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Using Collaborative Research and GIS Technology to Prove Natural Contaminants in the Alberta Oil Sands and in Alberta Grasslands Do Not Require Remediation

October 16, 2013
2013 Remediation Technologies Symposium
Banff, Alberta

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Outline

- Project Objectives
- Background
- Methodology
- Case Studies
- Challenges
- Discussion
- Summary

Project Objectives

- Discriminate between impacts related to petroleum facilities and naturally occurring conditions

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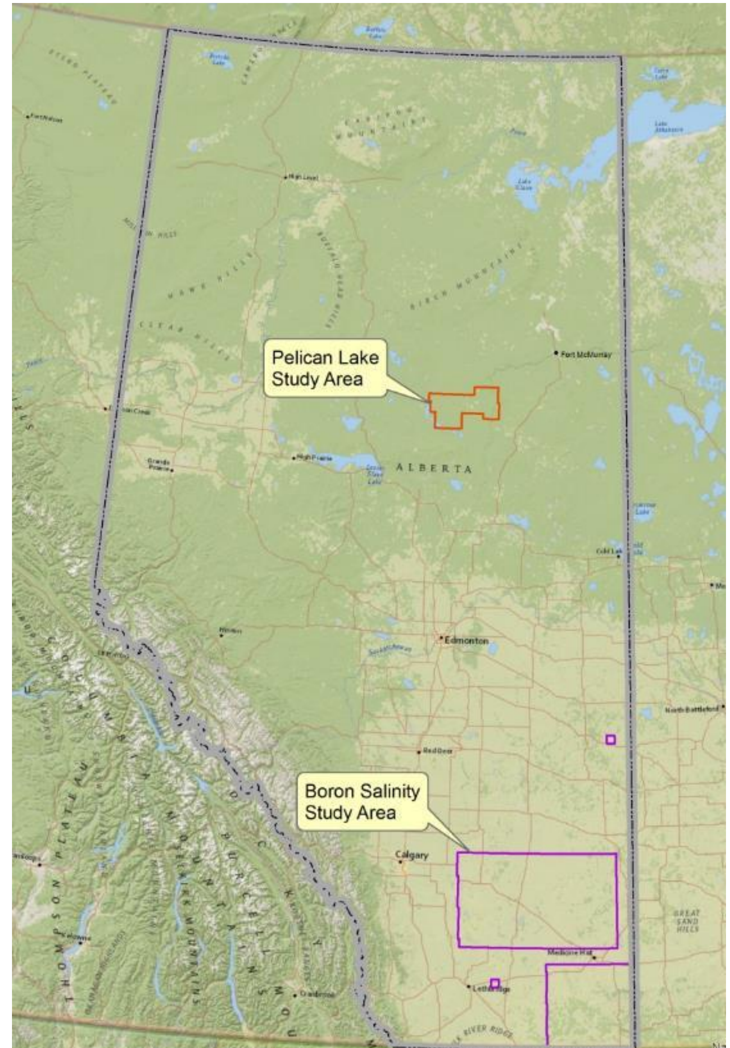
Background

- Two Studies:
  1. Pelican Lake Study within the Boreal Forest of Alberta
  2. Boron and Salinity Study within the Grasslands of Southeastern Alberta



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Methodology

- Selected Parameters of Interest (POIs)
- Refined the list of POIs using statistical analysis and background research

- Hydrocarbons
- PAHs
- Dioxins
- Furans
- Alcohols
- Metals
- Salinity
- Nutrients
- Physical

Methodology

- Developed null hypothesises and analyzed using statistical analysis

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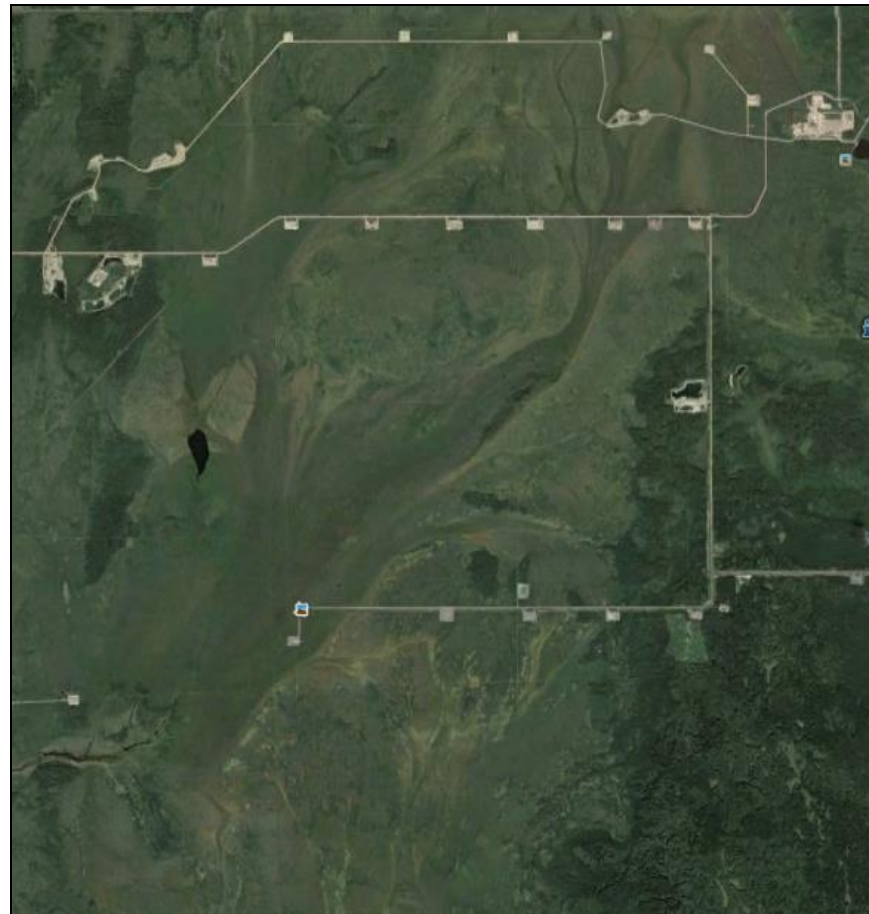
Methodology

