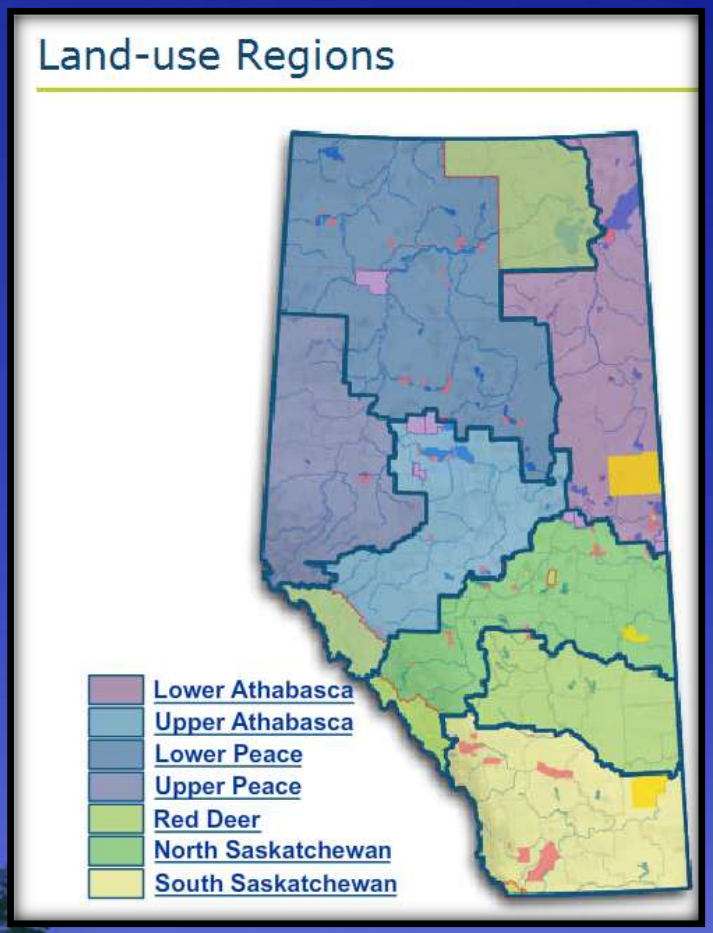
Assessing the Cumulative Effects of Alberta's Land Uses using ALCES

www.alces.ca

A Presentation to the
Central Modeling Workshop



Why are we here? - an Awakening has Occurred

Natural Resource Production System

Alberta is Firing on All Land Use Cylinders

- 1-1.5 million head of cattle harvested
- 2-3 million head of swine harvested
- 100-120 million kg of poultry harvested
- 25-35 million tonne of crop harvested
- 20-25 million m^3 of timber harvested
- 150-160 billion m^3 of natural gas produced
- 25-35 million m^3 of conventional oil produced
- 60-80 million m^3 of bitumen produced
- 25-35 million tonne of coal produced
- 1200-1500 petajoules of electricity produced

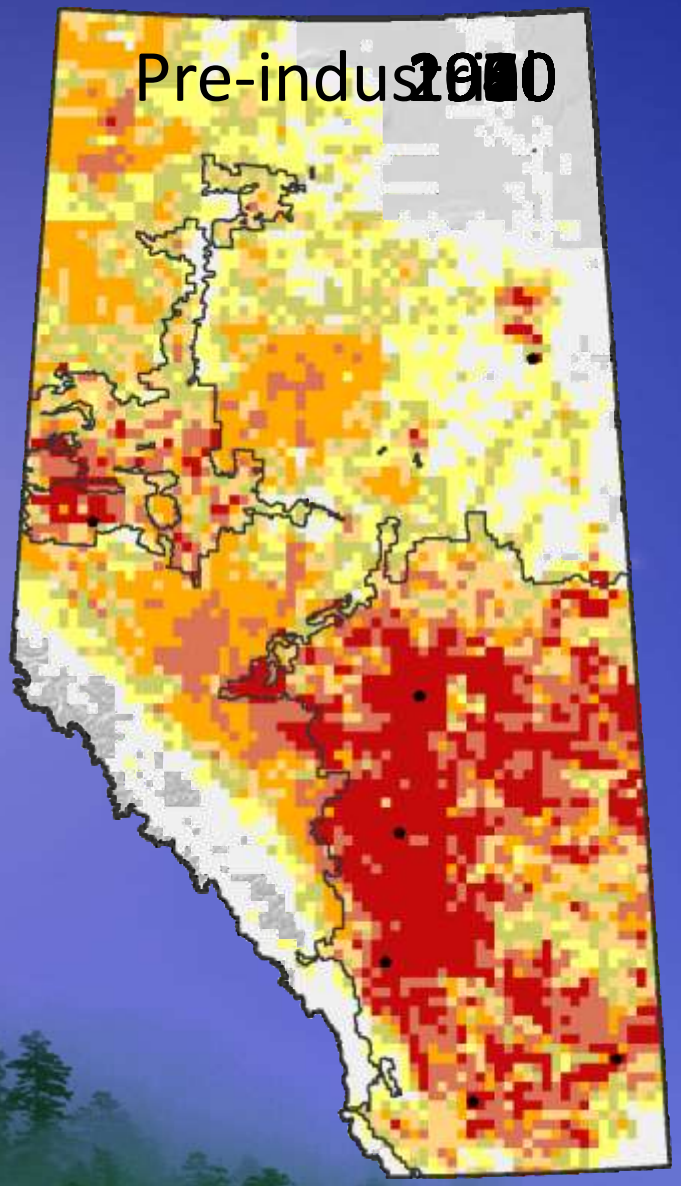




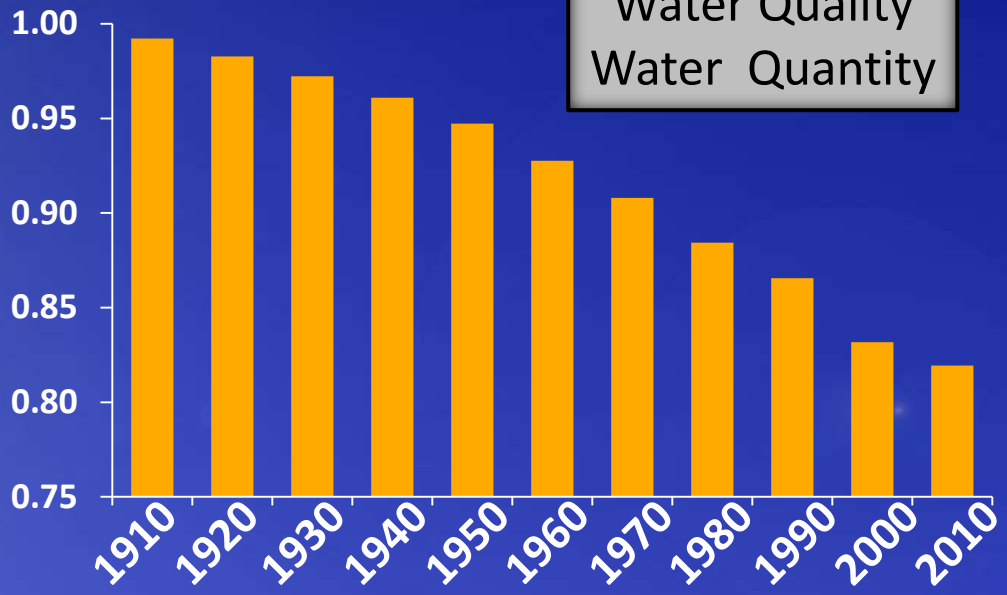




Reductions in Ecological Goods and Services



Biotic Carbon
Water Quality
Water Quantity



Land Use Index

- 0.935 - 0.999
- 0.874 - 0.934
- 0.808 - 0.873
- 0.748 - 0.807
- 0.726 - 0.747
- 0.678 - 0.725
- 0.325 - 0.677

Areas without a coloured grid cell have an index of 1 meaning no threat.

Home Back

Multiple Communities, Multiple Demands

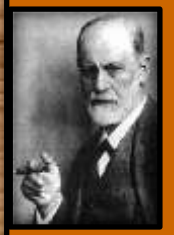
Control Switches
















Energy Analyst | Economist | Mining Analyst | Ecologist | Soils Scientist | Military | Cropland Specialist

Hydrologist | Sociologist

Forester | Urban Planner | First Nations | Climate Scientist | Fire Ecologist | Transport Engineer | Ranching Specialist

4.05

Balancing the Equation

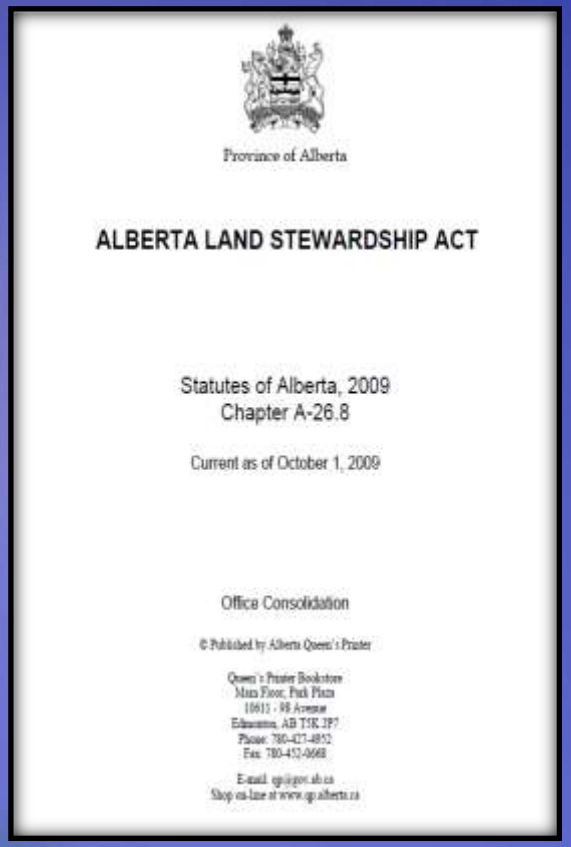
Internalization of Natural Capital into Decision Making

An Integrated Approach: Management by Objective

- Food
- Settlements
- Fuel
- Fiber
- Water Quantity
- Water Quality
- Carbon Stocks
- Air Quality

Trade-Offs
Limits
Thresholds
Risks
Knowledge

Alberta Land Stewardship Act (ALSA)



Province of Alberta

ALBERTA LAND STEWARDSHIP ACT

Statutes of Alberta, 2009
Chapter A-26.8

Current as of October 1, 2009

Office Consolidation

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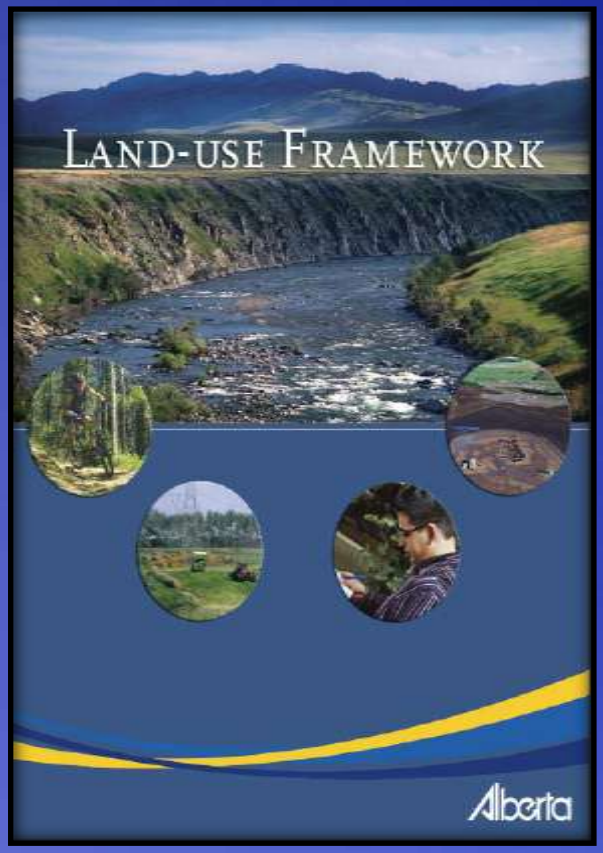
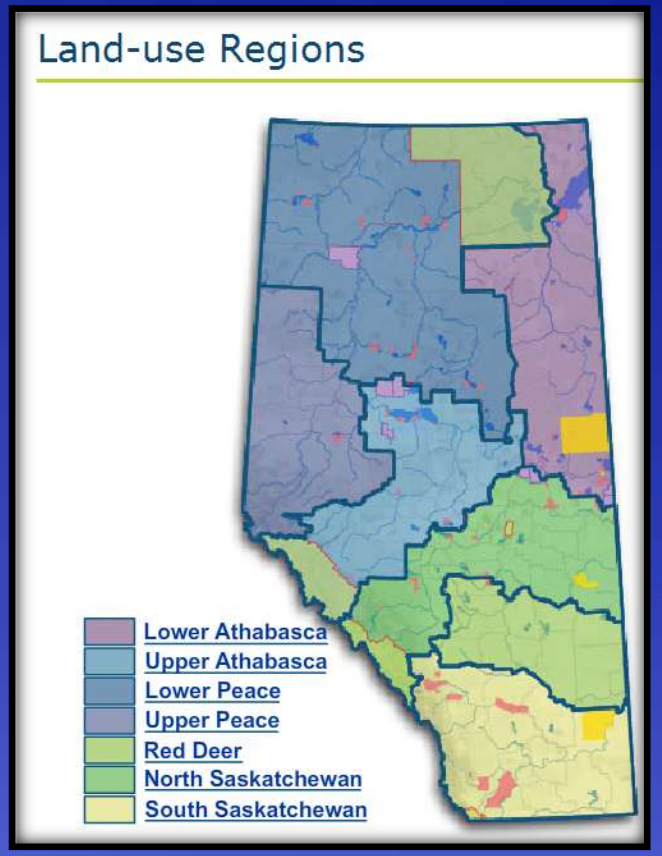
Alberta Land-Use Framework (ALUF)



Alberta Land Use Framework Regions



The ALCES Simulator Toolkit

- Several Tools in the Toolkit
- "What-If" Simulators
- Long-term (chronic = year DT) not acute (day DT) temporal domain
- Alberta has been the Geographic Focus
- Model Gradient from Simple to Comprehensive but focus has generally been more on shuttle architecture (focus on 1st and 2nd order dynamics)
- Educational Focus to Professional Grade
- Temporal Domain of Past, Current, and Future
- Triple Bottom Line Indicators
- Major Focus on Beneficial Management Practices
- Enable "Management by Objective" Solutions

