Remote Sensing Tools for Environmental Monitoring and Certification of Wellsites

Remediation Technologies Symposium 2023

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Overview

- Introduction
- Background on Earth Observation
- Project Objectives and Progress
- Questions

Eduardo Loos

Manager, Earth Observation and Spatial Data

- Leading the EO and Spatial Data groups
- Collaborator with the Canadian Space Agency over the last 12 years
- Adjunct Professor at the Dept Geography at UVic

Earth Observation

"Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface *without actually being in contact with it.*

This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."

https://natural-resources.canada.ca/maps-tools-and-publications/satellite-imagery-and-air-photos/tutorial-fundamentals-remote-sensing/introduction/9363

EARTH OBSERVATION

A Matter of Scale

Acquisition Platforms

Spaceborne

Airborne

Ground-based (drones)

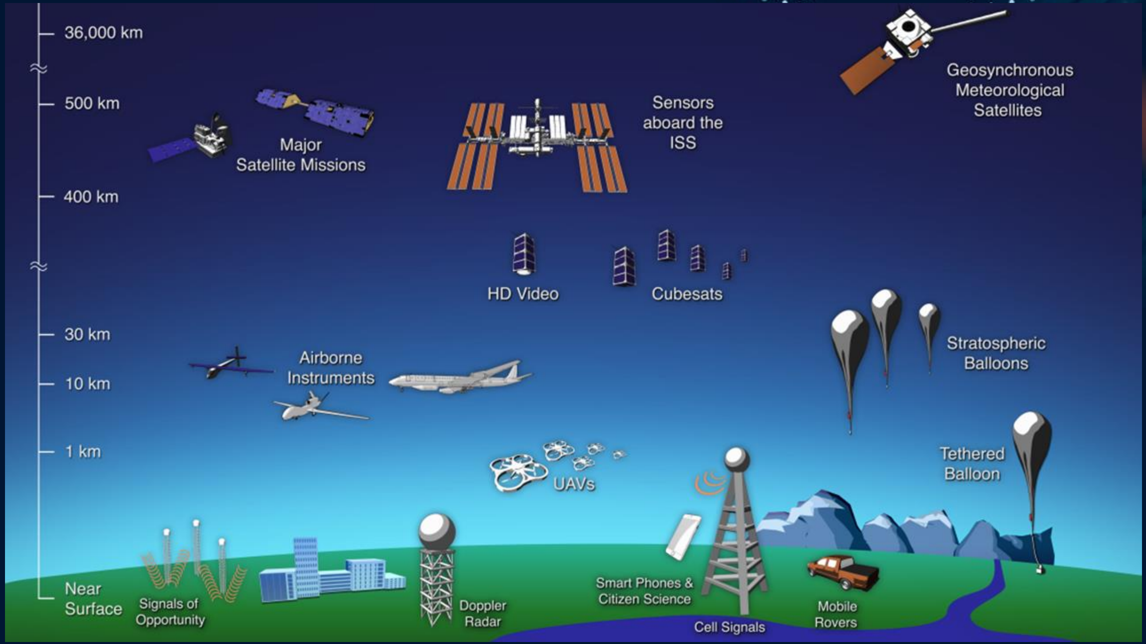


IMAGE RESOLUTIONS

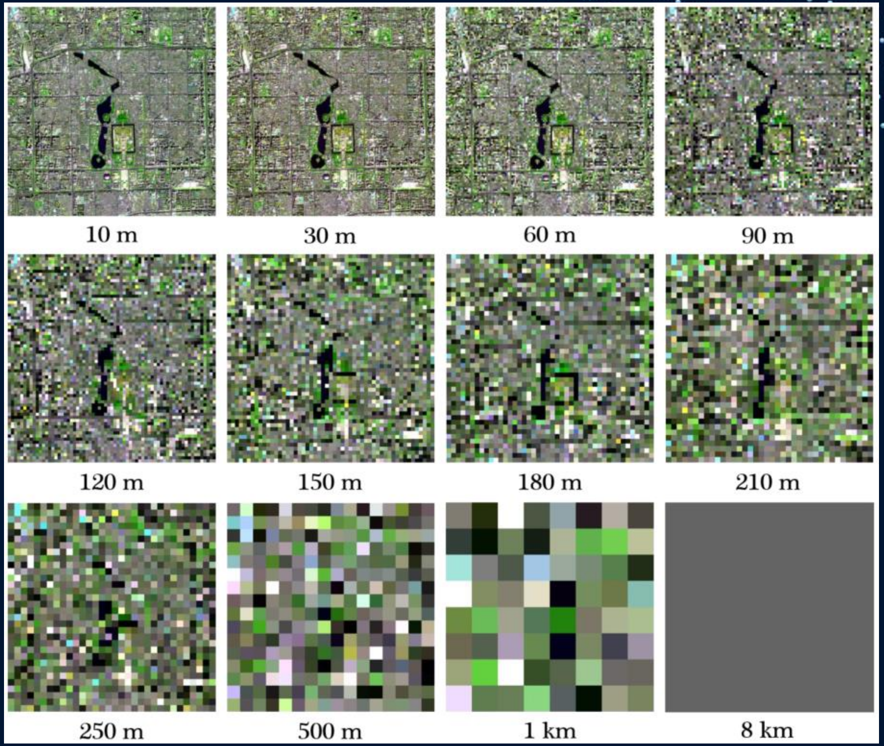
Resolutions

Spatial

Spectral

Radiometric

Temporal



Tian, J.; Zhu, X.; Wu, J.; Shen, M.; Chen, J. Coarse-Resolution Satellite Images Overestimate Urbanization Effects on Vegetation Spring Phenology. *Remote Sens.* **2020**, *12*, 117. https://doi.org/10.3390/rs12010117

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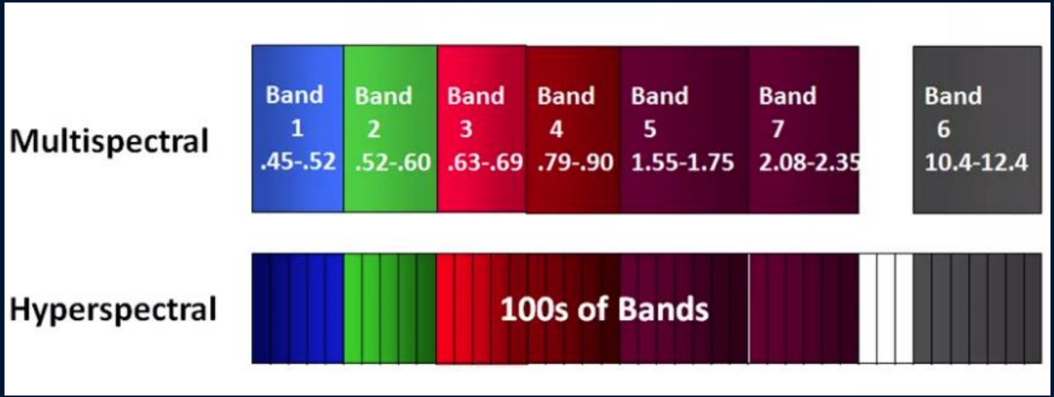

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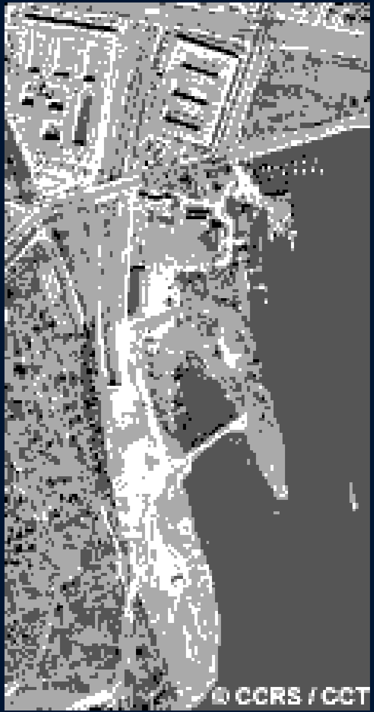


2-bit data (4 shades of grey)

8-bit data (256 shades of grey)