- Compared statistical analysis against findings of background research:
  - U of C MultiSearch
  - Google Scholar
  - NEOS Catalogue
  - SciVerse Science Direct
  - SciVerse Scopus
  - Proquest Digital Dissertations and Theses
  - Pollution Management
  - United States Department of Agriculture – Agricultural Research Service

Case Study #1 – Pelican Lake

- 120 km NE of Slave Lake in Northern Alberta
- Approximately 300,000 ha
- Within the Central Mixedwood Natural Subregion



Case Study #1 – Pelican Lake

- 372 records of historical data
- 60 records from field
- Created a single tabular dataset with 432 records

Case Study #1 – Pelican Lake

- Created a research list of POIs

Hydrocarbons (n=9)	Polyaromatic Hydrocarbons (n=16)	Dioxins (n=1)
Furans (n=1)	Alcohols (n=4)	Metals (n=20)
Salinity Parameters (n=9)	Nutrients (n=4)	Sample Physical Characteristics (n=3)

Case Study #1 – Pelican Lake

- Focused the list POIs based on statistical analysis, literature review, and recommendations

Hydrocarbons

Toluene, F3, F4

Polyaromatic Hydrocarbons

Napthalene, Phenanthrene, Pyrene

Metals

Boron, Molybdenum, Selenium, Zinc

Salinity Parameters

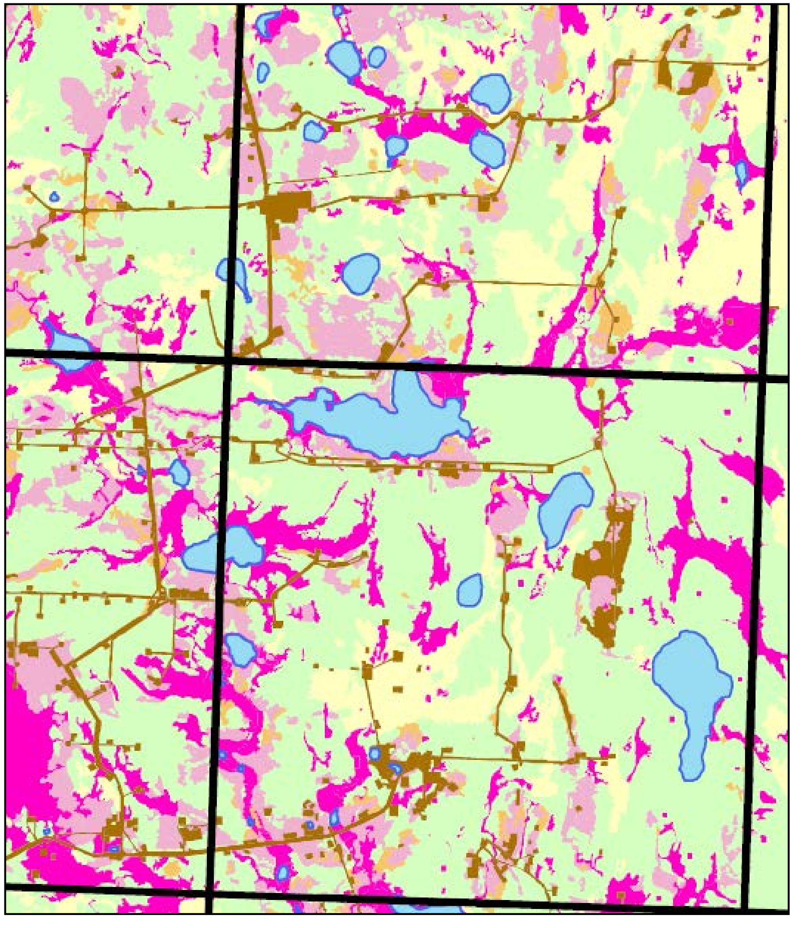
pH

Sample Physical Characteristics

Texture, Particle size, Organic mater

Case Study #1 – Pelican Lake

- Characterized the study area into broad forest cover groups based on Alberta Vegetation Inventory (AVI) standards



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Case Study #1 – Pelican Lake

- The study area was comprised of:
  - 49% black spruce
  - 13% larch
  - 1% jack pine
  - 9% wet shrub
  - 23% upland mixedwood
  - 2% disturbed
  - 3% is water

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Case Study #1 – Pelican Lake

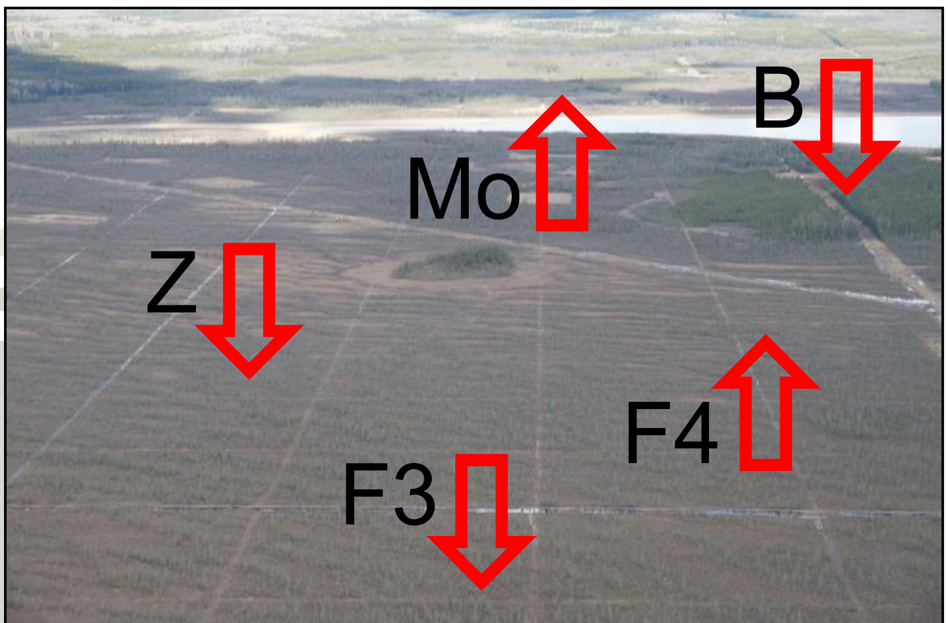
- Detectable levels of toluene, petroleum hydrocarbon (PHC) fractions F3 and F4, naphthalene, and phenanthrene were detected in background soils