ALCES ToolKit

Licensed
End User Computer

Licensed
End User Computer

Subscription and
Internet Delivered

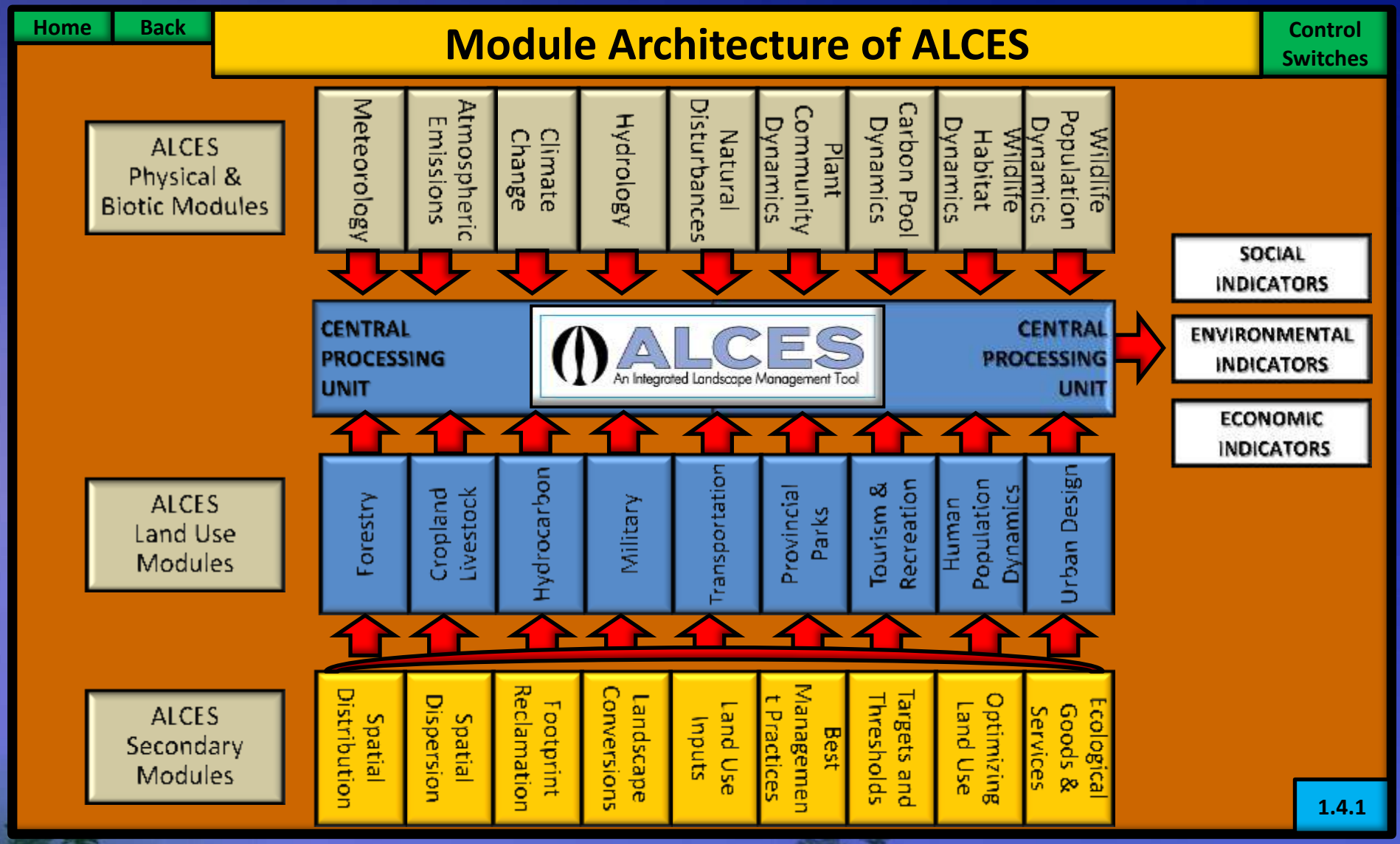
Free and Internet Delivered

Free and Internet Delivered

Free and Internet Delivered

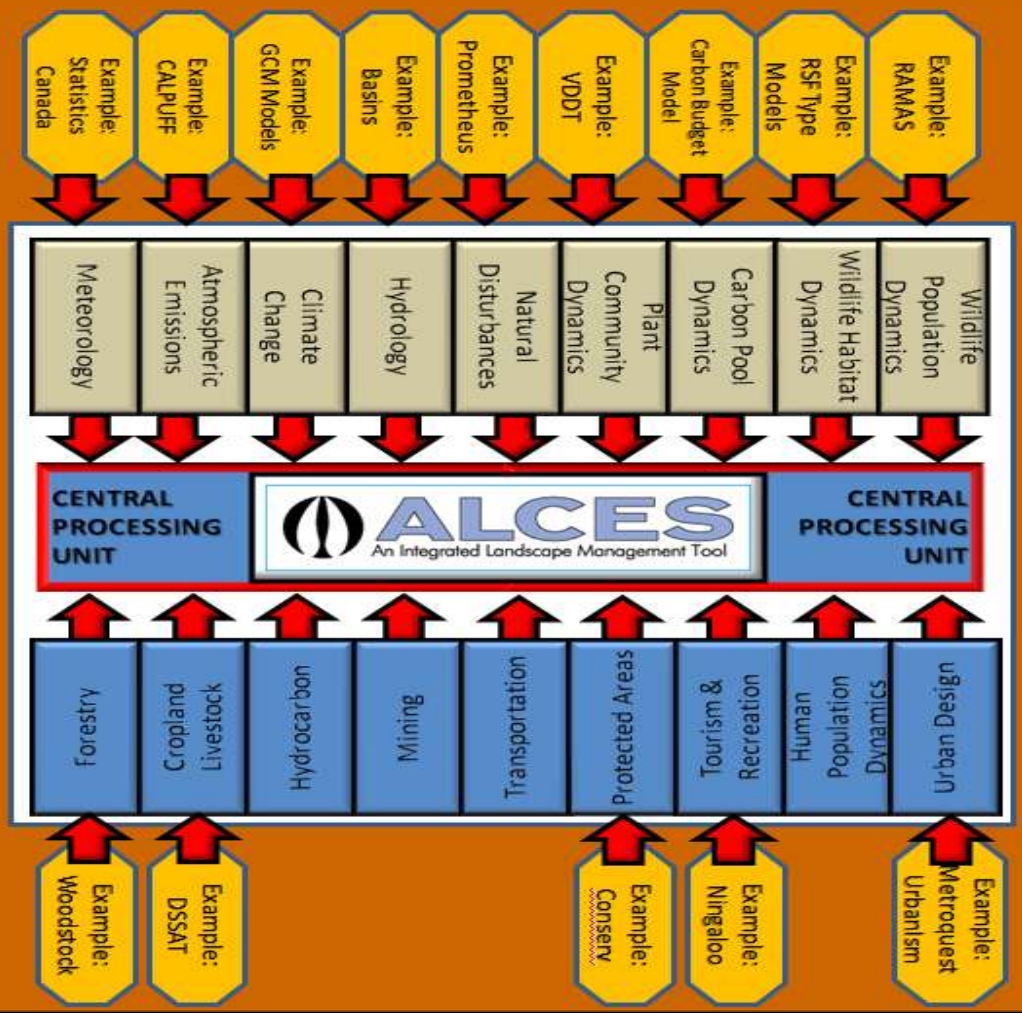
Successful Assessment of Cumulative Effects of Land Uses requires Simulators to address:

- Air, Land, Water
- All Relevant Land Uses
- All Relevant Natural Disturbance Regimes
- Triple Bottom Line Indicators
- Temporal Domain of Past, Present, and Future
- Reference Points for Indicator Performance
- Uncertainty = Sensitivity Analyses
- “Beneficial Management Practices”
- Output that is Tabular, Graphic, and Maps
- Transparent Models where Users can readily see structure and Assumptions



Multi-Model Integration with ALCES

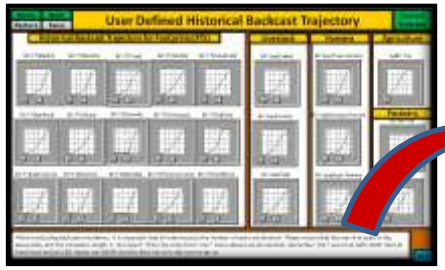
For Projects where detailed and mechanistic sectoral models have already been constructed, ALCES can be informed (receive input) from the output from these models



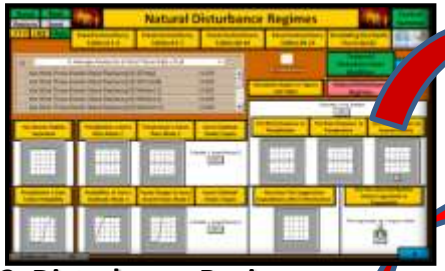
1.4.2

The basic steps of simulating land use in ALCES

General Input-Output Pathways of ALCES Municipality

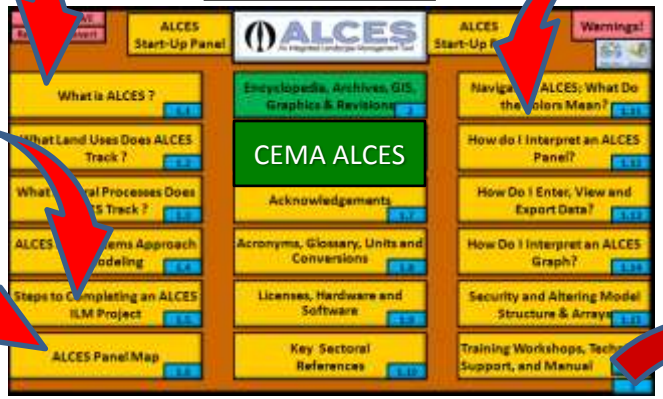


2. Historical Land Use Trajectory



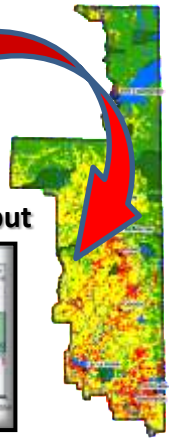
3. Disturbance Regimes

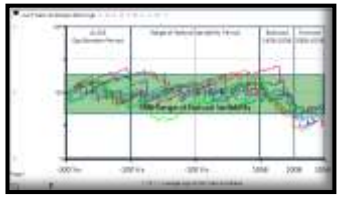
4. Future Land Use Trajectories and Metrics



5. Conduct Simulations in Central ALCES Engine

1. Initial GIS Data and Landscape Composition





6. ALCES Output

Tracking Land Uses in ALCES

Home | Back | Control Switches

What Land Uses Does ALCES Track?

8.1		Forestry	8.5		Cropland Aquaculture	8.9		Protected Areas
8.2		Energy	8.6		Livestock	8.10		Tourism Recreation
8.3		Mining	8.7		Human Population Urban	8.11		Hunting, Fishing Trapping
8.4		Transport	8.8		First Nations	8.12		Assorted Industry

1.2

Tracking Natural Disturbances in ALCES

Home | Back | Control Switches

What Natural Processes Does ALCES Track?

1.3.1  Climate and Climate Change

1.3.2  Hydrological Cycle

1.3.3  Natural Disturbance Regimes

1.3.4  Plant Community Dynamics

Carbon Pool Dynamics  1.3.5

Wildlife Habitat  1.3.6

Wildlife Populations  1.3.7

Landscape Metrics  1.3.8

1.3

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Landscape Type (LT) Stratification; Alberta Example

Control Switches

LT1  Hardwood Forest	LT6  Fen	LT11  Shrubland	LT16  Foothills
LT2  Mixedwood Forest	LT7  Bog	LT12  Cereal Cropland	LT17  Beach
LT3  Mesic Spruce Forest	LT8  Lentic (Lakes and Ponds)	LT13  Forage Cropland	LT18  Prairie Potholes
LT4  Hygric Spruce Forest	LT9  Lotic (Streams and Rivers)	LT14  Alpine	LT19  Non-vegetated (dunes)
LT5  Pine Forest	LT10  Native Grassland	LT15  Glaciers	LT20  Shoreline

4.1

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Footprint Type (FT) Stratification; An Alberta Example

Control Switches

FT1  Major Road (highway)	FT6  Air Strip	FT11  Recreational Feature
FT2  Minor Road	FT7  Recreational Trail	FT12  Seismic Lines
FT3  Railway	FT8  Golf Course	FT13  Wellpad
FT4  Inblock Road	FT9  Downtown City	FT14  Pipeline
FT5  Transmission Line	FT10  Suburbia	FT15  Surface Mines

