



# Remote Sensing for Evaluating Health of Agricultural Ecosystems

**Bing Lu**, Ali Jamali, Parisa Ahmadi, Lilian Yang, Margaret Schmidt  
Department of Geography, Simon Fraser University  
b\_lu@sfu.ca



# Overview



1. Crop Health: Monitoring Blueberry Plants and Scorch Virus

2. More Applications of Remote Sensing for Crop Health

3. Soil Health: Mapping Amount of Crop Residues

4. More Applications of Remote Sensing for Soil Health

5. Ecosystem Health: Landscape Fragmentation

# 1. Crop Health: Monitoring Blueberry Plants and Scorch Virus



A healthy bush

Aphid



Infected bushes (e.g., leaf blighting)



Photo Credit: Carolyn Teasdale



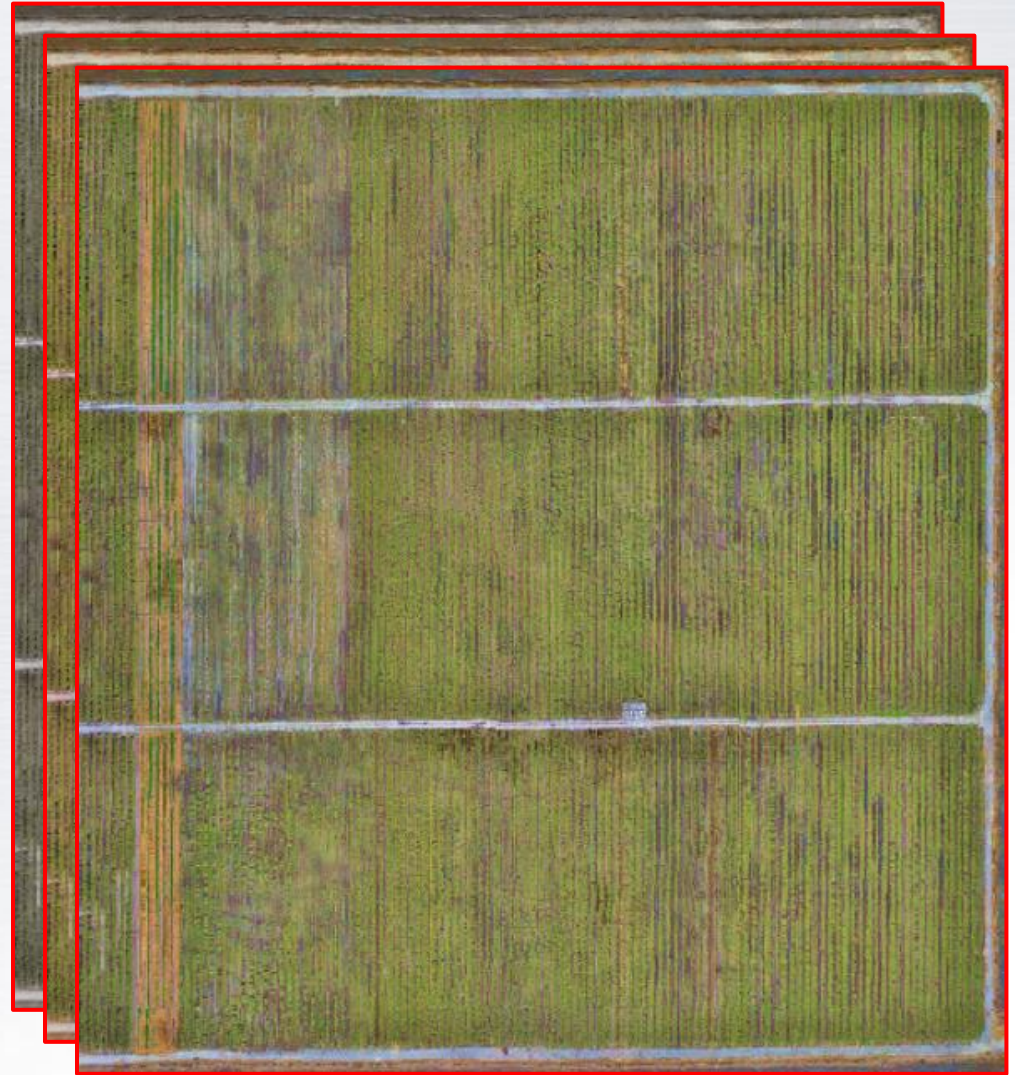
Benefits of early detection: aphid control and removal of infected plants, reduce the spread, save resources, support insurance claim etc.