Case Study #1 – Pelican Lake

- Wetland types (larch, black spruce, and wet shrub) have higher boron, selenium, toluene, and PHC fractions F3 and F4 than upland stand types

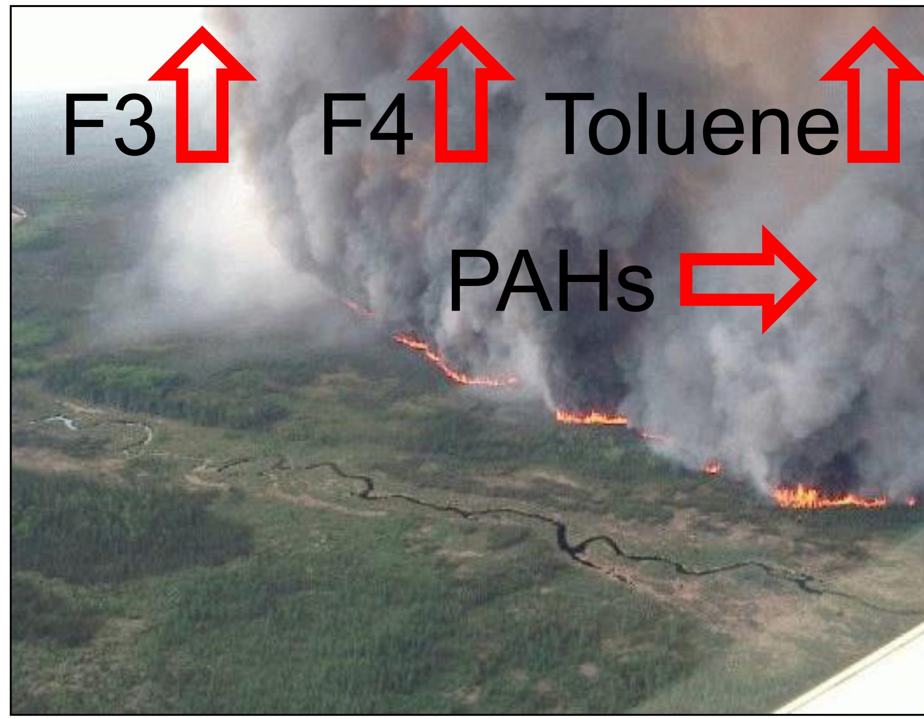
Case Study #1 – Pelican Lake

- Approximately 73% of the study area is wet, a portion of which is known to be flooded
- Flooding affected levels of boron, molybdenum, zinc, and PHC fractions F3 and F4



Case Study #1 – Pelican Lake

- Approximately 36% burned since 1940
- Wildfires affected levels of PHC fractions F3 and F4, certain polyaromatic hydrocarbons (PAHs), and toluene



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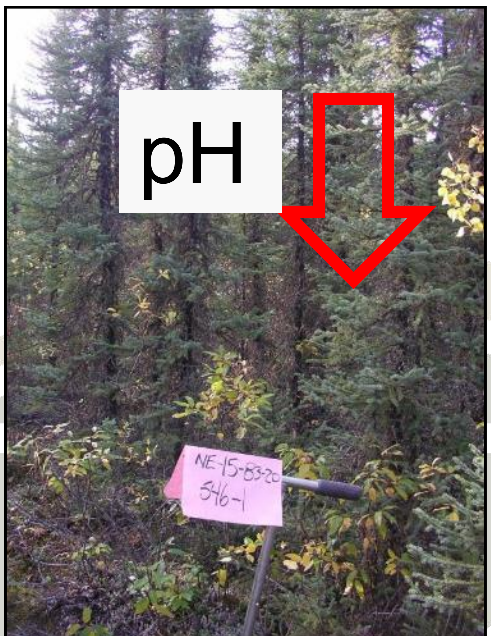
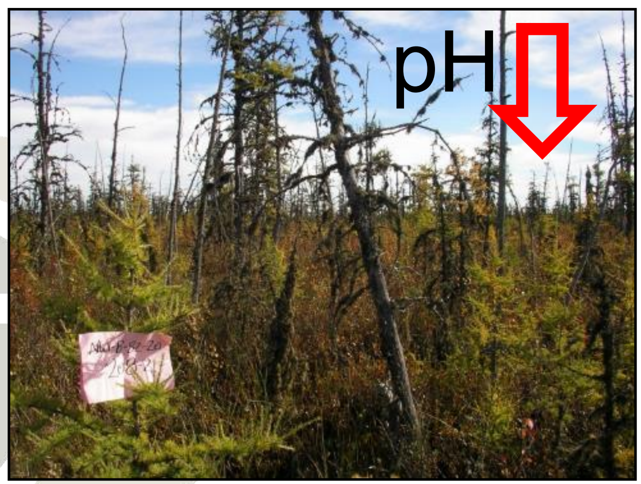
Case Study #1 – Pelican Lake

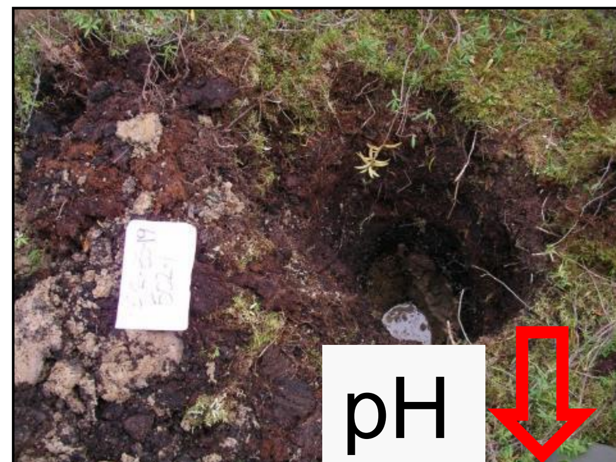
- Values of pH ranged between 2.8 and 8.6, with a median value of 5.0