4.2

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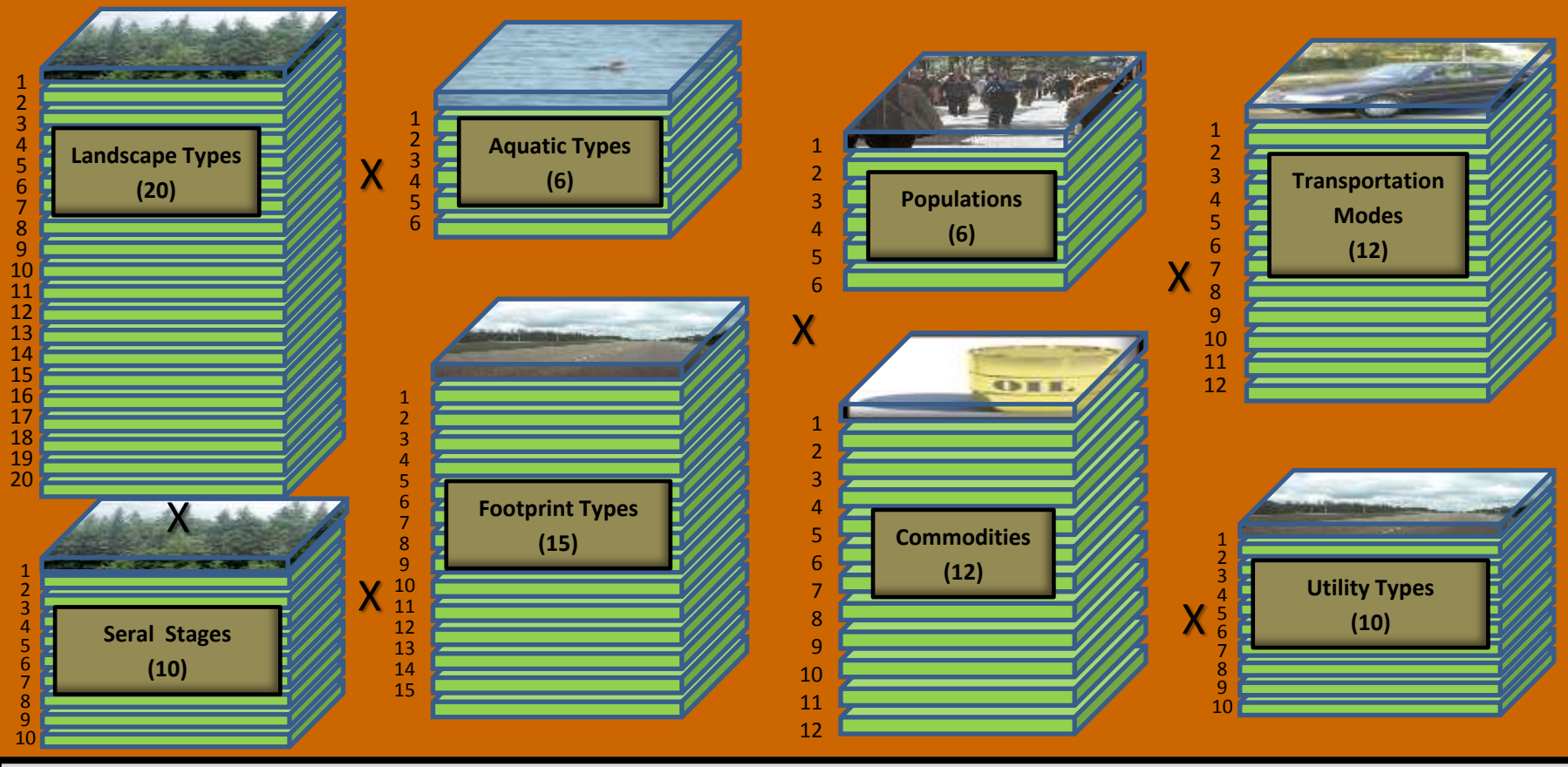
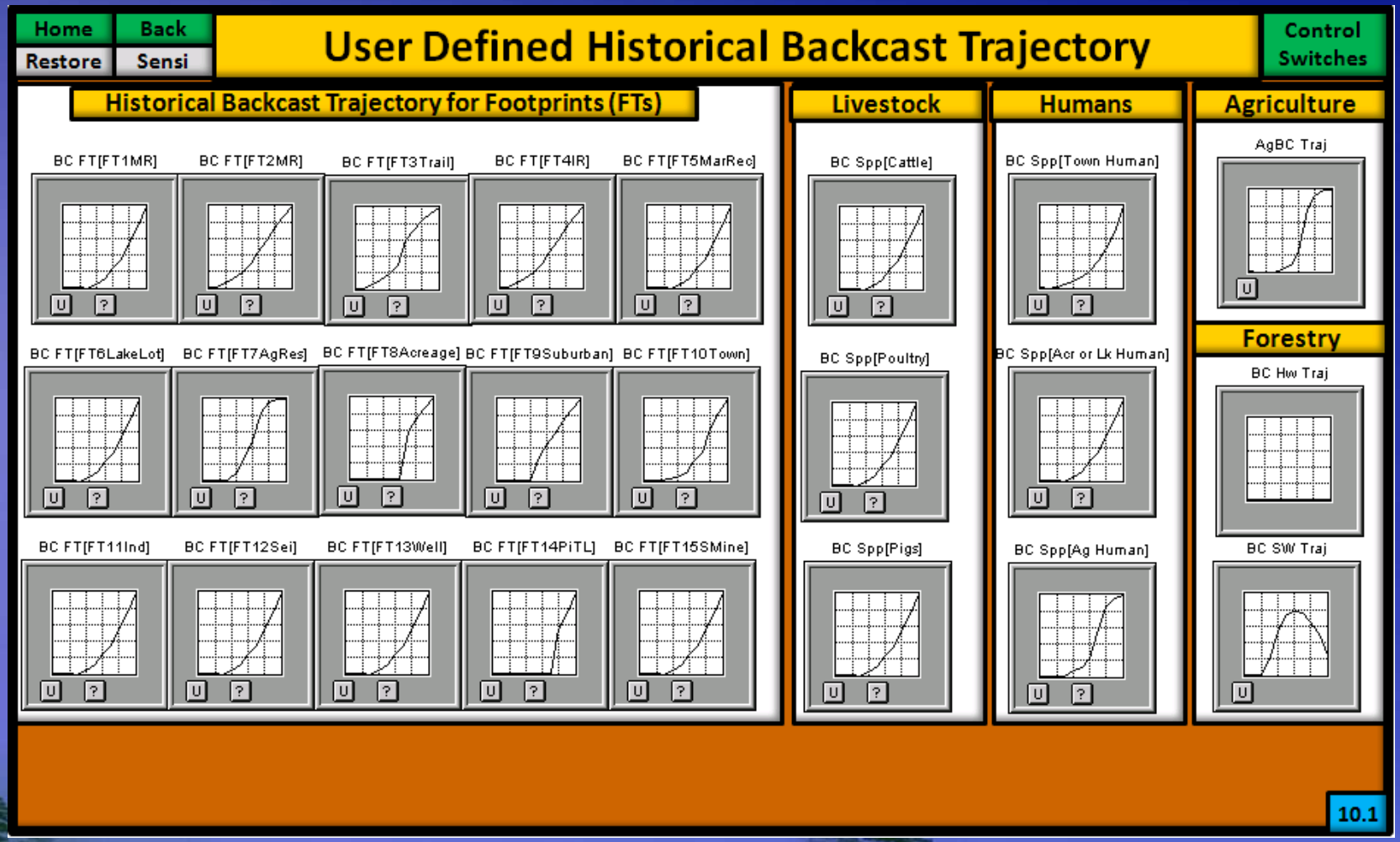
Permutations for Stratification Themes



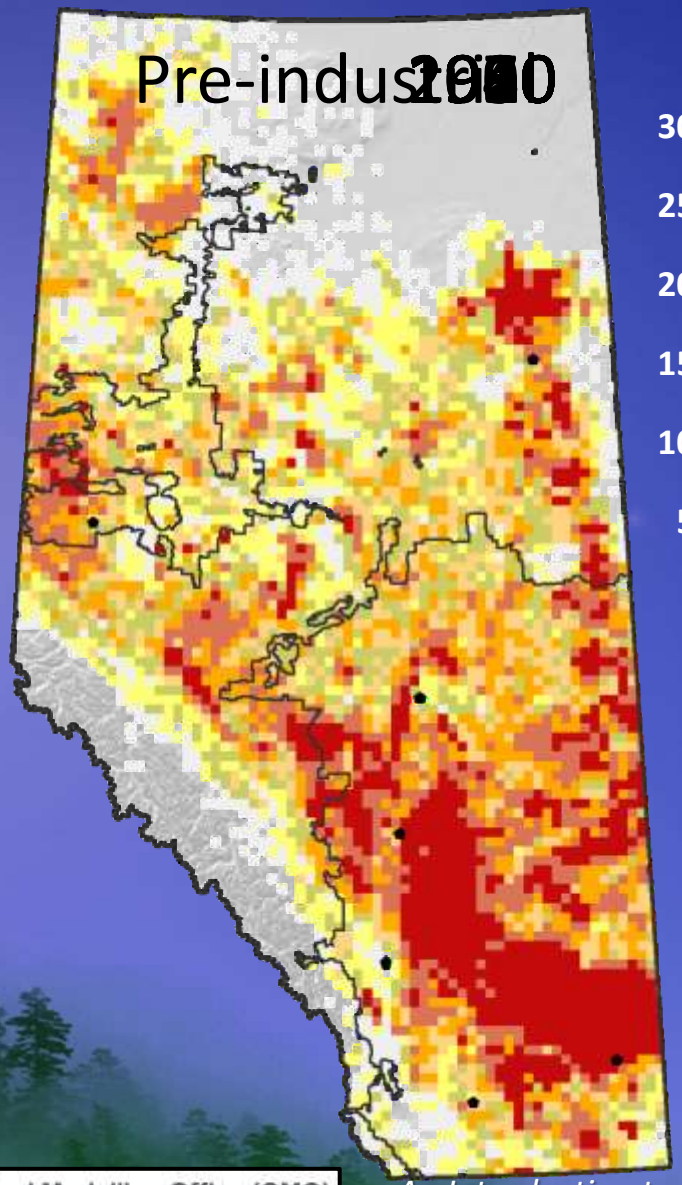
20 Landscape Types	X	10 Seral Stages	X	6 Aquatic Types	X	15 Footprint Types	X	6 Populations Types	X	12 Commodities Types	X	12 Transport Types	X	10 Utility Types	=	155,520,000 Combinations

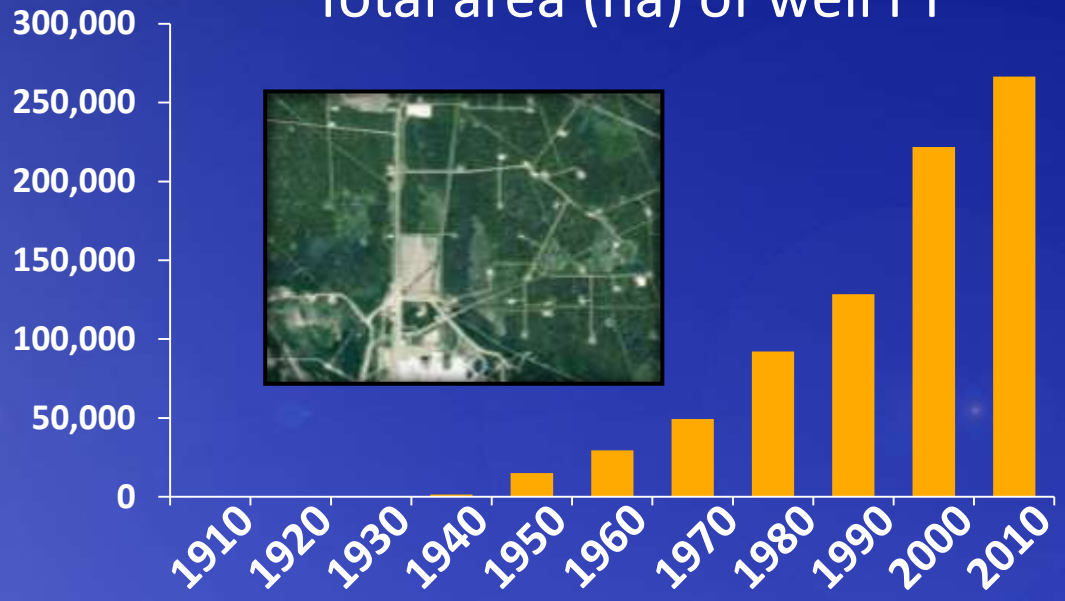
4.7

Reconstructing the History of Land Use Footprints



Hydrocarbon Well Footprint



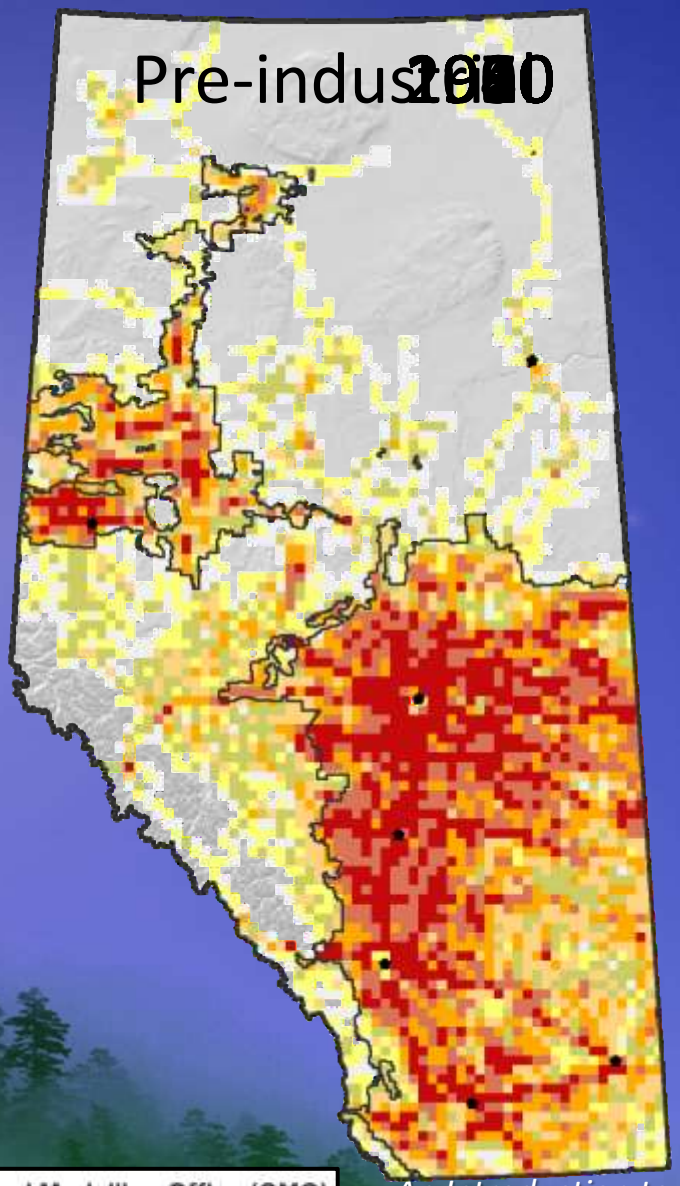


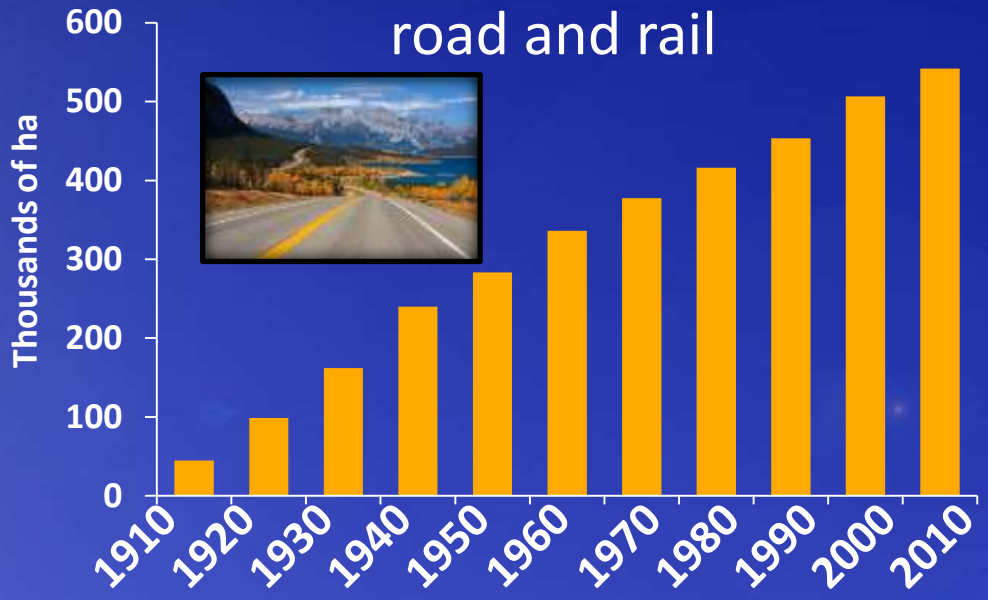
% Well FT

- 0.001 - 0.033
- 0.034 - 0.096
- 0.097 - 0.188
- 0.189 - 0.308
- 0.309 - 0.485
- 0.486 - 0.951
- 0.952 - 10.488

Central Modelling Office (CMO)

