of livestock production in Alberta.

Considerations when Simulating Future Land Uses

All simulation projects involving explorations of future land use trajectories encounter challenges that both the analysts and stakeholders must understand and address. The following points summarize the central difficulties and potential opportunities of "exploring the future".

1. The future of land use and natural disturbance regimes cannot be predicted in any exact manner. There are too many uncertain and unknowable externalities.
2. The value of simulating the future lies in its ability to explicitly state and discuss assumptions and in exploring both the benefits and liabilities of alternative sets of assumptions.
3. A systems-based approach to future land use simulation allows stakeholders to better understand the key "drivers" of land use and to explore the consequences of uncertainty by adopting sensitivity analyses

The analysts of this project also recognize that it is frequently not in the best interest of individual companies/corporations to divulge strategic or operational information about their individual plans for future development. Some effort was made to read through online corporate shareholder documents for those companies that are publicly traded. Where available, strategic information published by industrial associations generally provide good insight into possible future land use trajectories.

All scenarios described in this update report should be considered exploratory and receptive to the need for revision. One of the main reason for circulating this document is to solicit input from sector experts that can be used to improve the sensitivity analyses. This belief is why the Alces team has customized ALAO to allow for its "live" modifications as stakeholders discuss the specifics of growth rate, geographic positioning, and the relationships between various elements within the "system".

The analysts wish to emphasize to users that the greatest value of ALAO lies in its ability to be rapidly altered as new land use information emerges, and hence allows stakeholders to quickly explore both opportunities and risks in fluid and uncertain marketplaces and policy arenas.

Uncertainty and Sensitivity Analyses

A commonly used analytical approach to address uncertainty in system behavior is to conduct "sensitivity analyses". With this approach, key drivers of the system (for example, commodity production of the oil and gas sector), are grown at different rates (low, medium, and high) to empirically test the extent to which key indicators respond numerically to management levers or natural dynamics. In this project, the Alces Online simulator is used to explore different growth rates (Figure 20) that bracket a "feasible variation" given available sectoral knowledge.

In addition to conducting simulations at different levels (i.e., low, medium, high), embedded random variation in each of these levels can be explored using Monte Carlo simulations.

The Alberta Livestock Alces Online (ALAO) Simulator

What is Alces Online?

Alces Online (www.alces.ca) is a landscape/landuse simulator used by the Alces Group and its clients to explore past, present and future relationships involving land uses (residential, transportation, croplands, livestock, mining, oil and gas, forestry, tourism/recreation) and natural disturbances regimes (fire, insects, landslides, storms, climate, climate change).

ALCES Online is a web-based GIS and simulator designed to inform strategic planning through the analysis and visualization of ecological and economic data. The tool increases the accessibility of spatial analysis and simulation modeling through a user-friendly interface and an integrated GIS and simulation environment. The tool's database architecture and adoption of current technologies such as WebGL provides the performance to accommodate complexities of land use planning such as large study areas at fine scale spatial resolutions (millions of cells), long time horizons, and multiple drivers and indicators while still delivering rapid results.

A published overview of the structure and function of Alces Online is provided in ALCES Online: Web-delivered Scenario Analysis to Inform Sustainable Land-use Decisions, *International Environmental Modelling and Software Society (iEMSs)* 7th Intl. Congress on Env. Modelling and Software, San Diego, CA, USA, Daniel P. Ames, Nigel W.T. Quinn and Andrea E. Rizzoli (Eds.), which can be viewed at:

https://www.dropbox.com/s/icqyq7xwudqpn10/Carlson%20et%20al%202014%20Alces%20Manuscript.pdf?dl=0

