

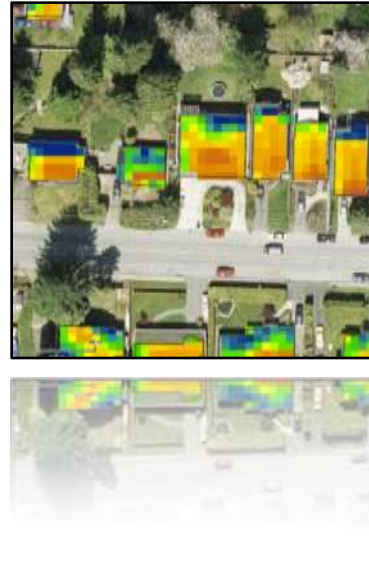
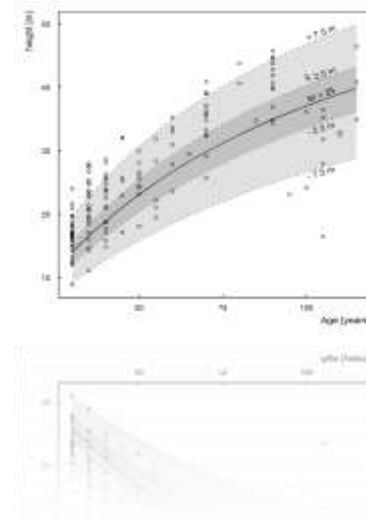
**That's
amazing...
I did not know
remote
sensing could
do that**

Dr. Nicholas Coops



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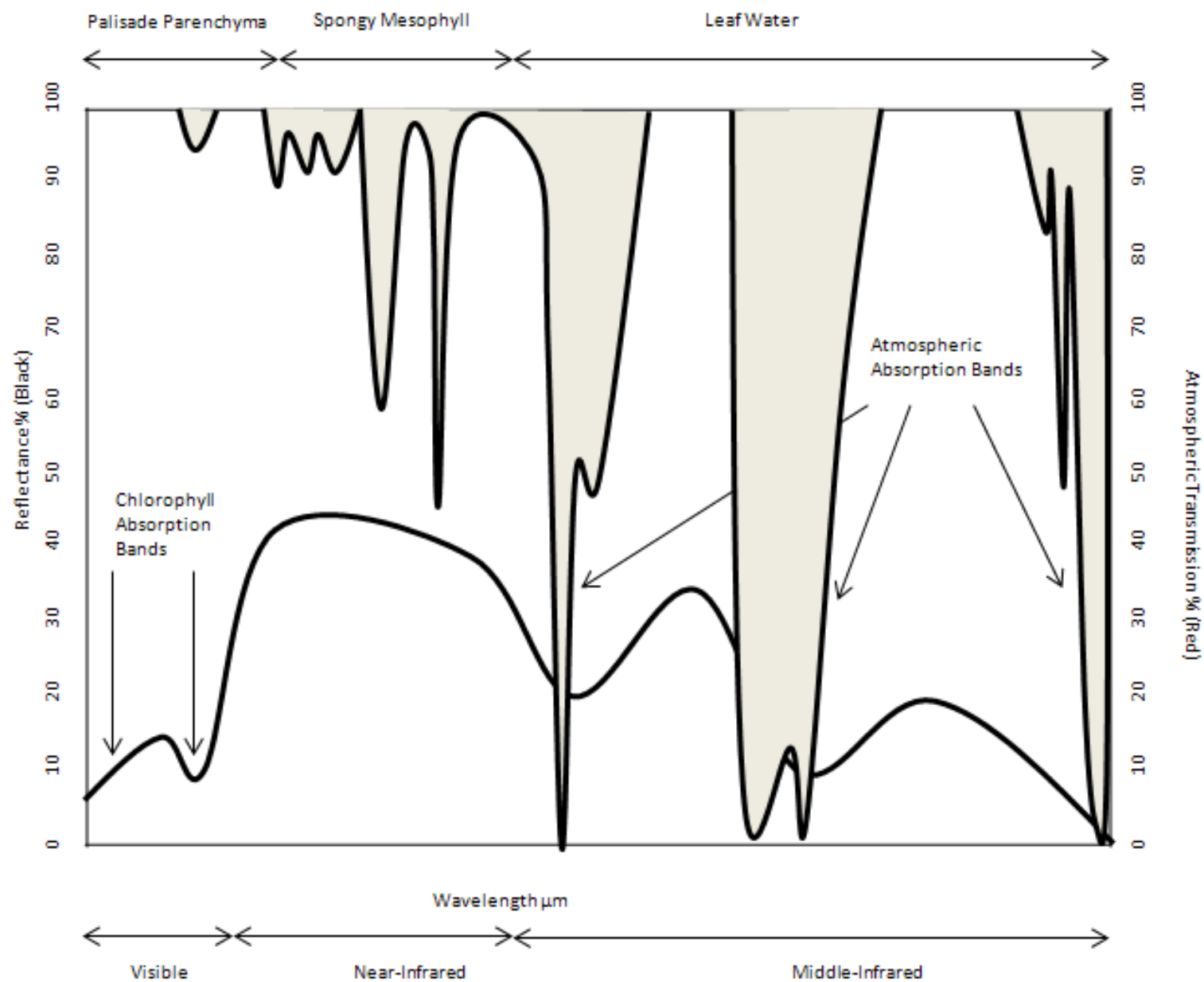


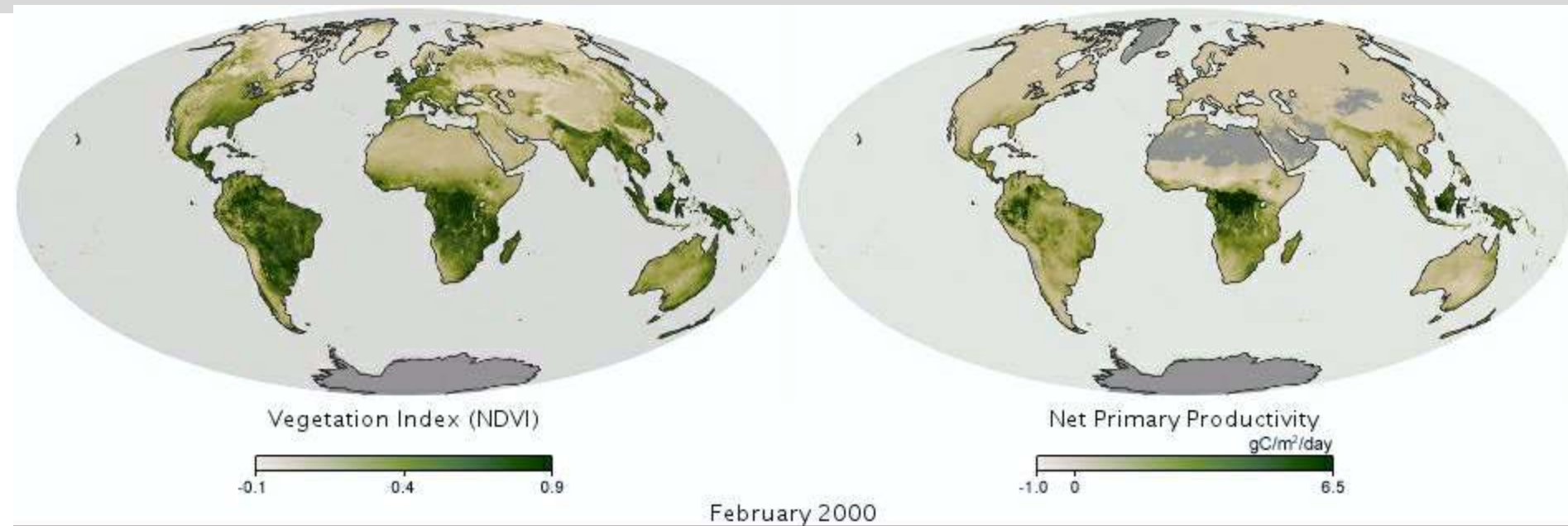


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Image acquired from FLICKR: Photographer: [Eva the Weaver](#). Create commons licence

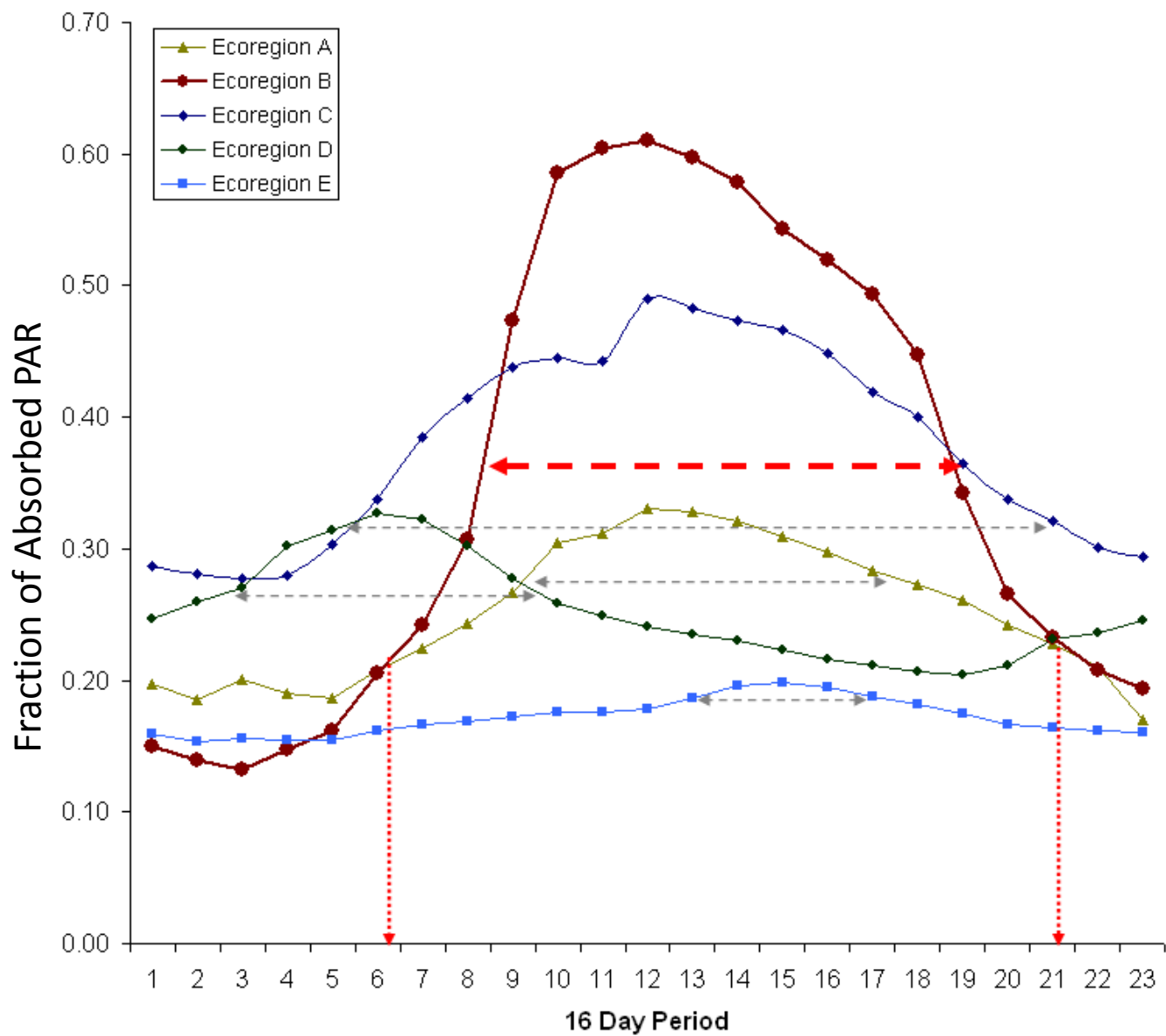




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Imagery provided by NASA. Permission for use is granted



Biodiversity Monitoring From Space

Minimum fPAR

An indication of the base annual level of production
Indicative of capacity to support and maintain cover over the year.
The lowest annual fPAR the lowest amount of green cover available throughout the year.

Integrated fPAR

Providing an indication of overall site and environmental productivity.

COV fPAR

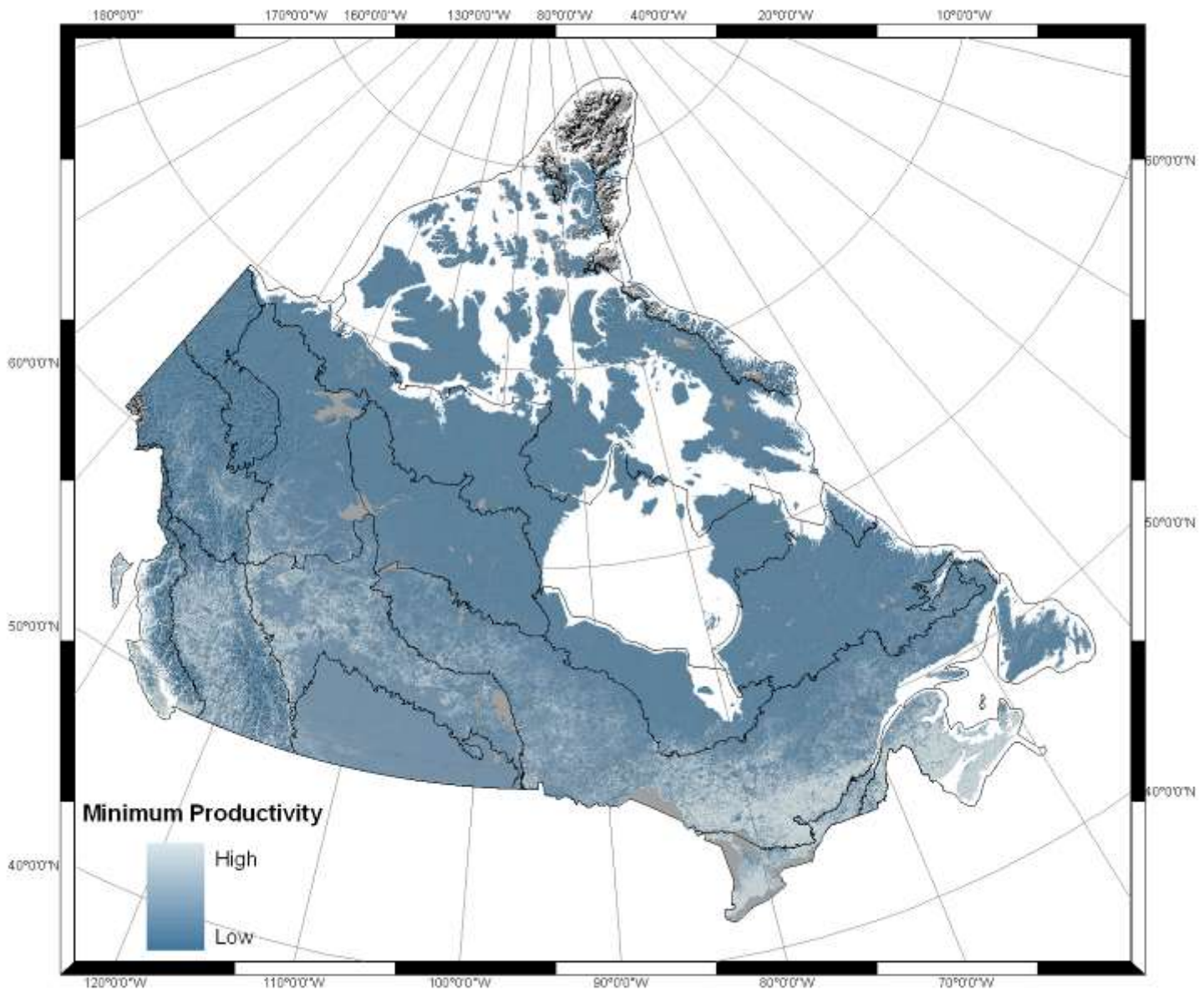
Variation of the annual production, estimated as the coefficient of variation.