History of Alberta's Road Network



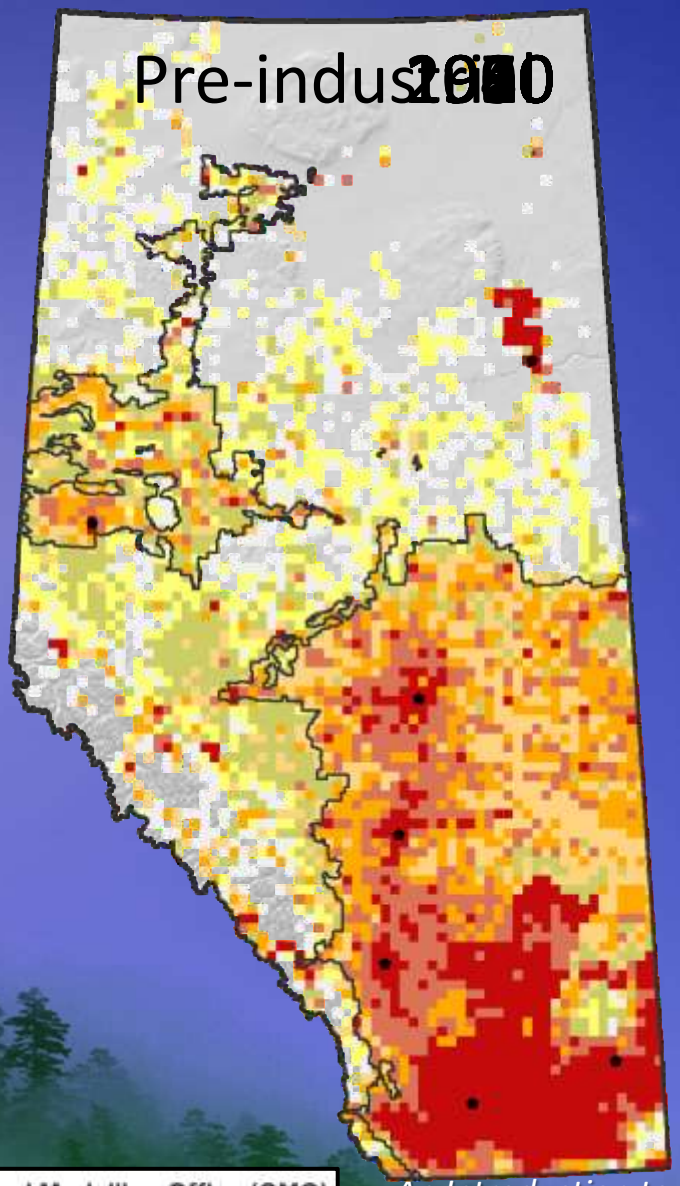


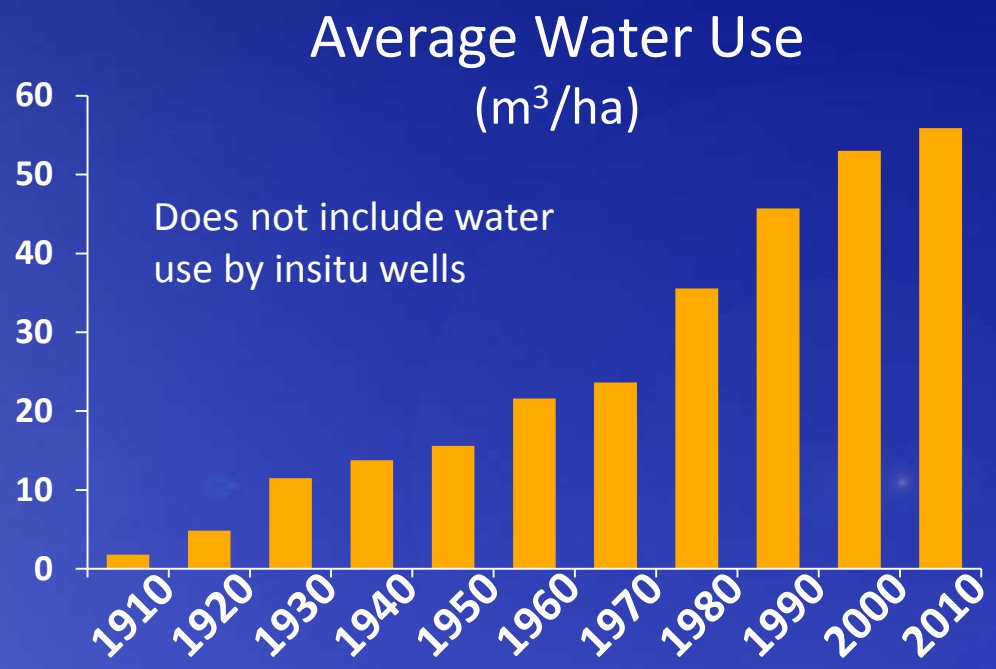
% Transportation FT

- 0.001 - 0.260
- 0.261 - 0.535
- 0.536 - 0.928
- 0.929 - 1.382
- 1.383 - 1.897
- 1.898 - 2.384
- 2.385 - 6.059

Central Modelling Office (CMO)

Water Demand





Water Use (m³/ha)

- 0.001 - 0.105
- 0.106 - 0.464
- 0.465 - 2.472
- 2.473 - 6.835
- 6.836 - 20.272
- 20.273 - 93.737
- 93.738 – 3,012.780

Exploring Alternative Futures

Define the House!!!!!

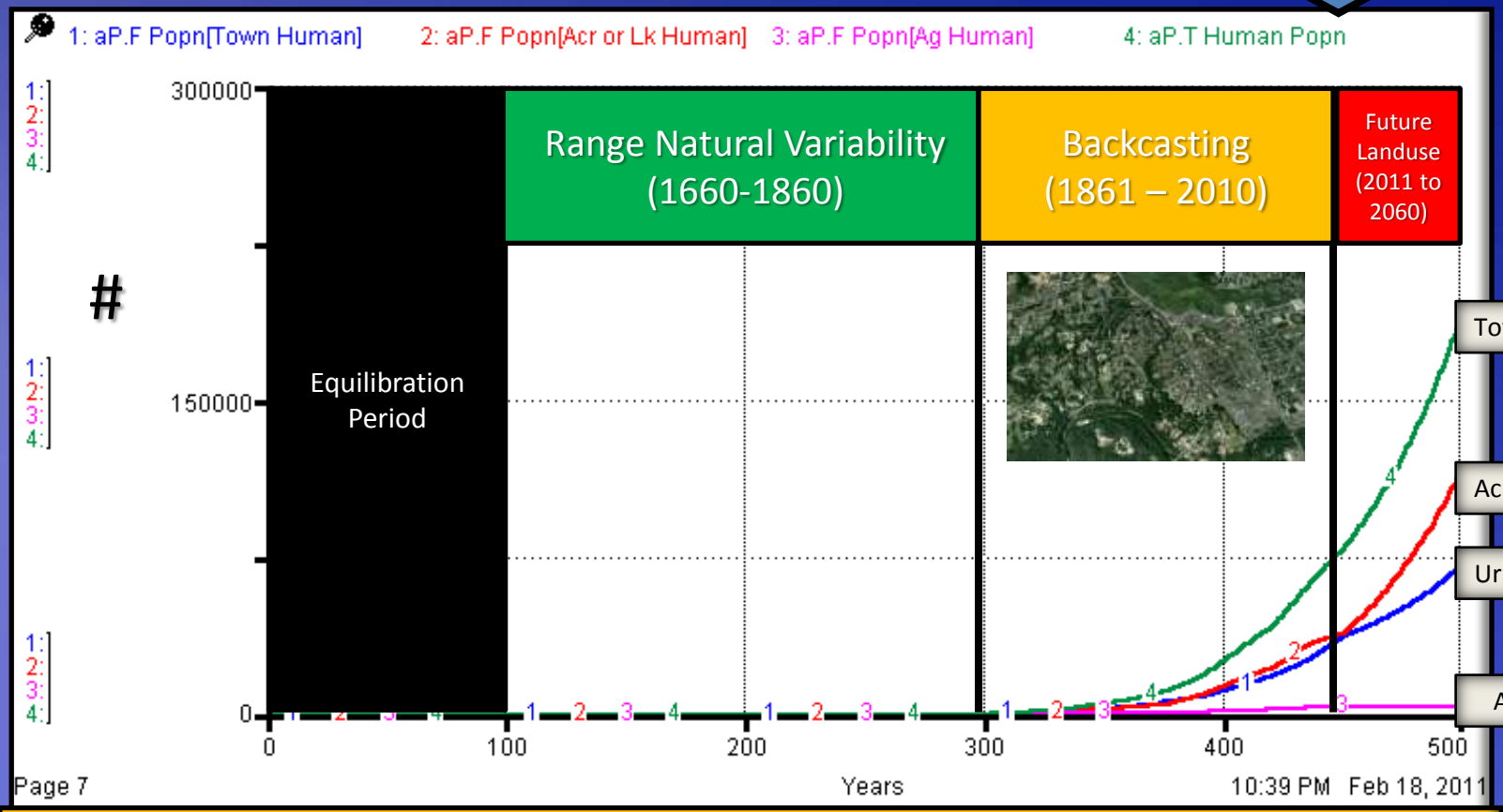
Strategy C

Strategy B

Strategy A

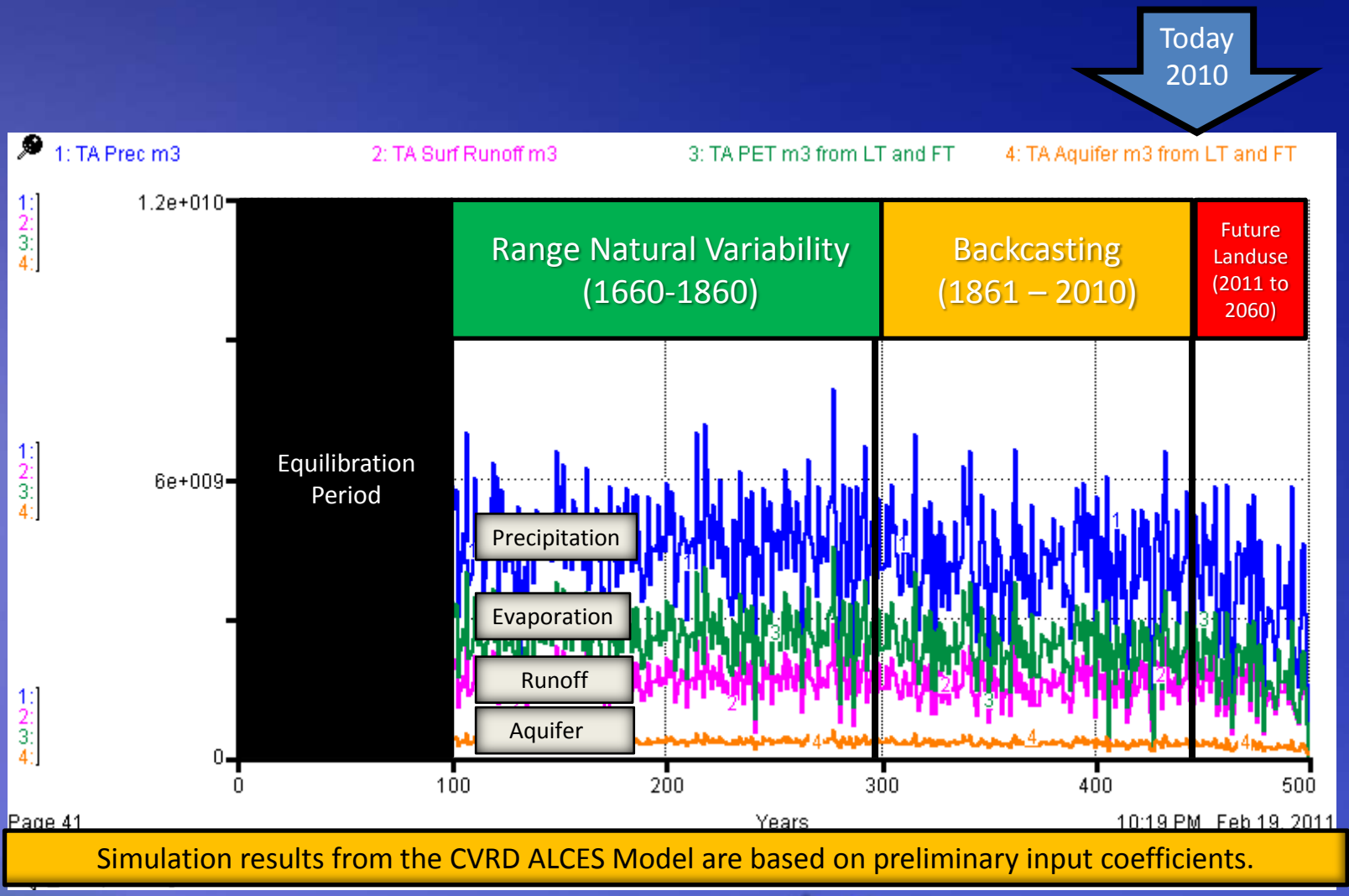
1905 → 2005

Graphic ALCES Output
Example: Human Population

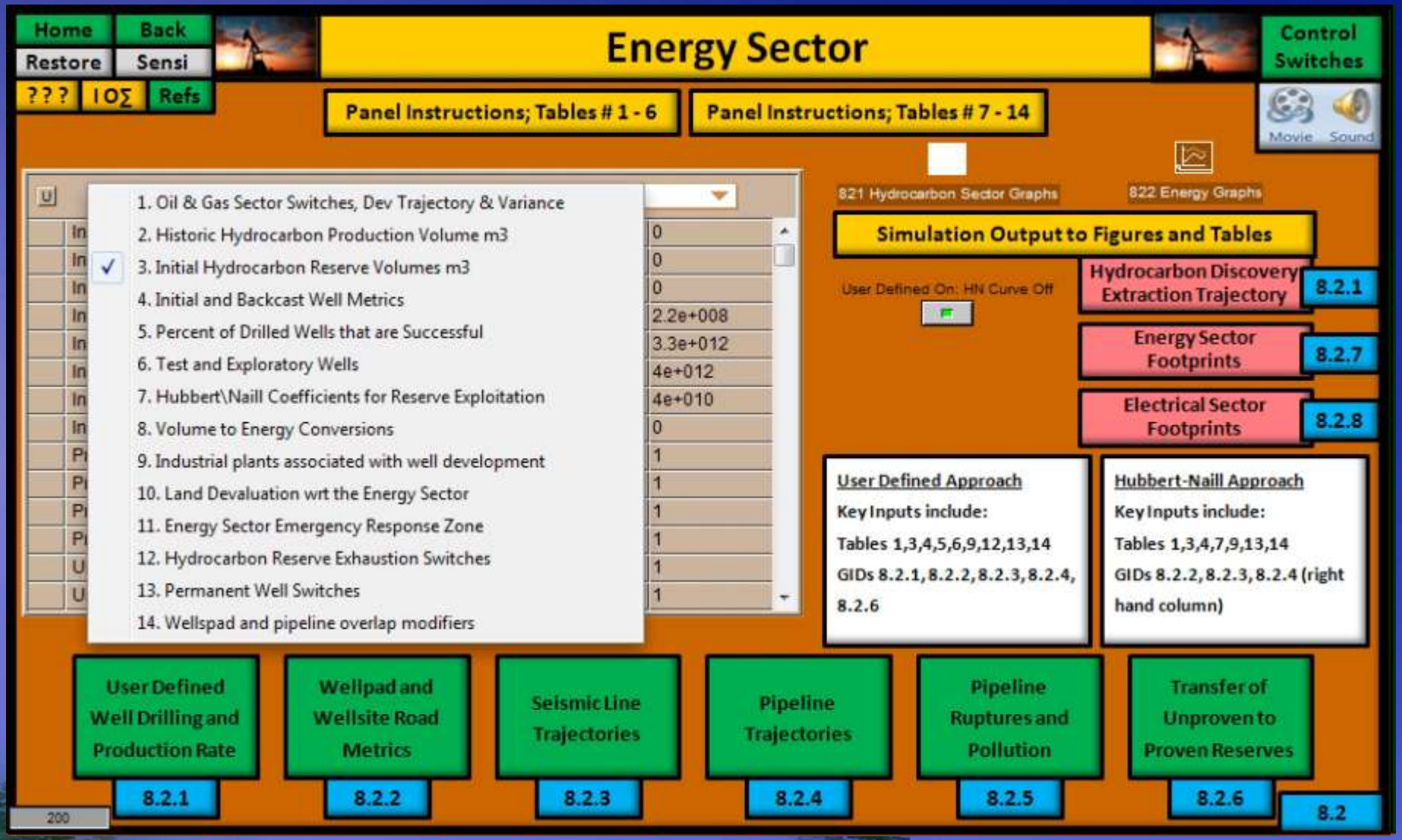


Simulation results from the CVRD ALCES Model are based on preliminary input coefficients.