Black Spruce



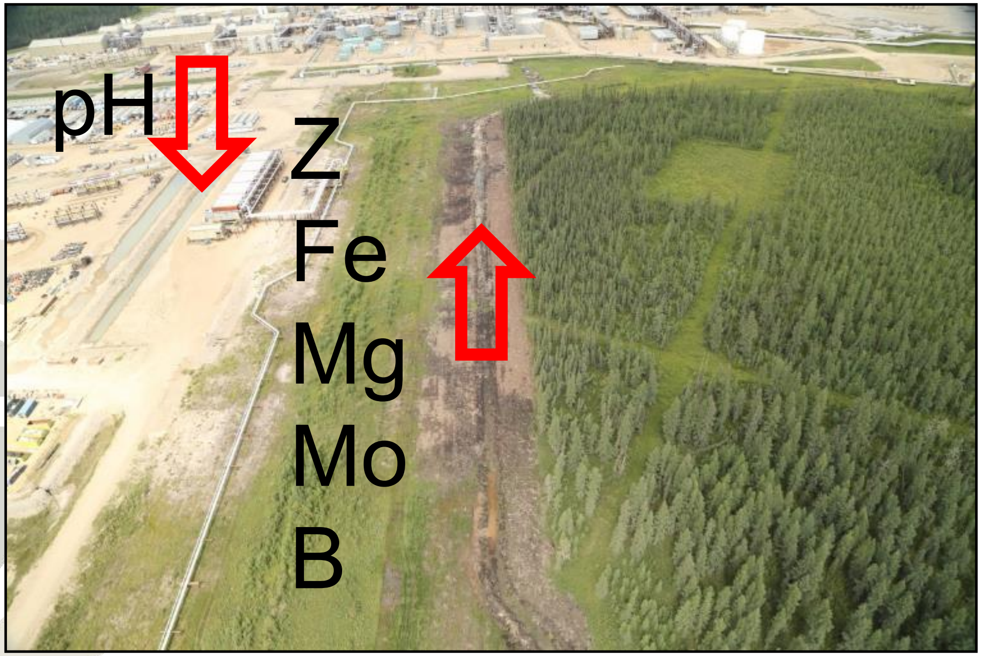
Larch



Organic Soils

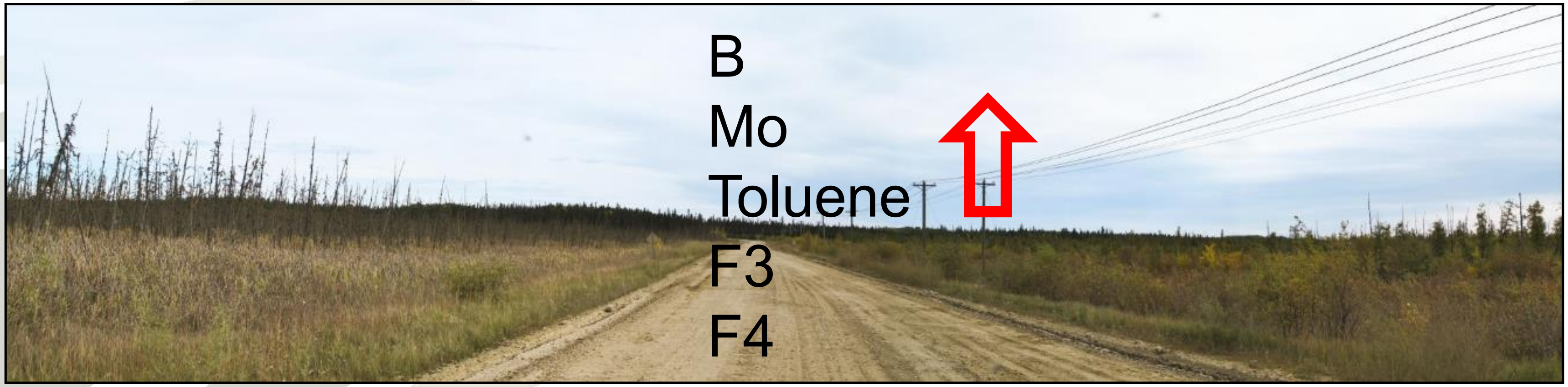
Case Study #1 – Pelican Lake

- With decreasing pH, the availability of elements such as zinc, iron, manganese, molybdenum, and boron are enhanced by desorption from soil particles



Case Study #1 – Pelican Lake

- Organic soils dominate the study area (71% of the area)
- Organic soils have a lower average pH, and higher levels of boron, molybdenum, toluene, and PHC fractions F3 and F4 than that found in mineral soils



Case Study #1 – Pelican Lake

- Mineral soils comprise 24% of the study area
- There were no mineral soil samples within the study area with elevated levels of toluene or PHC fraction F3

Case Study #1 – Pelican Lake

- Organic (peaty) soils analyzed for PHCs using the CCME method were 10X higher than mineral soils due to high volume to weight ratio

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Case Study #2 – Boron/Salinity

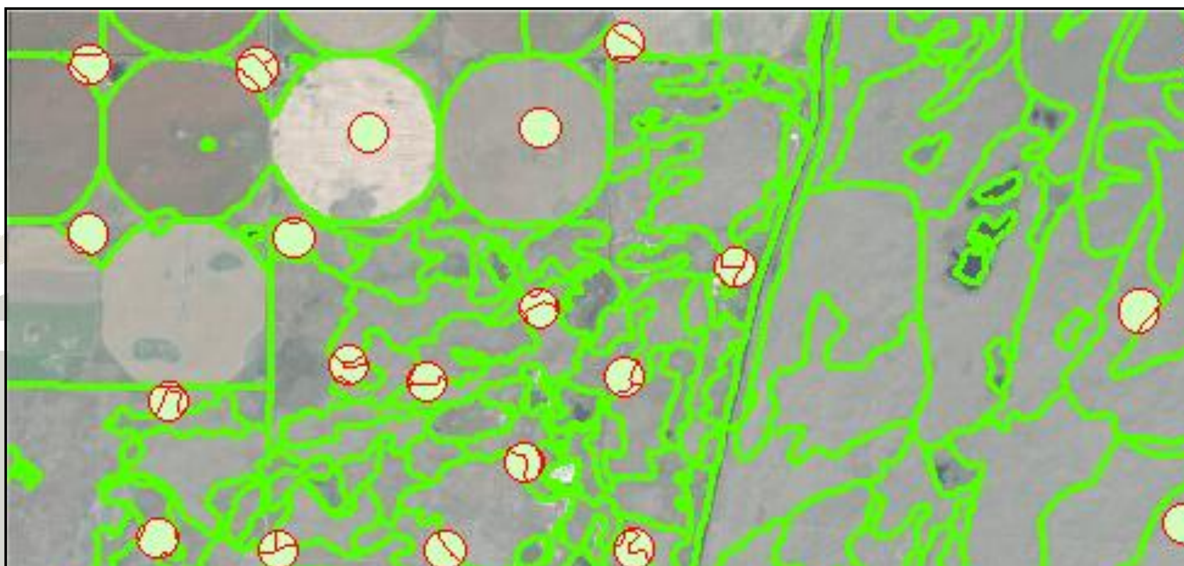
- Located in Southeastern Alberta
- Approximately 3.45 million ha
- Within the Grassland Natural Region