IMAGE RESOLUTIONS

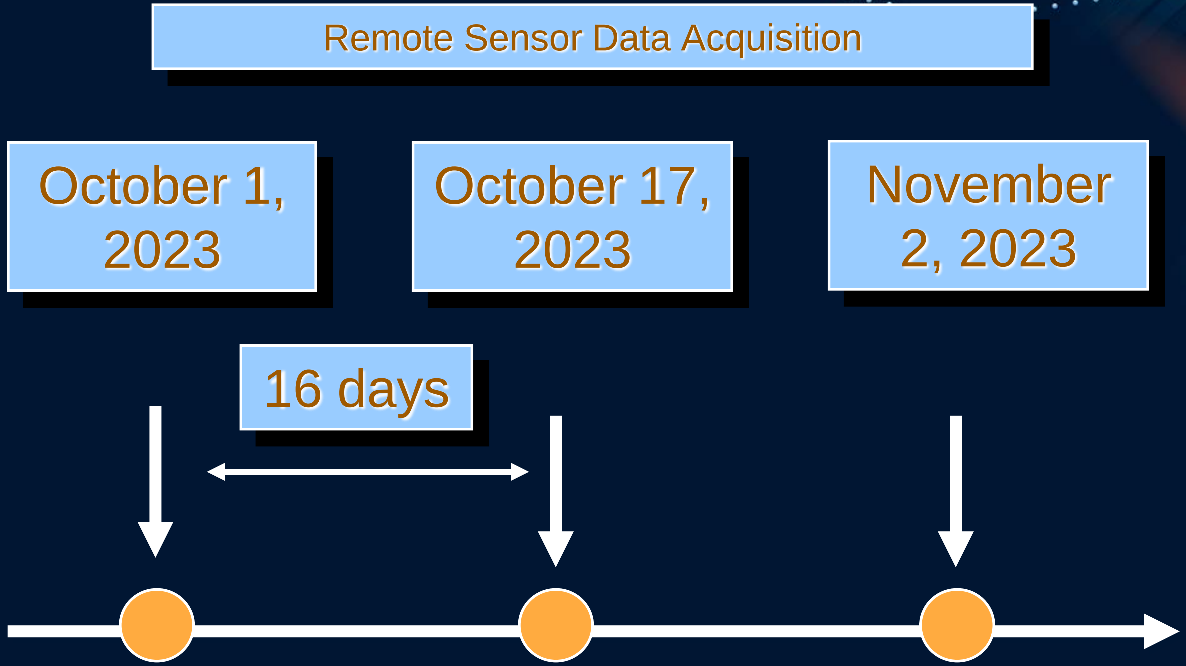
Resolutions

Spatial

Spectral

Radiometric

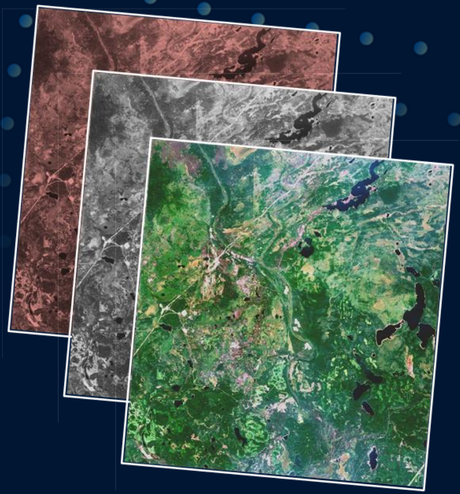
Temporal



Project Objectives and Progress

Goal

Test, validate, and develop digital tools to monitor terrestrial and wetland environments impacted by oil and gas operations



Develop remote sensing tools using Earth Observation (EO) image data and cutting-edge machine learning (ML) and artificial intelligence (AI) technologies to process large volumes of remotely-sensed imagery quickly and efficiently

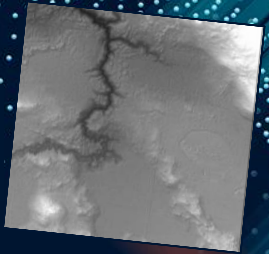
Objectives

1. Verification and assessment of sustainability of forests developing on pads
2. Development of digital remote sensing tools to detect impacts caused by pads on peatlands
3. Differentiation of bogs and fens and associated wellsites
4. Development and improvement of existing remote sensing tools for non-padded wellsites in the Green Zone

1. Verification and assessment of sustainability of forests developing on pads

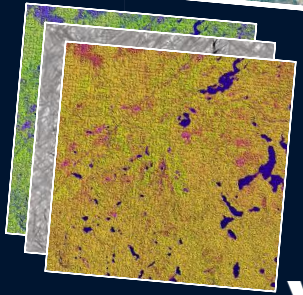
- We are expanding our results using available LiDAR data to identify small, discontinuous areas of forest cover on the padded sites through available canopy height metrics.
- Time-series optical data are being analyzed in a field data-based ecological recovery model to determine the trajectory of vegetation metrics over those areas that the LiDAR data identify as forested.
- The combination of these datasets allows us to determine whether the forested areas are sustainable, stagnant, or in decline.