Web-delivered GIS Features

- Rapid map-based rendering of geospatial data. Formats include polygonal, point, line, and raster.
- Powerful calculator for deriving new geospatial attributes through combination of data layers using various mathematical, logical, and geospatial (e.g., buffering) functions, dose-response curves, and regional modifiers
- Time-sequence maps and time-series graphs for temporal data layers.
- Point and click retrieval of metadata (e.g., text, images, videos, files) for polygon, point, and line features.
- Multiple options for viewing and summarizing raster data including grid or heat map formats and regional summary maps that display average or total value by administrative or physical subunit.
- 3-dimensional rendering of raster data to visualize spatial variation of an attribute.
- 2-D, 3-D, and 4-D scatterplots to explore and visualize relationships between variables
- Customization of maps through base map options (e.g., satellite imagery, terrain, basic, night light emissions, etc.). For raster data, user-defined breakpoints and colour schemes.
- Flexible graphing toolkit to build time-series graphs that compare multiple variables and incorporate "bands" that identify risk or management thresholds.
- Storage of numerous layers in hierarchical menus for convenient design of maps displaying multiple features.

- User-defined study areas through upload of boundary layer (shapefile), combination of study areas (add/subtract/intersect/exclude), or drawing of study area boundary with mouse.
- Convenient upload and management of geospatial data. Creation of point data using waypoints.
- Automated touring of data layer features or user-defined waypoints.
- Intuitive exploration of maps using zooming tools, panning, and adjustable opacity.

Simulator Features

- Synoptic simulation of cumulative effects by incorporating multiple land uses and natural disturbances as drivers.
- Land uses include forestry, mining, hydroelectric, hydrocarbon production, transportation, agriculture, settlements, and recreation.
- Flexible definition land-use scenarios by specifying rate of development, intensity of associated infrastructure, and rules governing spatial distribution.
- Numerous options for defining spatial land-use pattern:
    - Location of future footprint can be pre-defined or incorporate stochasticity and factors affecting relative likelihood of development (e.g., natural resource potential, annual allowable cuts, etc.).
    - Size of an individual disturbance is defined for each footprint type and can range from a portion of a cell to clusters of multiple cells.
    - Disturbance size can be fixed or governed by a size-class distribution.
    - Footprint can be dispersed or aggregated with existing footprint (e.g., outward growth of a town)
    - A footprint type's location can be coordinated with the location of another footprint type such as road segments linking the existing road network to new development (cutblock, mine, etc.)
- Numerous options for defining natural disturbance (e.g., fire)
    - Deterministic or stochastic disturbance rate
    - Location can be influenced by spatial attributes such as land cover
    - Variable fire size to fit a user-defined size-class distribution
    - User-defined post-disturbance trajectory
- Simulation of footprint reclamation and successional dynamics based on the age of footprint or land cover. Targeted reclamation events can also be simulated to accelerate the return of footprint to natural vegetation
- Integrated tracking of the consequences of land use, natural disturbance, and succession to landscape composition. Landscape composition is cell-based. An individual cell can be made up of multiple land cover and footprint types. Composition is tracked as proportion of each cell belonging to each land cover and footprint type, and the age of each land cover and footprint type.
- User-defined spatial resolution. Study area size can span millions of cells for tracking of landscape dynamics at high resolution and/or across large regions.
- User-defined simulation time-step, length, and reporting interval.
- Powerful calculator to define rules governing the response of indicators (e.g., wildlife, ecosystem services, socioeconomic) to simulated changes in land-use activity, landscape composition, and other drivers such as climate. Indicator relationships can integrate multiple

simulated attributes using mathematical, logical, and geospatial (e.g., buffering) functions, dose-response curves, and regional modifiers. Once defined, indicator relationships can be saved and used in subsequent simulations or as components of other indicators.

- Model integration through: upload of output from other models (e.g., climate) for use as simulation inputs; and export of output (shapefile, tabular) for use in other models.
- Backcasting capability to reconstruct historical changes in landscape composition.
- Numerous output formats including grid/heat map/subregional time-series maps, time-series graphs, 3-dimensional maps, and scatter plots.
- User-defined study areas through upload of boundary layer (shapefile), combination of study areas (add/subtract/intersect/exclude), or drawing of study area boundary with mouse.
- Rapid and interactive retrieval of previously saved simulations and indicators for use in meetings and workshops.