Meteorology



Simulation results from the CVRD ALCES Model are based on preliminary input coefficients.



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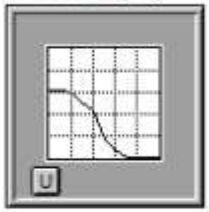
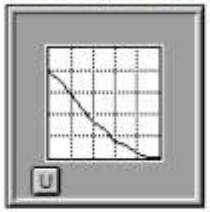
Future Well Drilling and Production Rates

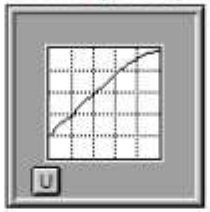
Control Switches

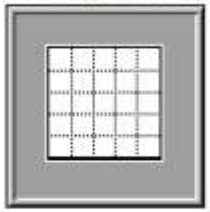
Simulation Output to Figures and Tables

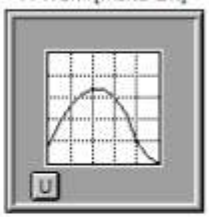
Annual # of Wells Drilled



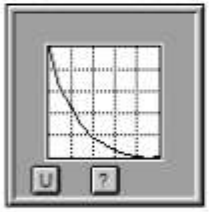


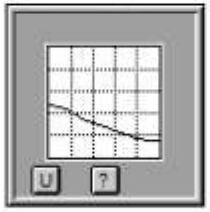


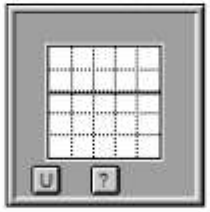


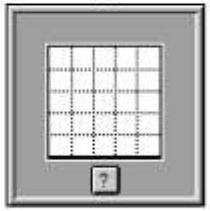


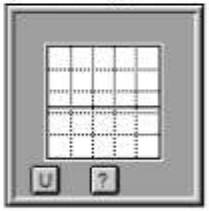
Well Production Rates (m^3/well/year)



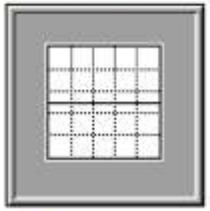


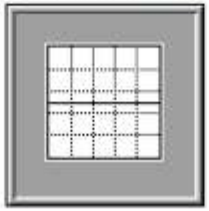


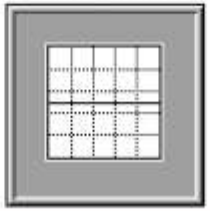


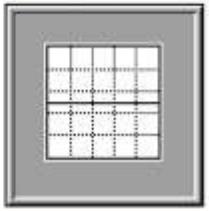


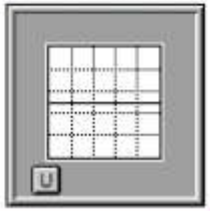
Well Production Rate Change (DF)







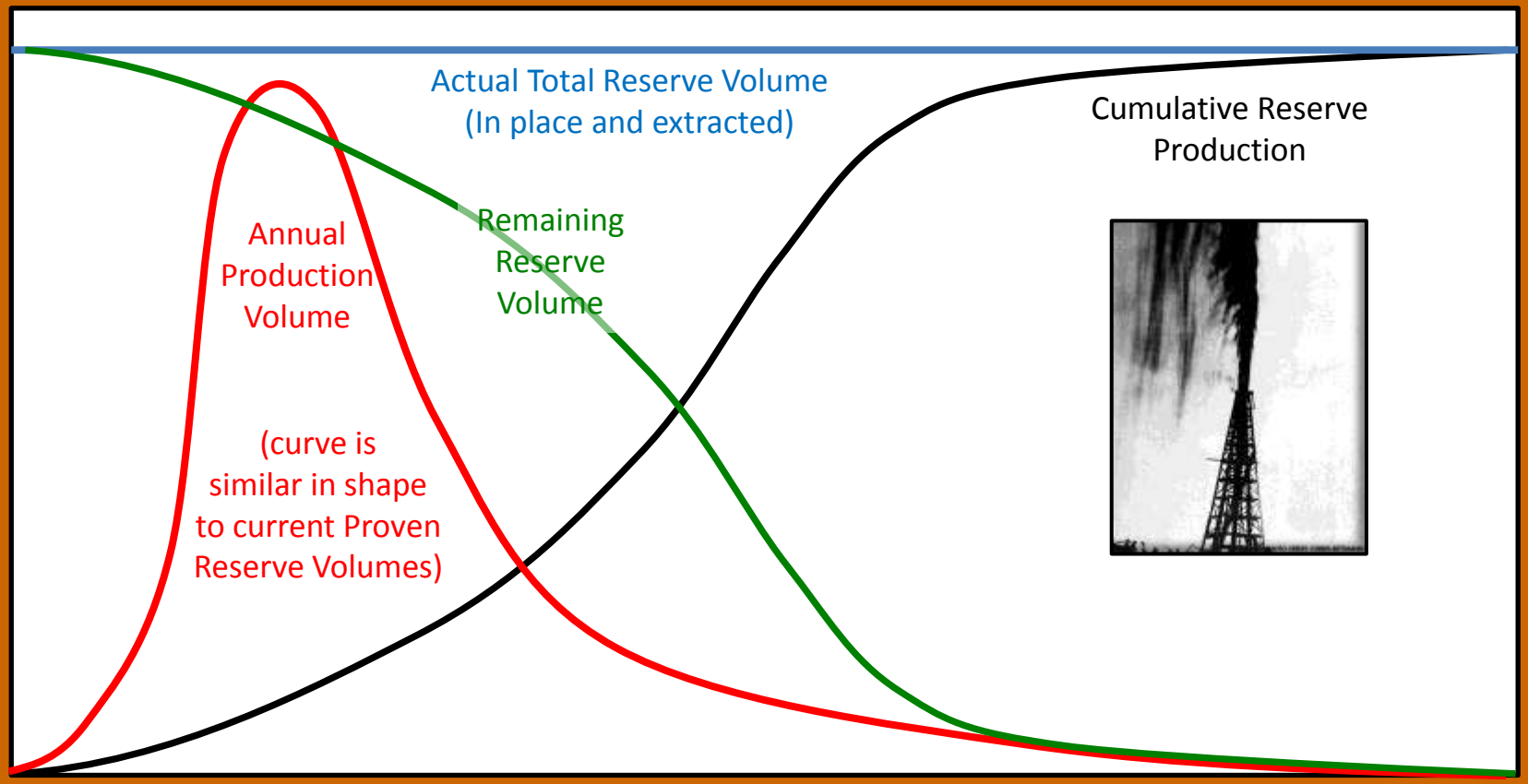




simulation year | 200

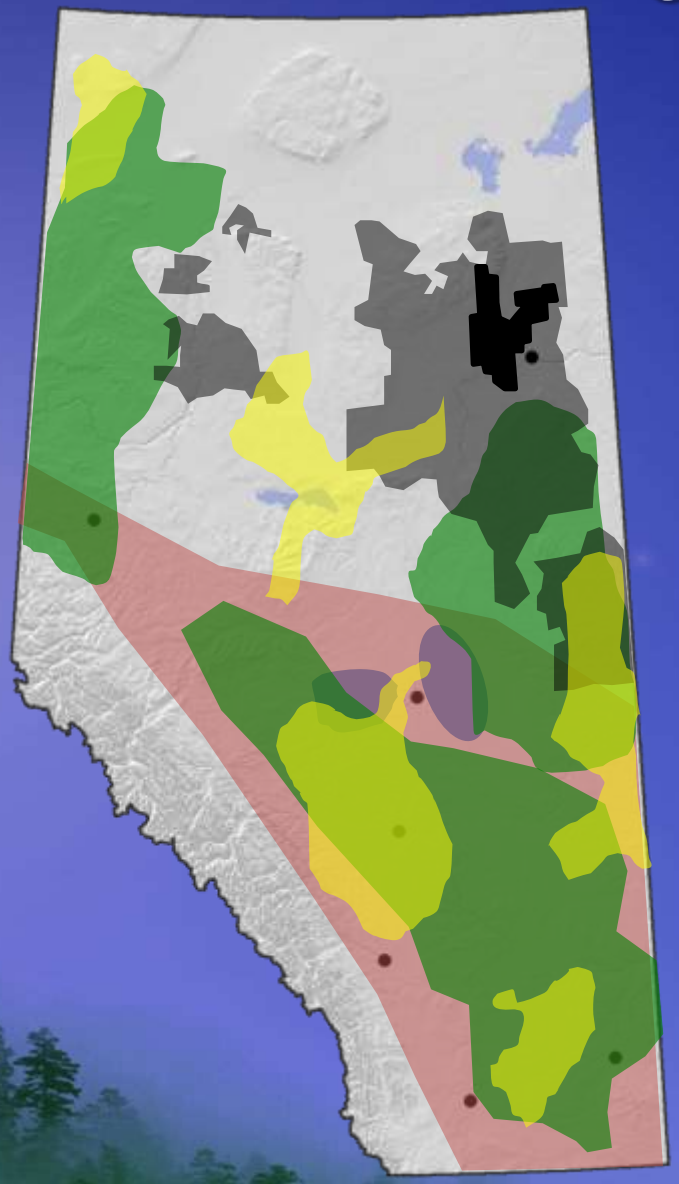
8.2.1

Generalized Hydrocarbon Discovery and Extraction Trajectory



8.2.5

An Example of Spatial Stratification of Future Hydrocarbon Growth Regions

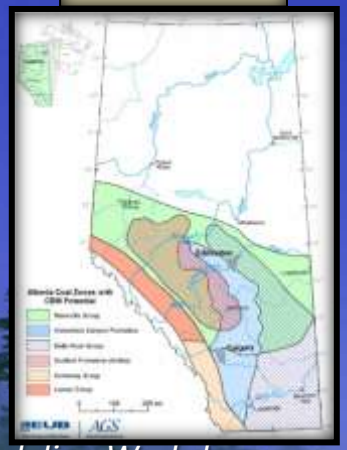


- Growth Area for Conv Oil
- Growth Area for Conv Gas
- Growth Area for Surf Bitumen
- Growth Area for Insitu Bitumen
- Growth Area for Coal Mining
- Growth Area for Unconv Gas (CBM, tight, shale)