# Why Use Remote Sensing for Detection?



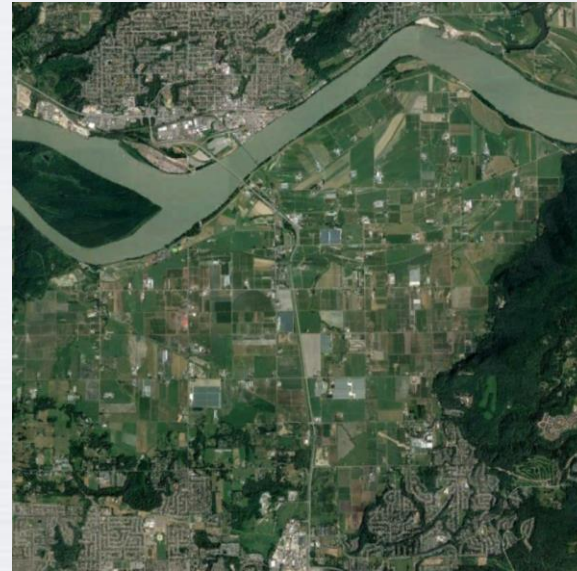
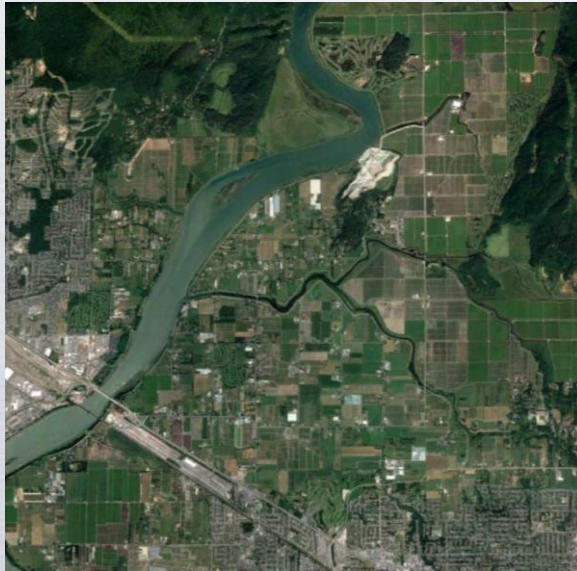
Field Survey  
VS  
Remote Sensing



Spatial and Temporal Analysis



# Study Areas and Field Surveys



Study Area in Pitt Meadows and Abbotsford, BC



Field Surveys in 2022



Severity Level Evaluation



# Drone Flights and Images



(Credit: Jonathon McIntyre)

Multi-rotors



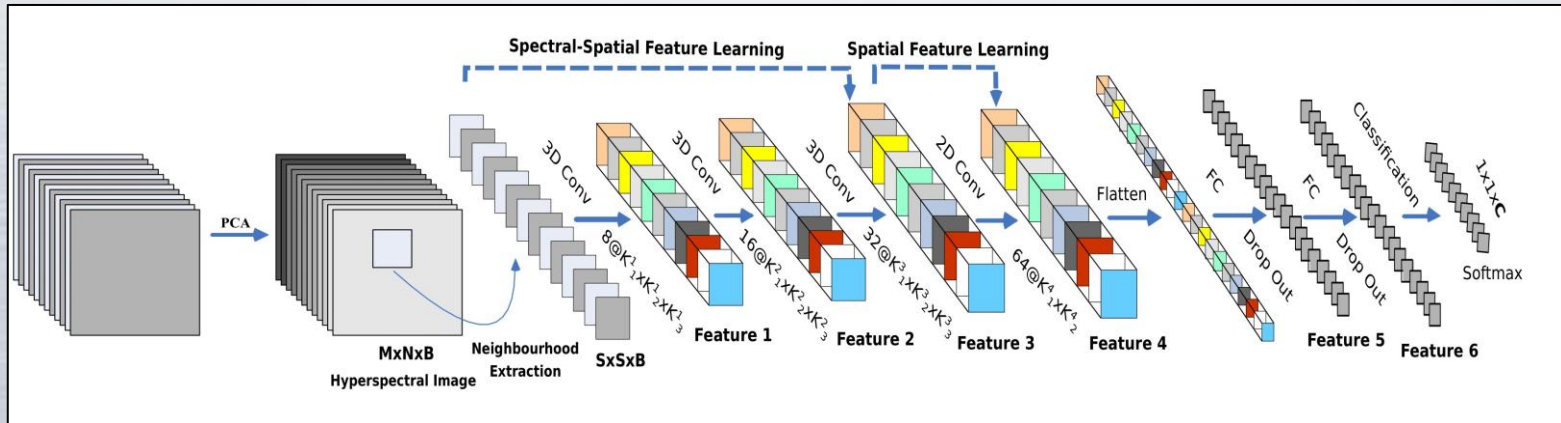
Fixed Wings (Terramera)