ALCES Online Technical Specifications (Version 1.1)

The following text outlines the basic technical specifications of the ALCES Online software environment on which the Alberta Livestock Alces Online simulator was constructed.

1. System Architecture

ALCES Online is developed with modern server and programming technologies including:

- Python
- JavaScript
- PostGIS
- GDAL
- WebGL
- Leaflet
- Web Map Tile Services

1.1. Cloud Platform

ALCES Online is a cloud platform and is delivered through standards-compliant web browsers. To make full use of the tool suite, we recommend a desktop computer with at least 4GB of RAM and a high-speed internet connection of at least 5 Mbps.

1.2. Browsers

ALCES Online is officially supported for Chrome. Additional browser support is in development for Safari, Firefox and Internet Explorer.

Full cross-browser support is expected to launch in December 2016.

1.3. OS Compatibility

ALCES Online is compatible with any major operating system (Windows, Linux, Mac) using a standards-compliant web browser.

1.4. WebGL

ALCES Online uses modern WebGL technology to deliver unparalleled graphics and mapping performance. WebGL requires a modern standards-compliant browser to function. As a result, the following browsers and operating systems are not supported:

- Microsoft Internet Explorer
- iOS mobile devices
- Android mobile devices

1.6. Non-WebGL - Light version

ALCES is currently developing a light version of ALCES Online that is cross browser, cross platform and mobile friendly. This version will not offer the same animation and video capabilities of the WebGL version, but it will allow all browsers including Internet Explorer and mobile devices to use ALCES Online.

1.7. GIS Data Compatibility

ALCES Online uses global OGC standards and all data is compatible with ESRI ArcGIS and Google Earth.

2. Security Technology

2.1. SSL

ALCES Online is delivered through a secure SSL connection. All connections to our server use an encrypted TLS 1.2 connection. Our certificate is signed using a SHA-256 RSA encryption algorithm.

2.2. Encrypted data

All sensitive data including user passwords is stored in an encrypted format in our database.

3. Security Protocols

3.1. User Logging

Access to the ALCES Online tool suite is logged for analytical and security purposes.

3.2. Breach Protocols

ALCES follows industry standard guidelines to prevent security breaches. In the event that a security breach is detected, actions are taken immediately to close the breach and notify affected account owners. Further analysis is undertaken to determine the source and cause of the breach and to take appropriate steps to rectify the situation and prevent future breaches.

3.3. Username and Password Protocols

Usernames and temporary passwords are provided to active account holders. Users are encouraged to reset their temporary password to something they can personally remember. Passwords are intended to be unique and private and are the responsibility of the user. Passwords are encrypted in the database and are not visible by any other users or administrators.

3.4. User Assistance - ALCES Technical Support Access

ALCES can provide technical support to users and will log into user accounts on a strictly as-needed basis and only after verified approval from the specific user asking technical support to access their account.

3.5. Data Management and Privacy Protocols

ALCES Online uses a spatial data ownership and sharing structure that ensures private spatial data is only viewable by the users and / or groups that own the specific private data. All data requests and responses from the system are authenticated and verified against the logged in user’s credentials.

All user account data including emails, names, usernames and user activity logs is kept private and confidential and is never shared with any outside parties.

4. Data Centre

The ALCES Online data center is hosted by Amazon Web Services with the Amazon EC2 infrastructure. The ALCES Online data center is in Oregon, USA.

5. Server and System Scaling

ALCES Online is designed to be highly scalable. ALCES is committed to delivering enterprise products that perform with high standards of availability and speed. Our system is scaled as needed to meet usage demands.

Key Spatial Input Themes for ALAO

Based on the reporting indicators required by our clients, the following GIS "input" themes (physical, land use, population, biotic) were assembled for the full geographic extent of Alberta. Each of these indicators was required as input variables required to compute ultimate reporting indicators.