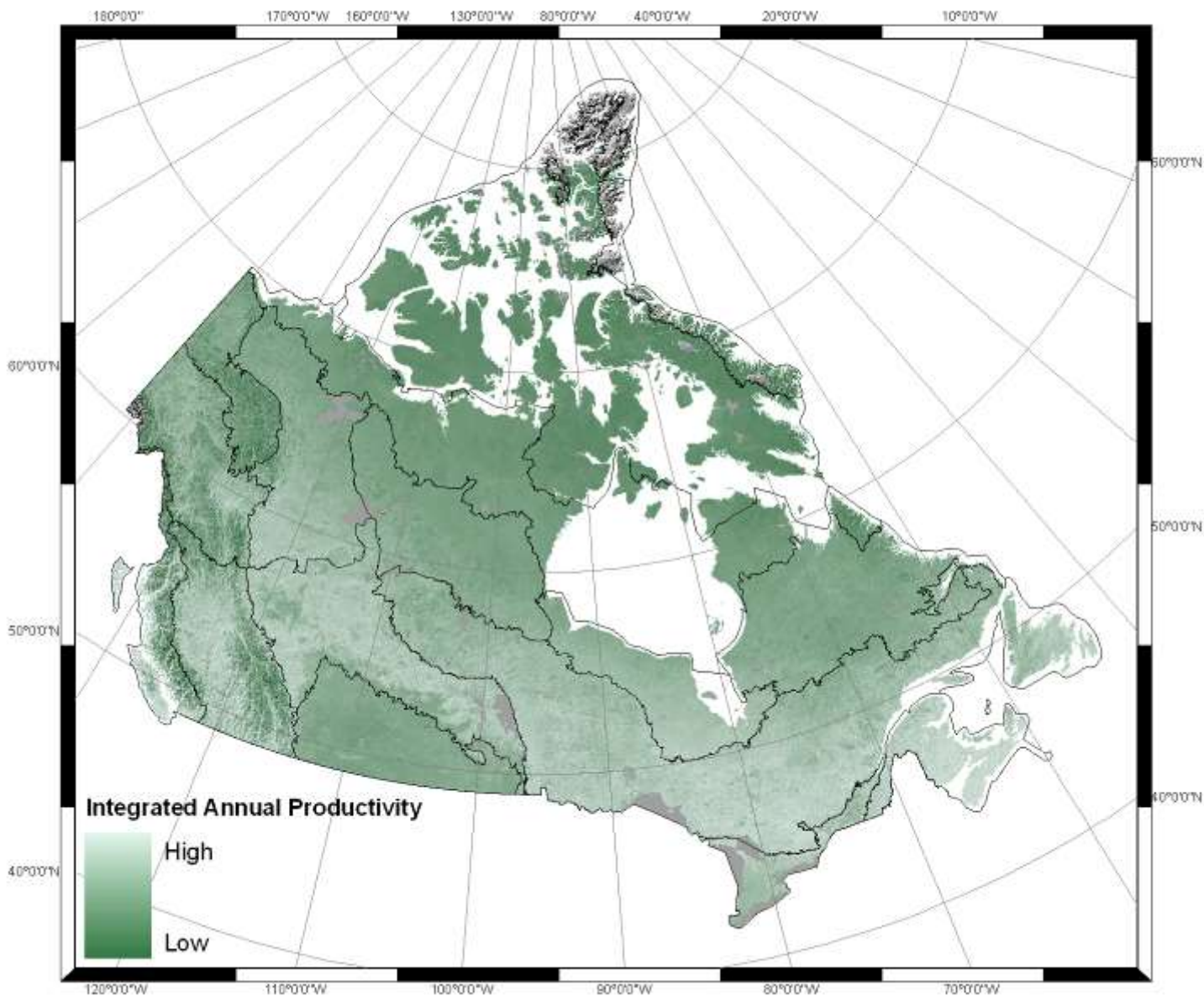


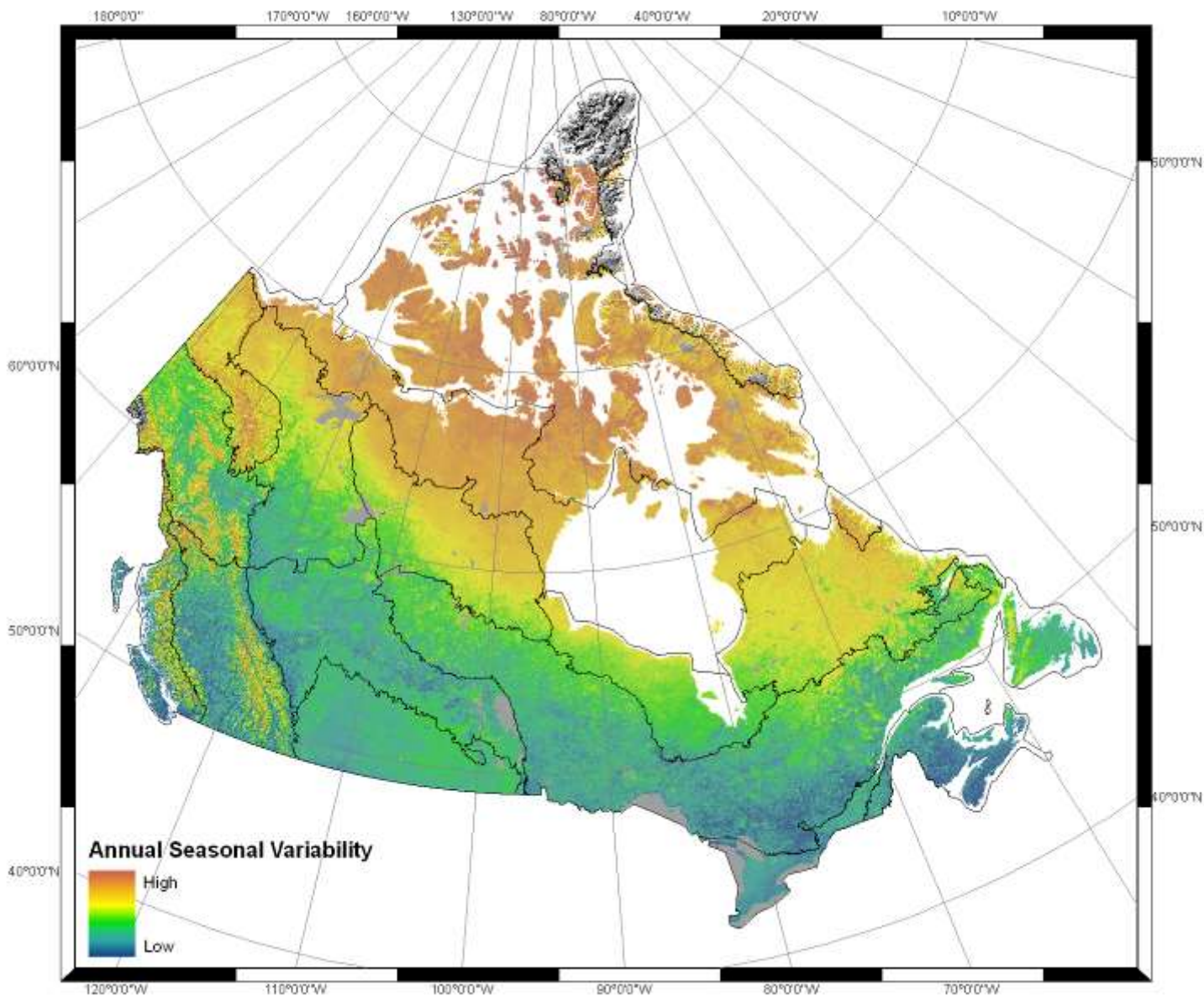
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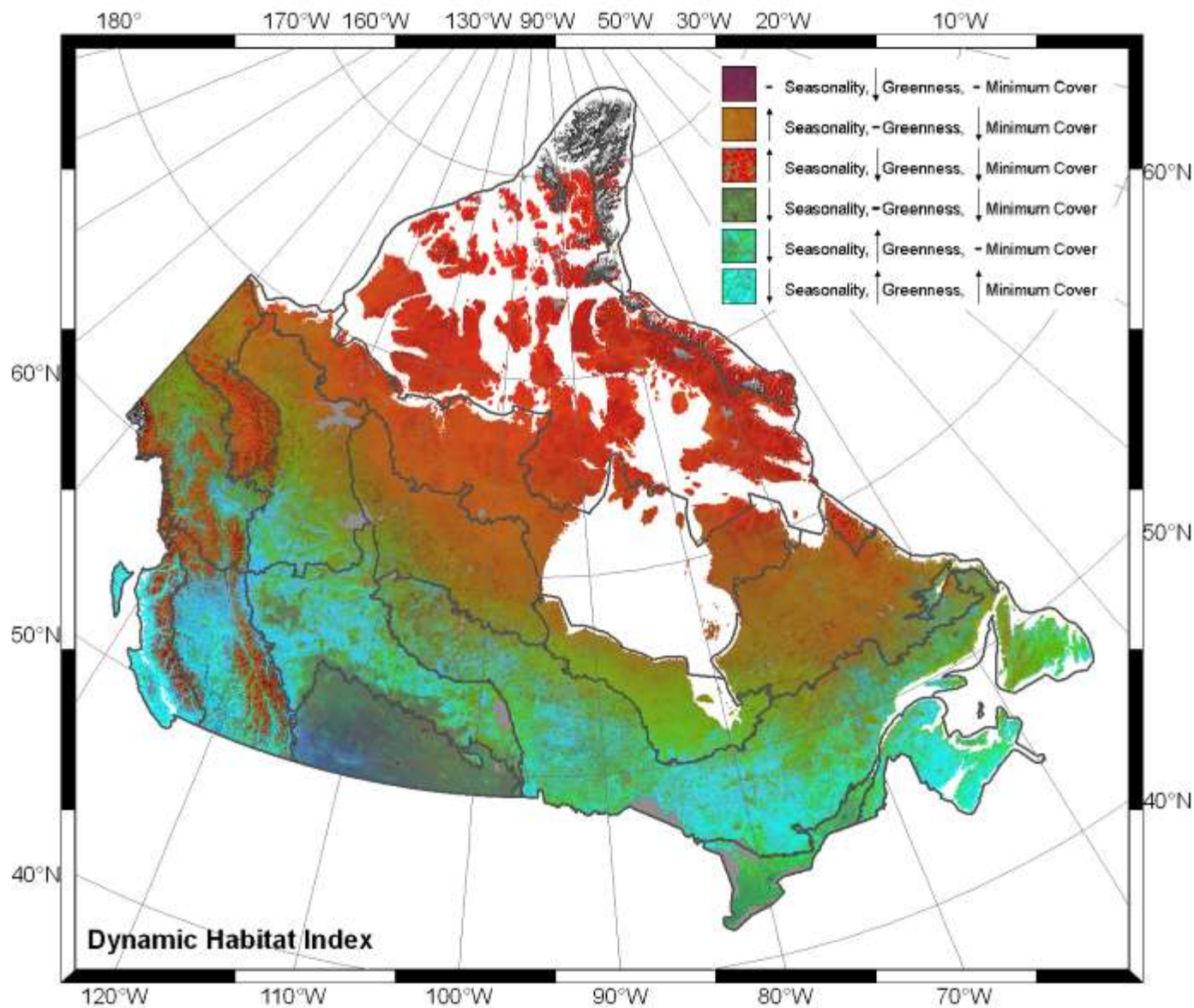
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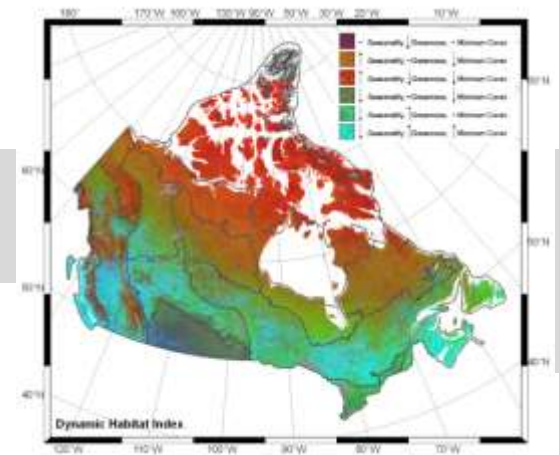
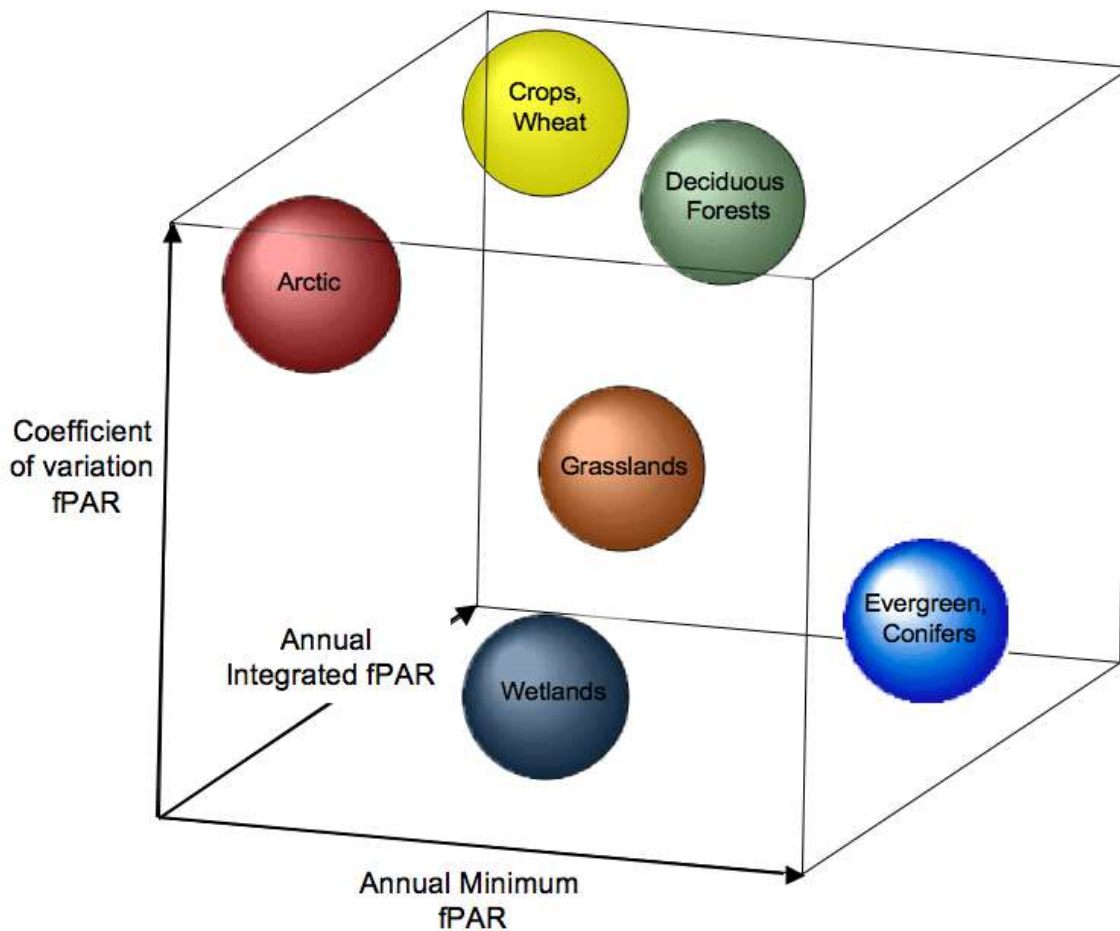
A collaborative project with Canadian Forest Service.
(Wulder and Andrew)



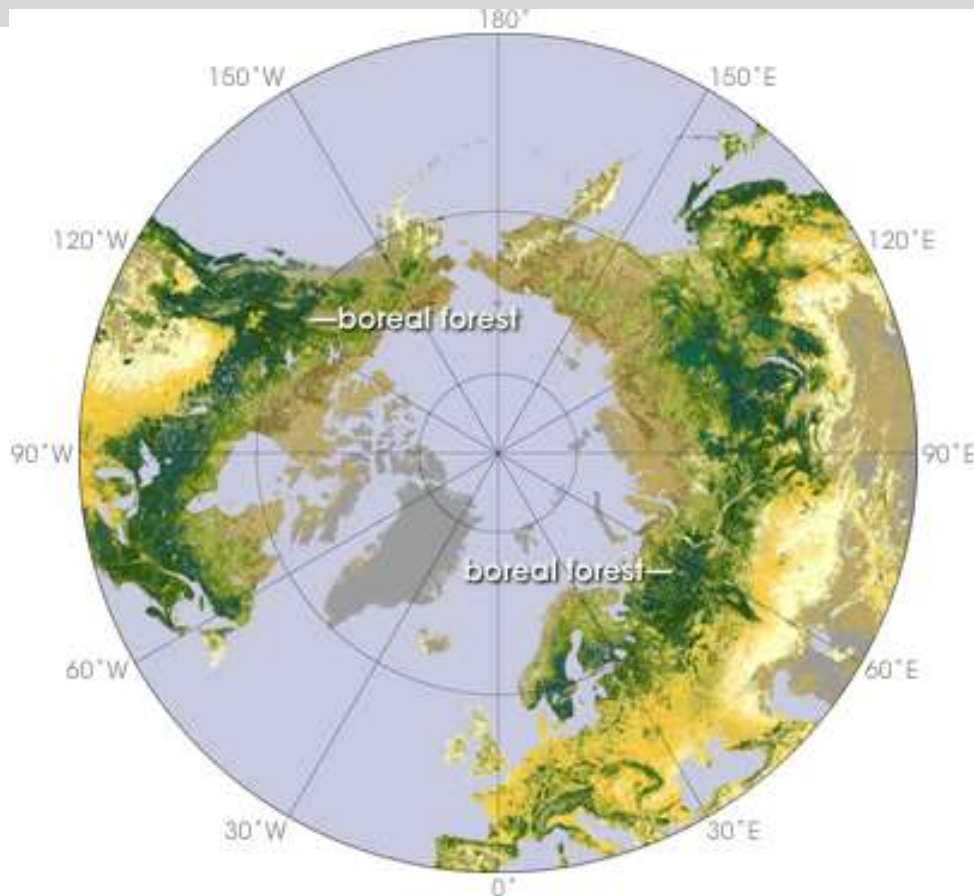








Canadian Boreal Characterization



- Encircles the Arctic
- 16.6 million square kilometers
- Canada boreal ~5.5 million square kilometres



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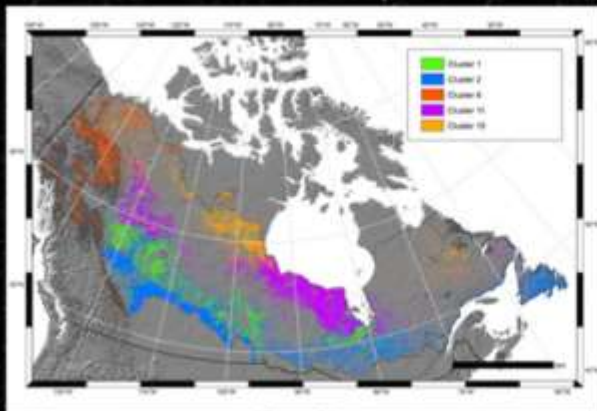
Source: Robert Simmon

Canadian Boreal Characterization

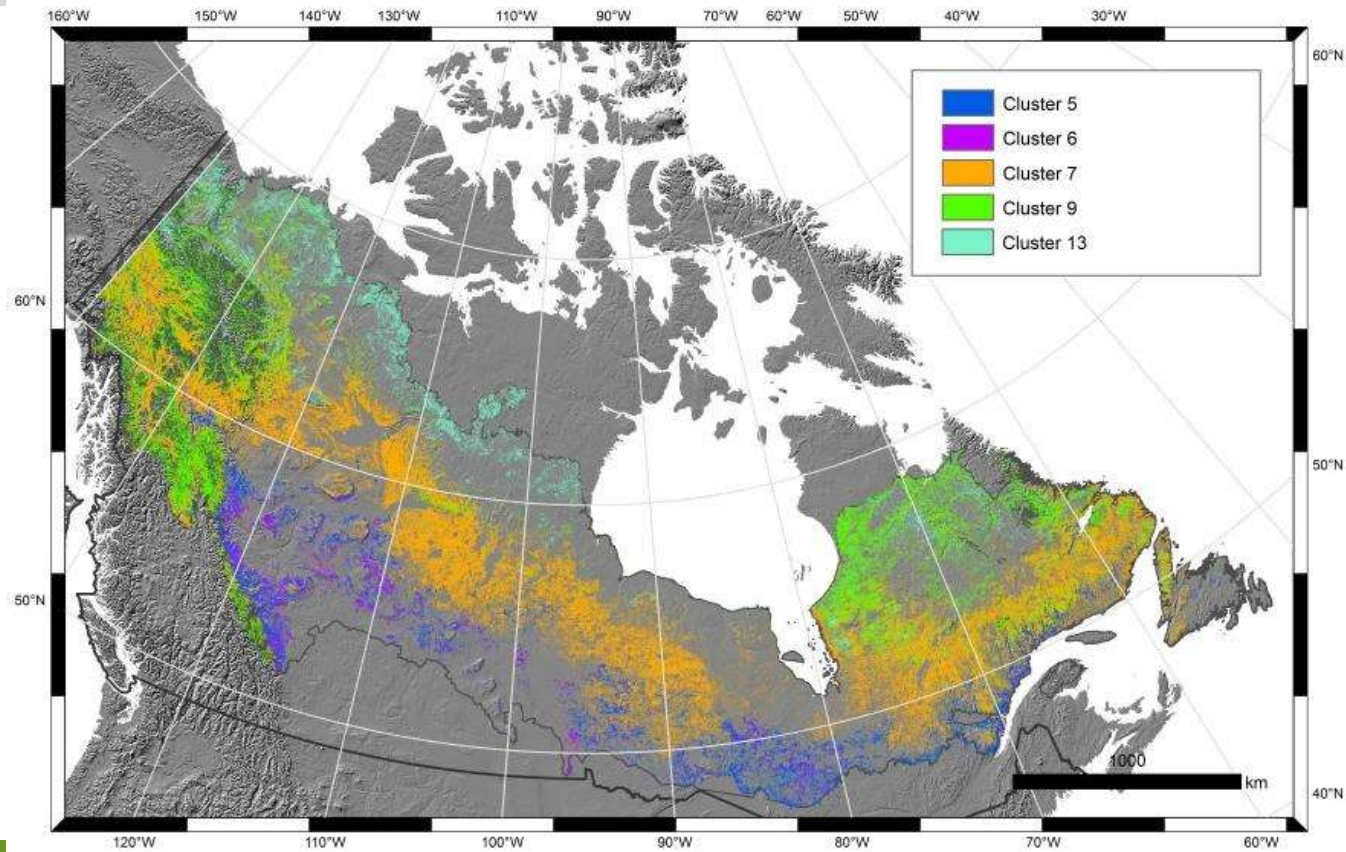
- Remotely-derived biodiversity indicators used to characterize habitat across Canadian boreal forest for conservation planning.
 - Evaluate the utility of biodiversity indicators for classifying the boreal into environmentally distinct areas (e.g., clusters or regionalizations)