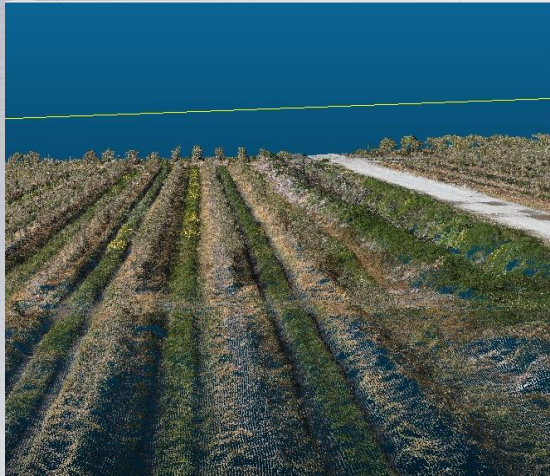
Images with Spatial Resolution of 0.4 ~ 10 cm



# Classification Modeling and Preliminary Results



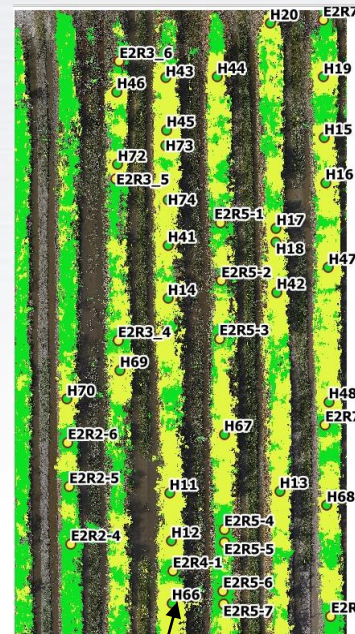
## Machine Learning and Deep Learning Models



Digital Elevation Model



Extraction of Bushes



Training sites



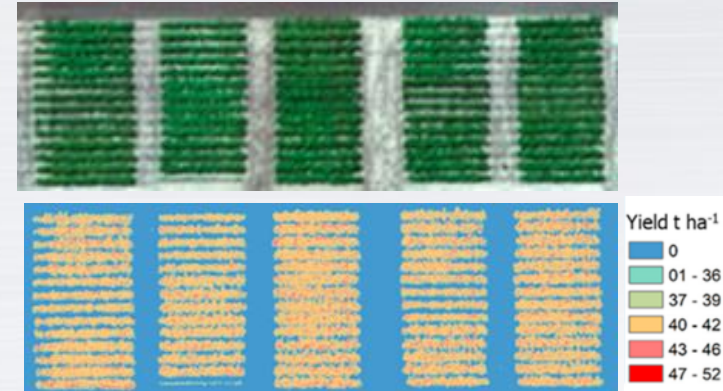
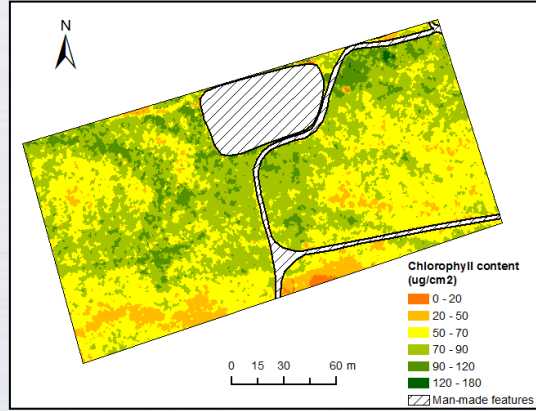
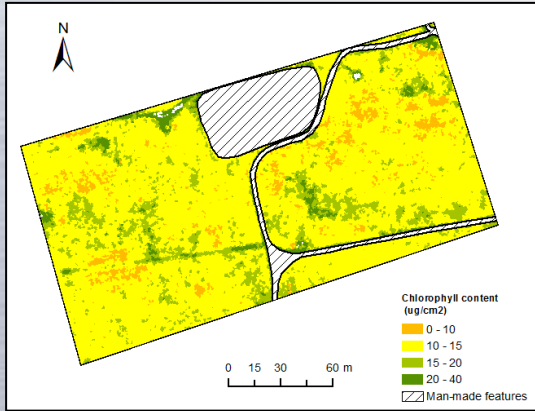
Healthy

Infected



# 2. More Applications of Remote Sensing for Crop Health

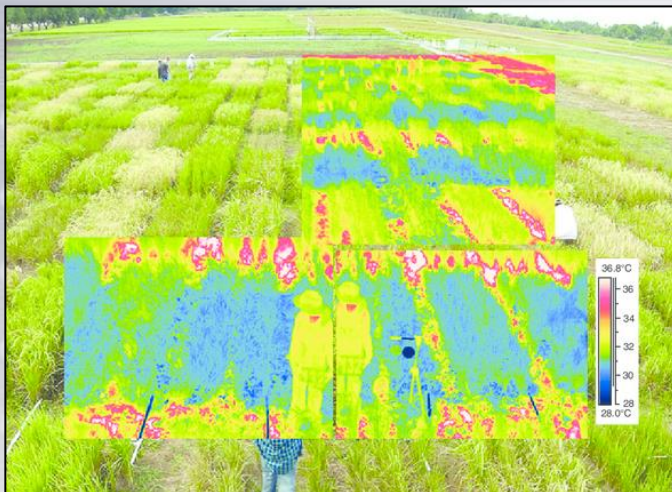
## 1). Leaf Area Index (LAI) / Chlorophyll Content / Biomass / Yield