Irrespective of the original data resolution, all data were imported into AO at a spatial grid size of 5 x 5 m.

All anthropogenic land use footprints were overlain onto natural landscape types or agricultural landscape types to generate a "unity" spatial coverage. For example, if a given 100 x 100 m cell (=1 ha) had 100 m of road that is 10 m in width, then ALAO would extract 0.1 ha of road from the underlying landscape types within that given cell. By following this methodology for all anthropogenic features, the model respects unity.

In completing a QA/QC exercise for each of the variables, it was clear that some GIS themes were more accurate than others. Several datasets were discarded based on conclusions of inadequate coverage, sampling intensity, or excessive antiquity.

Variable Category	Variable Name	Origin	Year	Descriptions
Plant Communities	Hardwood Forest	GVI, AAFC, EOSD, ABMI	2015	Grassland Vegetation Index, Alberta Biodiversity Monitoring Index, Earth Observation Satellite Data
	Softwood Forest	GVI, AAFC, EOSD, ABMI	2015	Grassland Vegetation Index, Alberta Biodiversity Monitoring Index, Earth Observation Satellite Data
	Mixedwood Forest	GVI, AAFC, EOSD, ABMI	2015	Grassland Vegetation Index, Alberta Biodiversity Monitoring Index, Earth Observation Satellite Data
	Shrublands	GVI, AAFC, EOSD, ABMI	2015	Grassland Vegetation Index, Alberta Biodiversity Monitoring Index, Earth Observation Satellite Data
	Wetlands	GVI, AAFC, EOSD, ABMI	2015	Grassland Vegetation Index, Alberta Biodiversity Monitoring Index, Earth Observation Satellite Data
Fire		Original data source was ESRD wildfires website: http://wildfire.alberta.ca/wildfire-maps/historical-wildfire-information/spatial-wildfire-data.aspx		Historical Wildfires from 1931 to 2015. Fires are grouped into decades (eg: 1931 to 1940 = Historical Wildfires for 1940). The decade 2010 includes fires from 2001 to 2015. Boundaries between fires within each decade have been dissolved - that is, fire overlaps do not exist within each decade however, there are overlaps between decades.
Hydrology	Lotic	AltaLIS (http://www.altalis.com/products/base/20k_base_features.html).	2016	Permanent (or Perennial) stream bed normally contains flowing water, except under drought conditions.
	Lentic	AltaLIS (http://www.altalis.com/products/base/20k_base_features.html).	2016	Permanent (or Perennial) stream bed normally contains flowing water, except under drought conditions.
	Anthropogenic	AltaLIS BF-Hydro Polygon, AltaLIS BF-SLNET	2015	AltaLIS BF-Hydro Polygon, AltaLIS BF-SLNET
Soils				
Geology Features		Alberta Geological Survey: http://www.ags.gov.ab.ca/publications/abstracts/Map_601.html	2010	
Topographic				
	Elevation	Natural Resources Canada, Earth Sciences Sector, Mapping Information Branch	2012	Canadian Digital Elevation Model Mosaic (CDEM)
	Slope	Natural Resources Canada, Earth Sciences Sector, Mapping Information Branch	2012	Derived from mean elevation
	Aspect		2012	Derived from mean elevation
	valley Confinement Index	http://www.fs.fed.us/rm/pubs/rmrs_gtr321.pdf?	2015	The Valley Confinement index is the average proportion of unconfined valleys to all valleys in a single Hydrological Unit Code 8 region for Alberta. This is a unit less indicator and was derived using the USDA Forestry Services Valley Confinement Algorithm tool for ArcGIS for more information please refer to http://www.fs.fed.us/rm/pubs/rmrs_gtr321.pdf?