Case Study #2 – Boron/Salinity

- The objective was to establish a link between EC, SAR, pH, and boron and site-specific characteristics (primarily soil and vegetation)
- Approximately 3700 records of historical data

Case Study #2 – Boron/Salinity

- Used Grassland Vegetation Inventory (GVI) with the Agricultural Region of Alberta Soil Inventory Database (AGRASID) to create 14 classes



Site Class	% of Total
Blank	5%
Blowout	4%
Coarse_Rapidly_Drained	7%
Coarse_Well_Drained	41%
Crop_Irrigated	5%
Crop_Non_Irrigated	1%
Developed	0%
Lentic (Alkali)	0%
Lentic_Vegetated	0%
Loamy	23%
Overflow	0%
Pasture_Irrigated	5%
Pasture_Non_Irrigated	7%
Subirrigated	1%

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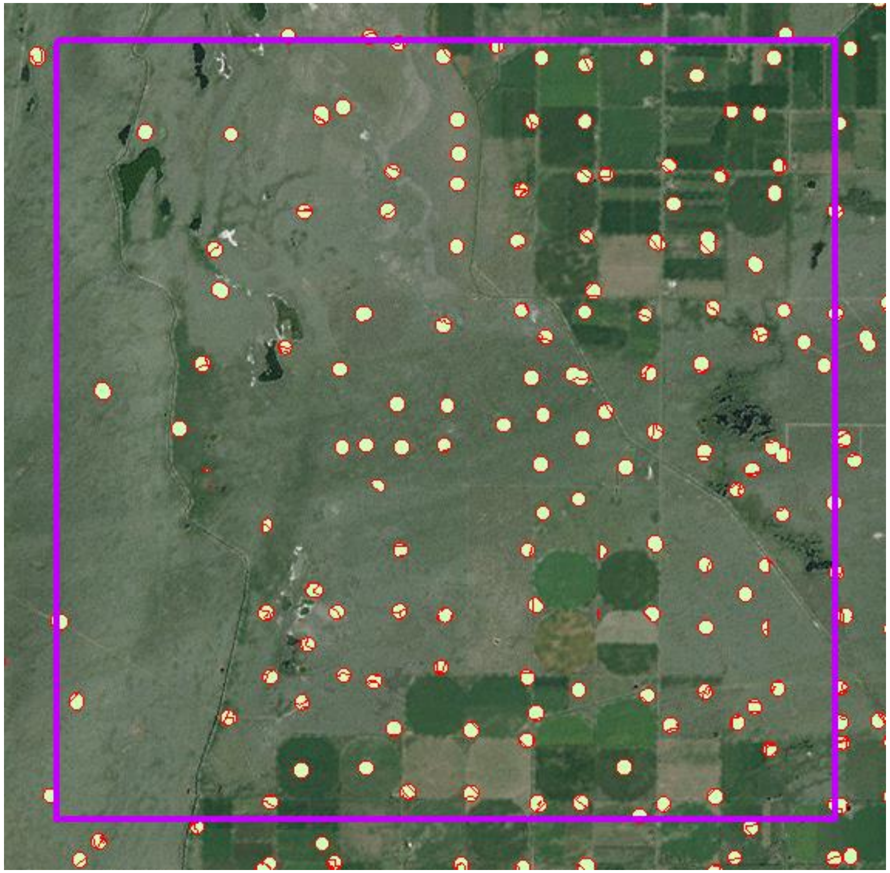
Case Study #2 – Boron/Salinity

- No statistical analysis for metals since there was very little variability, and values are almost all within AESRD Tier 1 limits

Case Study #2 – Boron/Salinity

- Townships do differ statistically (when aggregated across all ranges within a township) for both EC and SAR



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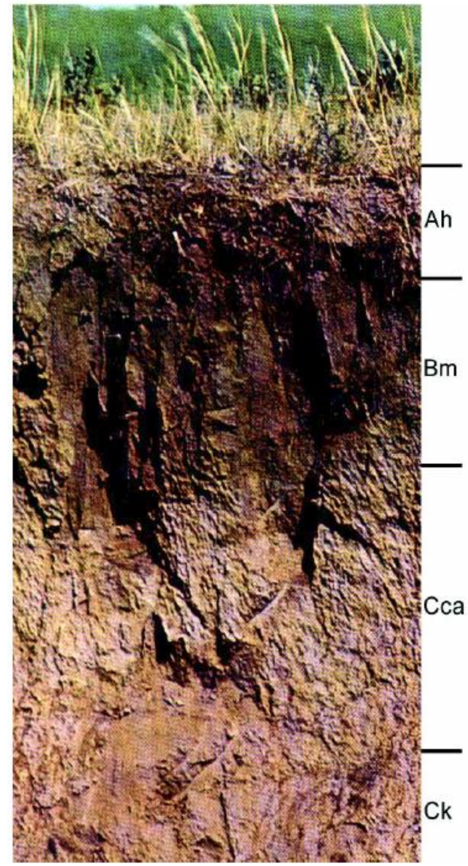
Case Study #2 – Boron/Salinity