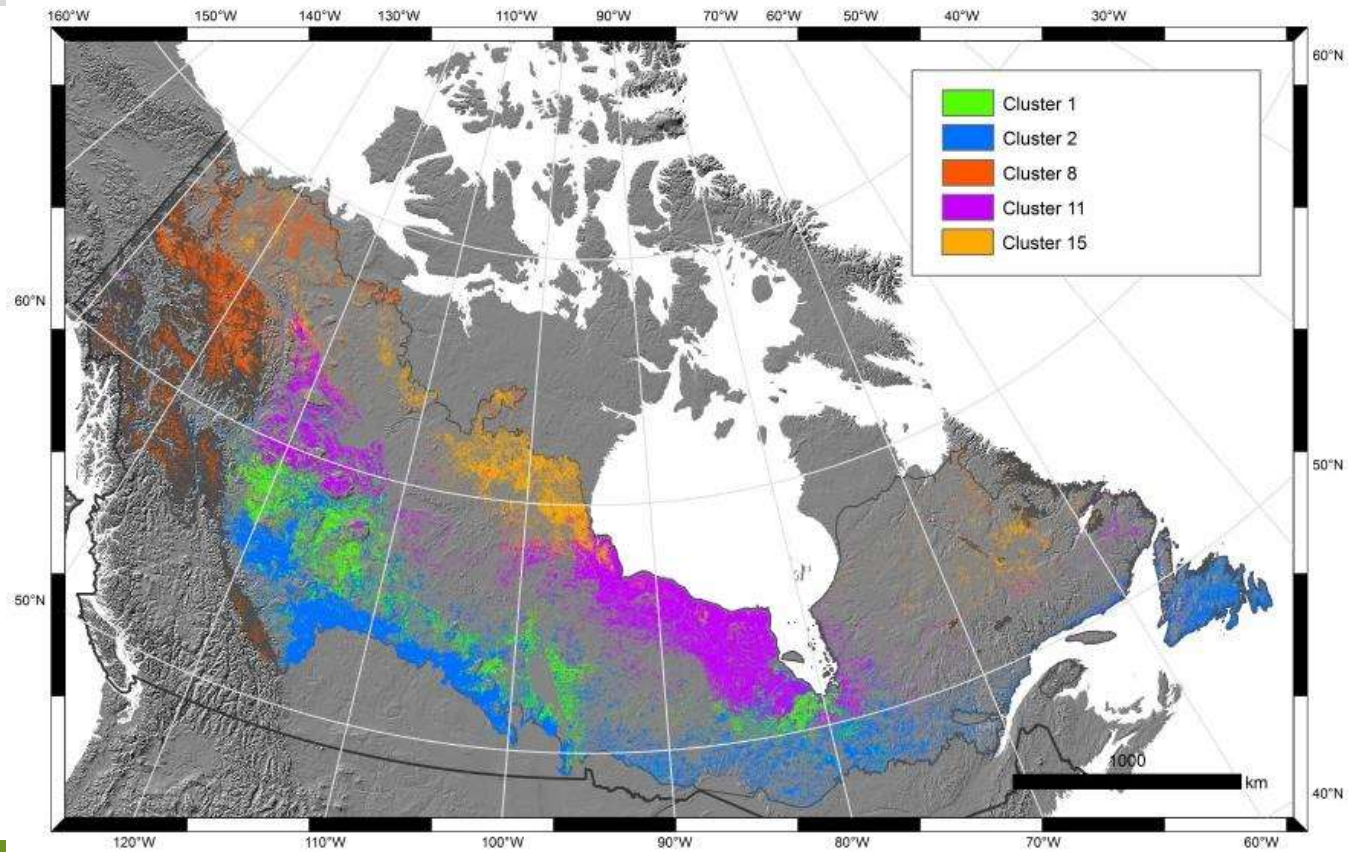
Domains



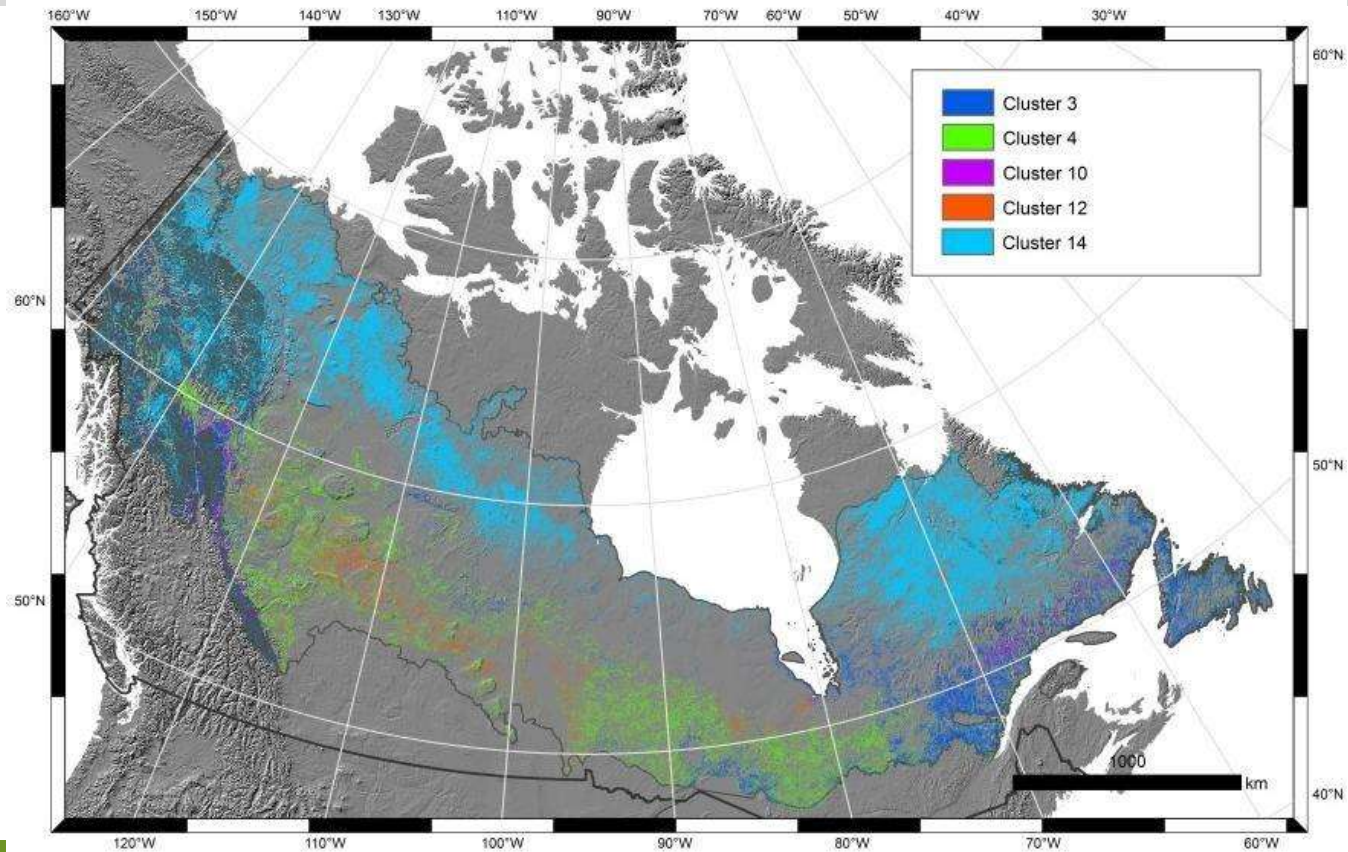
Canadian Boreal Characterization



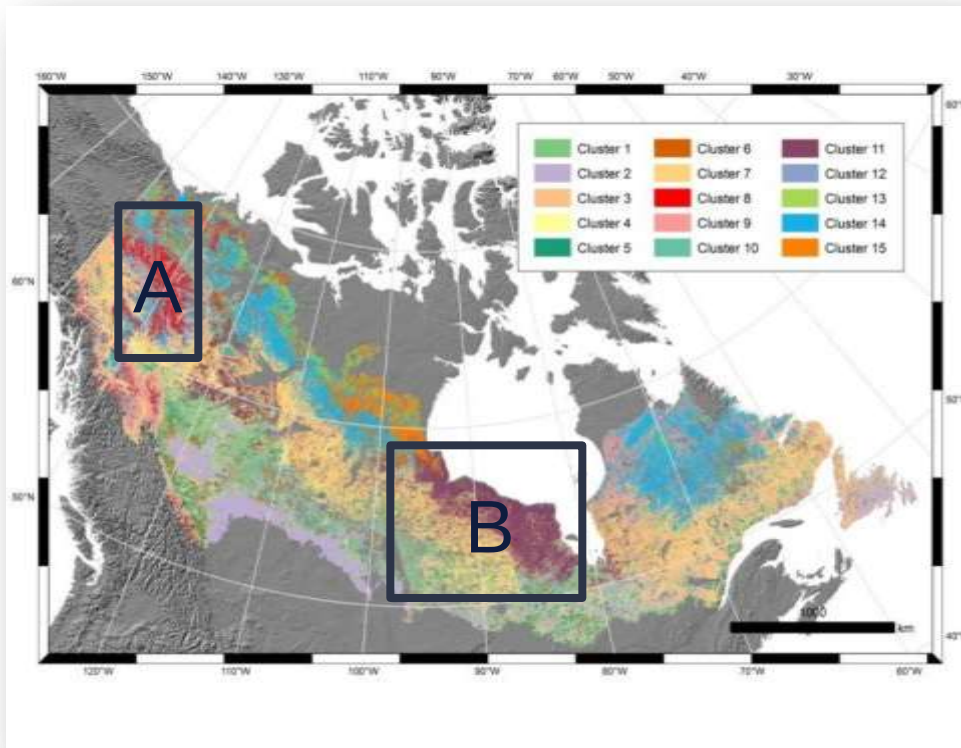
Canadian Boreal Characterization



Canadian Boreal Characterization



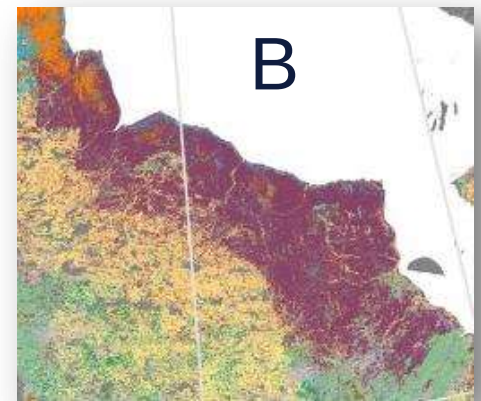
Canadian Boreal Characterization



Source: Powers et al, 2012



MacKenzie mountain range

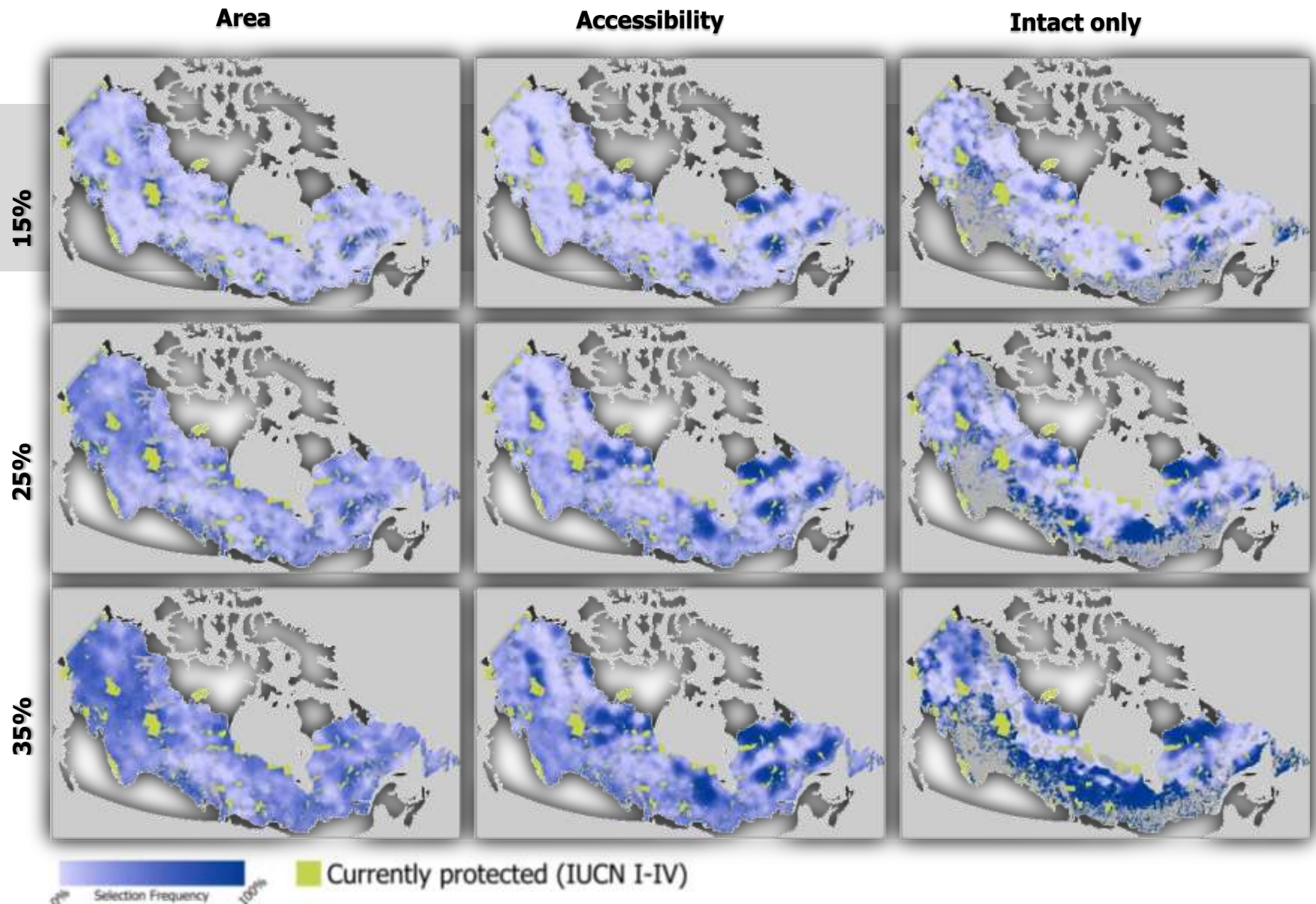


Hudson Bay Lowland



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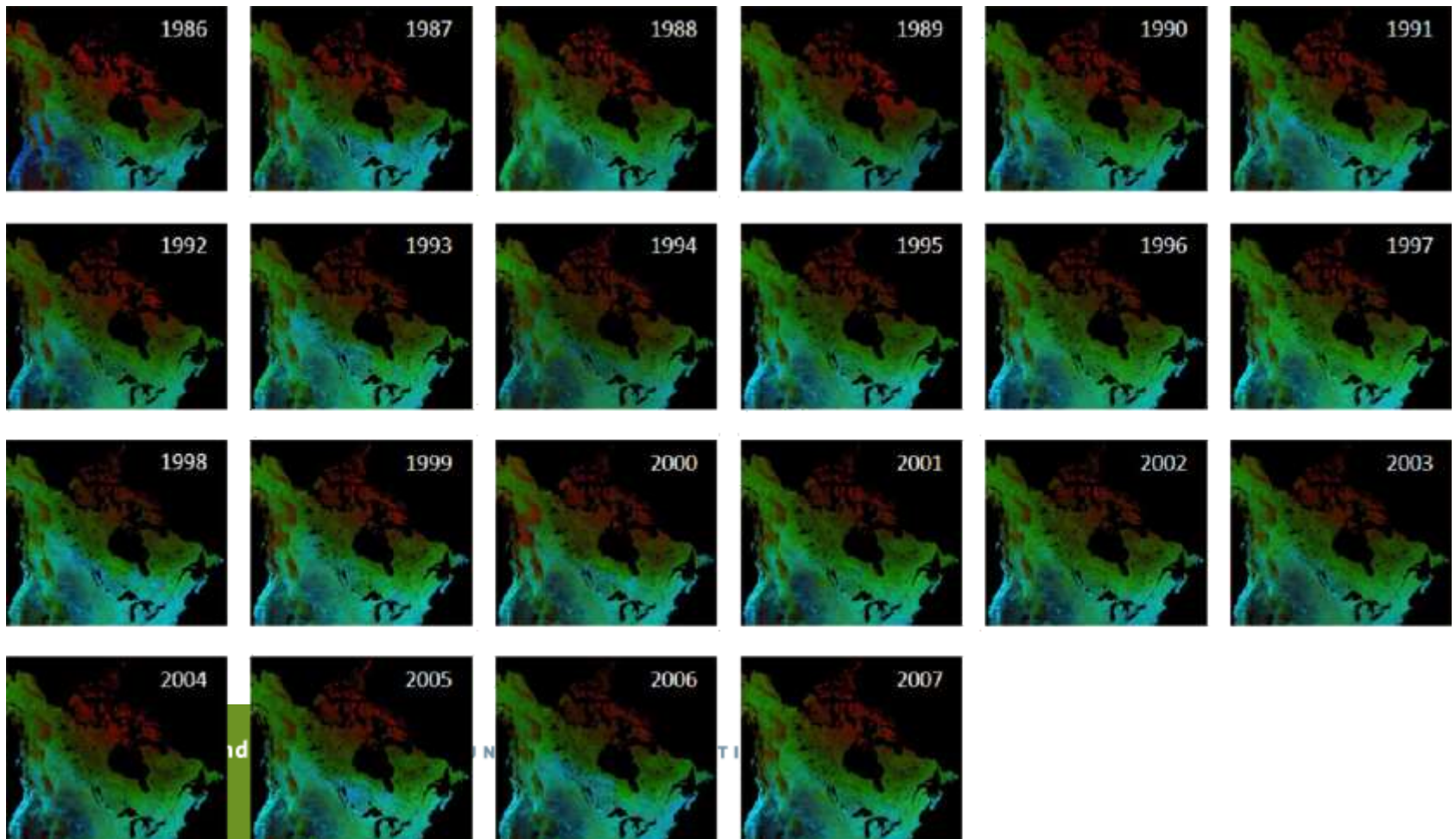
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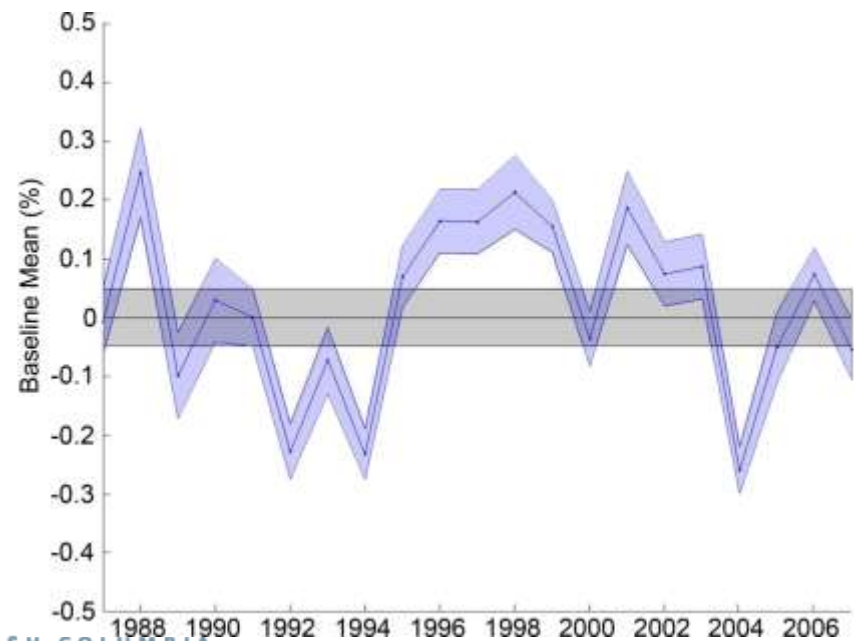
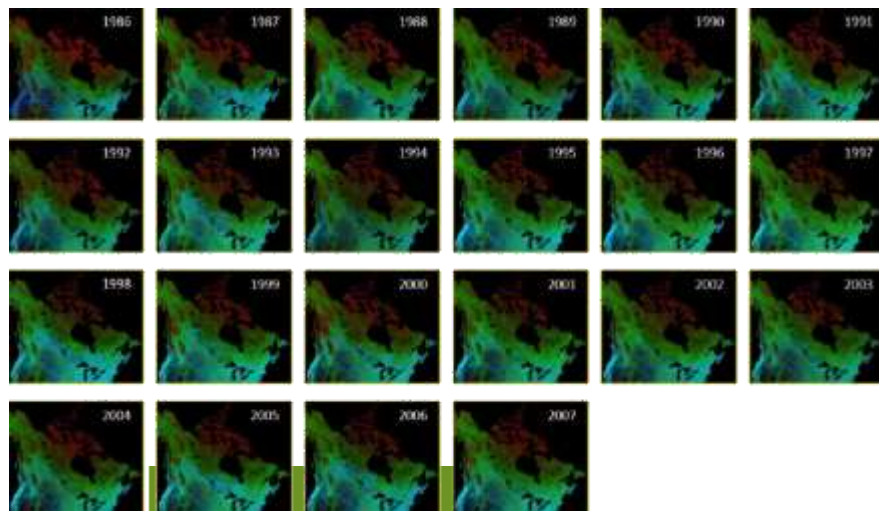
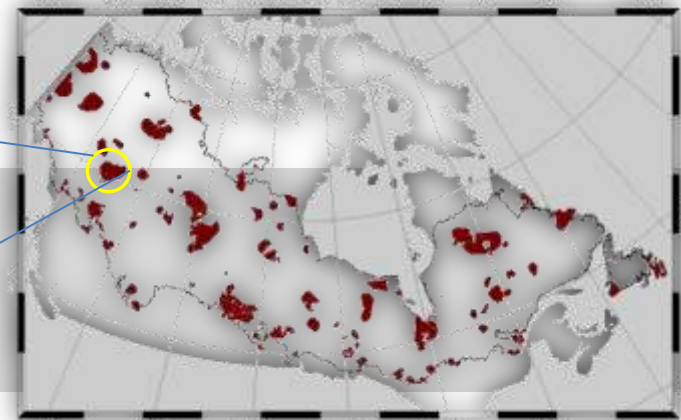
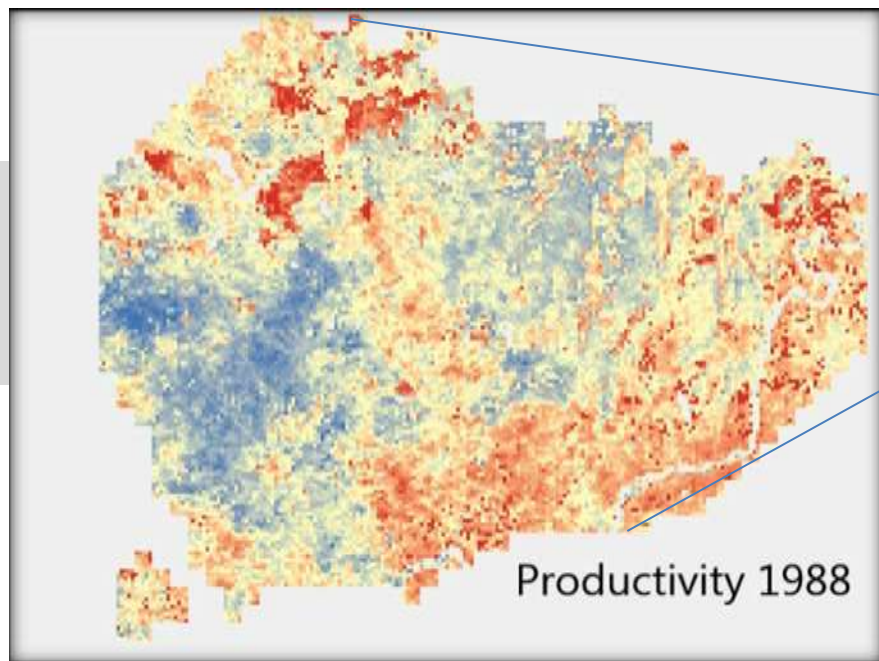


Reserve Efficacy



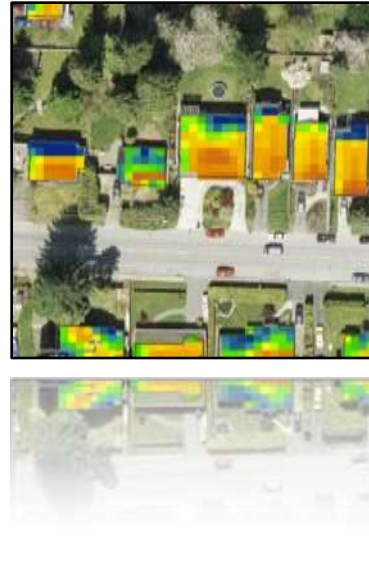
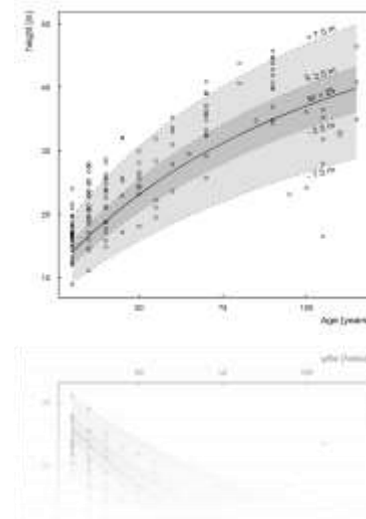
AVHRR Data Archive To See How Reserves Have Changed





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Citizen Science

- A relatively new area of research
- Use of the public to help gather and analyze data, often through grassroots mapping projects
- Ability to collect high spatial resolution data where traditional data sources are lacking
- Focus is on people and their location





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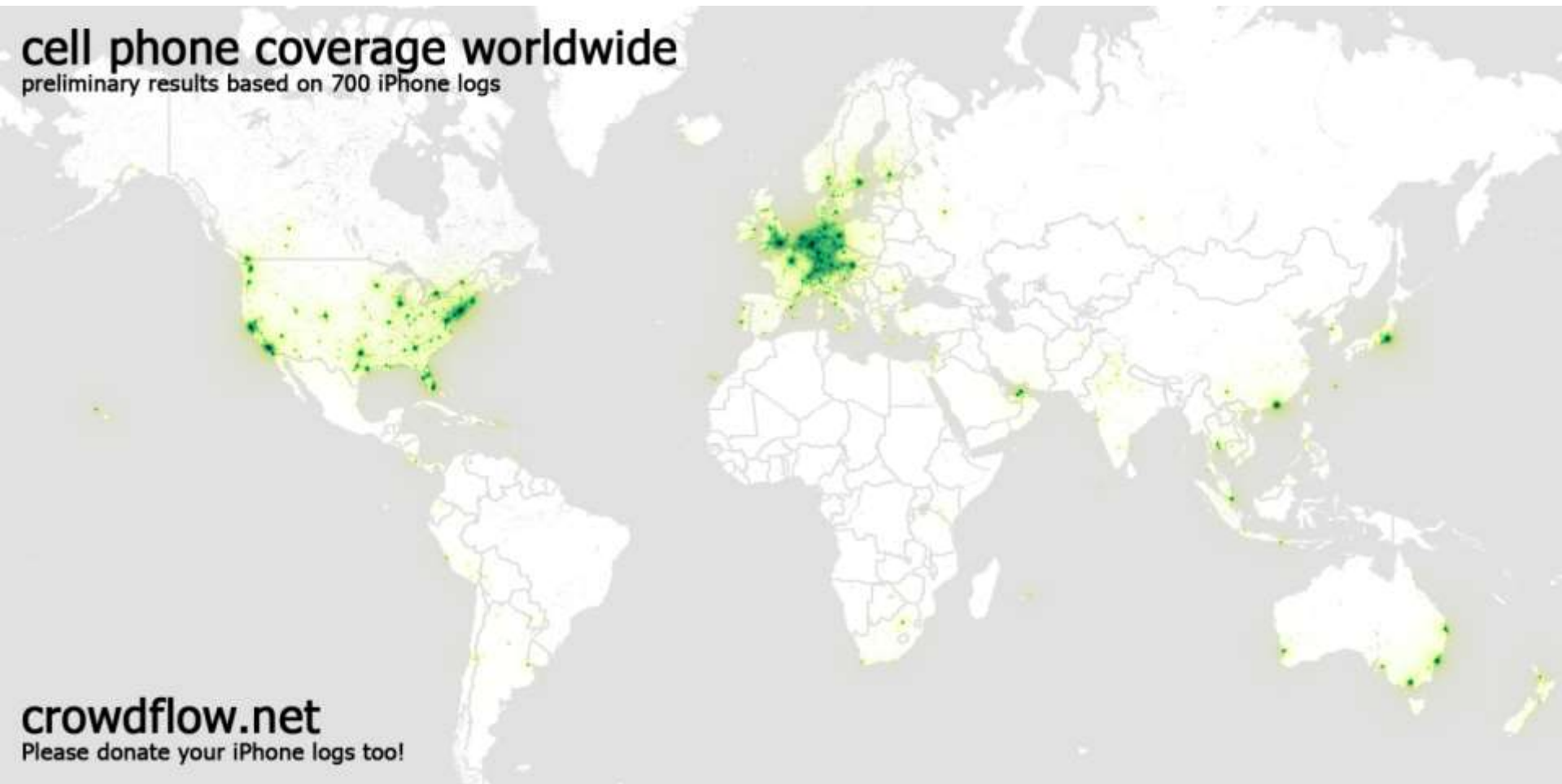
Imagery provided by NASA. Permission for use is granted

Smart phones help contributed to the huge development of Technology and Citizen Science



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5magazine.wordpress.com/2011/01/15/the-citizen-science-projects/
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iPhone Location Data Visualization

Based on the donated and anonymized data of 881 iPhones

00:10

01-04-2011

Michael Kreil
crowdflow.net



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Device Capabilities

Feature

Potential Use

Data

Storage

Store pictures, sounds, and observations.

Networking

Transfer data over a network.



User Input

Touch Screen / keyboard

Navigate UI, enter textual information.



Sensors

Camera

Capture imagery.

Microphone

Record sound.

GPS

Measure geographic position.

Compass

Measure device direction

Accelerometer /
Gyrometer

Measure device orientation





<http://www.msnbc.msn.com/>

eBird | Gulf Coast Oil Spill Bird Tracker

Hundreds of bird species could be impacted by the Gulf Coast oil spill, including species shown here.

Brown Pelican

Recently removed from the endangered species list, the rebounding population nests on coastal islands throughout the impact zone.



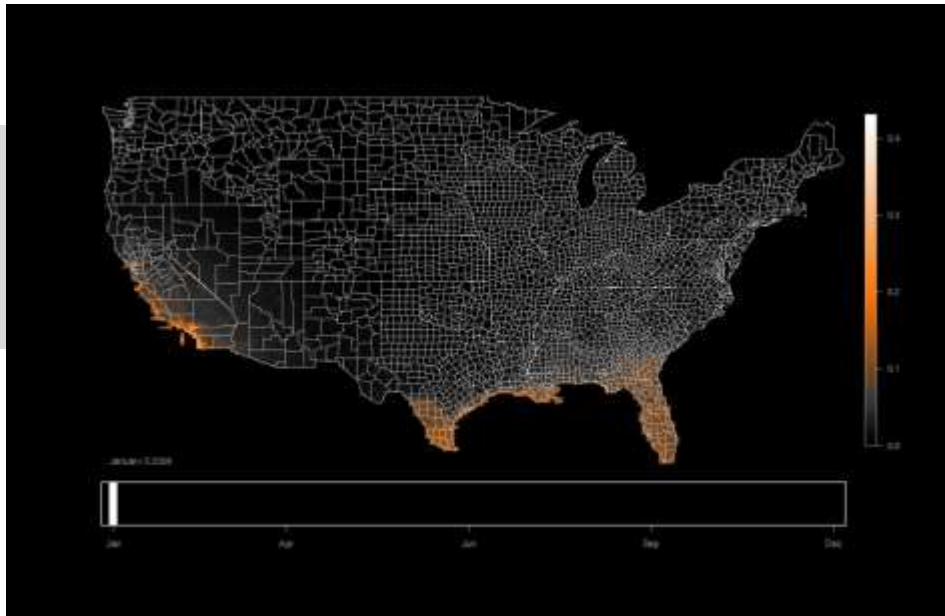
[Explore interactive sightings map](#)



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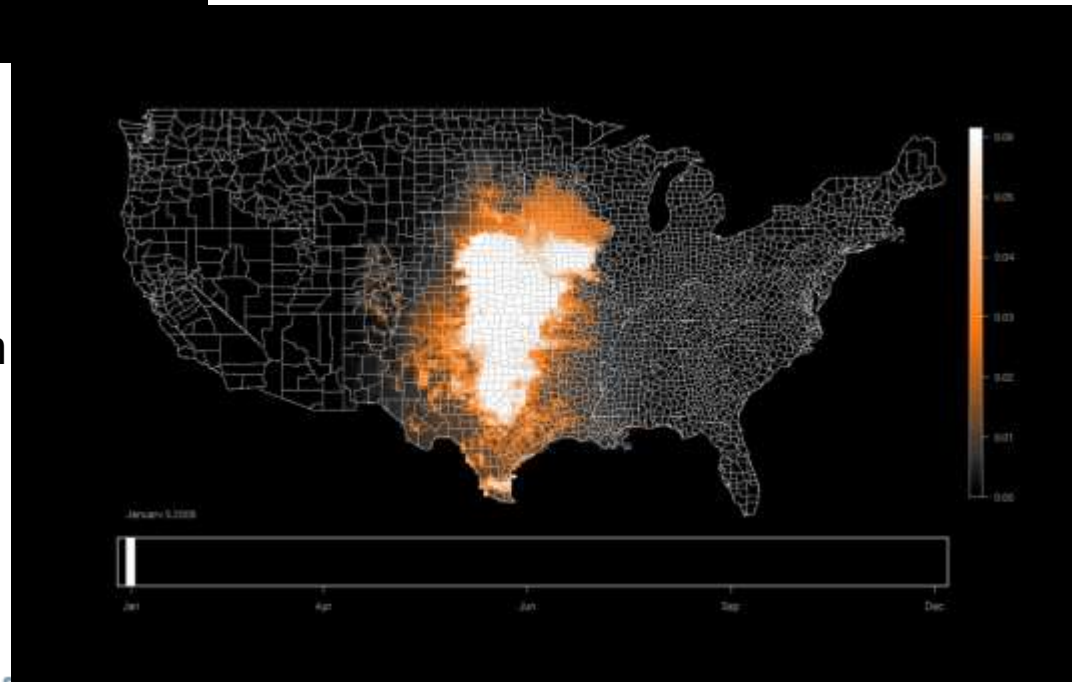
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<http://ebird.org>



Common Yellowthroat

1.5 Million observations per month
170000 observations for each
model



Harris's Sparrow

<http://ebird.org>



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Fire in the Urban- Wildland Interface



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2003 Okanagan Mountain Fire

Taken from the [National Archives of Canada](#) (reproduction: e002282894, copy negative number) No copyright restrictions



Measuring Forest Fuels

Rating Interface Wildfire Threats in British Columbia



SUBMITTED TO:

Mike Dittaro
Ministry of Forests and Range
Protection Branch

April 22, 2008



DEVELOPED BY:

Bruce Morrow, RPF
Bruce Morrow Forest Consulting Ltd.