LiDAR Bare Earth Digital Elevation Model



Optical Multispectral

Spectral Indices

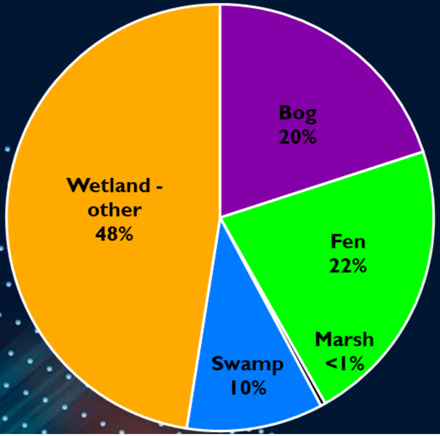


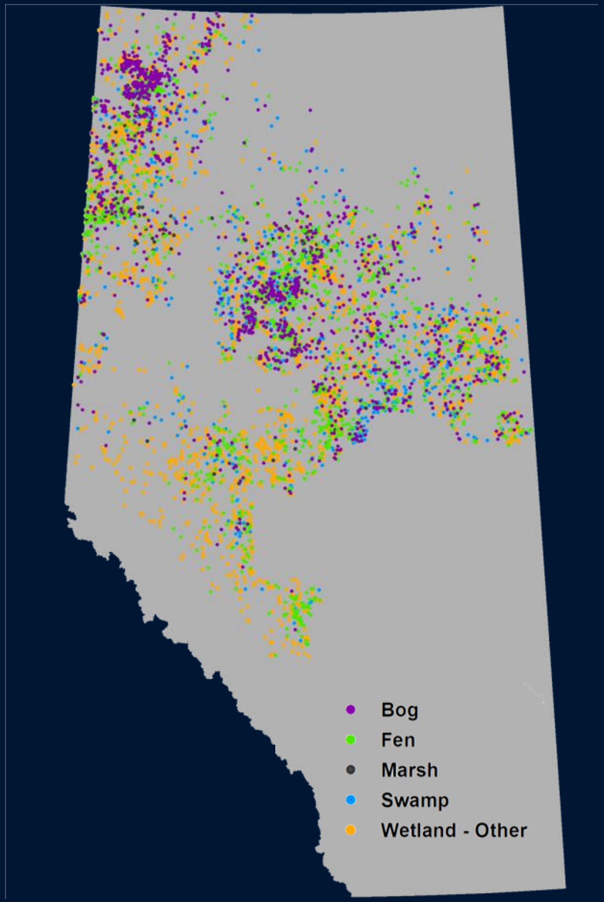
WELLPAD IDENTIFICATION

We merged our classification results with wetland polygons to stratify well sites by wetland type.

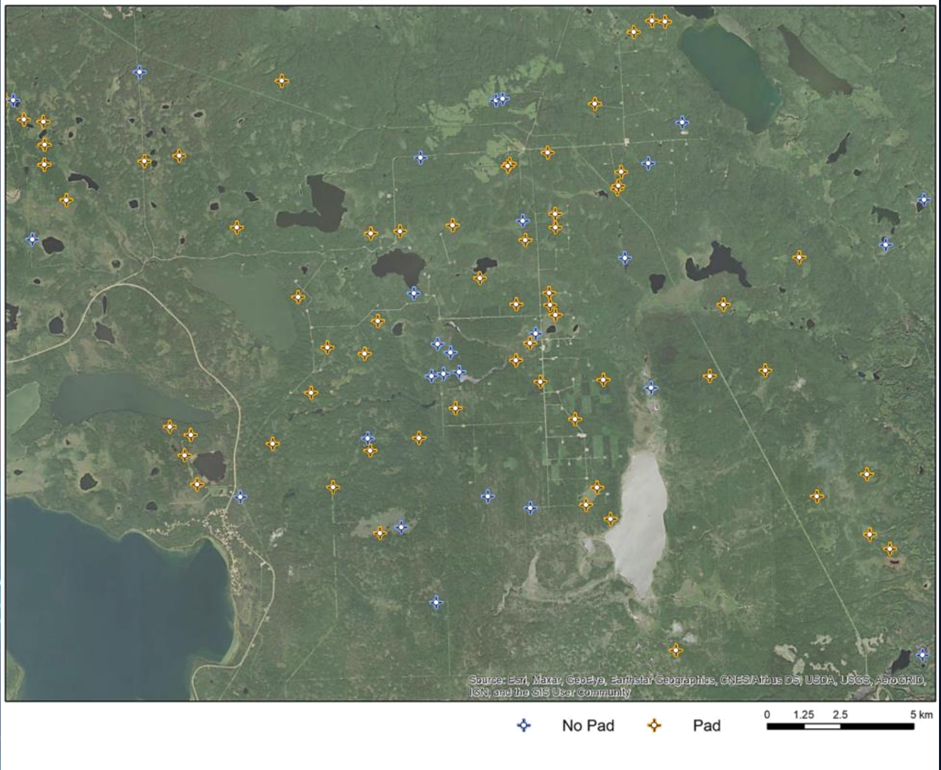
Nearly 50% of the sites occur in the wetland-other class. These are areas in the interface zone between upland and wetland.

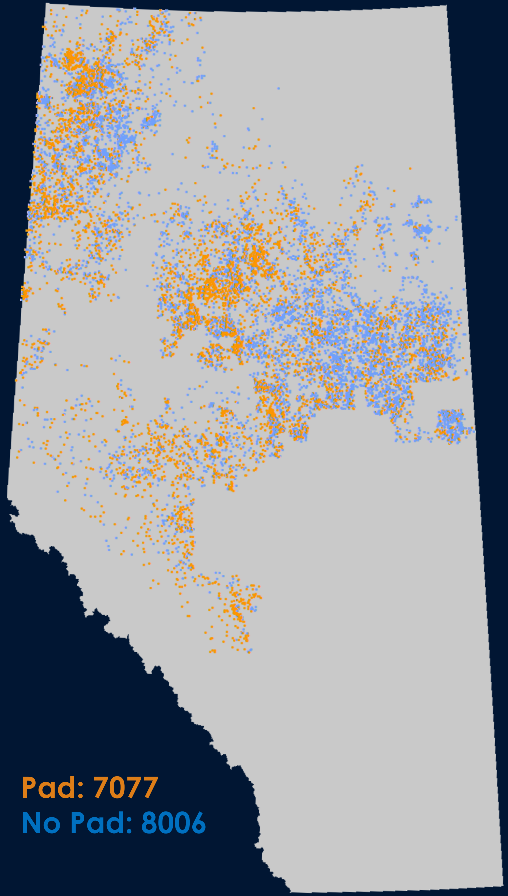
Over 40% of the padded sites occur in bogs or fens and roughly 10% of the sites occur in marsh or swamps.