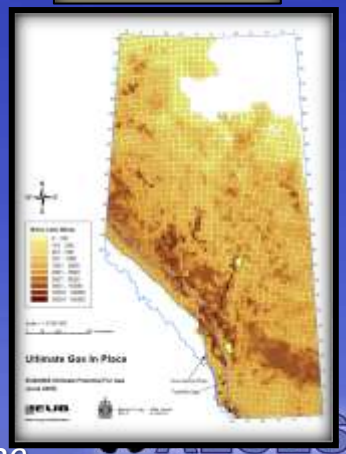
Deep Gas and CBM Gas

Oilsands and Oil

Unconventional Gas



Remaining Gas Reserves



Ecological indicators and key ecosystem drivers






Landscape Composition

Forest Age Structure

Forest Core Area

Landscape Fragmentation

Human Access

Water Flow Dynamics

Sediment Movement

Moose

Old Forest Bird Habitat

Fisher

Caribou

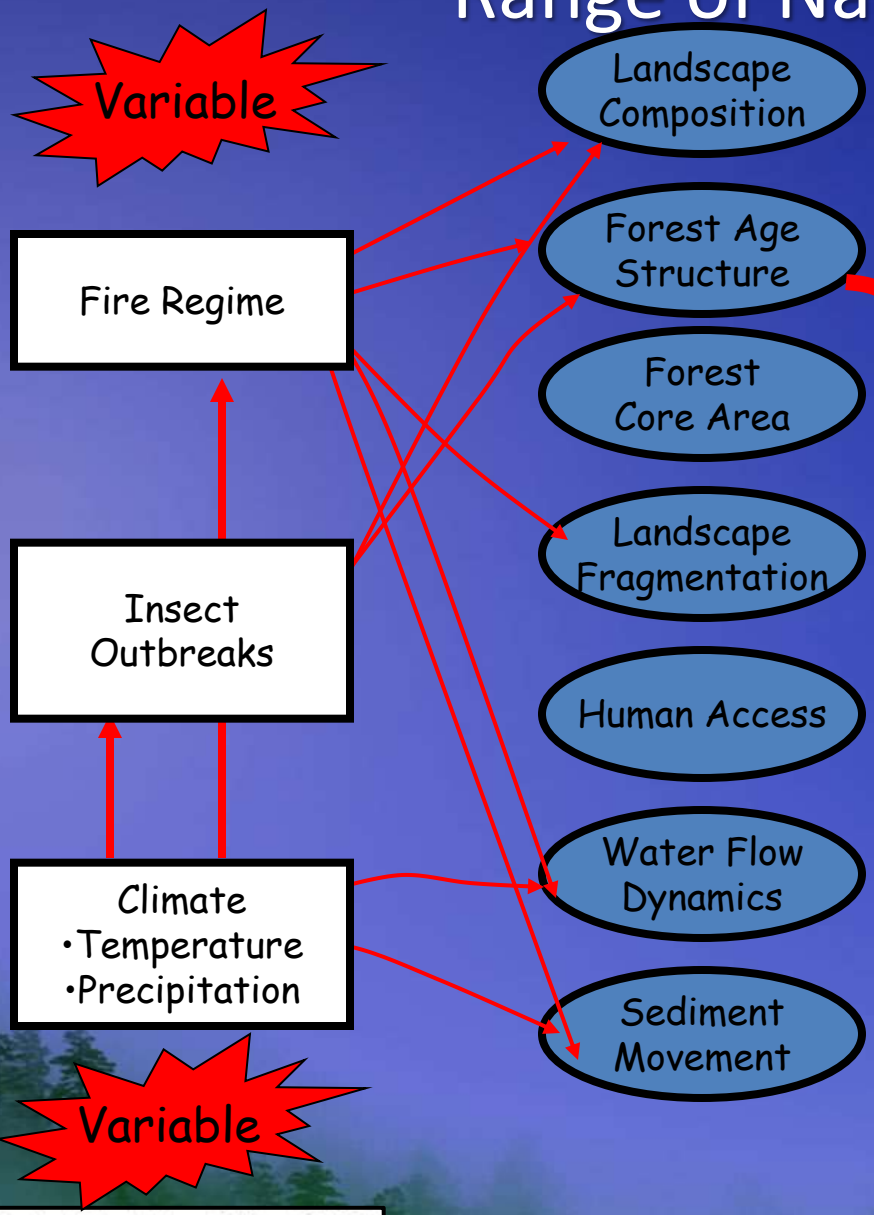
Grizzly Bear

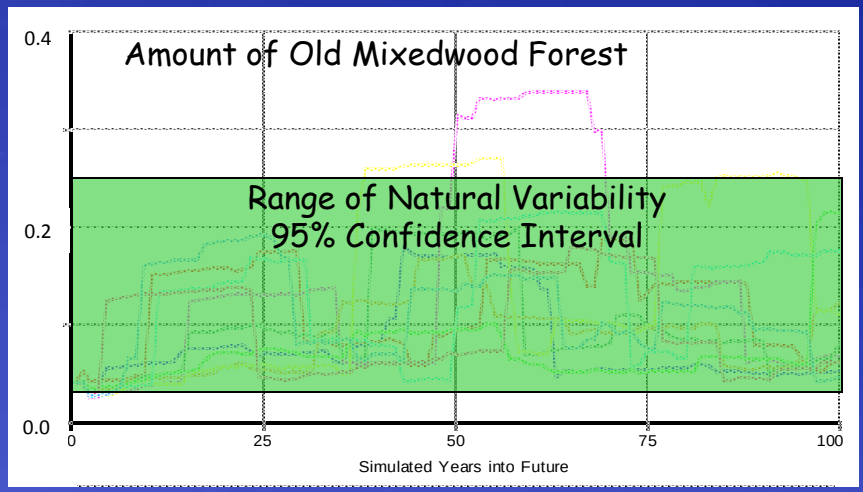
Walleye





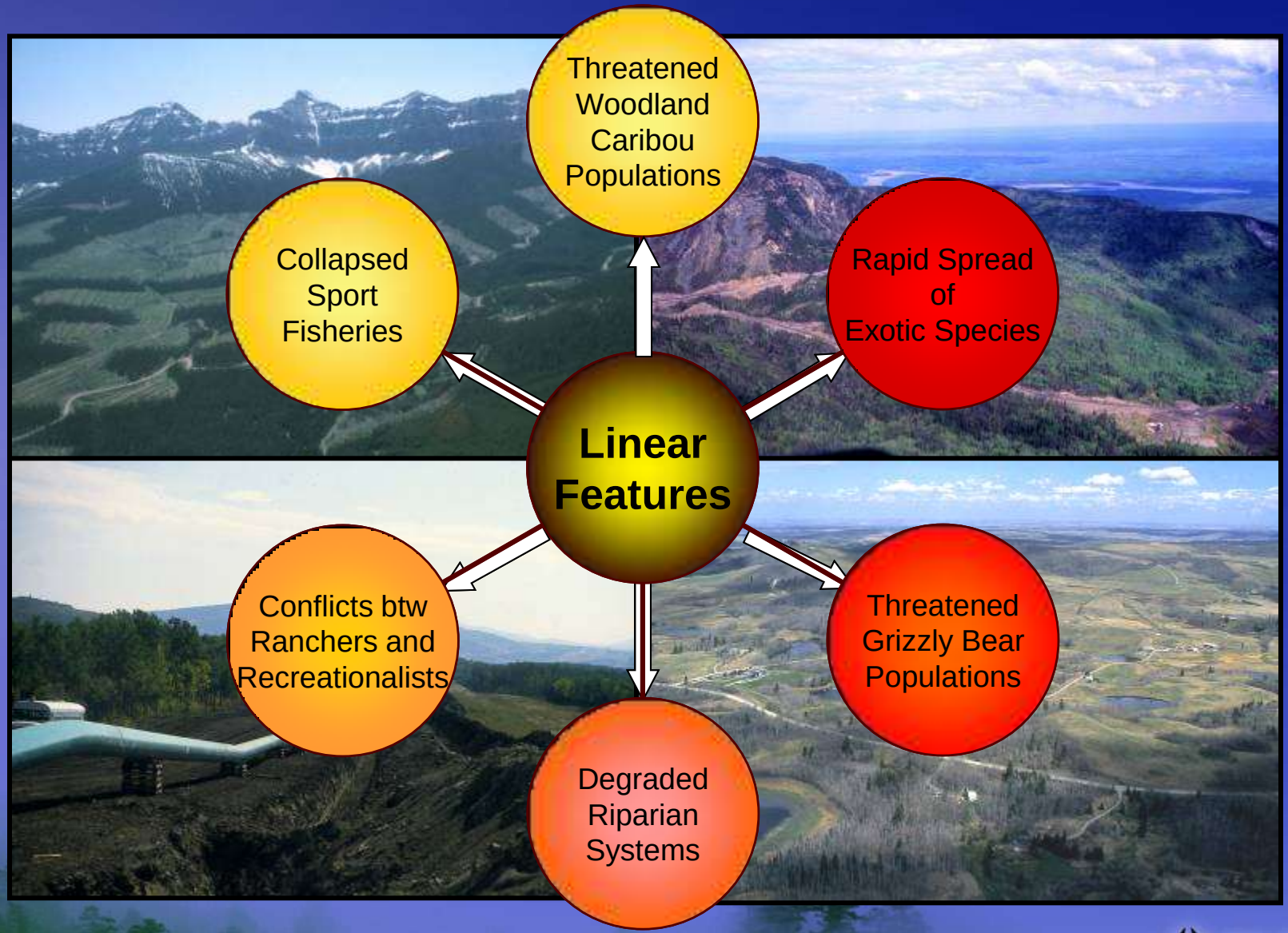

Ecological Drivers, Disturbance Regimes, & "Range of Natural Variability"

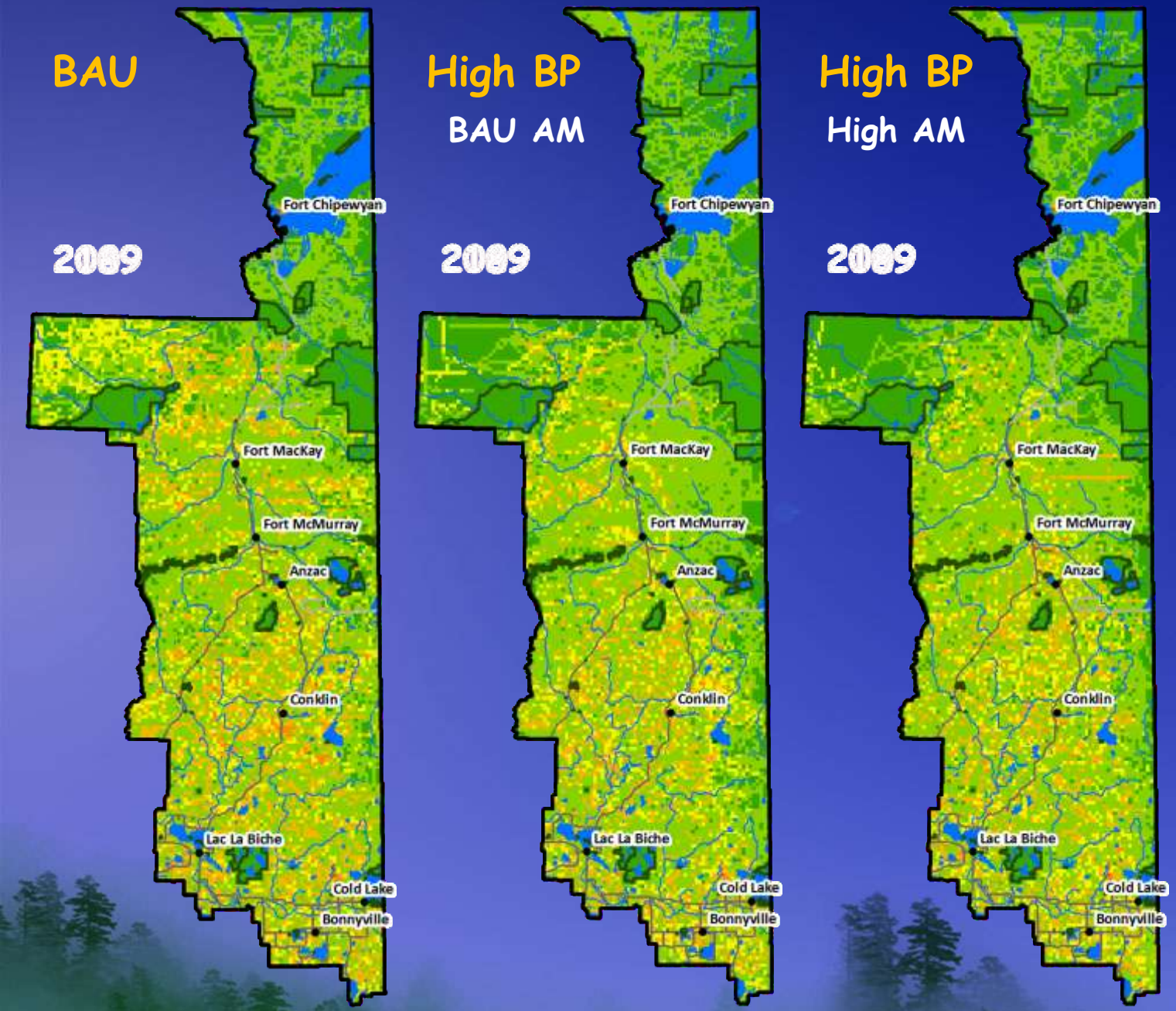




Linear Features and Access Management

A Common Thread





Linear Edge Density (km/km^2)

Linear Edge Density (km/km^2)

- 0
- 0 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- 4.1 - 5.0
- >5.0
- Highway
- Winter road
- Protected area
- Hydrography

0 25 50 100
Kilometres

Central Modelling Office (CMO)

33

ALCES Landscape & Land-Use Ltd.

Black Bear HSI

BAU

2089

High BP

BAU AM

2089

High BP

High AM

2089

Fort Chipewyan
Fort MacKay
Fort McMurray
Anzac
Conklin
Lac La Biche
Cold Lake
Bonnyville

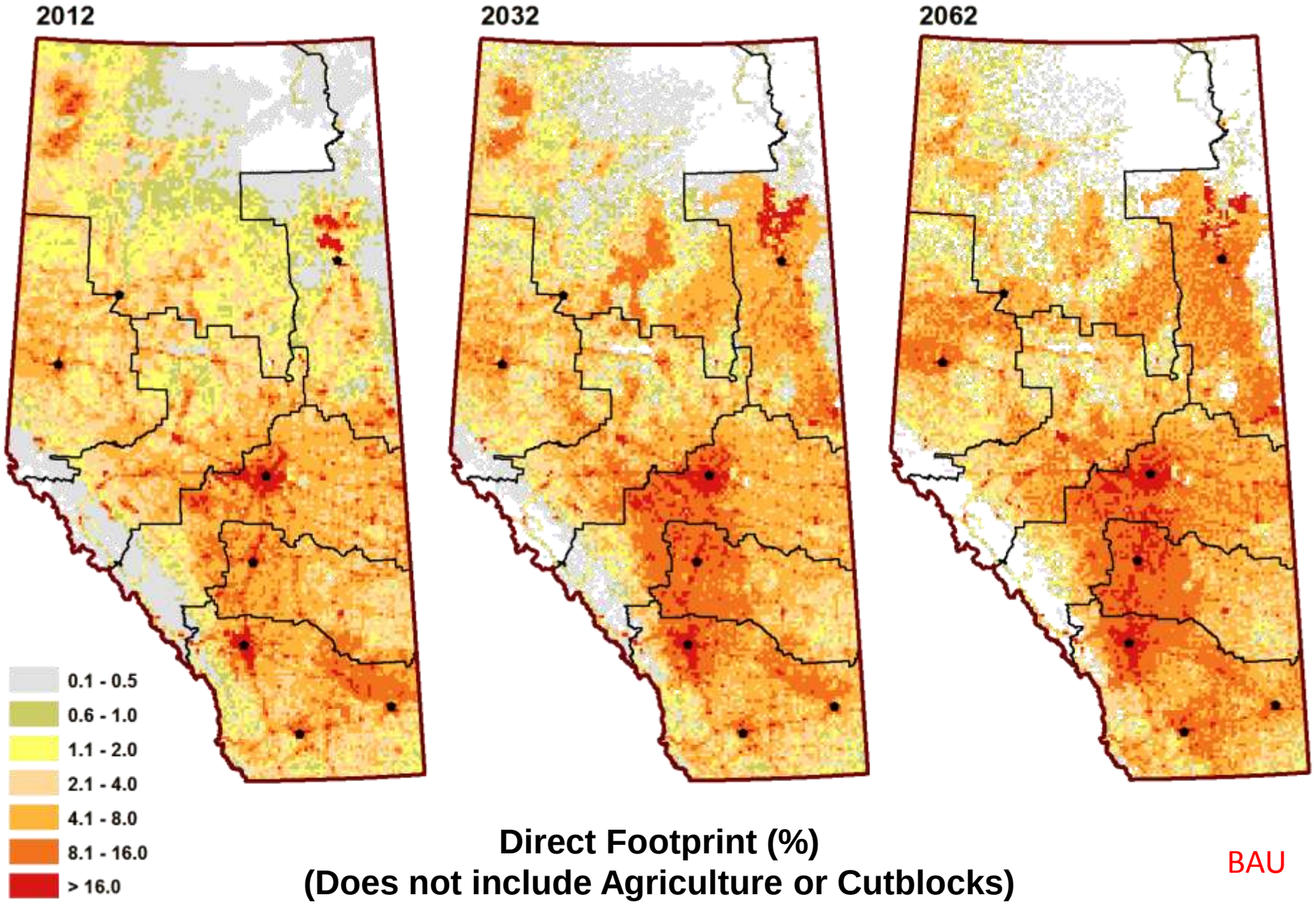
Black Bear HSI

- High Risk
- Moderate Risk
- Low Risk
- Stable
- RNV
- Highway
- Winter road
- Protected area
- Hydrography