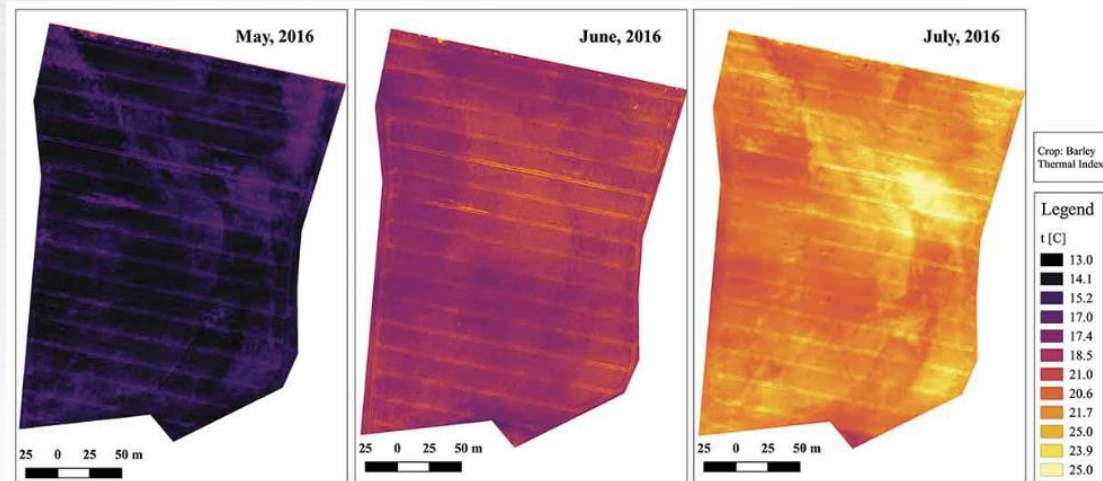
Chlorophyll Content of April and June ([Lu et al, 2017](#))

Potato Yield ([Li et al, 2021](#))

## 2). Temperature / Water Stress



Temperature Measured on Ground (Jones, 2009)

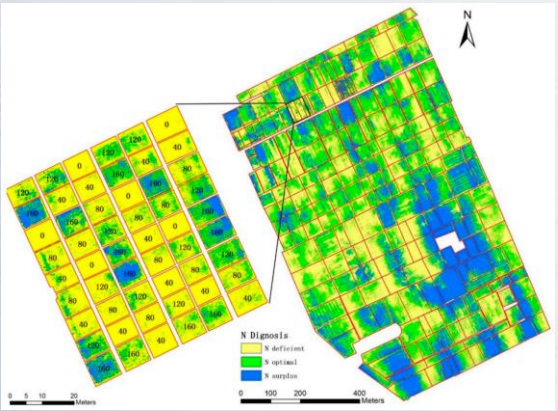


Temperature of Barley Field ([Raeva et al, 2021](#))





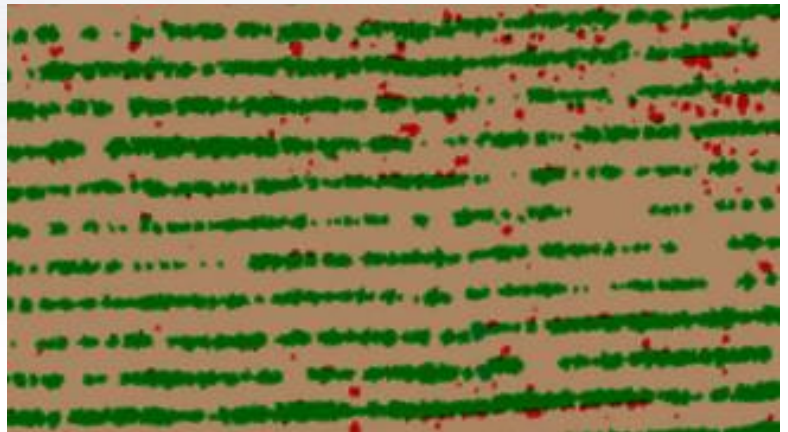
### 3). Nutrient Status / Diseases / Pests



Nitrogen Status Diagnosis ([Zha et al, 2020](#))

Pest Detection ([Gao et al, 2020](#))

### 4). Weeds



Detection of Weeds ([Peña et al, 2015](#))