Kelly Johnston, WFBS, FIT
Wildland Solutions



John Davies, RPF
Davies Wildfire Management Inc.



Figure 9b. Photos and accompanying ground and surface fuel information for jack pine – black spruce stand: 57 years after fire. Note: 1.0 kg/m² = 10 t/ha.

Forest floor				
Depth (cm)	Bulk density (kg/m ³)	Fuel load (kg/m ²)	Avg. depth (cm)	
< 2.0	100.7	2.0		
Total	142.4	7.9	5.5	
Dead and downed woody material				
Diameter (cm)	Load (kg/m ²)	Diameter (cm)	Load (kg/m ²)	
< 0.5	0.02	3.0–5.0	0.24	
0.5–1.0	0.06	5.0–7.0	0.15	
1.0–3.0	0.34	> 7.0	0.40	
		Total	1.21	
Understory vegetation				
	Load (kg/m ²)	Cover (%)	Avg. height (cm)	Max. height (cm)
Herbs	0.02	17.7	7.4	50.0
Shrubs	0.01	8.2	40.8	106.0
Total	0.04	50.9		
Main species (avg. % cover)				
Stair-step moss (19), twinflower (7), prickly rose (5), kinnikinnick (4), bunchberry (3)				
Summary of fuel information				
Fuel complex strata	Fine fuels load (kg/m ²)	Total biomass load (kg/m ²)		
Ground	2.01	7.89		
Surface	0.11	1.25		
Ladder and crown	2.04	6.91		
Total	4.16	16.05		

Fuels Photo Series: Ottmar 2002



Rating Interface Wildfires Morrow et al. 2008



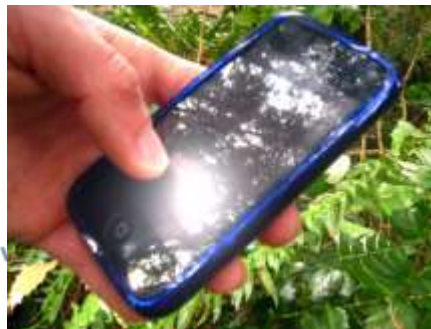
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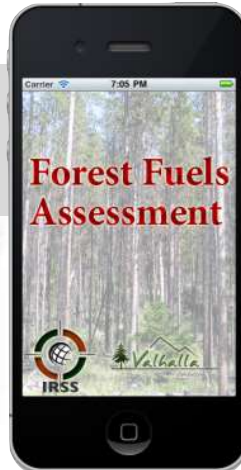
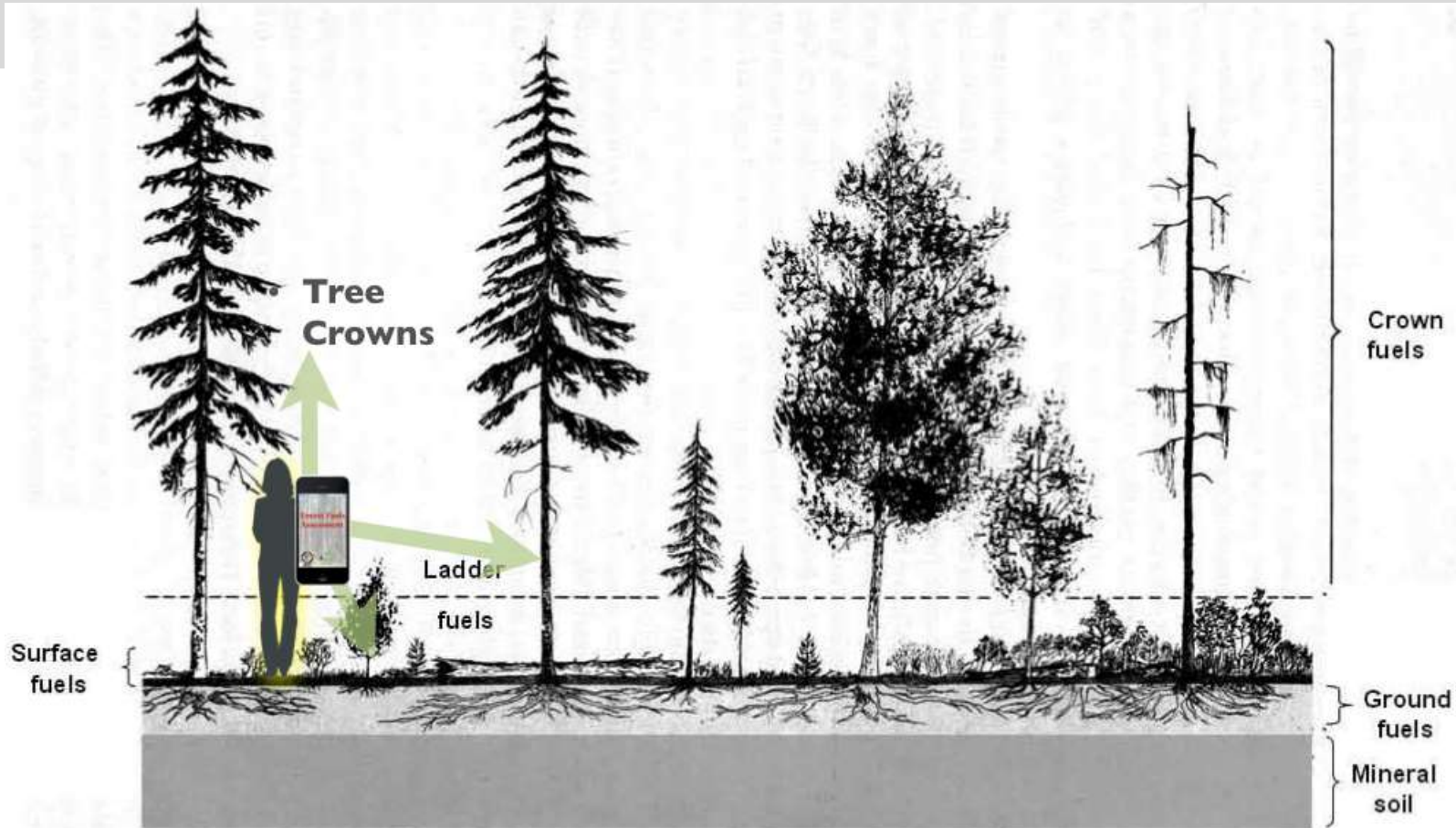
Photoload Sampling Technique: Keane and Dickinson 2007

Mobile Remote Sensing of Forest Structure Using Smart Phones

- Near surface remote sensing
- Application developed by UBC and Valhalla Consulting
- Addresses a need and provides a service
- Target users: Parks staff, private property holders, concerned citizens



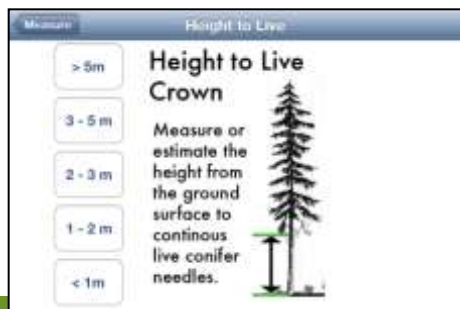
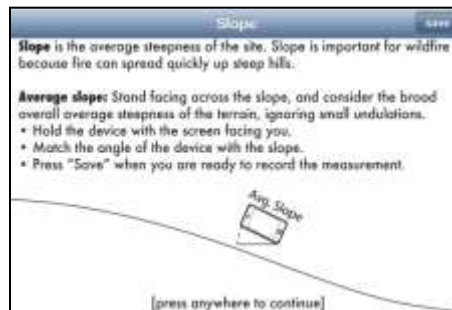
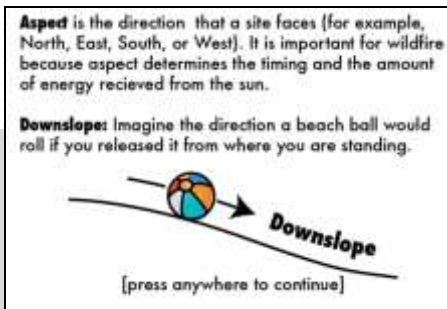
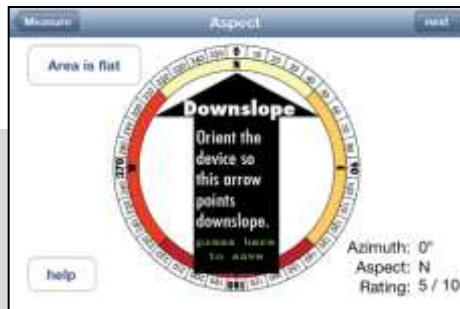
Forest Fuels App.

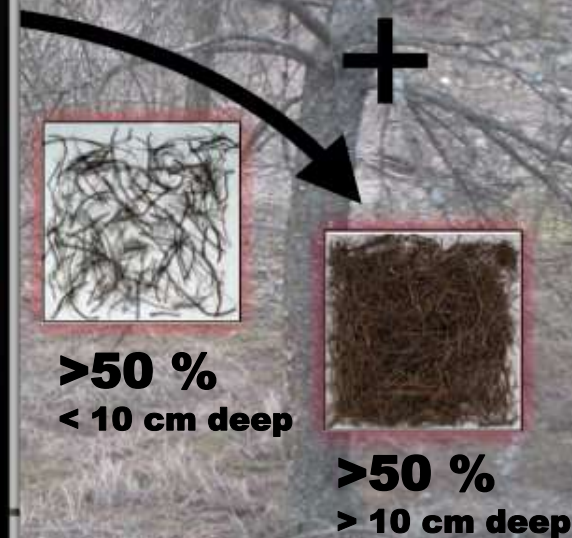
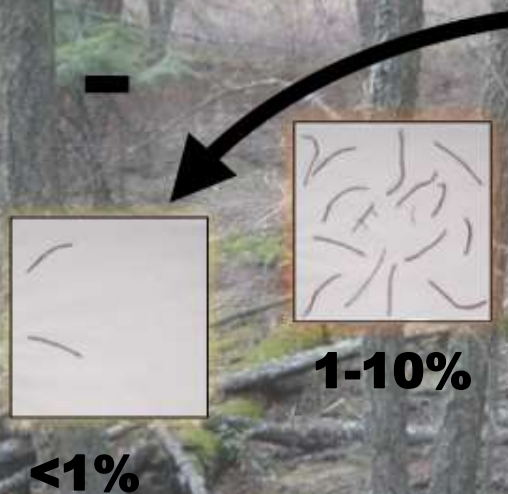
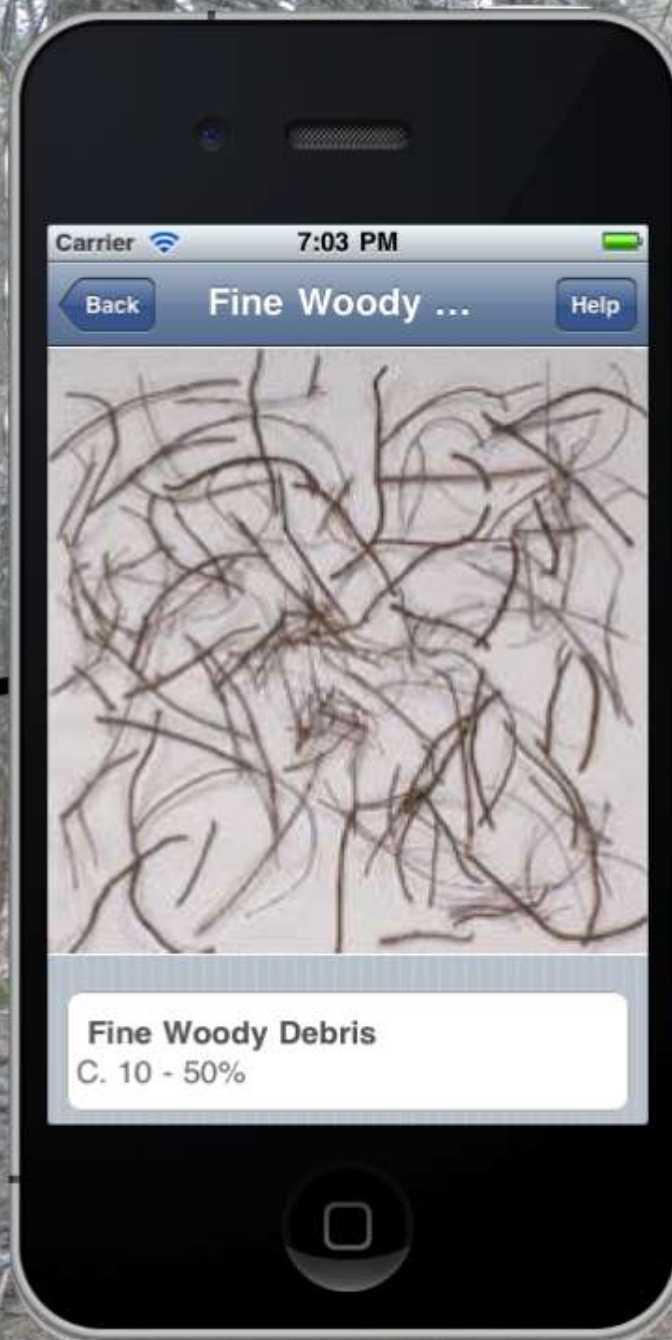


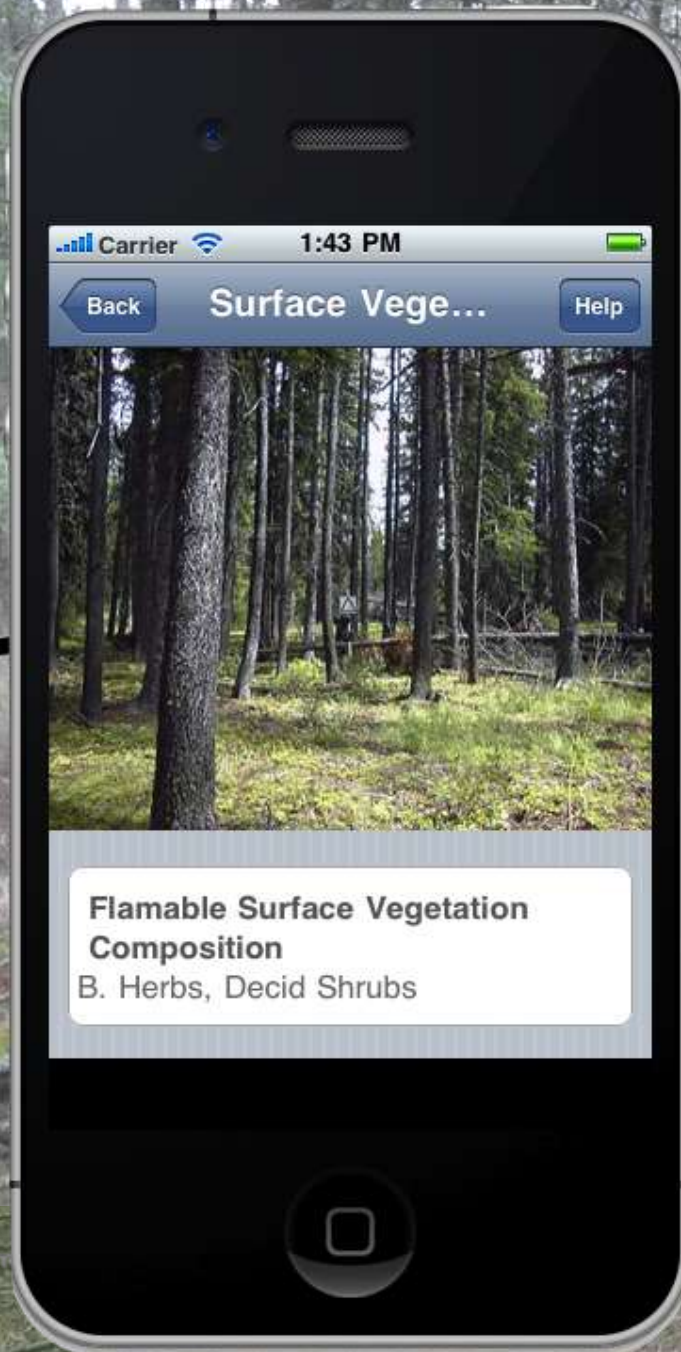
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Adapted from Brown and Davis (1973)







A) Moss



C) Lichens,
Conifer
Shrubs



D) Pinegrass,
Juniper



E) Sagebrush



Carrier 11:31 AM

Back Canopy Base... Help

Canopy Base Height

☐ A. > 5 m

☐ B. 3 - 5 m

☒ C. 2 - 3 m

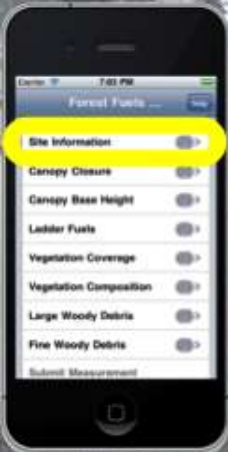
☐ D. 1 - 2 m

☐ E. < 1 m

☐ no data / not applicable

☒ Measured (uncheck for estimated)

Explanation of Base Height >



Carrier 7:04 PM

Back Site Information Help

Plot Number: [Generate Plot Number](#)
PLOT3934Day12Month4Year11

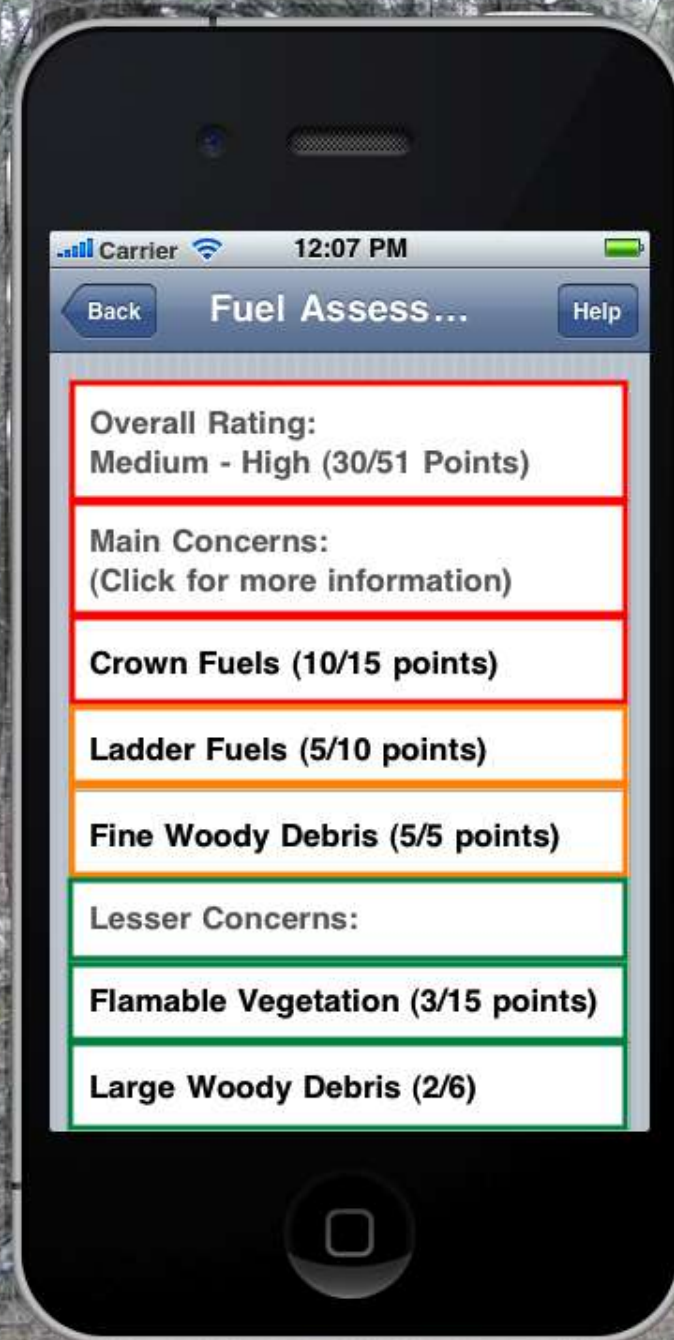
Location/Nearby Community:

Location: [Get GPS Reading](#)
Latitude (degrees):
49.260883
Longitude (degrees):
-123.248302
Accuracy (m):
134

Canopy Photo:
[Take Picture Facing Straight Up](#)







Canopy



Fine Woody Debris



Sideslope 1



Upslope



Sideslope 2



Downslope



a place of m

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	subjectID	plotID	fwdCont	lwdCont	surVegCont	vegFuelComp	supUndConf	conCrownBase	conCrownClose	latitude	longitude	gpsAccuracy	aspect	slope	terrain	slopeAngle	canopyClosure	dateTime
2	484_10-Aug-2012_11:28_S	p0	3	1	2	2	3	2		2 49.93769	-119.3931	5	-999	-999	-999	0	42.09028	10-Aug-2012-11:38
3	807_10-Aug-2012_11:23_S	p143	4	1	4	4	3	2		2 49.93796	-119.3938	5	5	1	-999	8	49.20313	10-Aug-2012-11:23
4	484_10-Aug-2012_11:28_S	p524	5	1	5	4	5	2		2 49.93726	-119.3924	5	-999	-999	-999	0	55.21701	10-Aug-2012-11:52

Dataset

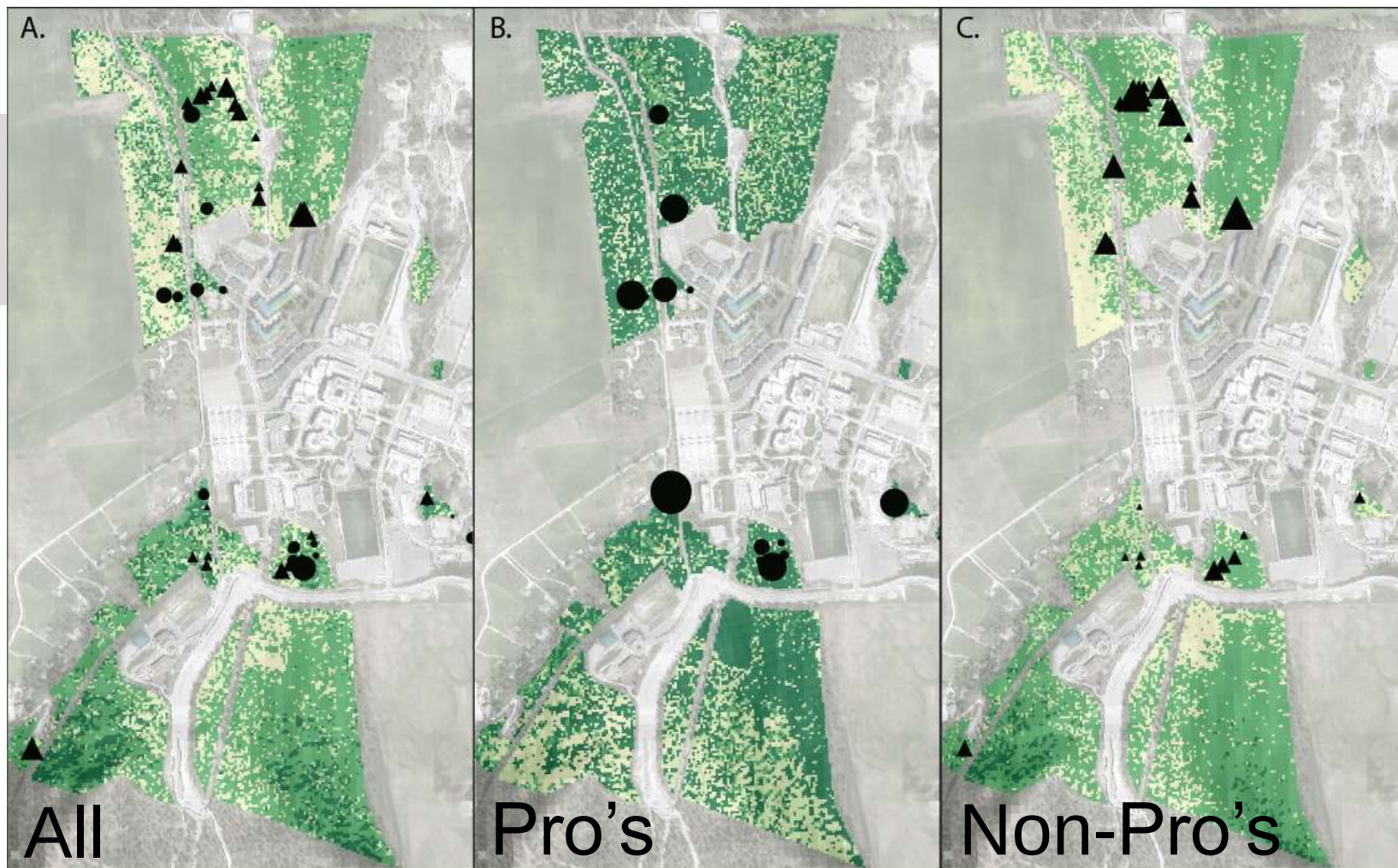
Component	Rating	Points	Description
Crown	C	5	41 - 60 %
CrownHt	A	0	> 5 m
Ladder	C	3	200-400 stems
FlamableVegetation	B	1	20-40 %
FlamableVegetationComB		2	Herbs, Decid.
LargeWoodyDebris	B	2	Scattered < 10
FWD	C	5	10 - 50%
Latitude	49.873692		
Longitude	-119.560551		
Accuracy	30		
PLOT	7992		
Day	29		
Month	March		
Year	2011		
Total Score		18 / 51	
Wildfire threat class:		Medium - High	