WELLPAD IDENTIFICATION



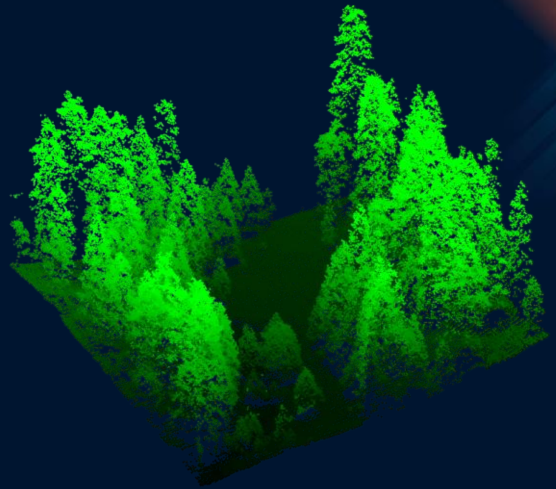


1. Verification and assessment of sustainability of forests developing on pads

Progress

- Development and testing of the code base for extraction of the forest polygons and generating trend data.

- Development of the time-series tool that will extract trend of vegetation health for a set of derived forested land cover polygons.



2. Development of digital remote sensing tools to detect impacts caused by pads on peatlands

- The main advantage of remote sensing is that it provides a wide coverage of areas of interest and high temporal resolution at lower cost when compared to traditional field-based data collection

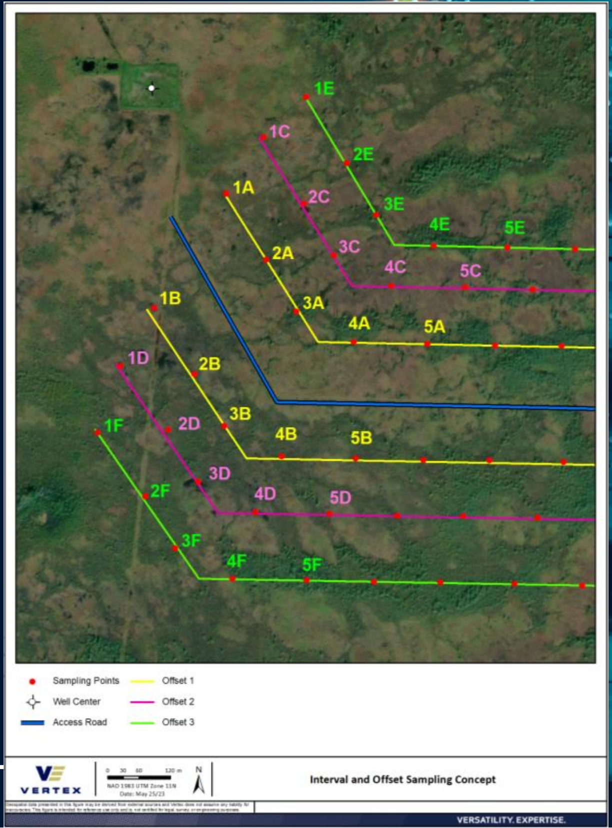
- We are developing tools that exploit remote sensing techniques to assess the environmental impacts of pads on peatlands.

- Investigating several options to attempt to classify access roads as padded vs unpadded.

2. Development of digital remote sensing tools to detect impacts caused by pads on peatlands

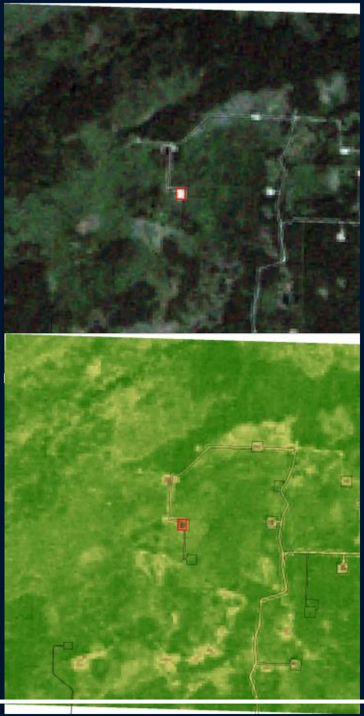
Progress

- ❖ Designed several different strategies to sample optical remote sensing imagery to assess vegetation and moisture conditions around study features.
- ❖ This included offset interval sampling (figure), pairwise interval sampling, and full area sampling.
- ❖ We generated these sampling interval products and derived a workflow to create these samples over large areas.