0 25 50 100
Kilometres

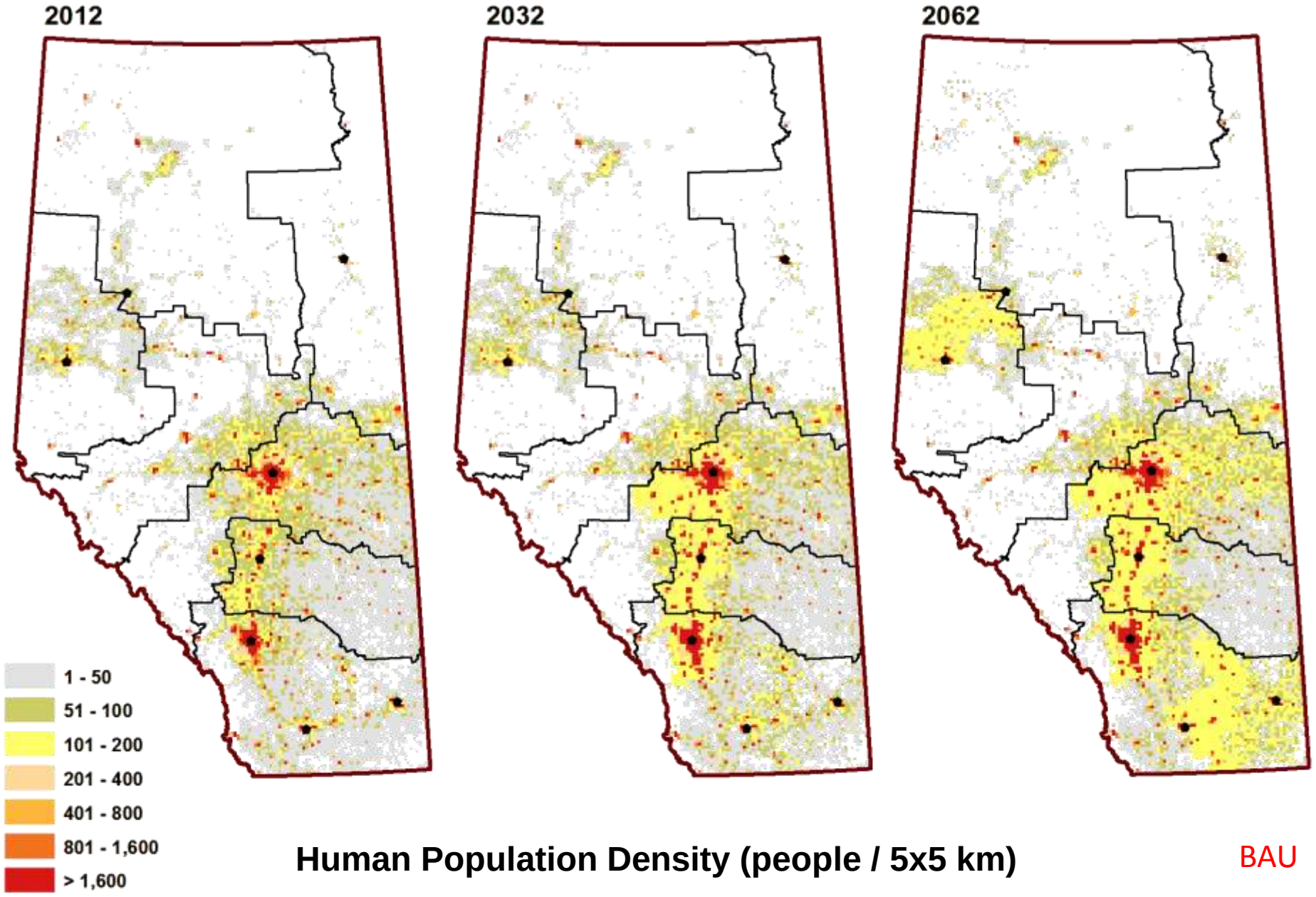
Central Modelling Office (CMO)

34



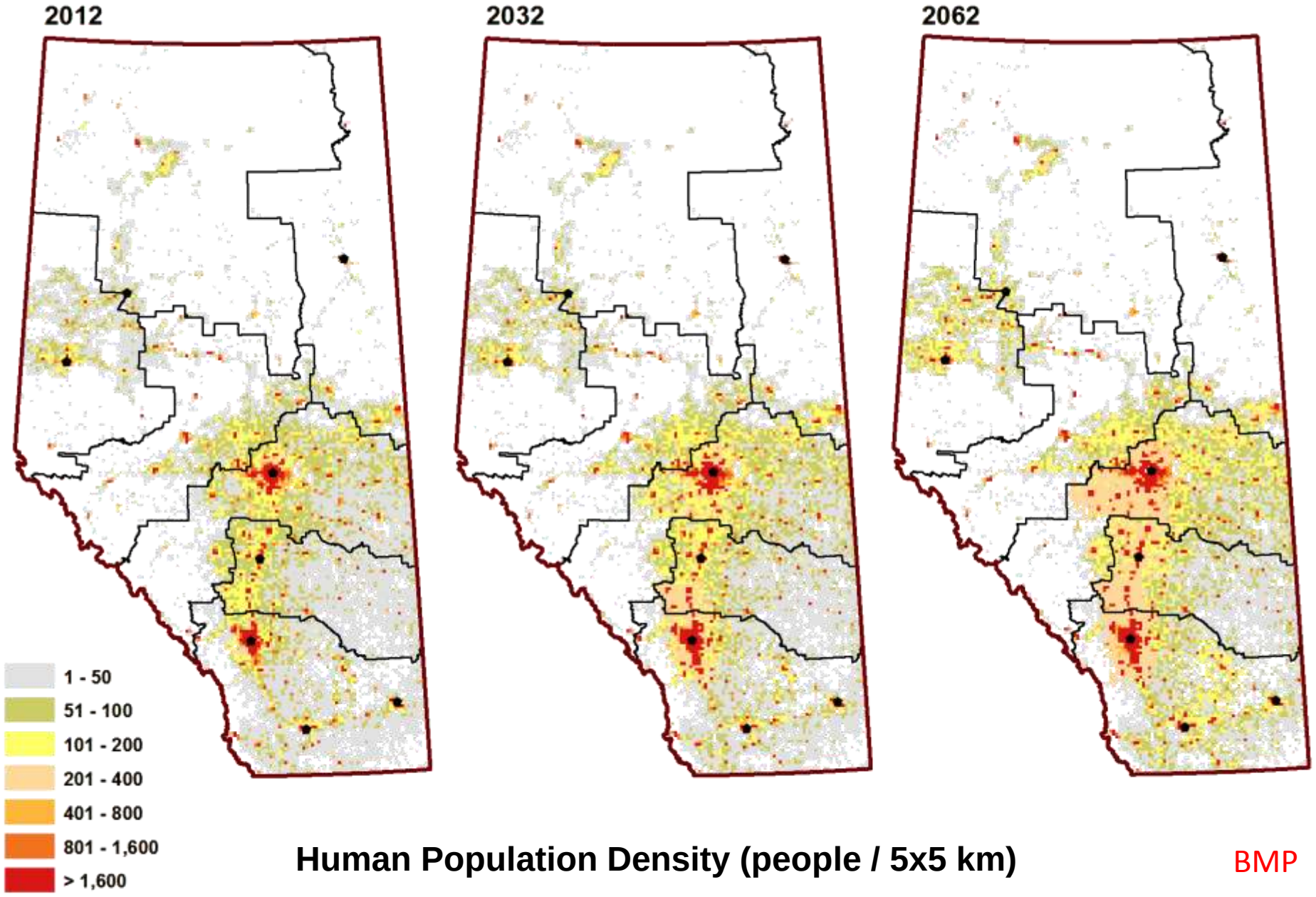
Direct Footprint (%)
(Does not include Agriculture or Cutblocks)

BAU



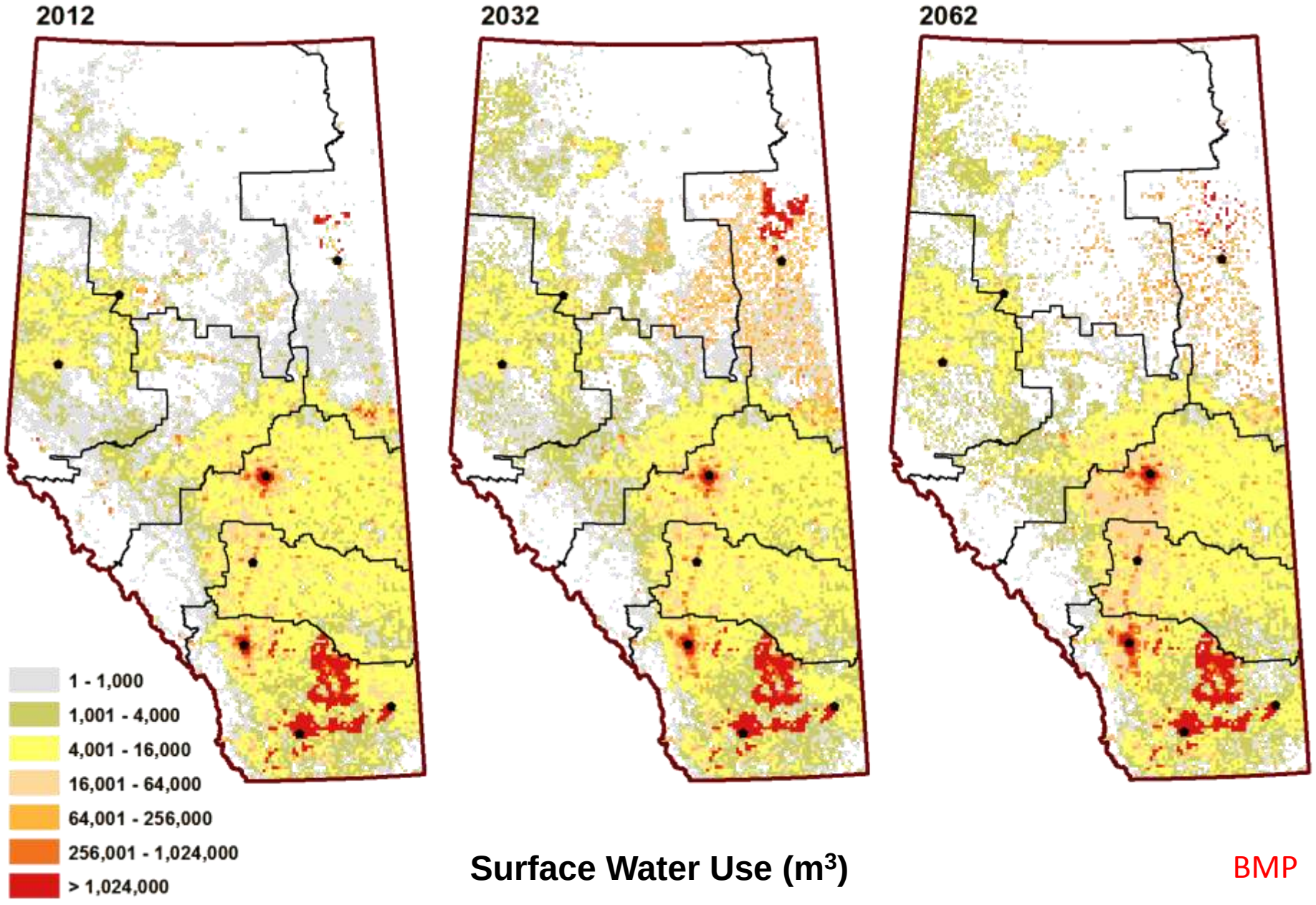
Human Population Density (people / 5x5 km)

BAU



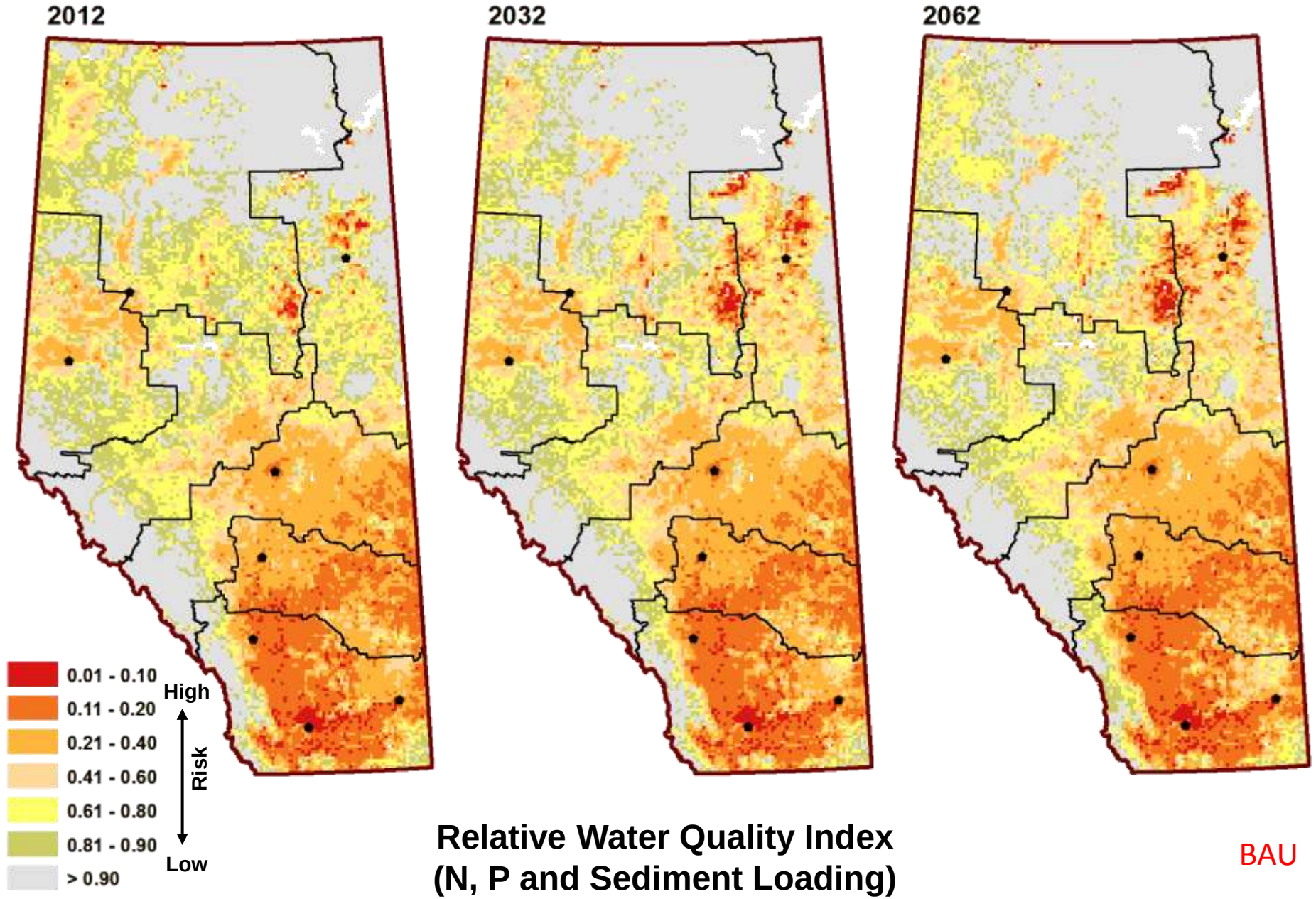
Human Population Density (people / 5x5 km)