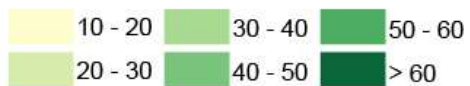


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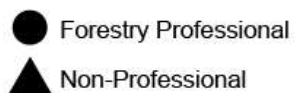
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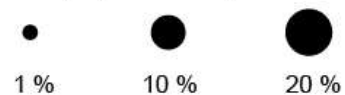
Conifer Crown Closure (%)

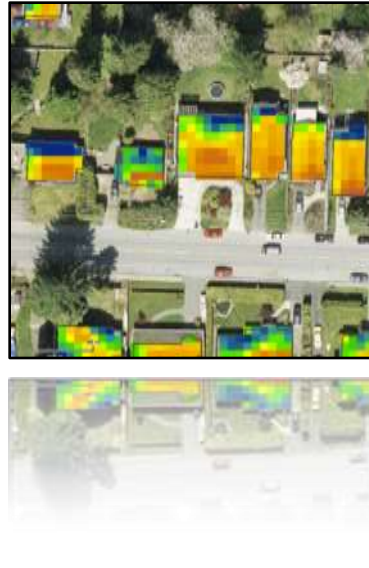
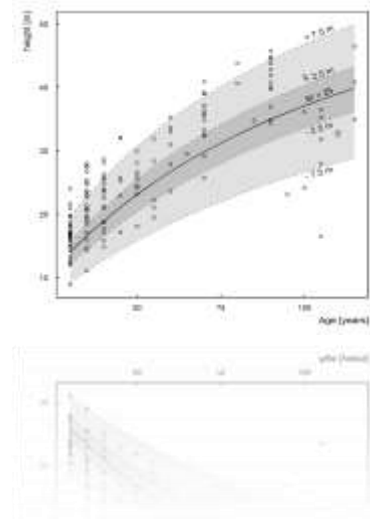


Observations



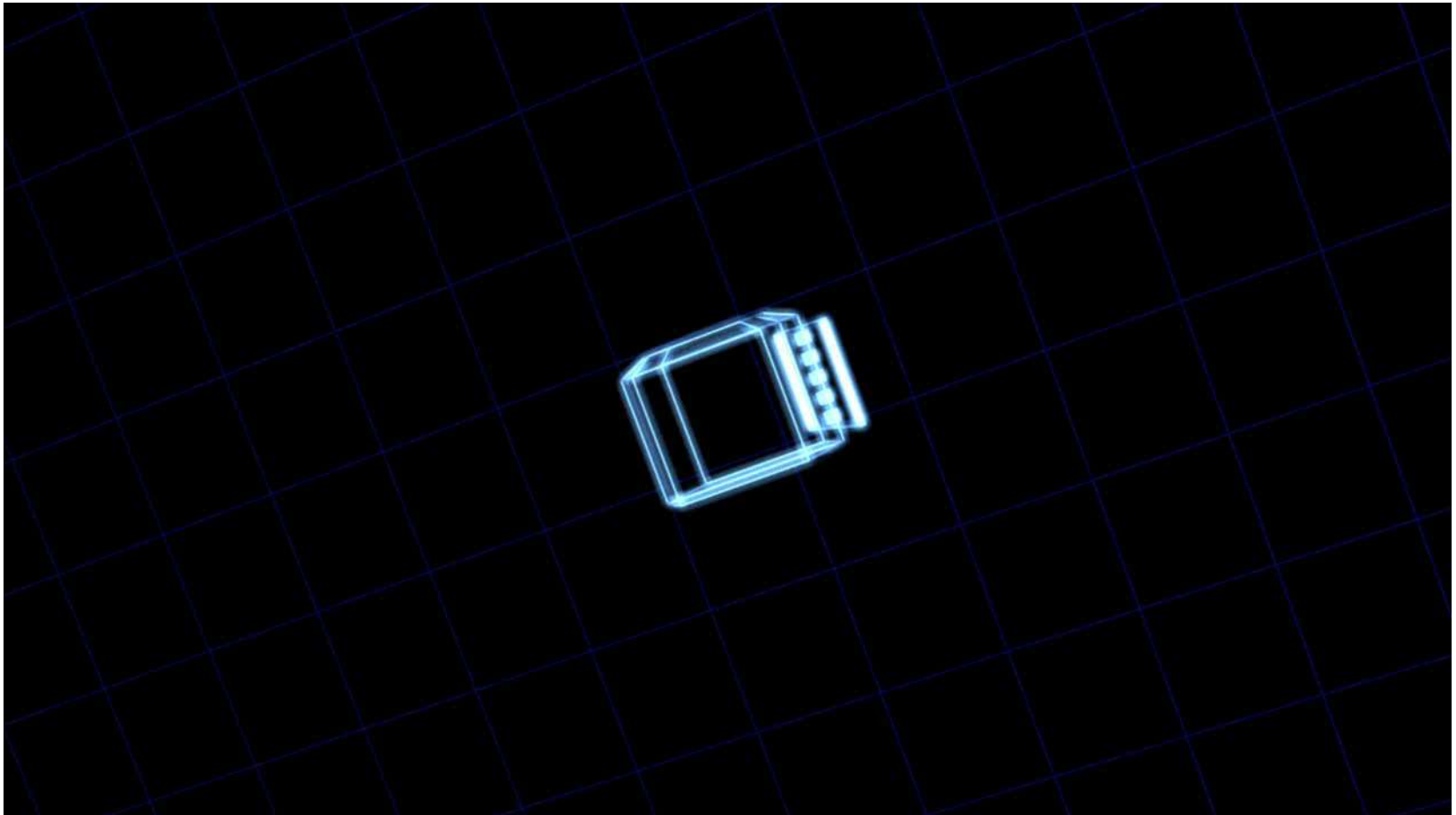
Area proportional to prevalence in imputation.





LIDAR is a conceptually simple remote sensing technology

Images and movies from NASA and used with permission



LiDAR Echo

Multiple Returns per Pulse



LiDAR Echo

Elevation

Return Strength



[Slide courtesy of **Darren T. Janzen**
Bluewater Business Solutions
darren@bluewatersolutions.ca]

LiDAR Echo

Multiple Returns per Pulse



LiDAR Echo

Elevation

Return Strength

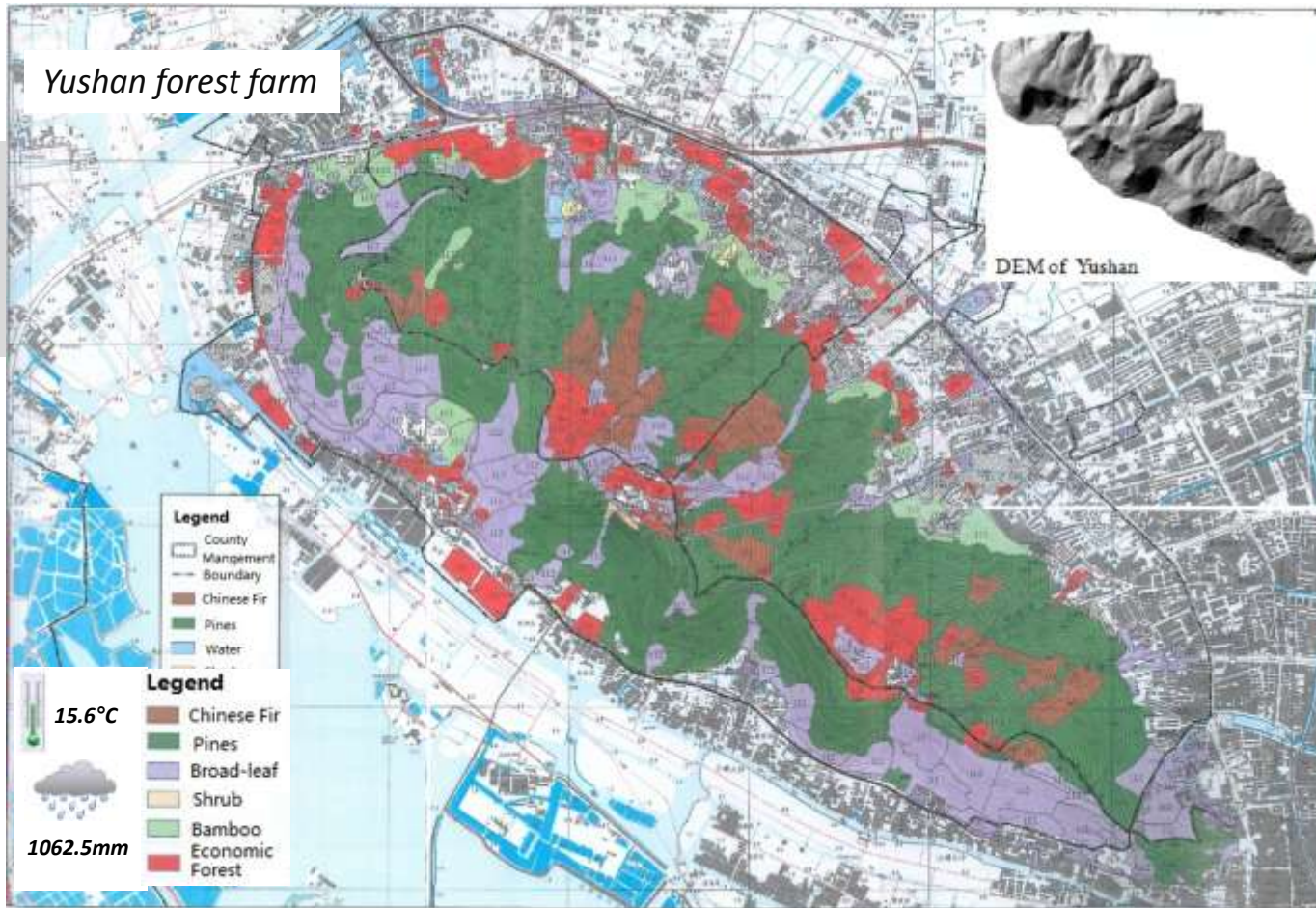


[Slide courtesy of **Darren T. Janzen**
Bluewater Business Solutions
darren@bluewatersolutions.ca]

What are the next big questions in ALS ?

- Full waveform vs discrete systems
- Different components of stand biomass
- Transferability of relationships across sites
- Species estimation from ALS

Yushan forest farm



- Forest area: **1103ha**
- Forest coverage: **78.8%**
- Coniferous: **Masson pine** (*Pinus massoniana*), **Chinese fir** (*Cunninghamia lanceolata*) etc.
- Broadleaves: **Sawtooth oak** (*Quercus acutissima*), **Chinese sweet gum** (*Liquidambar formosana*) etc.

Yushan Forest, a state-operated forest and national forest park (Southeast China)

a.



Coniferous forest

b.

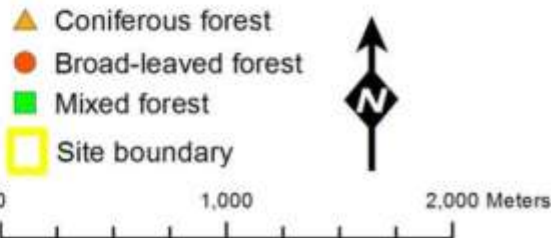
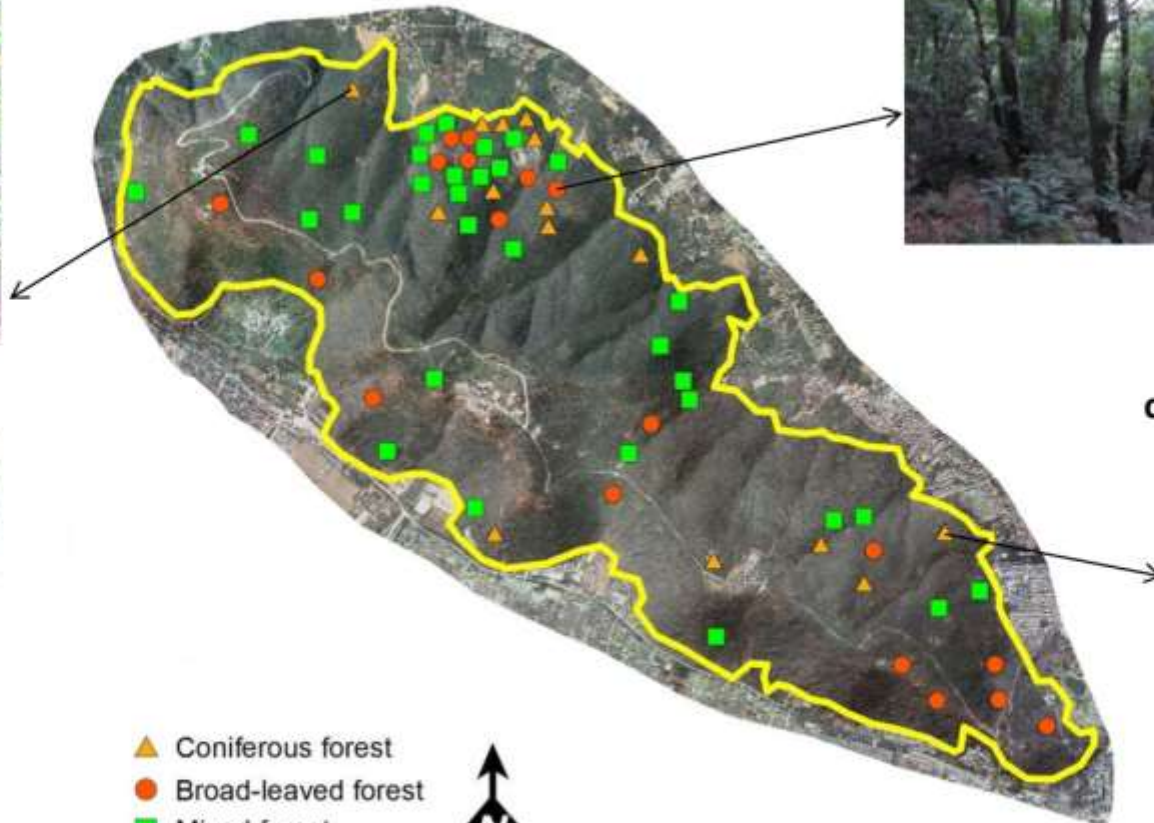


Broadleaved forest

c.



Mixed forest



65 square plots
(30×30 m)

• **Coniferous**

• **Broadleaved**

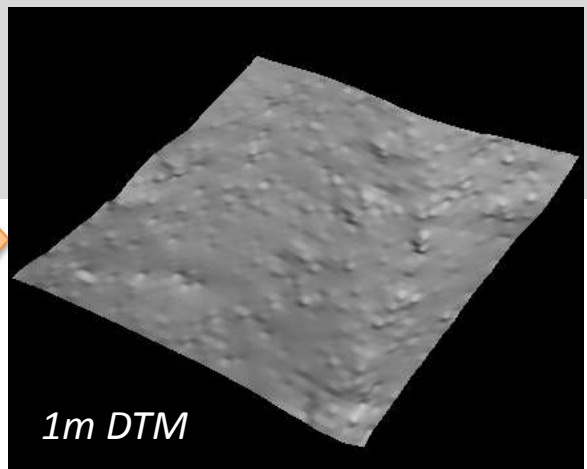
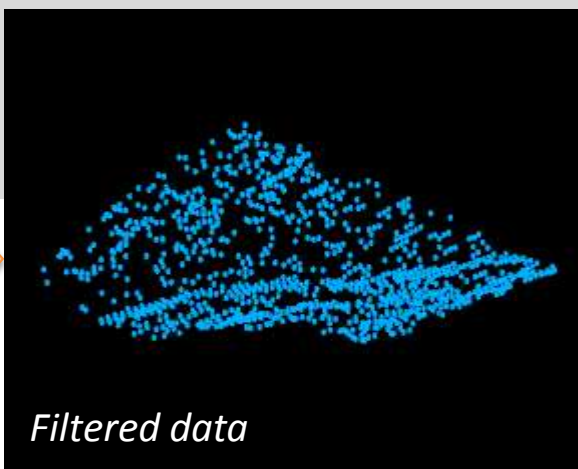
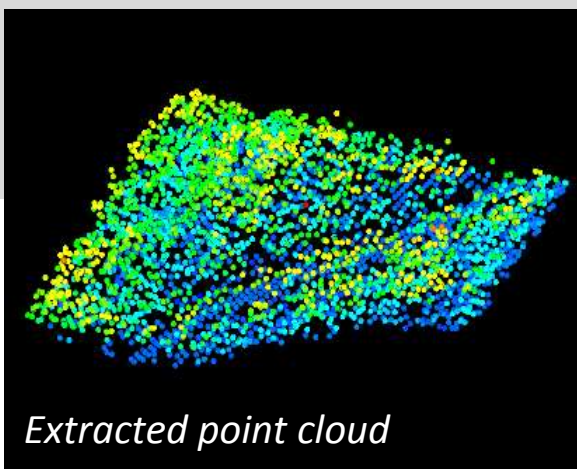
• **Mixed forests**

according to the
species composition.



a place of mind

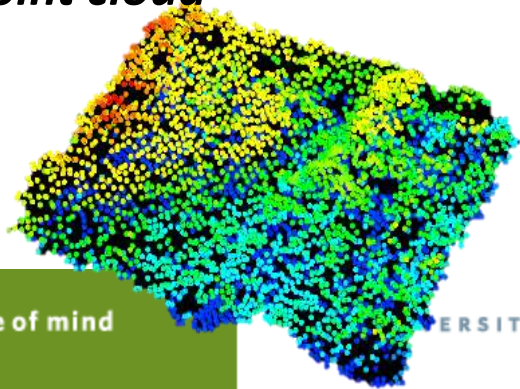
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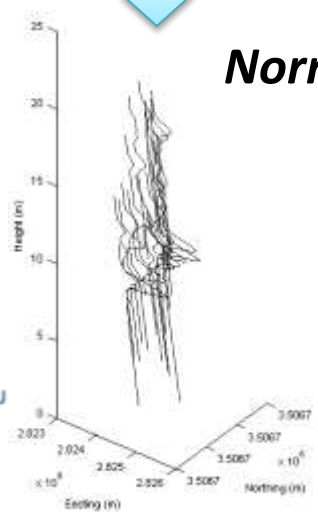
Kraus and Pfeifer, 1998

*average elevation
for all points within
a cell*

Normalized point cloud



Normalized waveform

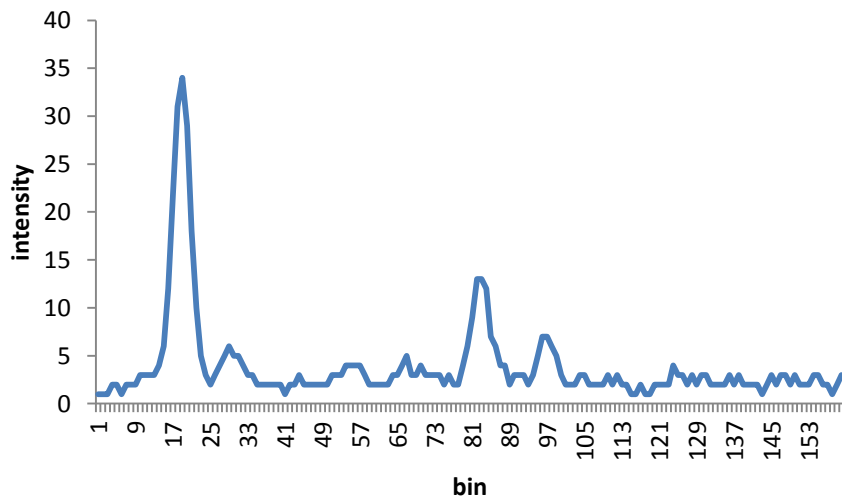


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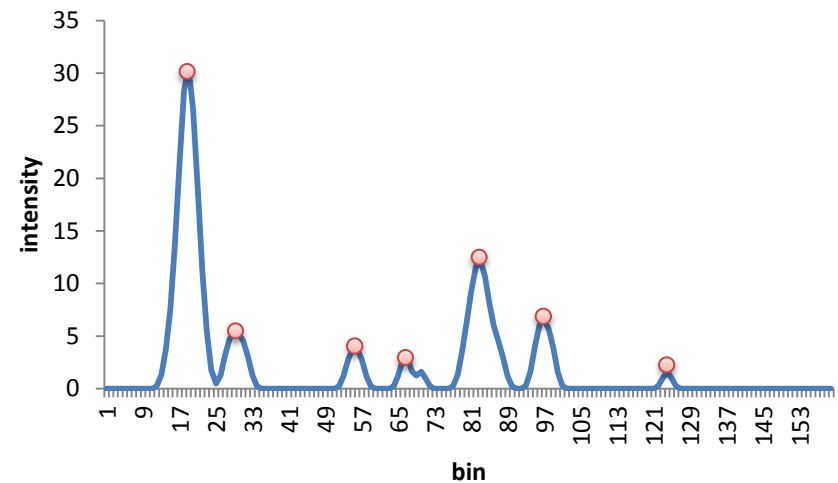
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Hermosilla et al, 2014

Raw waveform data

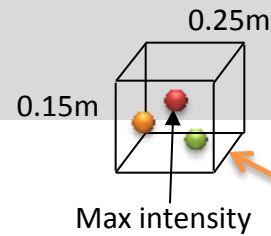
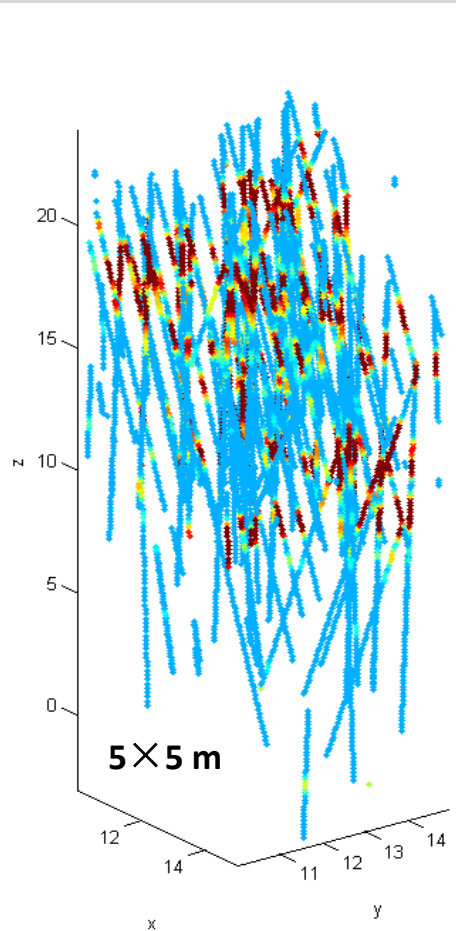


Peak detection (local maxima)