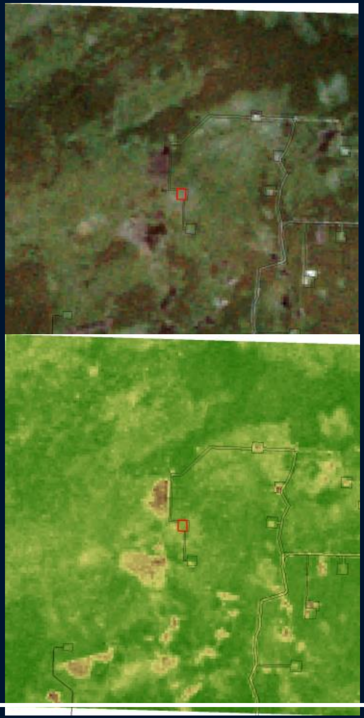


2. Development of digital remote sensing tools to detect impacts caused by pads on peatlands

1988



2010

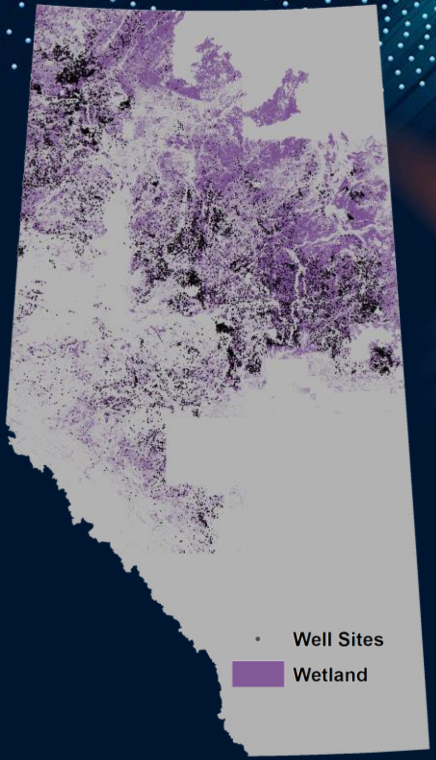


2020

3. Differentiation of bogs and fens and associated wellsites

- Using a combination of spaceborne synthetic aperture RADAR (SAR) and optical data, we are exploring ML/AI algorithms to reliably separate bog peatlands from fen peatlands

- This distinction could be important when deciding to remove or leave a padded site in place as its impacts may vary based on the type of wetland in which it is located.



3. Differentiation of bogs and fens and associated wellsites

Progress

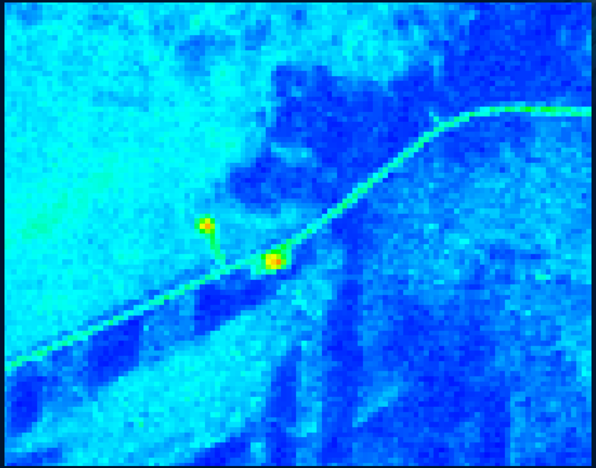
- Outlined a potential strategy to differentiate bogs from fens using indicator species of vegetation and set tasks to review the potential of this strategy.

- Literature review and internal discussion to understand if there are any characteristics that can both differentiate bogs from fens.

- Additional research into utilizing Synthetic Aperture RADAR (SAR) combined with aerial or ground base field observations.