# 3. Soil Health: Mapping Amount of Crop Residues



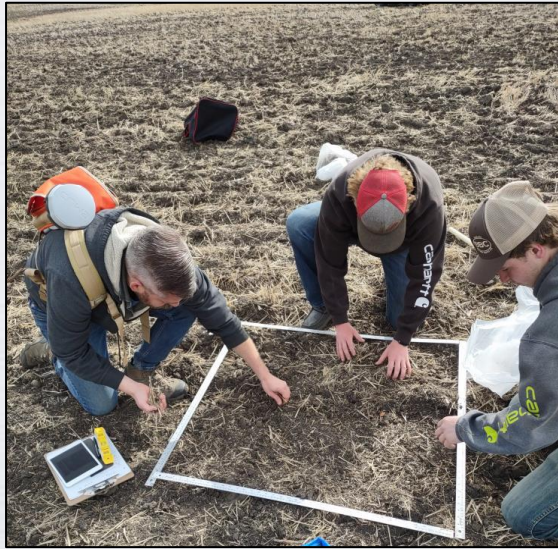
Crop Residues are Critical for Soil Health



Study Areas in Camrose, AB



# Field Surveys and Data Collection



(Photo credit: Bruce Milligan)

## Site Photos and Collection of Residue Samples in 2022



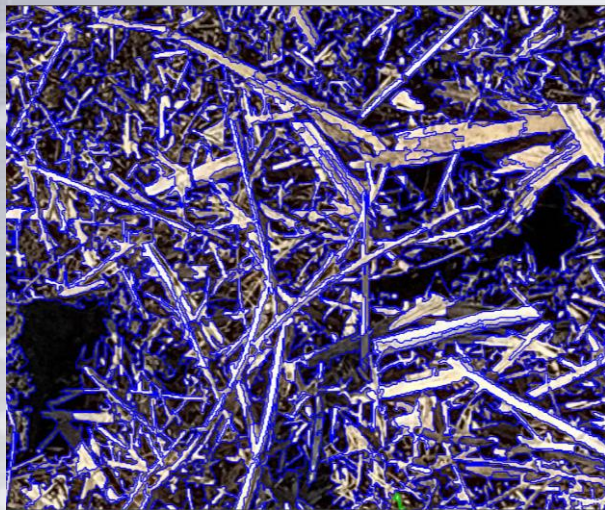
## Collection of Drone and Tasked-Satellite Images



# Data Processing Preliminary Results



Drone and Satellite Images



Differentiation of Residues/Soils on Ground Photos

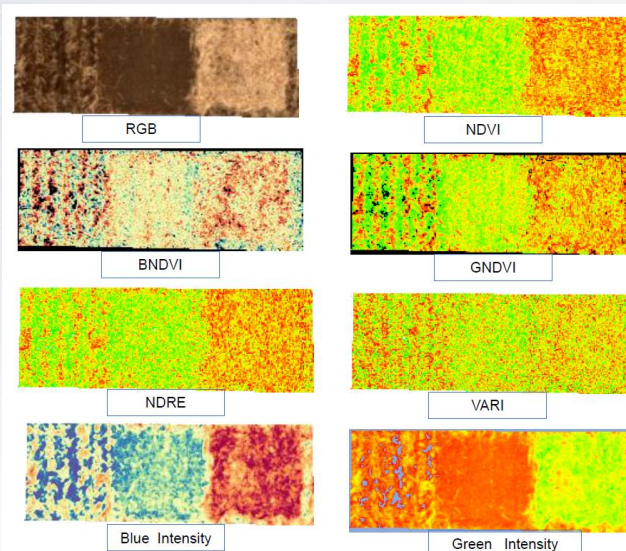
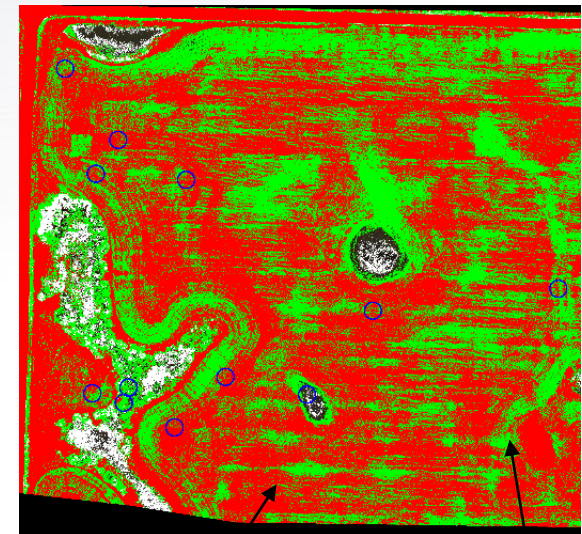