Climate	Precipitation (as rain)	Wang, T., Hamann, A. Spittlehouse, D.L. and Murdock, T.Q. 2012. ClimateWNA High-resolution spatial climate data for western North America. Journal of Applied Meteorology and Climatology 51:16-29.	2016	Mean Annual Precipitation as derived by ClimateBC v5.21. Mean Annual Precipitation in mm is a directly calculated annual variable. Model output generated at a 100m raster resolution.
	Precipitation (as snow)	Wang, T., Hamann, A. Spittlehouse, D.L. and Murdock, T.Q. 2012. ClimateWNA High-resolution spatial climate data for western North America. Journal of Applied Meteorology and Climatology 51:16-29.	2016	Mean Annual Precipitation as derived by ClimateBC v5.21. Mean Annual Precipitation in mm is a directly calculated annual variable. Model output generated at a 100m raster resolution.
	Temperature	Wang, T., Hamann, A. Spittlehouse, D.L. and Murdock, T.Q. 2012. ClimateWNA High-resolution spatial climate data for western North America. Journal of Applied Meteorology and Climatology 51:16-29.	2016	Mean Annual Air Temperature as derived by ClimateWNA v5.21. Mean Annual Air Temperature in degrees Celsius is a directly calculated annual variable. Model output generated at a 100m raster resolution.
	Evapotranspiration	Wang, T., Hamann, A. Spittlehouse, D.L. and Murdock, T.Q. 2012. ClimateWNA High-resolution spatial climate data for western North America. Journal of Applied Meteorology and Climatology 51:16-29.	2016	Hargreaves Reference Evaporation as derived by ClimateBC v5.21. Hargreaves Reference Evaporation in mm is a derived annual variable. Model output generated at a 100m raster resolution.
Transportation	Airstrips	Open Street Map, AltaLIS, CanVec, ESRI Basemap, City of Edmonton		Open Street Map, AltaLIS, CanVec, ESRI Basemap, City of Edmonton
	Trails	TransCanada Trail, QuadSquad, Open Street Map, HikeAlberta, City Data, AltaLIS, AB Parks		
	Roads	Two data sources were used to create the finalized road dataset. Open Street Map data (highway_line_1, highway_line), AltaLIS (BF_ROAD_ARC). Website links to source data are as follows: Open Street Map (https://market.trimbledata.com/#/datasets/osm-openstreetmap-planet?east=-	2016	Roads: Service Roads Pre-Hierarchical Edge represents the centerline of the service road footprint type. This edge dataset is NOT influenced by the footprint hierarchy in order to ensure that the edge of individual features is not exaggerated due to the splitting of polygons from footprint of higher precedence. Service roads represent the alleyways within residential urban areas and access into industrial sites such as urban industrial parks or rural industrial facilities.

		96.18530273437509&north=59.26922534192724&south=49.3866334784889&west=-131.40747070312509&zoom=6), AltaLIS (http://www.altalis.com/products/base/20k_base_features.html).		
Residential	Rural and Urban	Combination of individual pre-hierarchical footprint edge (RuralUndiffNHEdge, RuralFarmUndiffNHEdge, RuralAcreageUndiffNHEdge, UrbanUndiffNHEdge)	2016	Rural Residence and Urban: Total Pre-Hierarchical Edge represents the boundary of rural residential and urban footprints (includes rural residential farm, rural residential acreage, rural residential undifferentiated and urban undifferentiated). This edge dataset is NOT influenced by the footprint hierarchy in order to ensure that the edge of individual features is not exaggerated due to the splitting of polygons from footprint of higher precedence. This dataset has NOT been adjusted for visible footprint in agriculture and grasslands area as was done in the unity footprint.
Energy	Wellsites	Alberta Biodiversity Monitoring Institute, Alberta Energy Regulator	2015	Map Display Units
	Pipelines	Alberta Biodiversity Monitoring Institute, Alberta Energy Regulator	2015	
	Seismic Lines	Alberta Biodiversity Monitoring Institute, Alberta Energy Regulator	2015	
Croplands	Crop Types	Agriculture and Agri-Food Canada (AAFC), Earth Observation Service (EOS)	2014	AAFC_EOS_2014
	Pasture Types	Agriculture and Agri-Food Canada (AAFC), Earth Observation Service (EOS)	2014	AAFC_EOS_2014
Forestry	Cutblocks	Alberta Biodiversity Monitoring Institute,	2015	
Water Wells		Data was originally obtained in 2010 via a DVD containing the groundwater well database. https://geodiscover.alberta.ca/geoportal/catalog/search/resource/details.page?uuid=%7BCAF5F6AF-A19A-4323-85D2-1BEF41110045%7D	2010	Water Well Locations represents the groundwater well locations upto 2010 based on Alberta Environment Groundwater Information Centre's (GIC) database.
Reservoir				
Groundwater		Data obtained from the ESRD in three parts - North Saskatchewan, South Saskatchewan and Red Deer:	2010	Excerpt from the Abstract of the original data source: The groundwater vulnerability mapping provide a high level overview of the sensitivity of shallow groundwater quality to potential impacts by surface activities. The final groundwater vulnerability is ranked as Low, Medium, High and Very High providing relative risk to groundwater quality from land-based activities.