4. Development and improvement of existing remote sensing tools for non-padded wellsites in the Green Zone

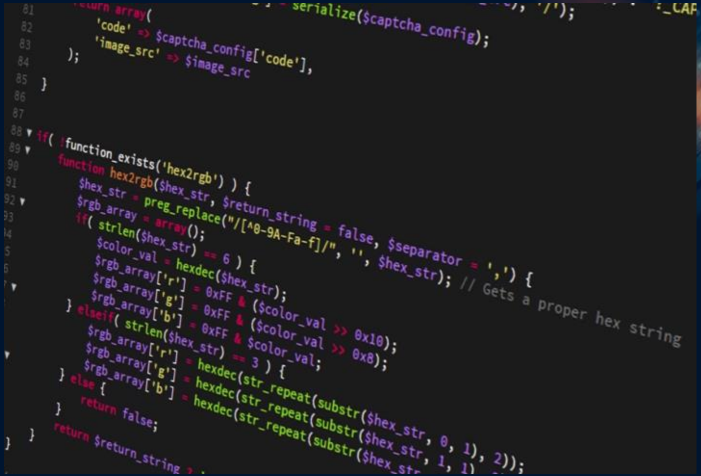
- We are developing and improving existing tools that exploit remote sensing techniques to assess the environmental impacts of non-padded wellsites in the Green Zone.
- Time-series of useful hydrologic and vegetation information will be extracted from optical and SAR data



4. Development and improvement of existing remote sensing tools for non-padded wellsites in the Green Zone

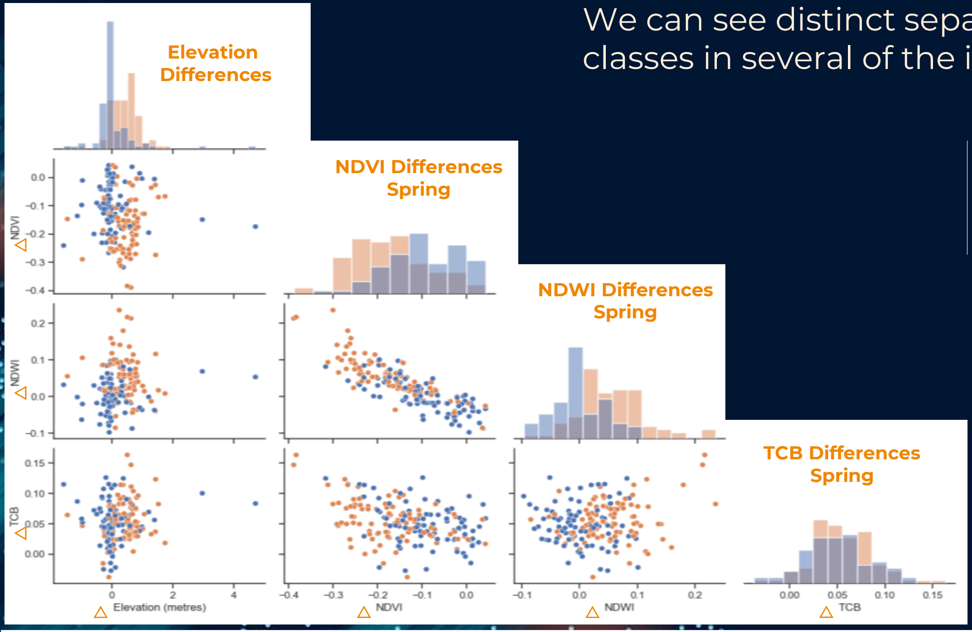
Progress

- Development work was undertaken to expand existing our Google Earth Engine codebase.
- Expanded the data searching and preprocessing to search both Sentinel and Landsat optical imagery and develop processing and sampling routines.
- Existing code was refactored to improve its reusability and make it easily maintainable.

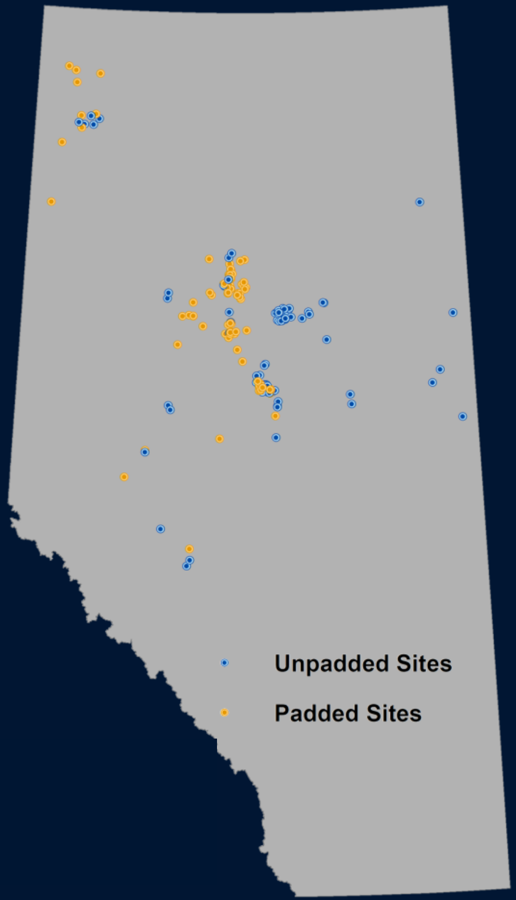


WELLPAD CHARACTERIZATION

We can see distinct separability between classes in several of the input variables



Training Site Locations



Questions

THANKS!