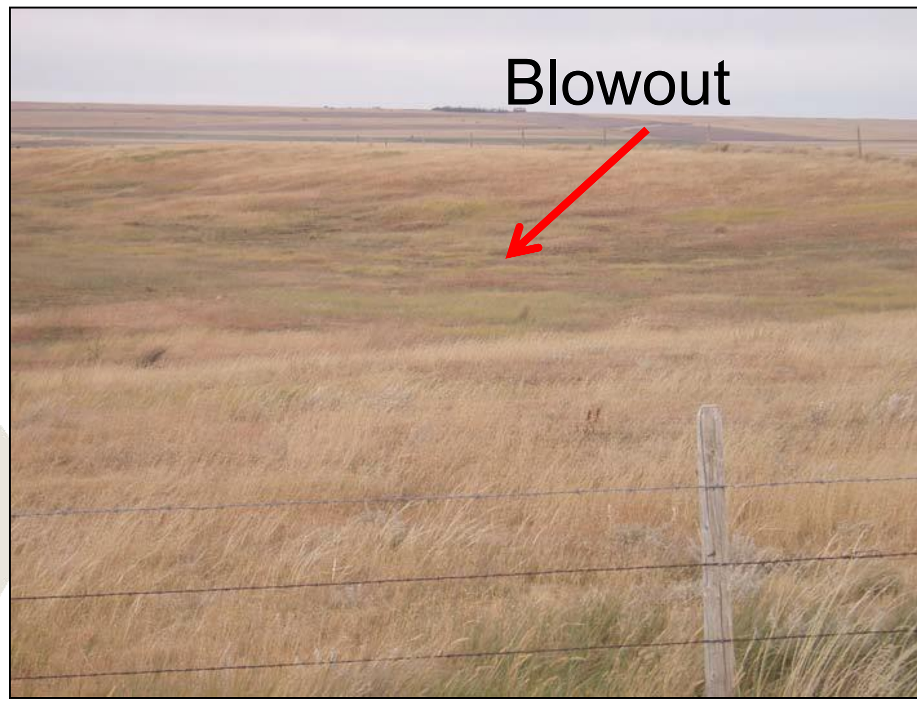
- There are no strongly apparent trends in pH throughout the profile
- Surface soil layer (0-50 cm) had significantly lower EC and SAR values than the deeper soil horizons, down to a depth of about 3 m



EC & SAR

Case Study #2 – Boron/Salinity

- Cover classes blowouts was significantly higher than upper values and only for EC in the 0-50 cm layer



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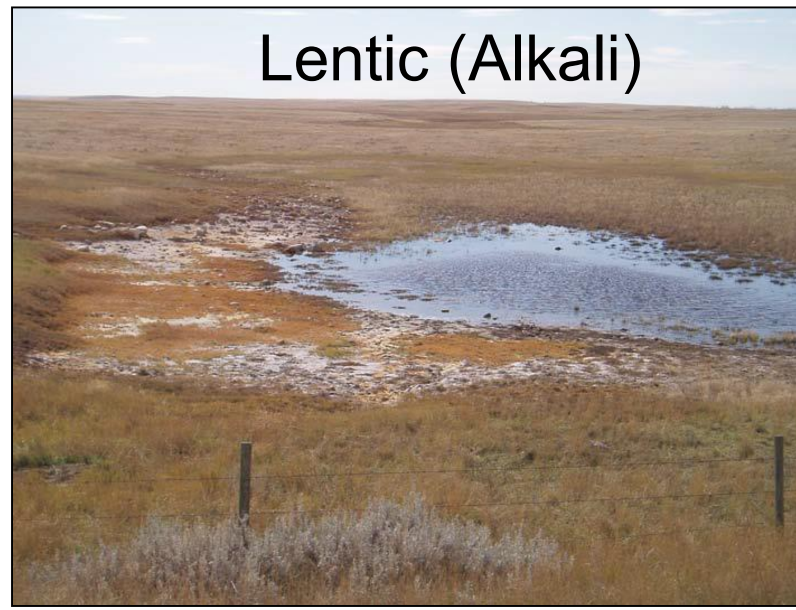
Case Study #2 – Boron/Salinity

- Cover classes Blowout, Clayey, Lentic (Alkali), Overflow and Subirrigated trend toward exceeding maximum limits for EC



Case Study #2 – Boron/Salinity

- Cover types Blowout, Lentic (Alkali), Overflow and Subirrigated sites trend toward exceeding maximum limits for SAR

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Case Study #2 – Boron/Salinity

- Some classes - Clayey, Lentic (Alkali), Lentic (vegetated), Overflow, Saline Lowland and Thin Breaks, and Badlands are not well sampled

Challenges

- Site characteristics vary across the province and Natural Subregions

Grasslands

Boreal Forest

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Challenges

- Datasets did not contain built in error checks and were created for data entry and reporting and not statistical analysis

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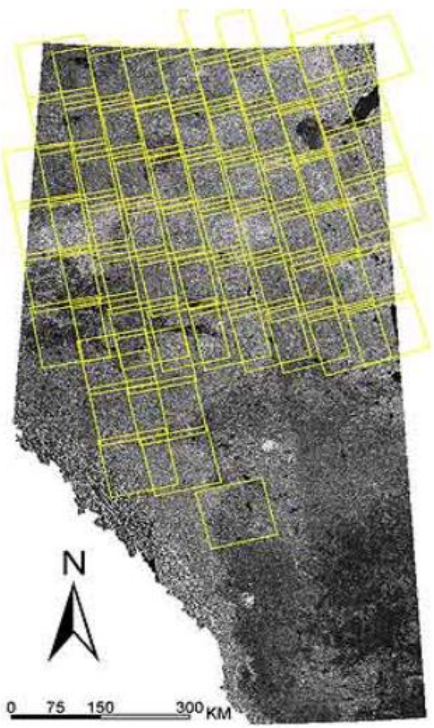
Challenges