		http://esrd.alberta.ca/forms-maps-services/maps/resource-data-product-catalogue/hydrological.aspx. There were significant overlaps within each data source and between the three different data sources. Manual removal of these overlaps was conducted before processing the final dataset.		
Forest Age		Alberta Vegetation Index	2015	Decades since disturbance
Grassland Vegetation Inventory		GeoDiscover Alberta - https://geodiscover.alberta.ca/geoportal/catalog/search/resource/details.page?uuid=%7BD3AB9031-8EC0-4589-9335-C1E50AE05992%7D. Originator of data: Alberta Environment and Parks, Government of Alberta	2015	Crop (Non-Irrigated) Dominant Site Type: "Non-irrigated agricultural land relies only on direct rainfall for crop growth and the process is referred to as rain-fed or dry-land farming. Cropland includes row crops, small grains, oilseeds, sod, and fallow. Includes tree/shrub farms or nurseries." GVI polygons can contain up to 4 different site types in various combinations based on percentage of polygon occupied. This dataset determined the dominant site type for each polygon based on the site type with the highest percentage value. Where no dominant site type could be ascertained (eg: 50% one site type and 50% a second site type), the site type was randomly selected (this situation occurred on less than 2% of the total GVI area). Excerpt from the Abstract of the source data: " The Grassland Vegetation Inventory (GVI) represents the Government of Alberta's comprehensive biophysical, anthropogenic and land-use inventory of the southernmost portion of the province's White Area. The compilation of the inventory commenced in 2006 in the southeast corner of the province using digital colour-infrared stereo photography. The Grassland Vegetation Inventory is intended as an update to the Native Prairie Vegetation Inventory (NPVI) that was completed circa 1993. The Grassland Vegetation Inventory product is a more comprehensive and detailed geospatial representation of land cover that is intended to meet a multitude of business needs integral to land-use planning and management in Alberta. The Grassland Vegetation Inventory is a biophysical and land-use inventory rather than a purely vegetation inventory. It is comprised of ecological range sites based on soils information for areas of native vegetation and general land use for areas of non-native vegetation, namely those associated with agricultural, industrial, and residential developments."

Variable Category	**Variable Name**	**Origin**	**Year**	**Descriptions**
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Fire		Original data source was ESRD wildfires website: http://wildfire.alberta.ca/wildfire-maps/historical-wildfire-information/spatial-wildfire-data.aspx		Historical Wildfires from 1931 to 2015. Fires are grouped into decades (eg: 1931 to 1940 = Historical Wildfires for 1940). The decade 2010 includes fires from 2001 to 2015. Boundaries between fires within each decade have been dissolved - that is, fire overlaps do not exist within each decade however, there are overlaps between decades.