Image Features



Crop Residues

Soils



# 4. More Applications of Remote Sensing for Soil Health

## 1). Soil Carbon Mapping



Drone and Satellite  
Imaging



+



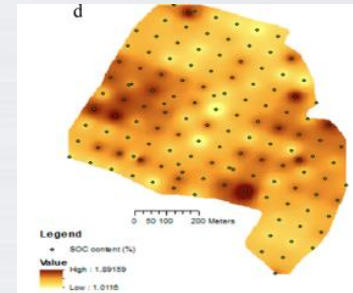
Field Sampling  
and Lab Analysis

+



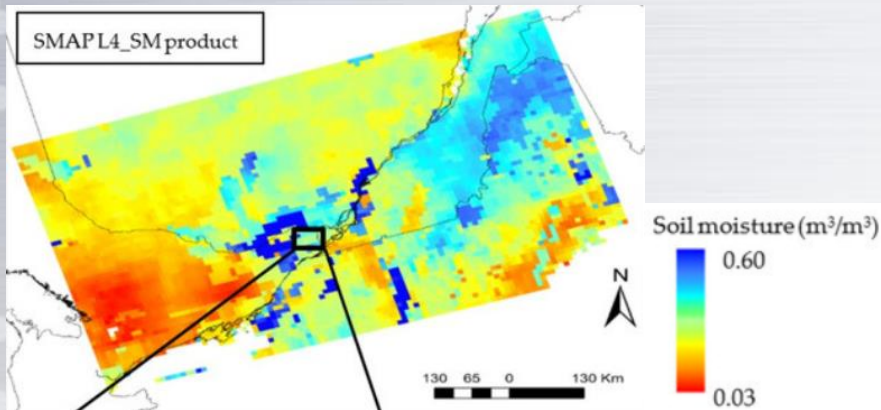
Mid-Infrared Spectroscopy  
(Smukler, 2023)

=

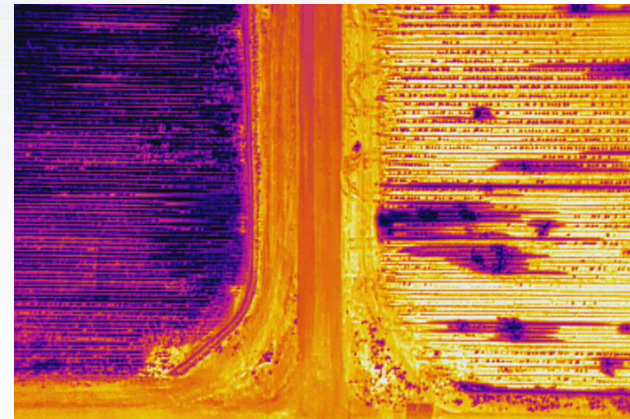


Organic Carbon Maps  
([Biney et al, 2021](#))

## 2). Soil Moisture / Temperature



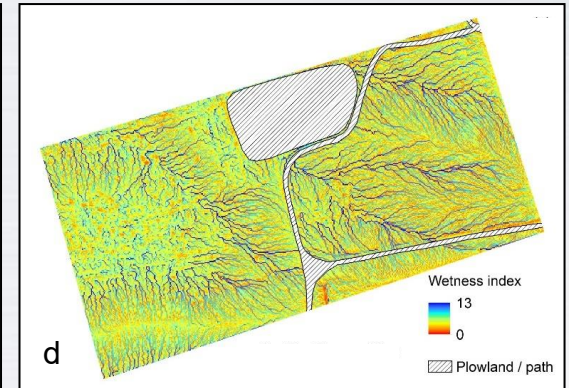
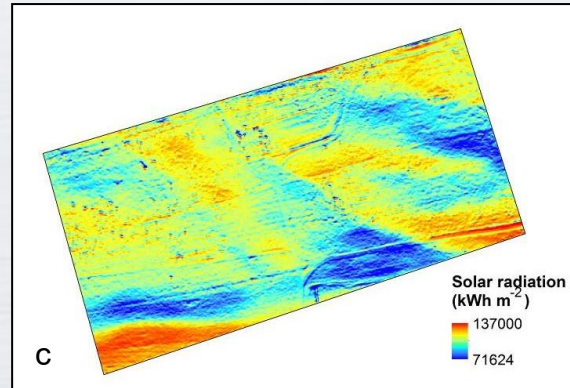
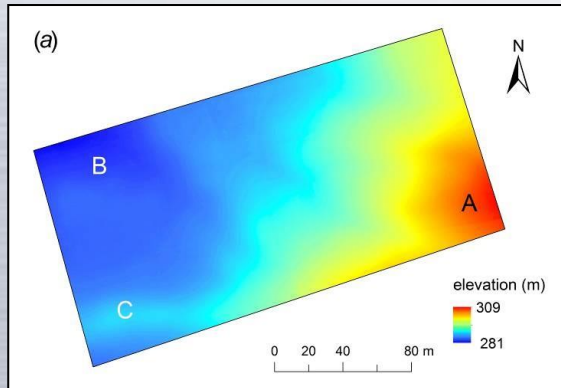
Soil Moisture Map ([Merzouki et al, 2019](#))



Soil Temperature Map ([Reference](#))