- Availability of spatial datasets varies across the province



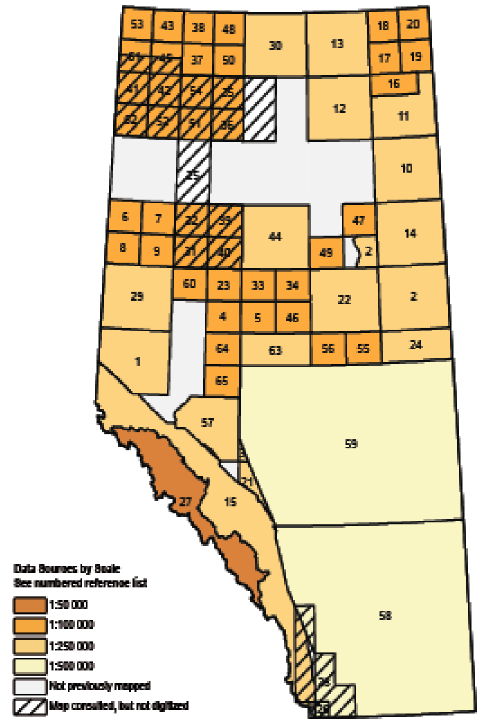
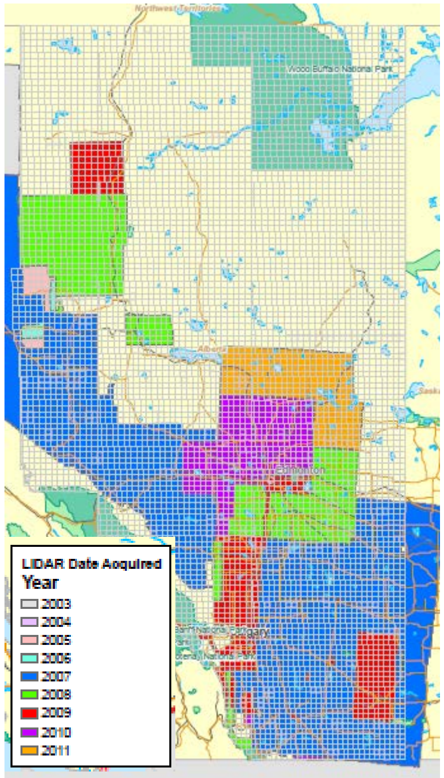


Figure 1. Location of Compiled Data Sources



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Challenges

- Literature pool is relatively limited

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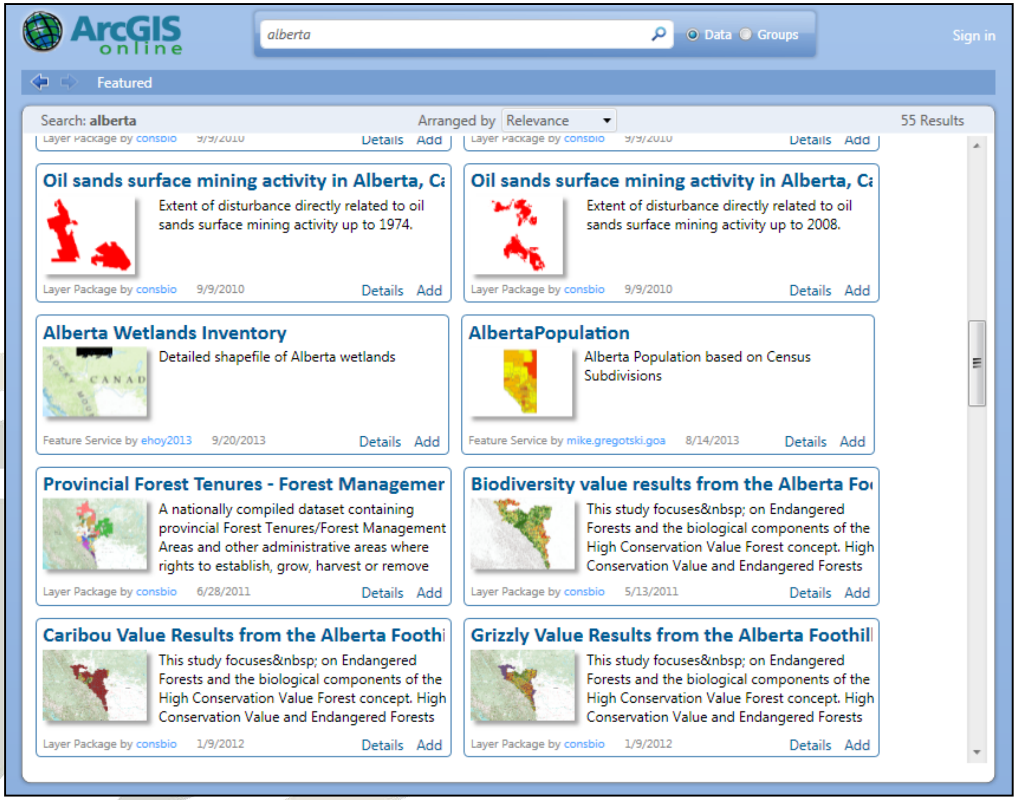
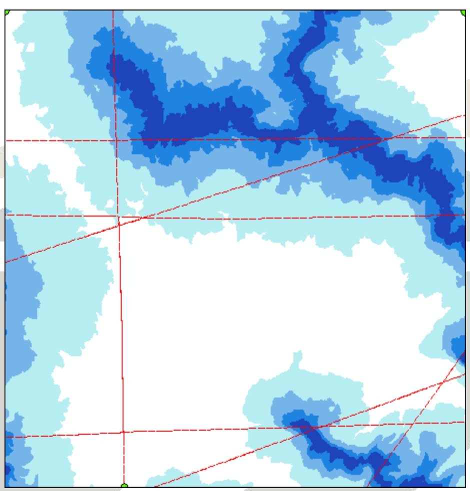
Discussion

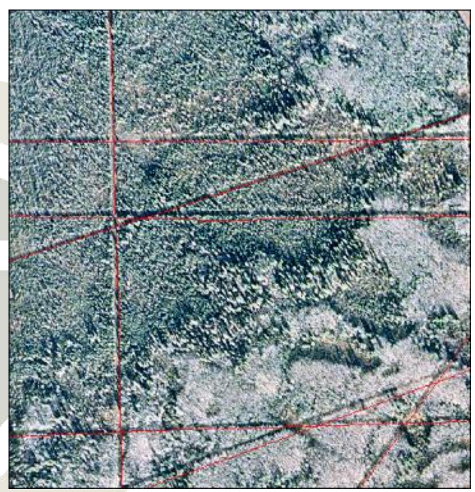
- Incorporate new information and spatial datasets as they become available