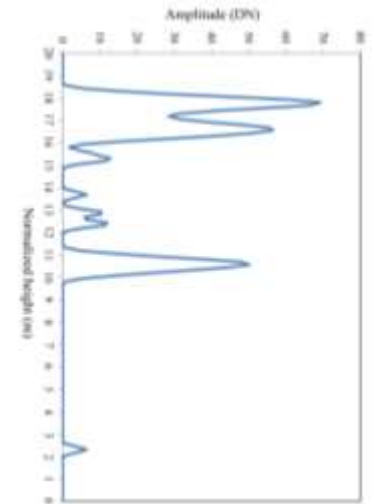
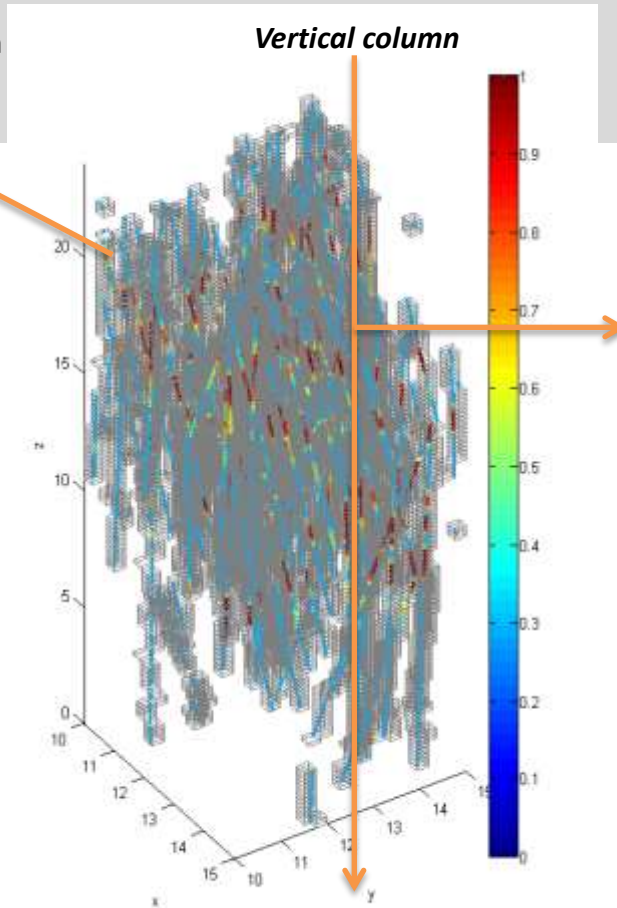


Normalized and pre-processed waveform

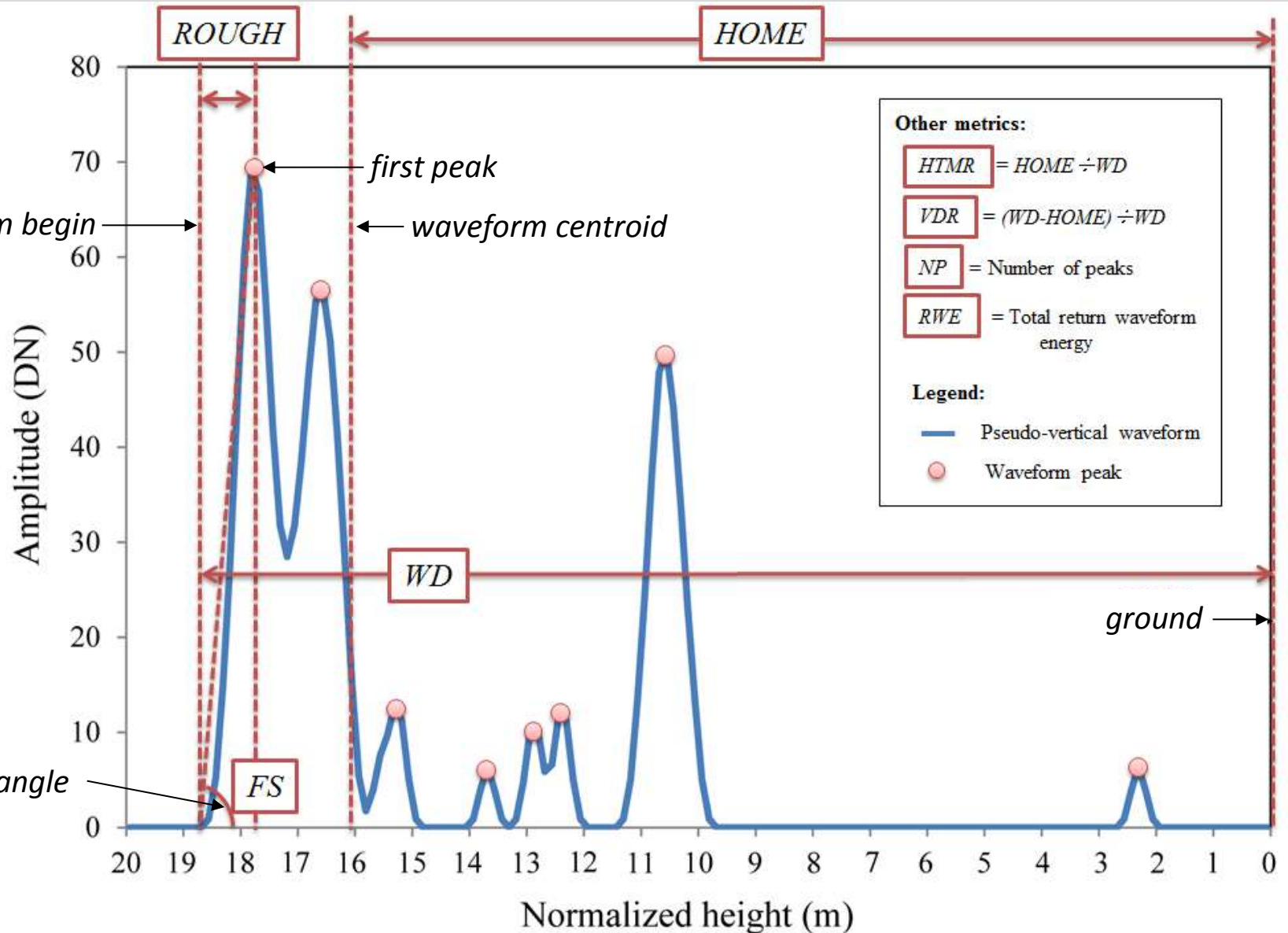
Vertical space partitioning of forest canopies by voxels



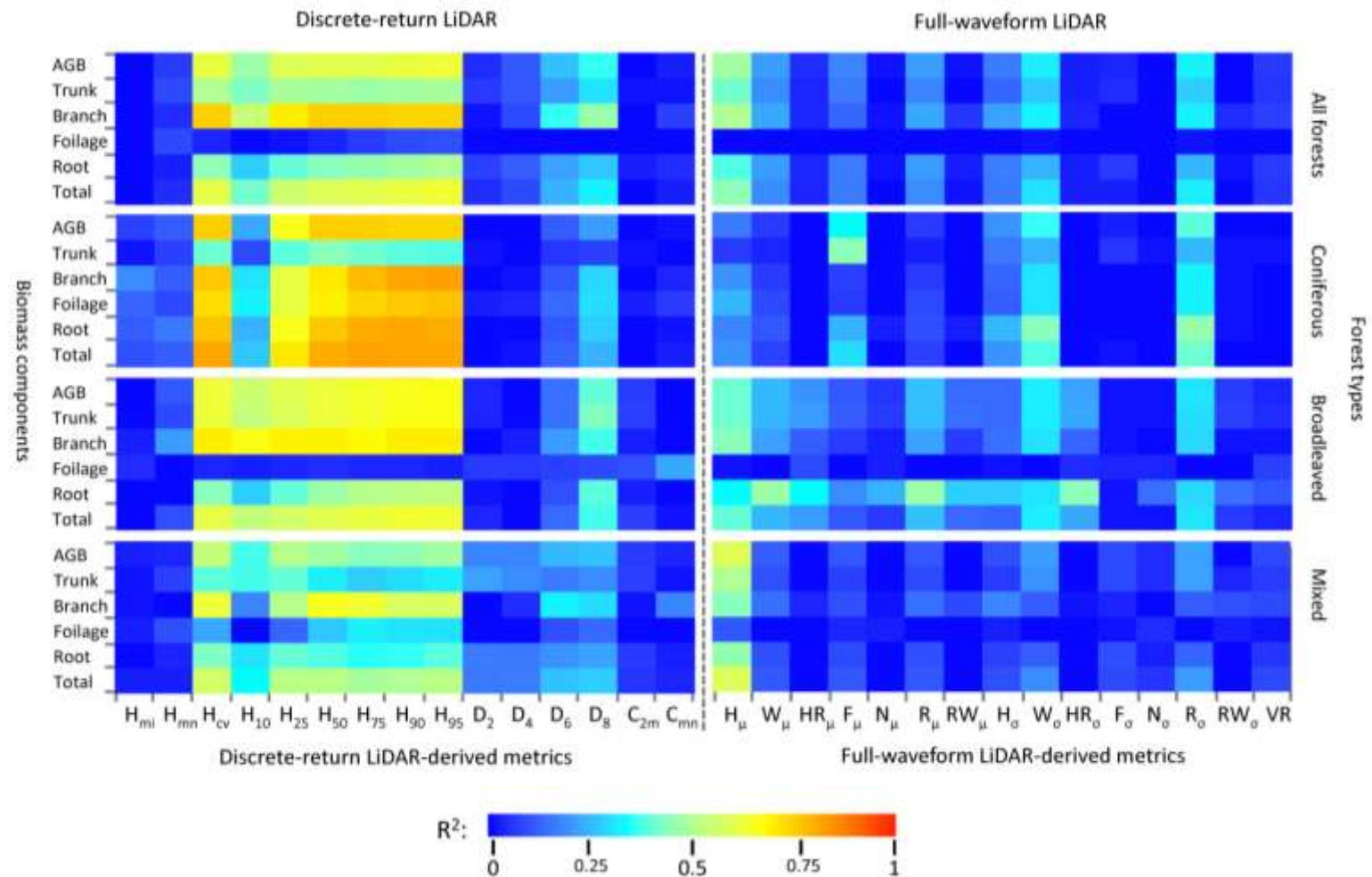
synthesized

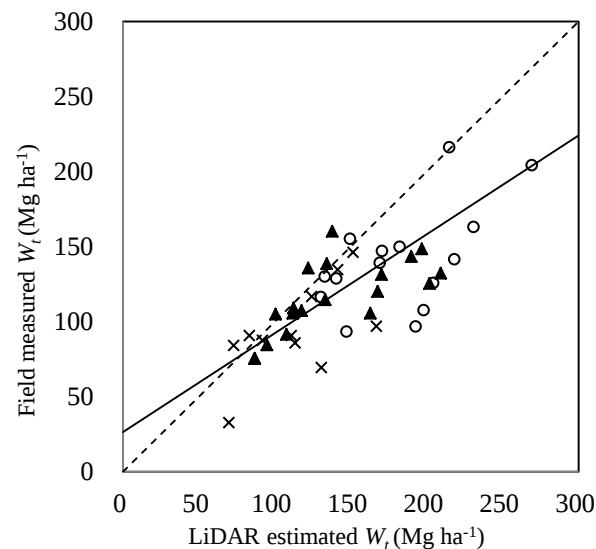
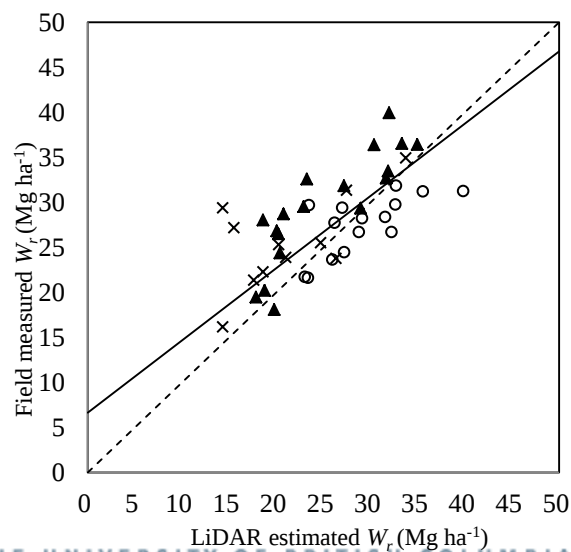
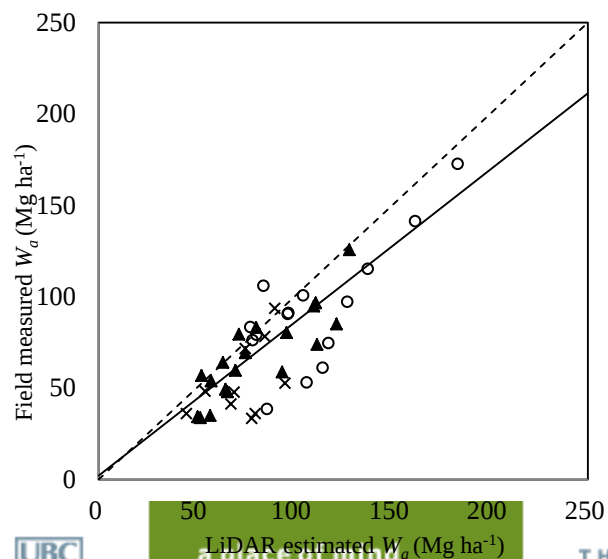
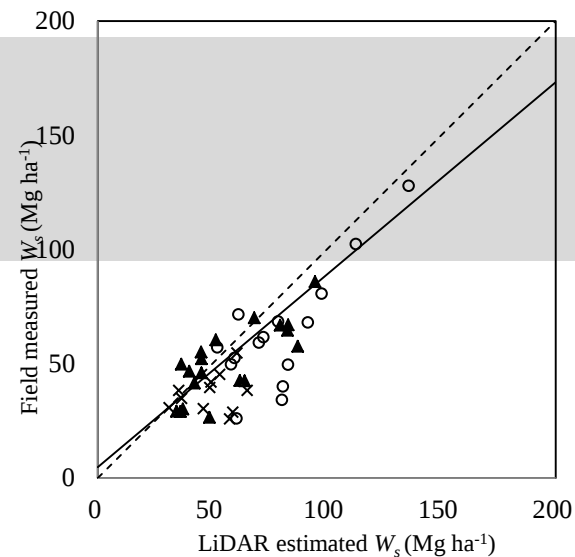
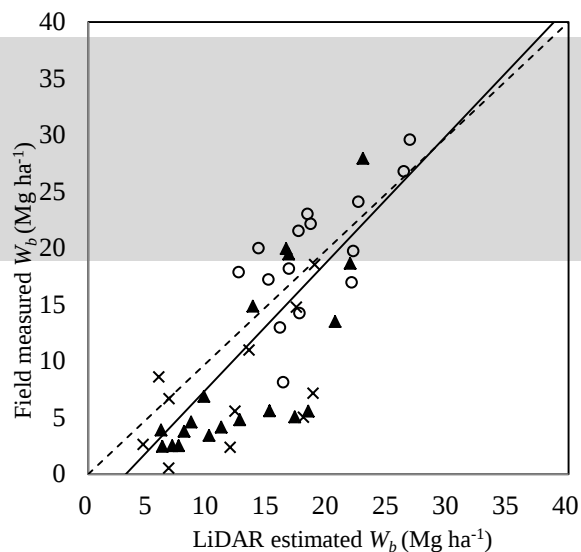
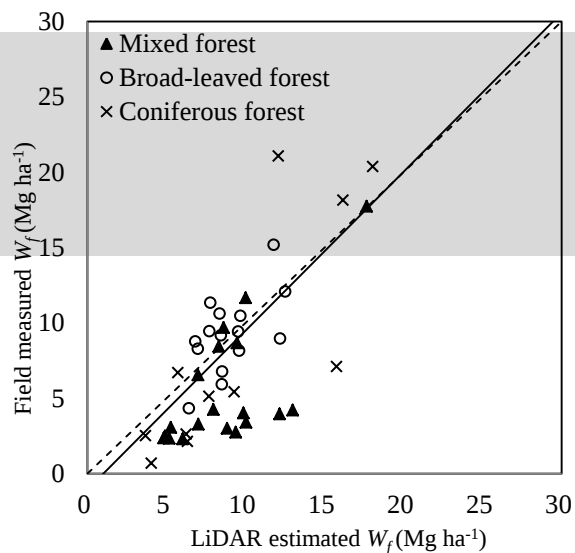


Pseudo-vertical waveform



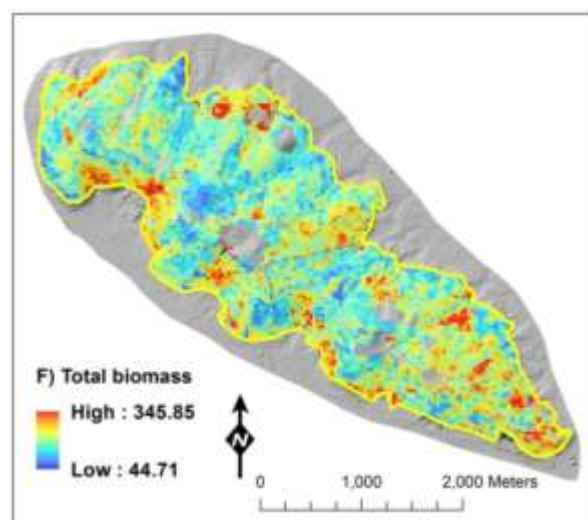
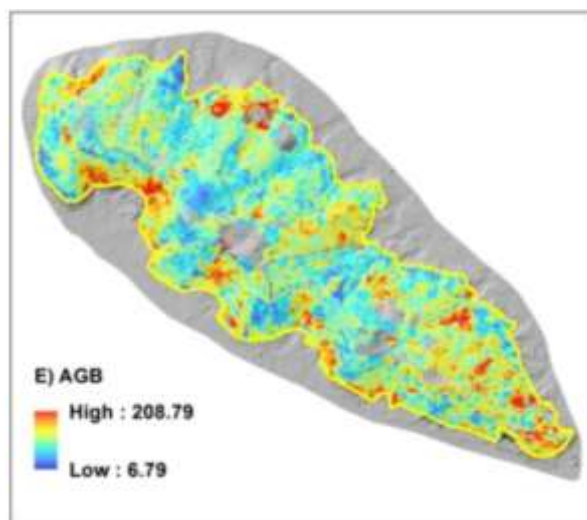
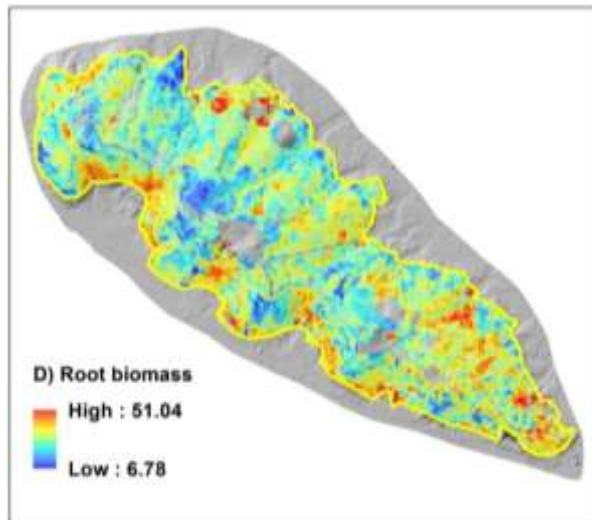
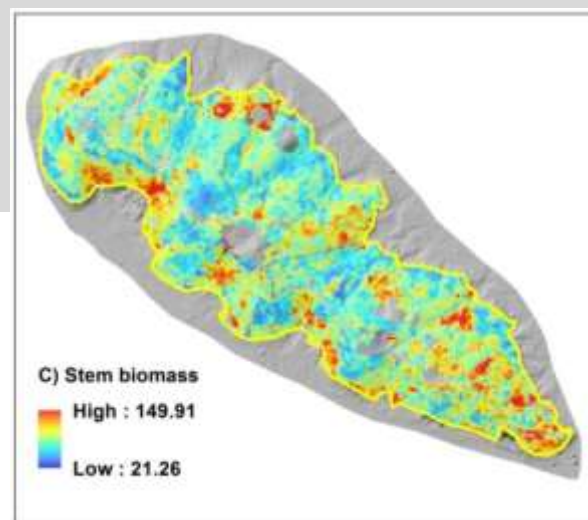
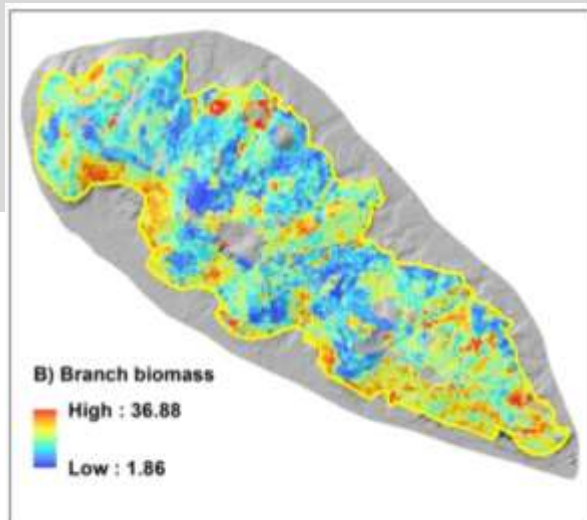
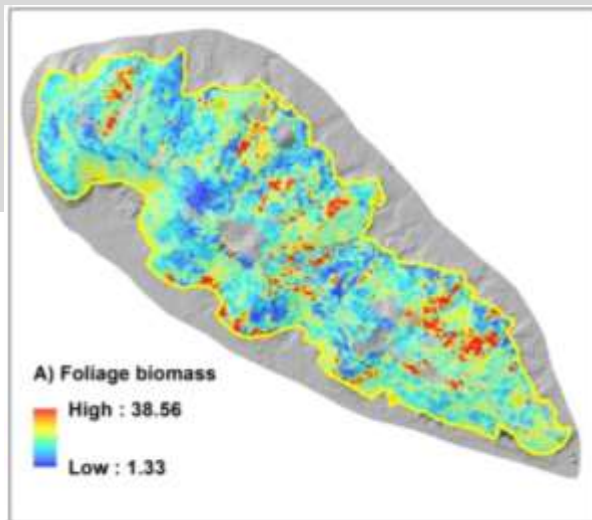
Intensity graph of the square of the **Pearson's correlation coefficient** between each biomass components and LiDAR-derived metrics.

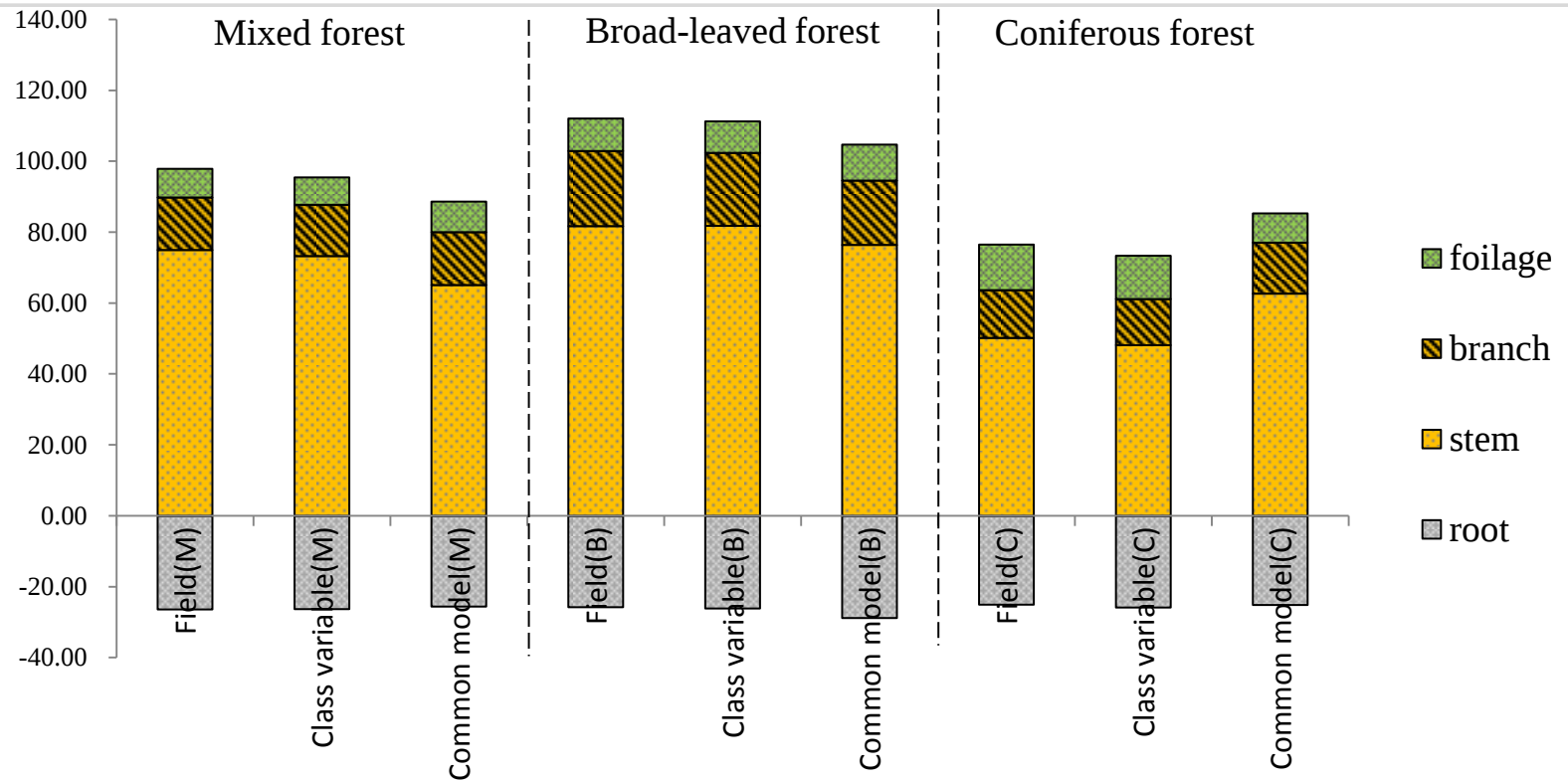




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LiDAR gives us structure at one time.
How do we look at change ?