BMP



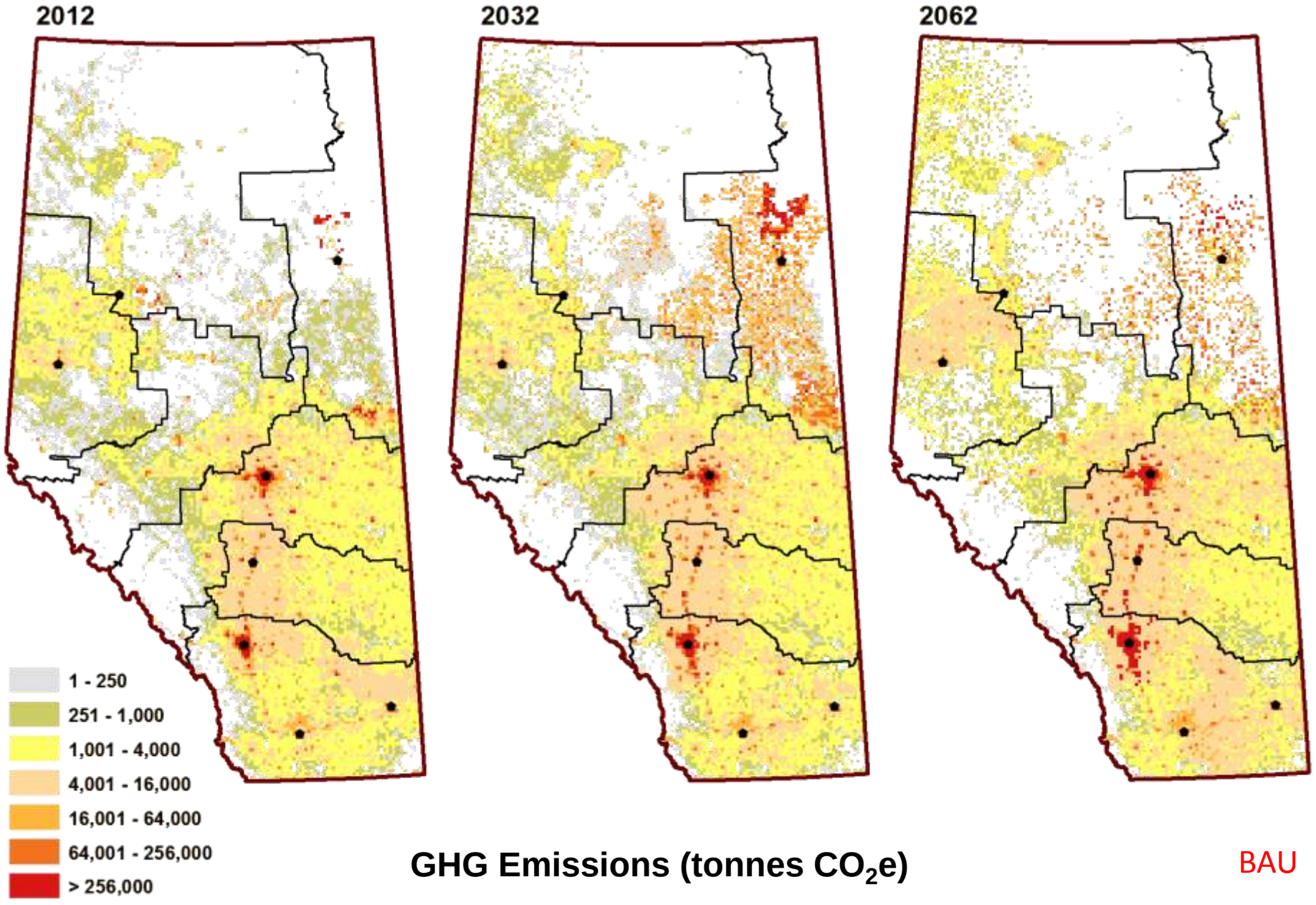
Surface Water Use (m^3)

BMP



Relative Water Quality Index (N, P and Sediment Loading)

BAU

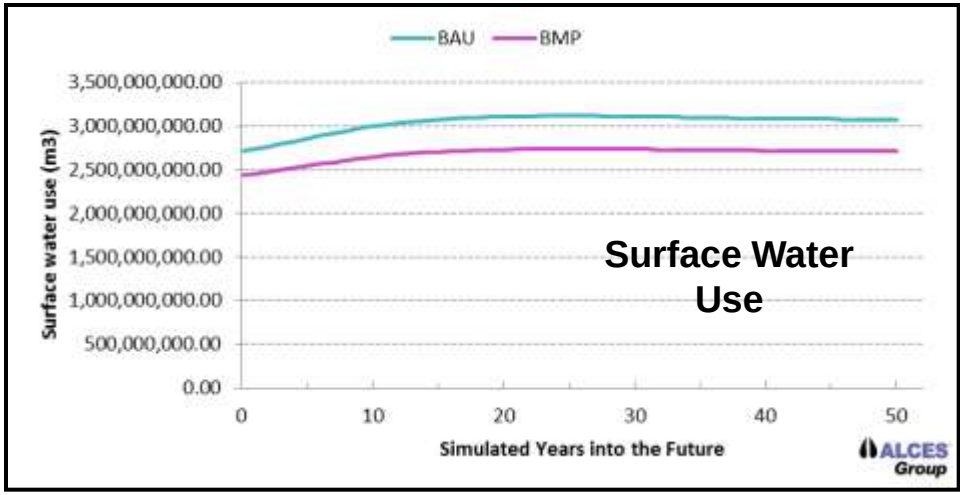


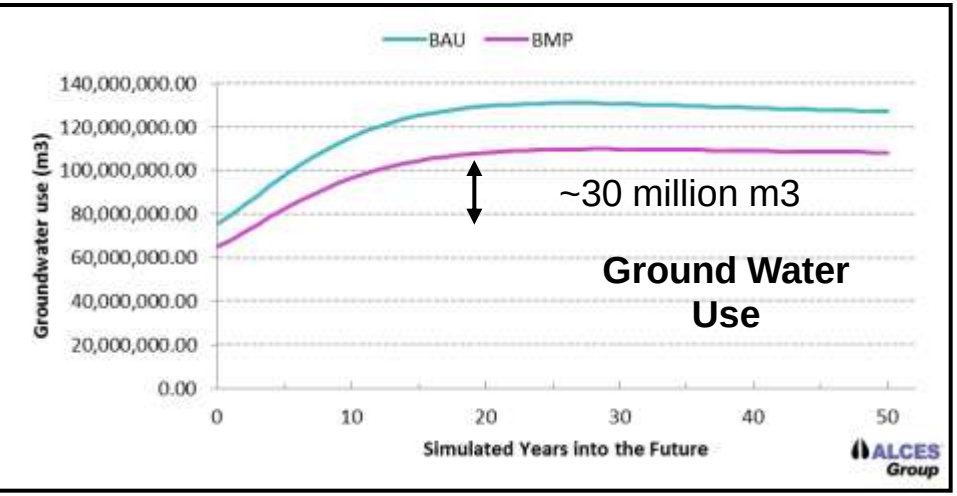
GHG Emissions (tonnes CO_2e)

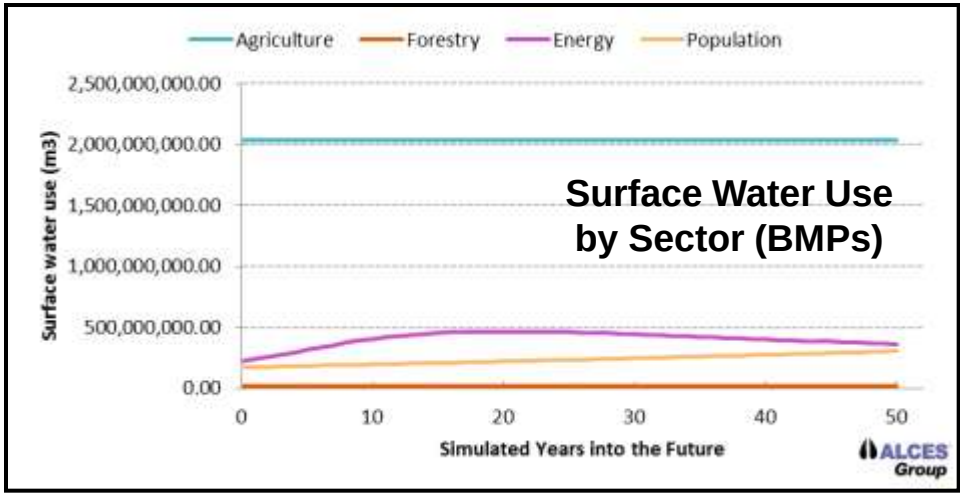
BAU

Environmental Future

- **Water Demand Best Practices**
  - More efficient water use
  - Result:
    - Increases still required in many regions







Relating Management Strategies to Inputs and Outputs

Home | Back | Control Switches

Input and Output Rates

Types / Units	Landscapes/Footprints (ha)	Commodities (m^3)	Human Populations (Individuals)	Livestock (Individuals)	Fish & Wildlife (Individuals)
Input Rates	Fuel (m3/ha/yr) Electricity (kHz/ha/yr Direct Labor (FTE/ha/yr) Indirect Labor (FTE/ha/yr) Natural Gas (m3/ha/yr) Water (m3/ha/yr) Nitrogen (tonne/ha/yr) Phosphorus (tonne/ha/yr) Herbicide (tonne/ha/yr) Insecticide (tonne/ha/yr) Manure Applications (tonne/ha/yr) Infrastructure Construction ($/ha/yr) Infrastructure Maintenance ($/ha/yr)	Fuel (m3/m3/yr) Electricity (kHz/m3/yr Direct Labor (FTE/m3/yr) Indirect Labor (FTE/m3/yr) Natural Gas (m3/m3/yr) Water (m3/m3/yr) Operating Costs ($/m3/yr)	Fuel (m3/ind/yr) Electricity (kHz/ind/yr Direct Labor (FTE/ind/yr) Indirect Labor (FTE/ind/yr) Natural Gas (m3/ind/yr) Water (m3/ind/yr) Exercise (Calorie/ind/yr)	Fuel (m3/ind/yr) Electricity (kHz/ind/yr Direct Labor (FTE/ind/yr) Indirect Labor (FTE/ind/yr) Natural Gas (m3/ind/yr) Water (m3/ind/yr) Nitrogen (tonne/ind/yr) Forage (tonne/ind/yr) Operating Costs ($/ind/yr)	Fuel (m3/ind/yr) Electricity (kHz/ind/yr Direct Labor (FTE/ind/yr) Indirect Labor (FTE/ind/yr) Natural Gas (m3/ind/yr) Water (m3/ind/yr) Nitrogen (tonne/ind/yr) Forage (tonne/ind/yr) Operating Costs ($/ind/yr)
Output	Crop Production (m3/yr) Nitrogen Runoff (tonne/yr) Phosphorus Runoff (tonne/yr) Sediment Runoff (tonne/yr) Manure Production (tonne/yr) Direct Labor (FTE/yr) Indirect Labor (FTE/yr) Royalties ($/yr) Carbon Fixation (tonne/yr) Waste Water (m3/yr) Fuel Consumption (m3/yr) Greenhouse Gas Emission (Co2e/yr) Infrastructure Costs ($/yr)	Conventional Oil (m3/yr) Natural Gas (m3/yr) Oilsand (m3/yr) Ore (m3/yr) Carbon Emissions (tonne/yr) Waste Water Emission (m3/yr) Sulfur Emission (tonne/yr) Acid Emission (tonne/yr) Direct Labor (FTE/yr) Indirect Labor (FTE/yr) Royalties ($) Electricity (kHz\yr)	Carbon Emissions (tonne//yr) Human Waste (tonne/yr) Water Consumption (m3/yr) Waste Water (m3//yr) Garbage (tonne/yr) Direct Labor (FTE/yr) Indirect Labor (FTE/yr) Anthro Footprint (ha/yr) Exercise (calories/yr)	Methane Emissions (m3/yr) Manure Waste (tonne/yr) Waste Water (m3/yr) Meat Production (tonne/yr) Milk Production (tonne/yr) Direct Labor (FTE/yr) Indirect Labor (FTE/yr) Electricity (kHz\yr)	Methane Emissions (m3/yr) Manure Waste (tonne/yr) Waste Water (m3/yr) Meat Production (tonne/yr) Sport Harvest (tonne/yr) Aboriginal Harvest (tonne/yr) Direct Labor (FTE/yr) Indirect Labor (FTE/yr)

8.15.5

Energy Sector

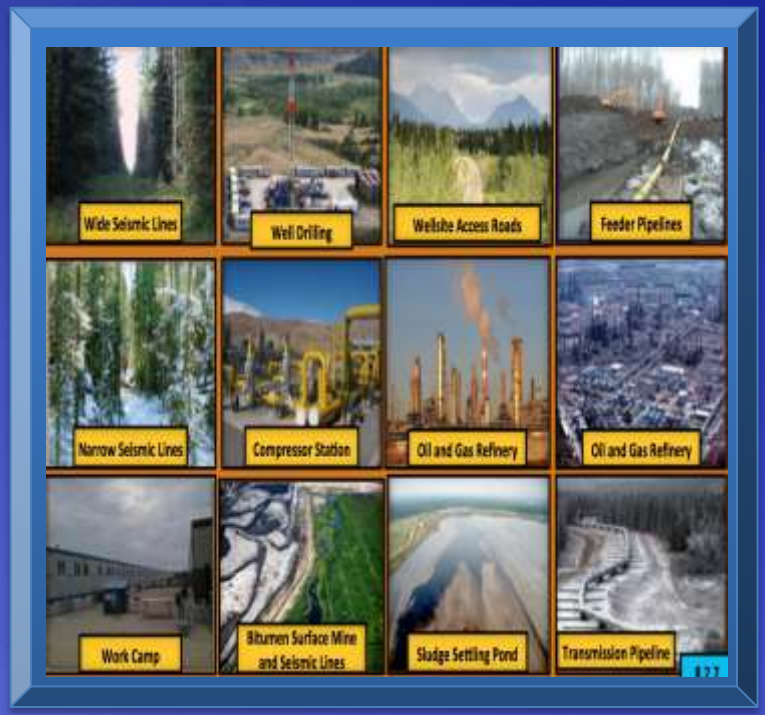
Historical, Current and Future Alberta tracked in 27,200 cells that are each 5 x 5 km

Cost of Footprint:
- Construction
- Maintenance
- Reclamation

Inputs (amount, cost):
- Labour
- Fuel
- Materials
- Water

5 km

5 km



Outputs
- Commodity
- Revenue
- Royalties
- GDP
- Emissions

Landscapes
- Area
- Edge
- Forest Age
- Fragmentation
- Core Area

Home Back

Multiple Demands and Domains

Control Switches





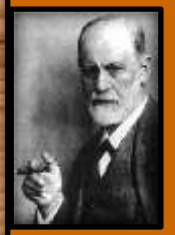


Energy Analyst | Economist | Mining Analyst | Ecologist | Soils Scientist | Military | Cropland Specialist

Hydrologist

What modeling architecture (structure, resolution, scale, integration) best communicates issues and opportunities for Alberta

Sociologist



Forester | Urban Planner | First Nations | Climate Scientist | Fire Ecologist | Transport Engineer | Ranching Specialist







4.05

end