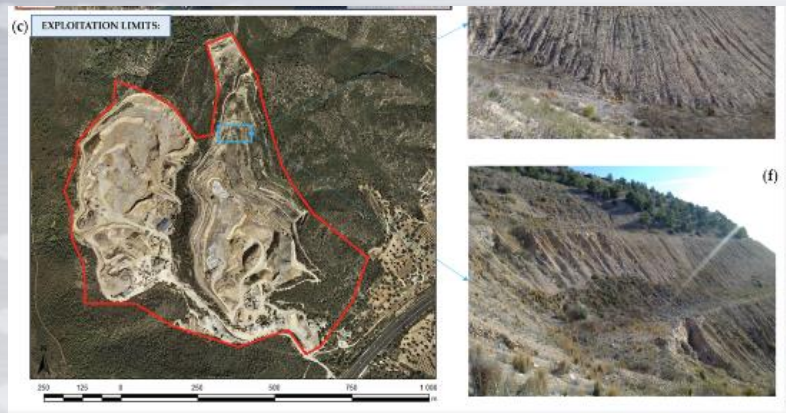
### 3). Micro Terrain



Digital Elevation Model (5cm) Area solar radiation (April)  
([Lu et al, 2017](#))

Wetness index

### 4). Soil Erosion / Stability



([Carabassa et al, 2021](#))

### 5). Dairy Farms / Greenhouse Gases



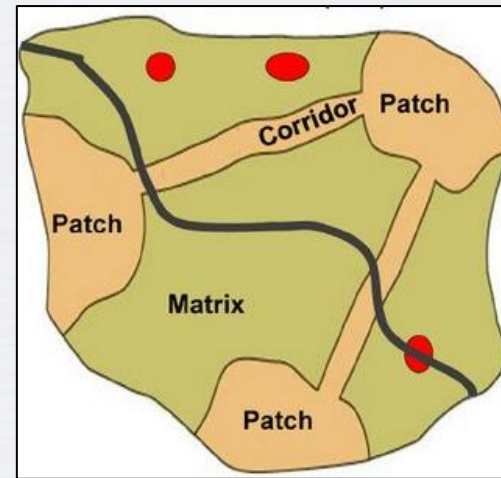
Manure Piles  
([Park et al, 2021](#))



PM<sub>10</sub> and CO<sub>2</sub> Maps  
([Becciolini et al, 2017](#))



# 5. Ecosystem Health: Landscape Fragmentation



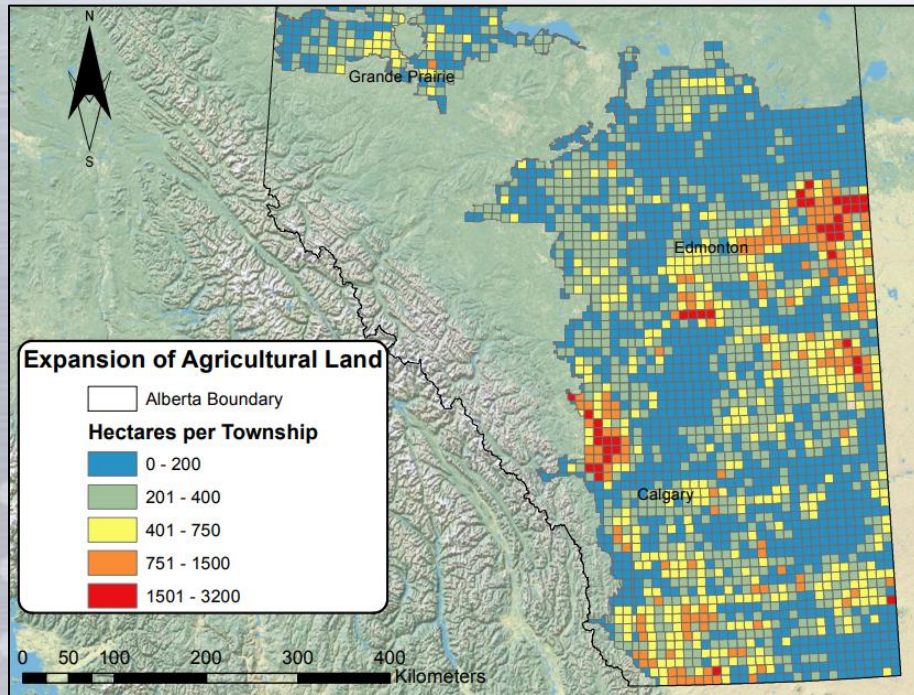
Landscape Elements ([Lausch et al., 2014](#))

Type	Landscape metric	Abbreviation	Description
Area metrics	Mean Patch Size*	MPS	The average area of all patches in the landscape (unit: ha).
	Total Core Area*	TCA	The sum of the core areas of each patch of the corresponding patch type (unit: ha).
	Normalized TCA**	NTCA	The TCA normalized by habitat abundance.
Density metrics	Patch Density*	PD	The number of patches per square kilometer (i.e., 100 ha).
	Edge Density*	ED	The total length of all edge segments per hectare for the class or landscape of consideration (unit: m/ha).
Shape metrics	Landscape Shape Index*	LSI	A modified perimeter-area ratio of the form that measures the shape complexity of the whole landscape or a specific patch type.
	Perimeter-Area Fractal Dimension*	PAFD	An index that reflects shape complexity across a range of spatial scales (patch sizes).
Connectivity metrics	Mean Euclidean Nearest Neighbor Distance*	NND	The distance to the nearest neighboring patch of the same type, based on shortest edge-to-edge distance (unit: m).
	Normalized NND**	NNND	The NND normalized by habitat abundance.
	Cohesion*	Cohesion	An index that measures the physical connectedness of the corresponding patch type.