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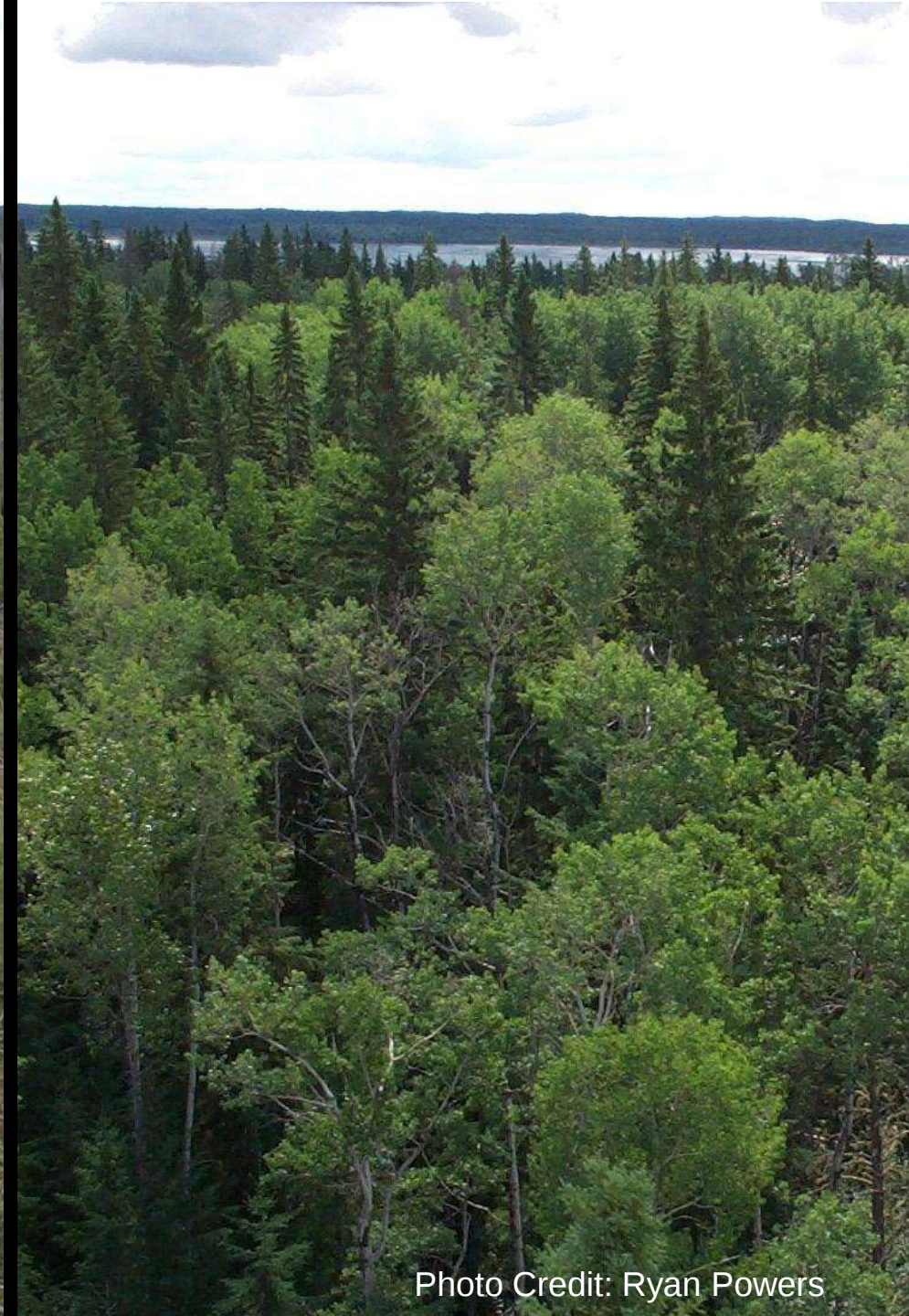
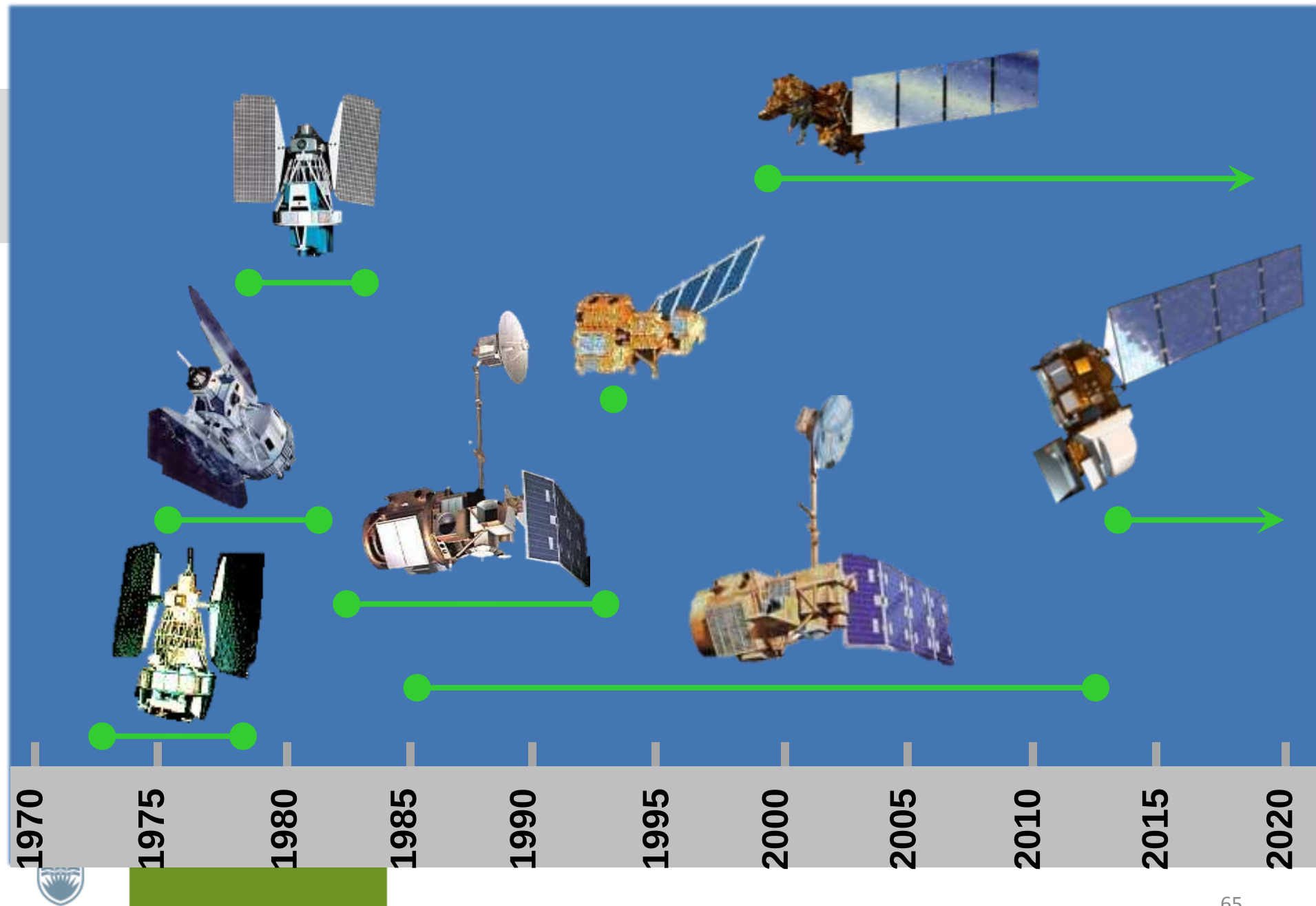
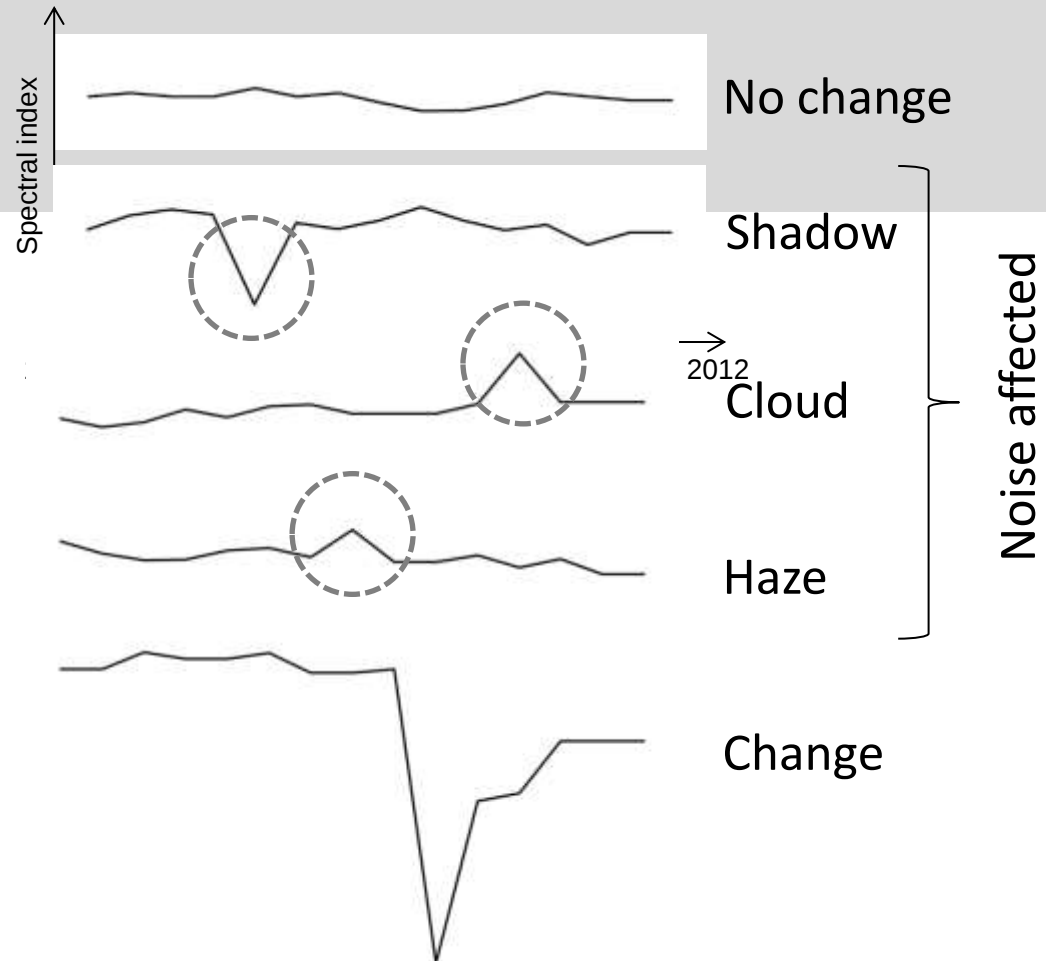
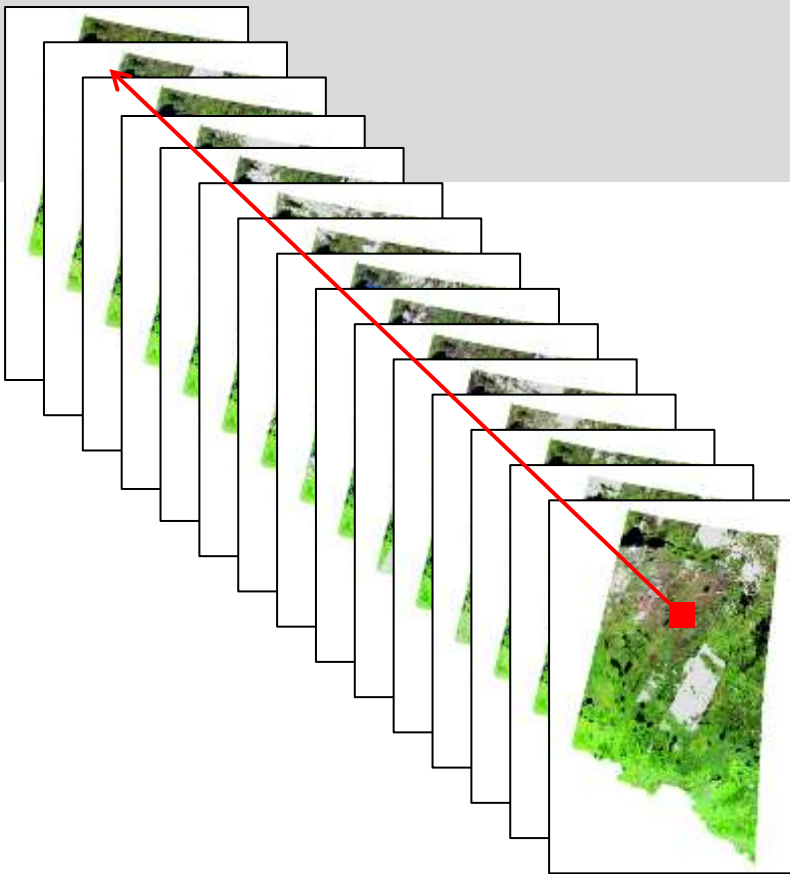
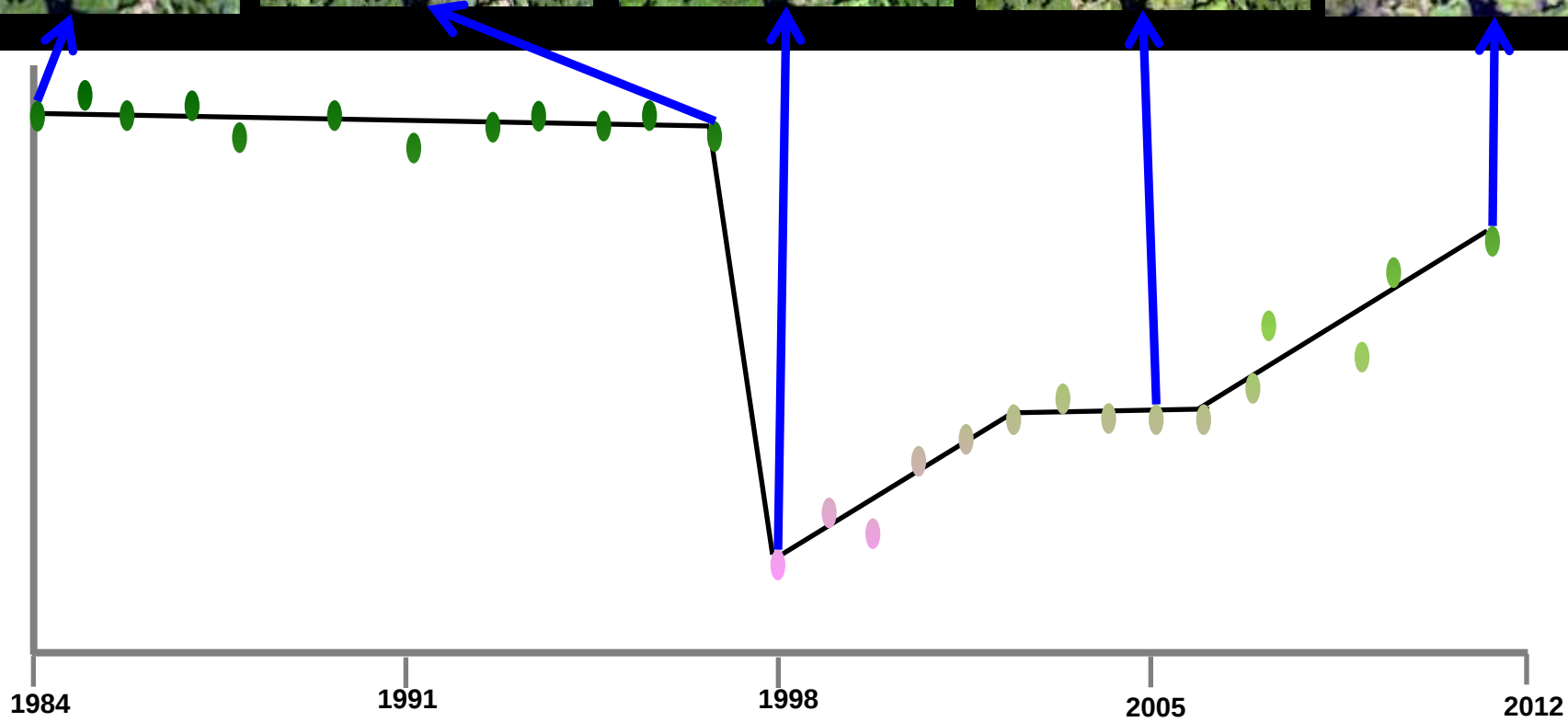


Photo Credit: Ryan Powers



Analysis of the spectral values in the temporal domain: pixel series

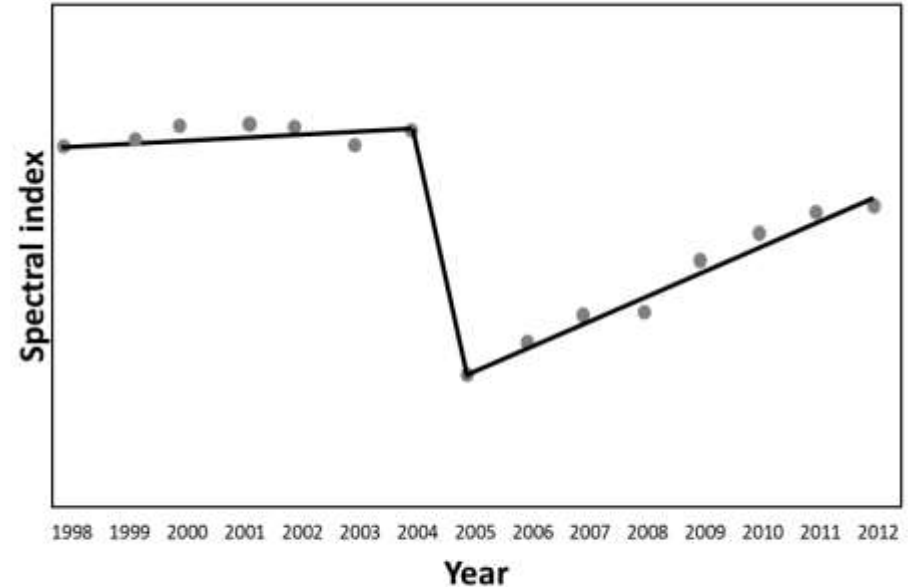
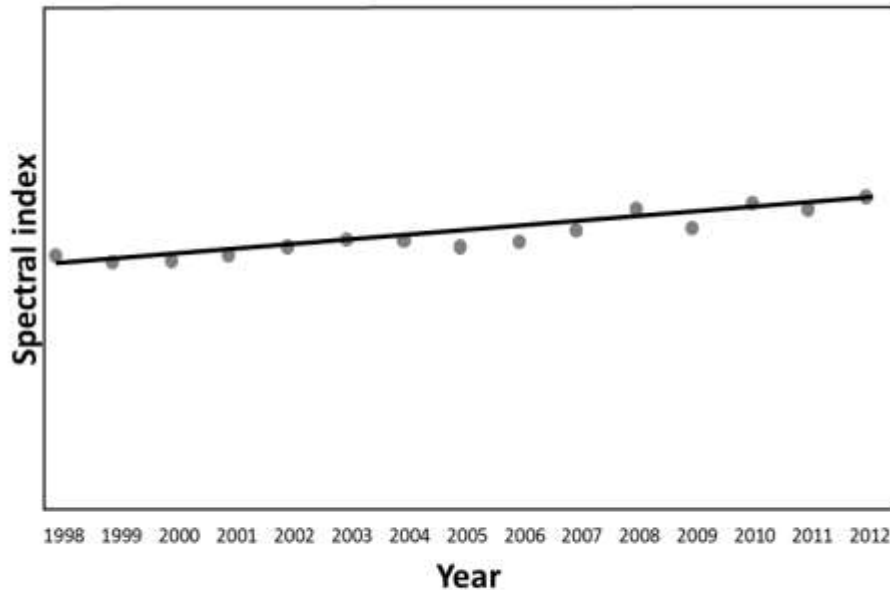