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		western North America. Journal of Applied Meteorology and Climatology 51:16-29.		
	Evapotranspiration	Wang, T., Hamann, A. Spittlehouse, D.L. and Murdock, T.Q. 2012. ClimateWNA High-resolution spatial climate data for western North America. Journal of Applied Meteorology and Climatology 51:16-29.	2016	Hargreaves Reference Evaporation as derived by ClimateBC v5.21. Hargreaves Reference Evaporation in mm is a derived annual variable. Model output generated at a 100m raster resolution.
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	Pipelines	Alberta Biodiversity Monitoring Institute, Alberta Energy Regulator	2015	
	Seismic Lines	Alberta Biodiversity Monitoring Institute, Alberta Energy Regulator	2015	
Croplands	Crop Types	Agriculture and Agri-Food Canada (**AAFC**), Earth Observation Service (**EOS**)	2014	AAFC_EOS_2014
	Pasture Types	Agriculture and Agri-Food Canada (**AAFC**), Earth Observation Service (**EOS**)	2014	AAFC_EOS_2014
Forestry	Cutblocks	Alberta Biodiversity Monitoring Institute,	2015	
Water Wells		Data was originally obtained in 2010 via a DVD containing the groundwater well database. https://geodiscover.alberta.ca/geoportal/catalog/search/resource/details.page?uuid=%7BCAF5F6AF-A19A-4323-85D2-1BEF41110045%7D	2010	Water Well Locations represents the groundwater well locations up to 2010 based on Alberta Environment Groundwater Information Centre's (GIC) database.
Reservoir				
Groundwater		Data obtained from the ESRD in three parts - North Saskatchewan, South Saskatchewan and Red Deer: http://esrd.alberta.ca/forms-maps-services/maps/resource-data-product-catalogue/hydrological.aspx. There were significant overlaps within each data source and between the three different data sources. Manual removal of these overlaps was conducted before processing the final dataset.	2010	Excerpt from the Abstract of the original data source: The groundwater vulnerability mapping provide a high level overview of the sensitivity of shallow groundwater quality to potential impacts by surface activities. The final groundwater vulnerability is ranked as Low, Medium, High and Very High providing relative risk to groundwater quality from land-based activities.
Forest Age		Alberta Vegetation Index	2015	Decades since disturbance

Grassland Vegetation Inventory	GeoDiscover Alberta - https://geodiscover.alberta.ca/geoportal/catalog/search/resource/details.page?uuid=%7BD3AB9031-8EC0-4589-9335-C1E50AE05992%7D. Originator of data: Alberta Environment and Parks, Government of Alberta	2015	Crop (Non-Irrigated) Dominant Site Type: "Non-irrigated agricultural land relies only on direct rainfall for crop growth and the process is referred to as rain-fed or dry-land farming. Cropland includes row crops, small grains, oilseeds, sod, and fallow. Includes tree/shrub farms or nurseries." GVI polygons can contain up to 4 different site types in various combinations based on percentage of polygon occupied. This dataset determined the dominant site type for each polygon based on the site type with the highest percentage value. Where no dominant site type could be ascertained (eg: 50% one site type and 50% a second site type), the site type was randomly selected (this situation occurred on less than 2% of the total GVI area). Excerpt from the Abstract of the source data: " The Grassland Vegetation Inventory (GVI) represents the Government of Alberta's comprehensive biophysical, anthropogenic and land-use inventory of the southernmost portion of the province's White Area. The compilation of the inventory commenced in 2006 in the southeast corner of the province using digital colour-infrared stereo photography. The Grassland Vegetation Inventory is intended as an update to the Native Prairie Vegetation Inventory (NPVI) that was completed circa 1993. The Grassland Vegetation Inventory product is a more comprehensive and detailed geospatial representation of land cover that is intended to meet a multitude of business needs integral to land-use planning and management in Alberta. The Grassland Vegetation Inventory is a biophysical and land-use inventory rather than a purely vegetation inventory. It is comprised of ecological range sites based on soils information for areas of native vegetation and general land use for areas of non-native vegetation, namely those associated with agricultural, industrial, and residential developments."