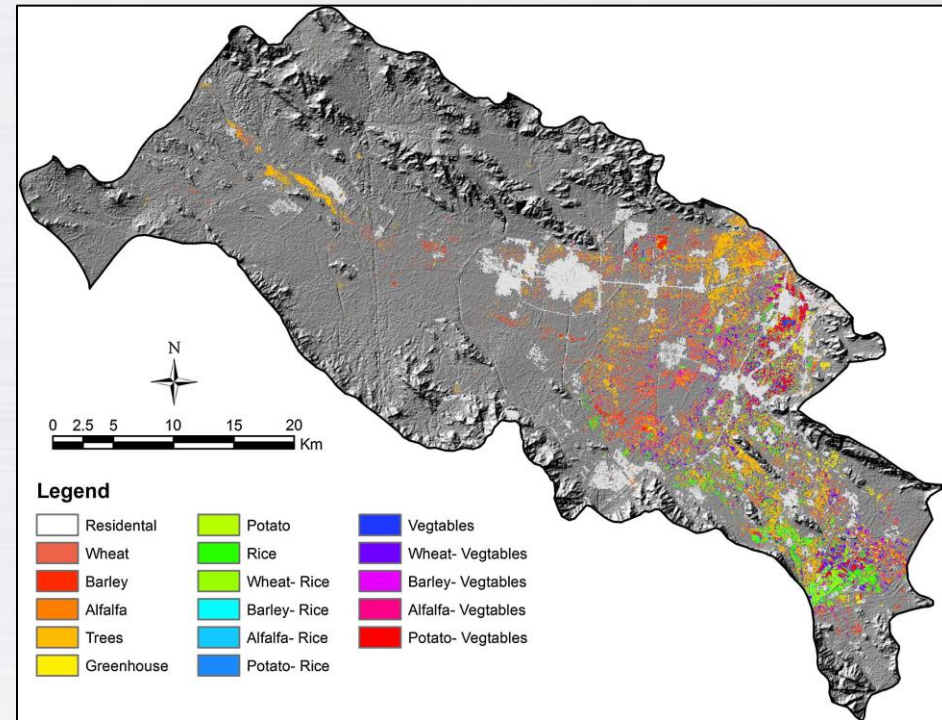
Landscape Metrics ([Liu et al., 2016](#))



# Ecosystem Health: Landscape Change



Grassland, Forestland, and Shrubland  
Converted to Agricultural land 2000 to 2012  
([Haarsma et al, 2014](#))



Crop Type Classification and Rotation  
Mapping ([Asgarian et al, 2016](#))



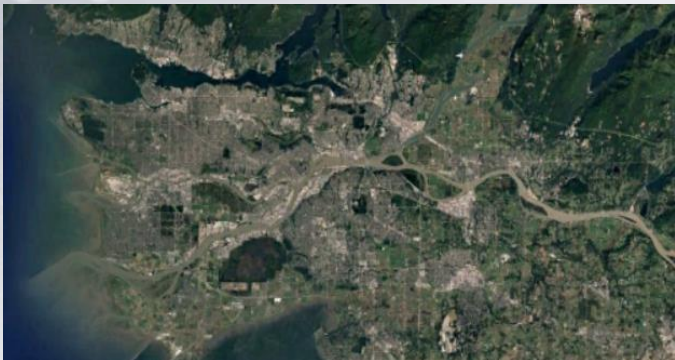
# Summary of Remote Sensing

## Advantages:

- 1) Spatial coverage from small to large: canopy, field, landscape, regional
- 2) Repeated data collection: daily, weekly, monthly, yearly, decadal
- 3) Retrieval of various ecosystem features: crop, soil, water
- 4) Images collected by different platforms/sensors are more and more available

## Limitations:

- 1) Cannot provide all the information needed for agricultural research (e.g., soil microbiological features)
- 2) Image collection can be limited by weather
- 3) Some images/technologies are free, some are very expensive
- 4) May generate large volume of data and thus large computational load





# Acknowledgements

This project was funded by the Canada's Digital Technology Supercluster, Mitacs, and BC Blueberry Council, .

Thanks to the growers in the study area for supporting this research!

Thanks to Jonathon McIntyre (i-Open Tech), David McCaffrey (Terramera), Carolyn Teasdale and Siva Sabaratnam (BC Ministry of Ag), Eric Gerbrandt (BCBC), Rishi Burlakoti (AAFC), and others for the great help in data collection.





# Thanks for your time. Questions?

Bing Lu  
Department of Geography,  
Simon Fraser University  
b\_lu@sfu.ca