Discussion

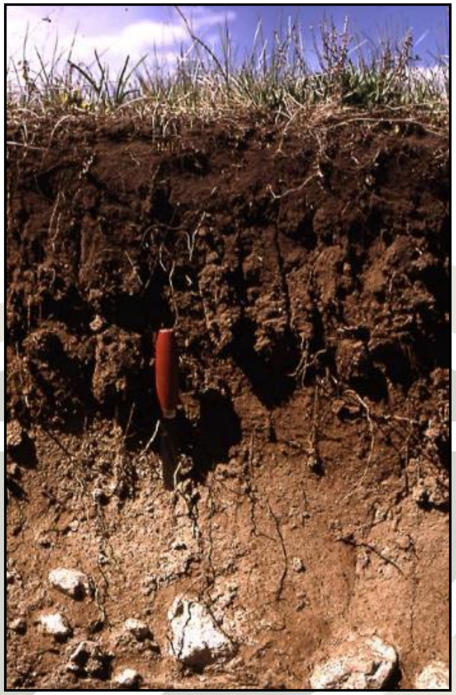
- When sampling for background conditions, choose locations that are representative of surrounding site conditions based on vegetation classification systems such as the AVI, GVI, or ecological classification





Discussion

- Mineral soils differ chemically and physically from organic soils



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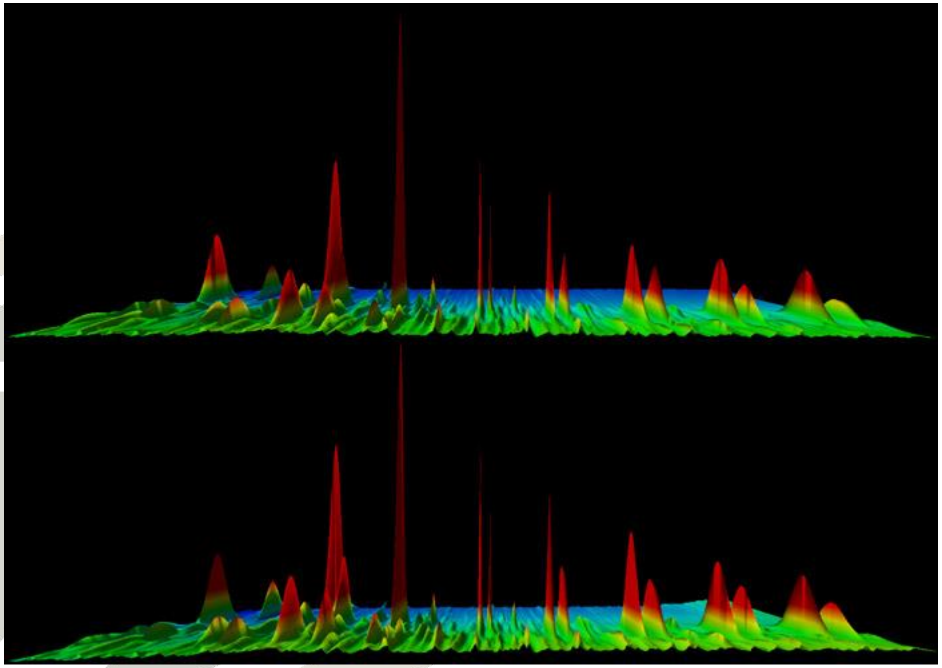
Discussion

- Certain PAHs may naturally be present in certain locations; therefore, include PAH analyses as part of the sampling for background conditions

Discussion

- Consider chromatographic analysis to identify typical “fingerprint” signatures of natural and petroleum-related hydrocarbons



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Discussion

- Continue to explore alternative laboratory analytical methods for boron that may more accurately represent boron's toxicity in the environment

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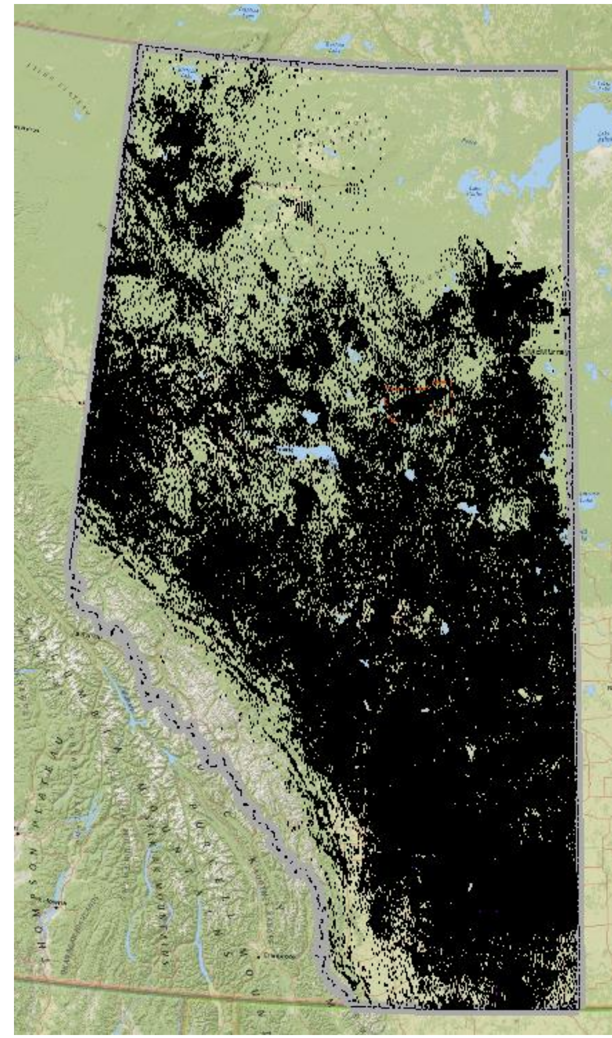
Discussion

- Data analyzed was from relatively small datasets; pooling data from other companies and organizations will increase statistical rigour



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Discussion

- Get results and findings into the hands of users
- Consider establishing standard operating procedures for collecting data

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Acknowledgements

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(all photographs by Ron Sparrow, aerial photographs, and general diagrams from Google)

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