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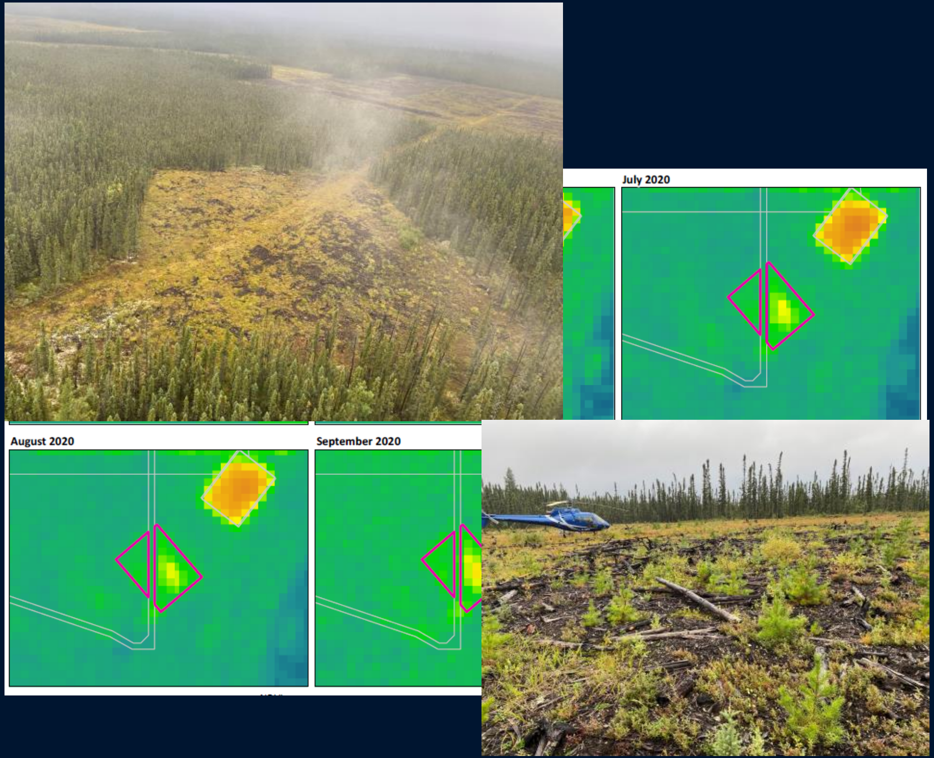
VERTEX

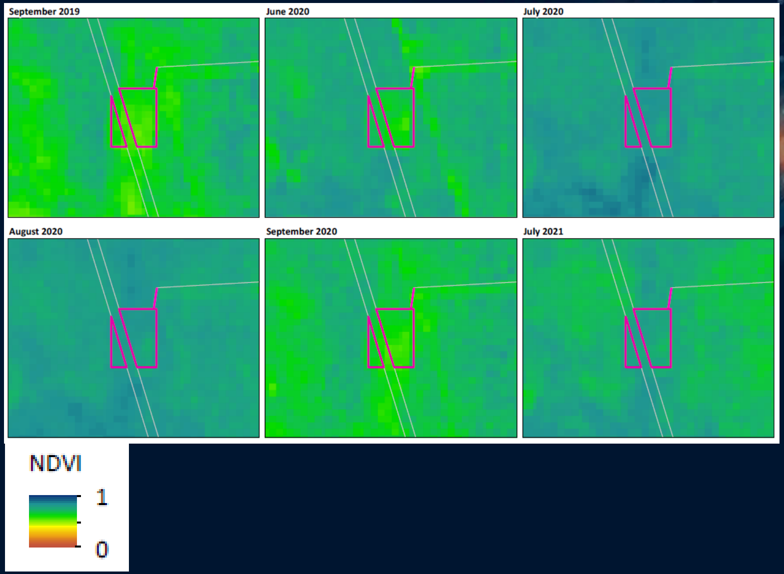
RECLAMATION

Normalized Difference Vegetation Index



Low (highest risk)

High (lowest risk)



Schedule

			2022			2023												2024		
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Task	**Description**	**Deliverables**																		
	Milestones							♦							♦					♦
0	Project Management	Planning, coordination, meetings, project control, reporting																		
1.1	Data Acquisition	Environmental data																		
1.2	Data Acquisition	Optical Earth Observation data																		
1.3	Data Acquisition	Synthetic Aperture RADAR Earth Observation data																		
2.1	Data Analysis	Integration of remotely-sensed data with in situ data																		
2.2	Data Analysis	Verification and assessment of sustainability of forests developing in pads																		
2.3	Data Analysis	Development of digital remote sensing tools to detect impacts caused by pads on peatlands																		
2.4	Data Analysis	Differentiation of bogs and fens and associated wellsites																		
2.5	Data Analysis	Development and improvement of existing remote sensing tools for non-padded wellsites in the Green Zone																		