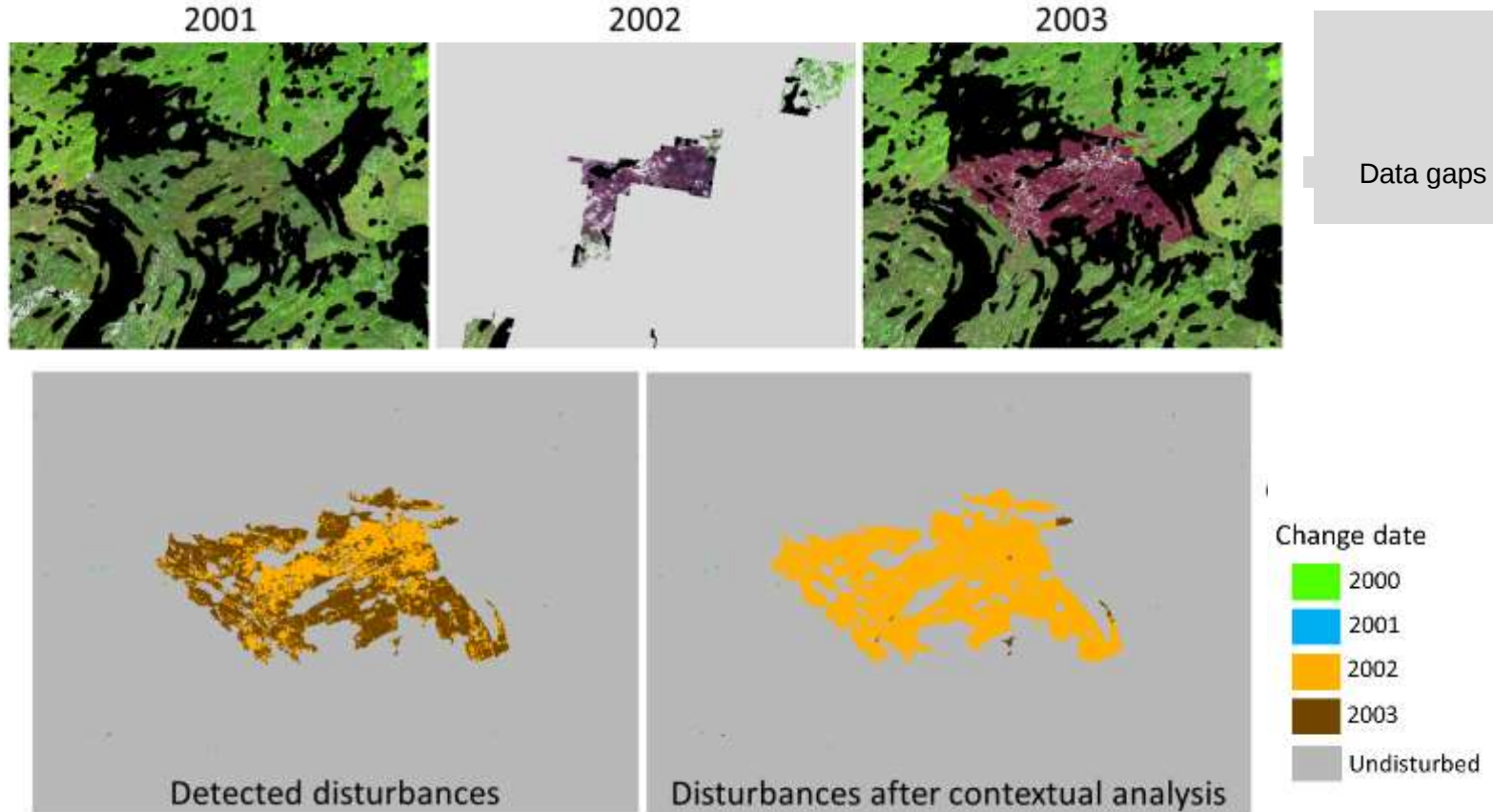


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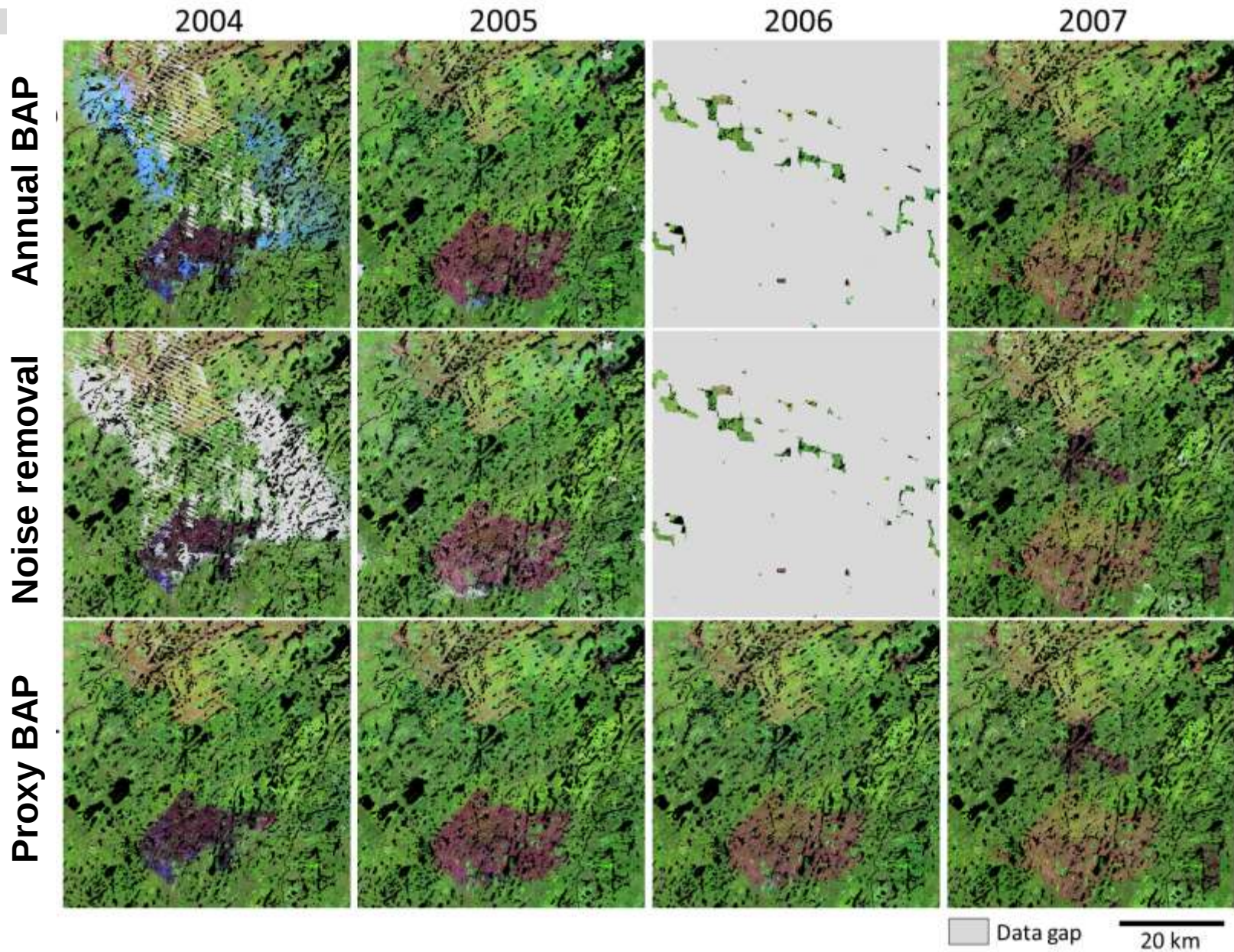
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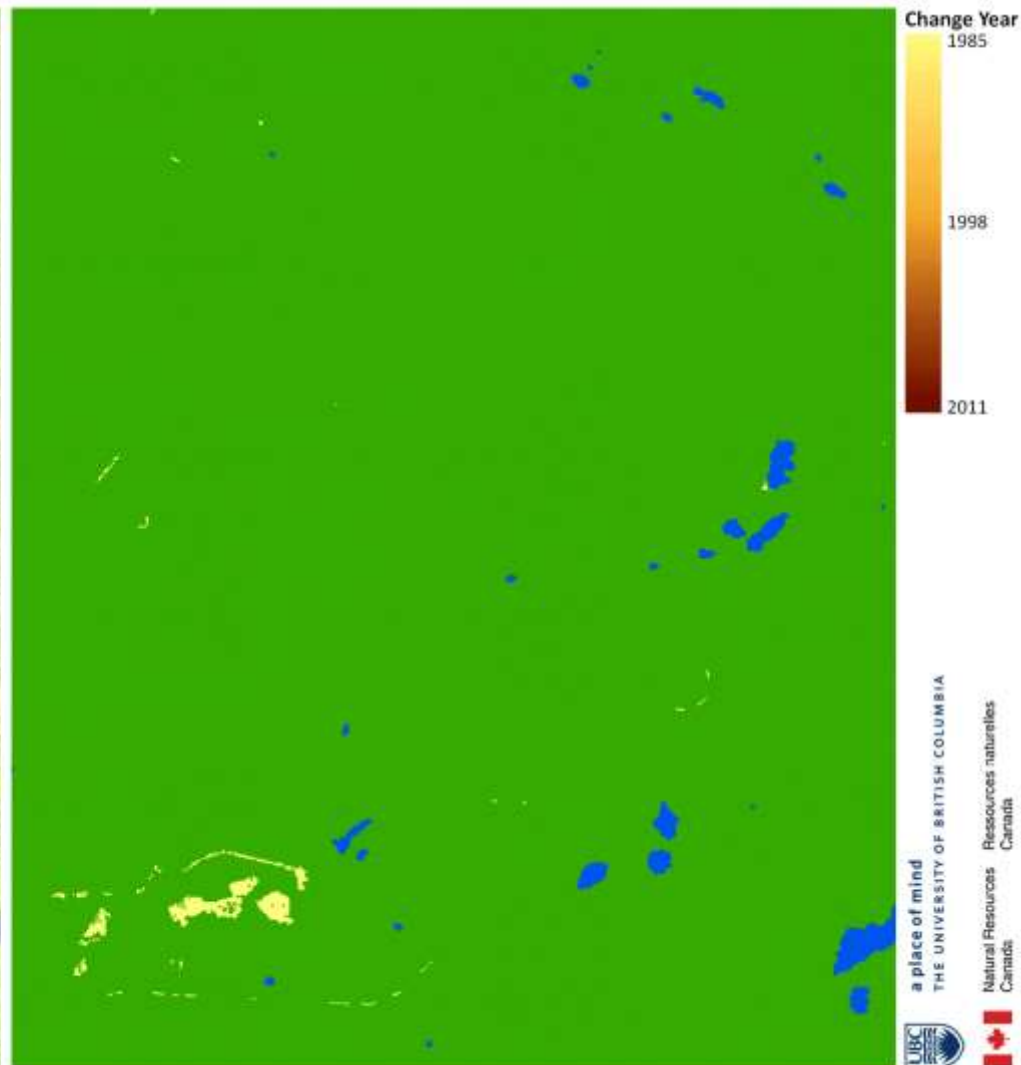
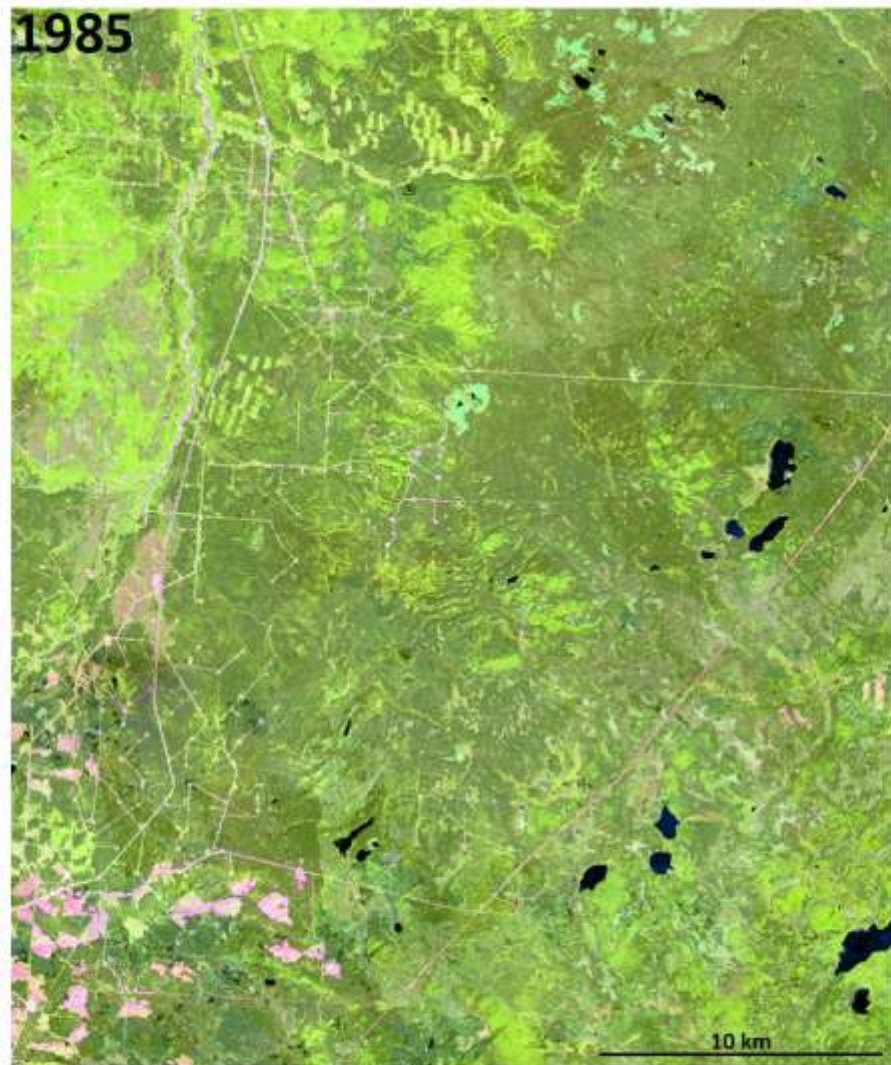
- Breakpoint: change in the trend of pixel series' values
- Used to assign proxy values and identify change events





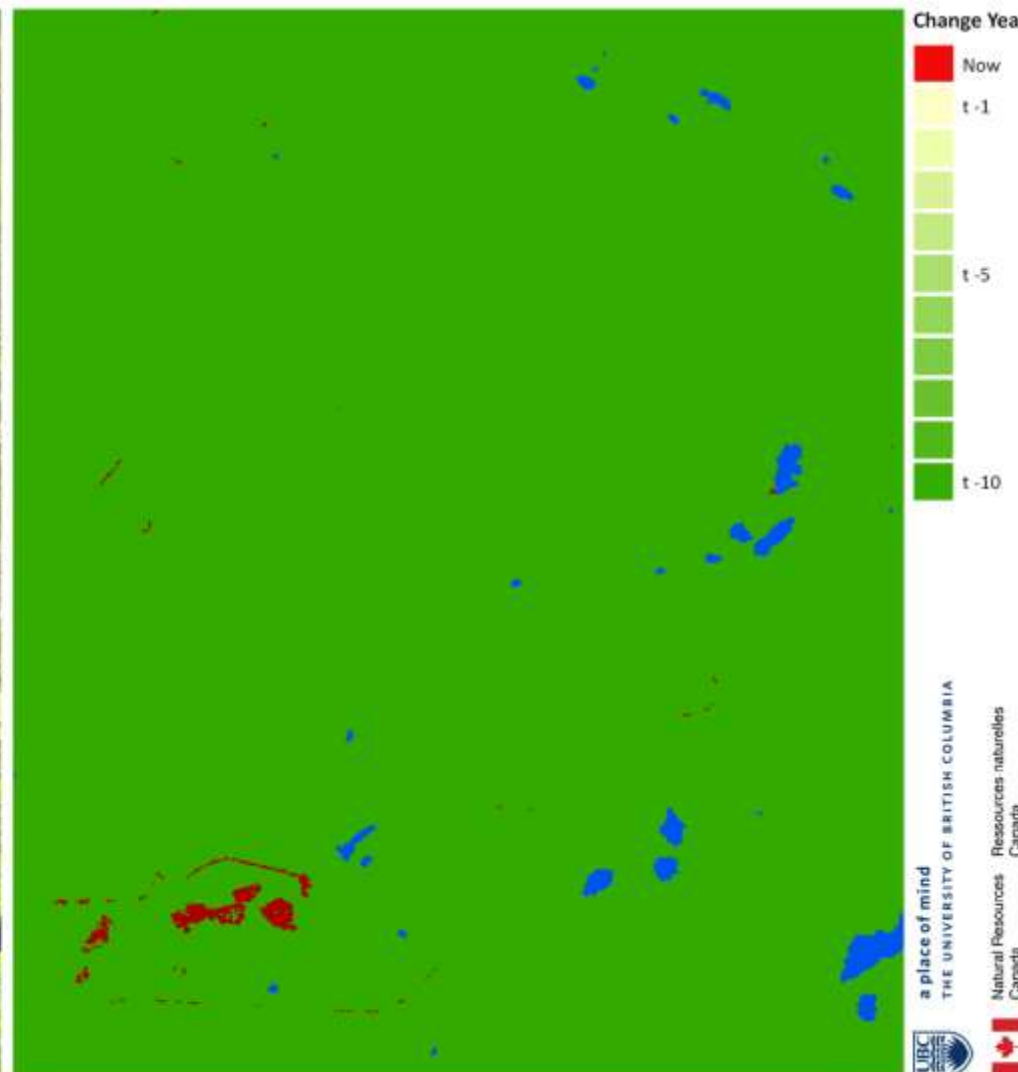
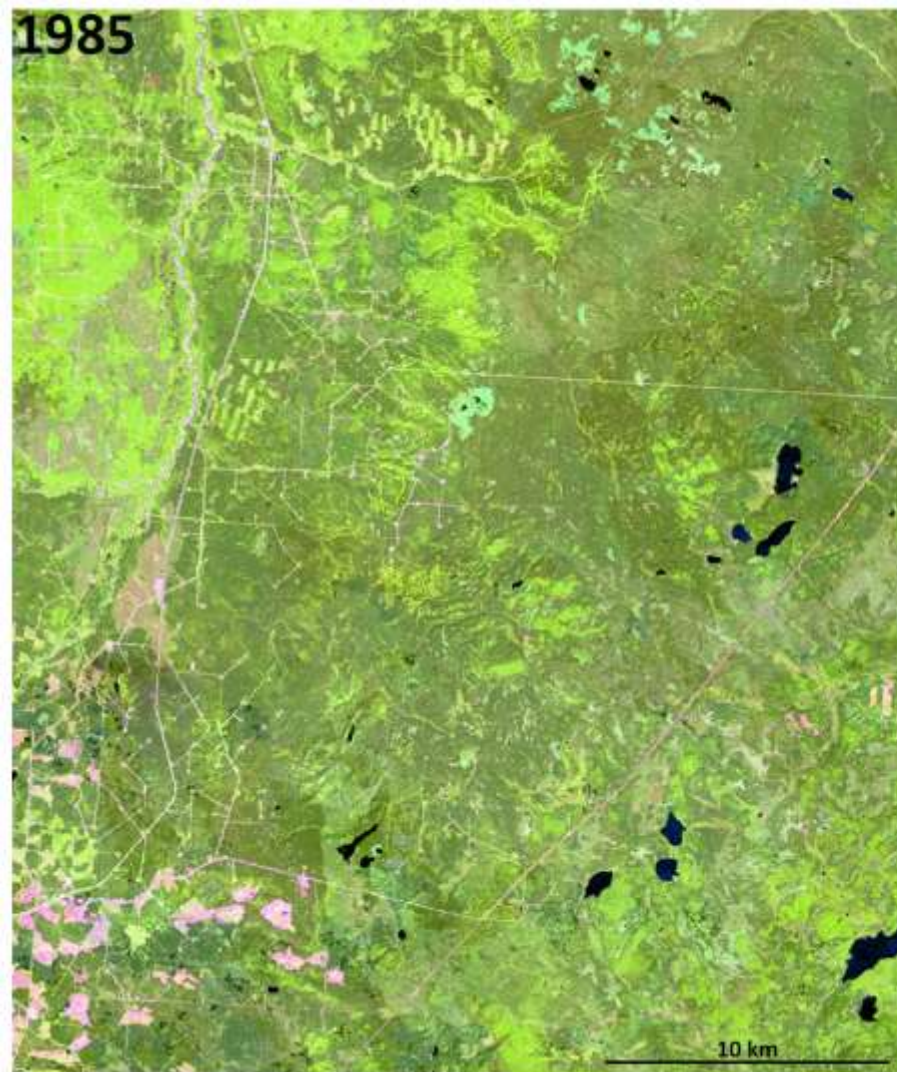
- Detected changes may show **spatial inconsistencies**
- Object based contextual analysis of the changes
 - **Confidence** based on data availability
 - **Low confidence changes relabeled** to pre- and post-change date if higher confidence

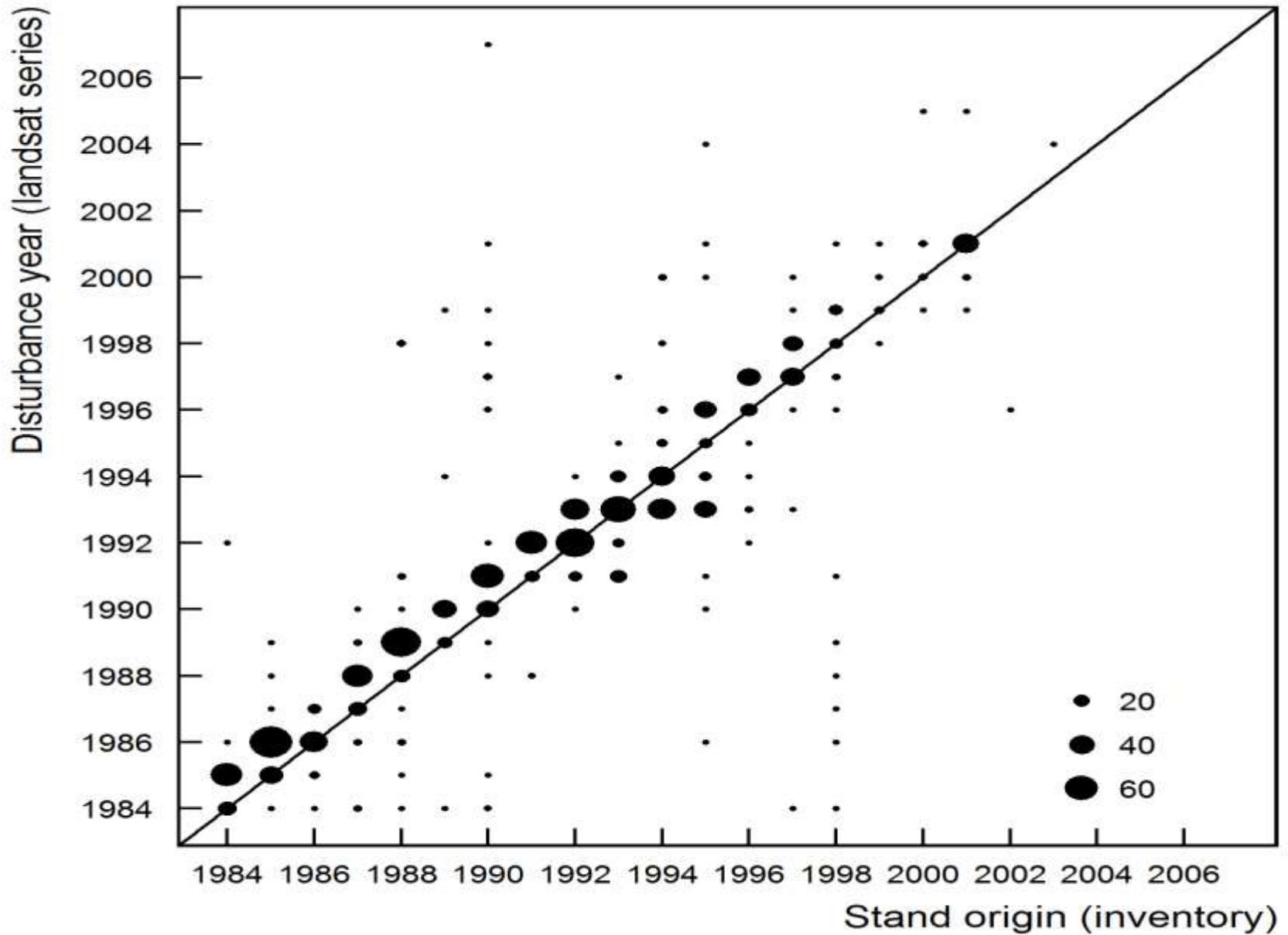


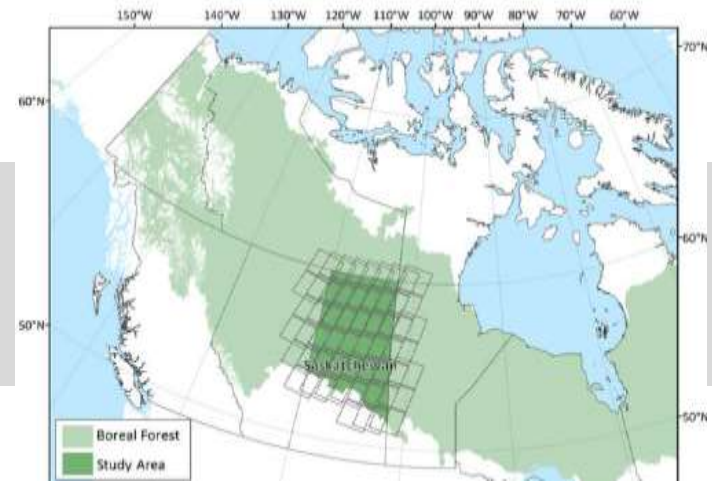
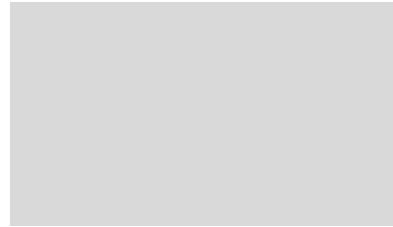
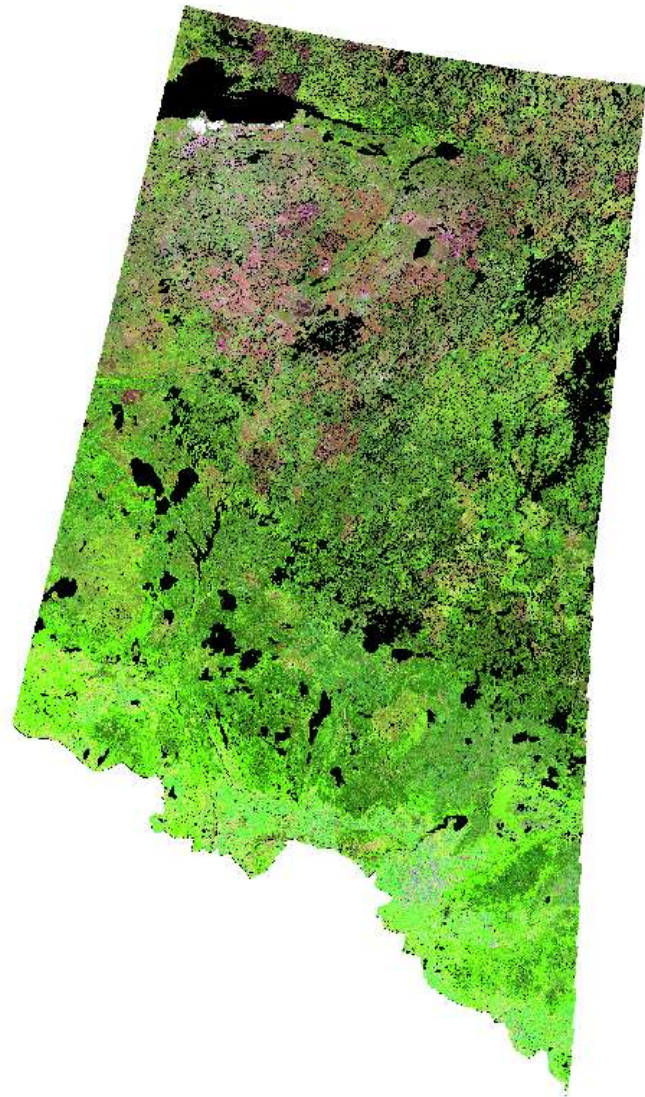


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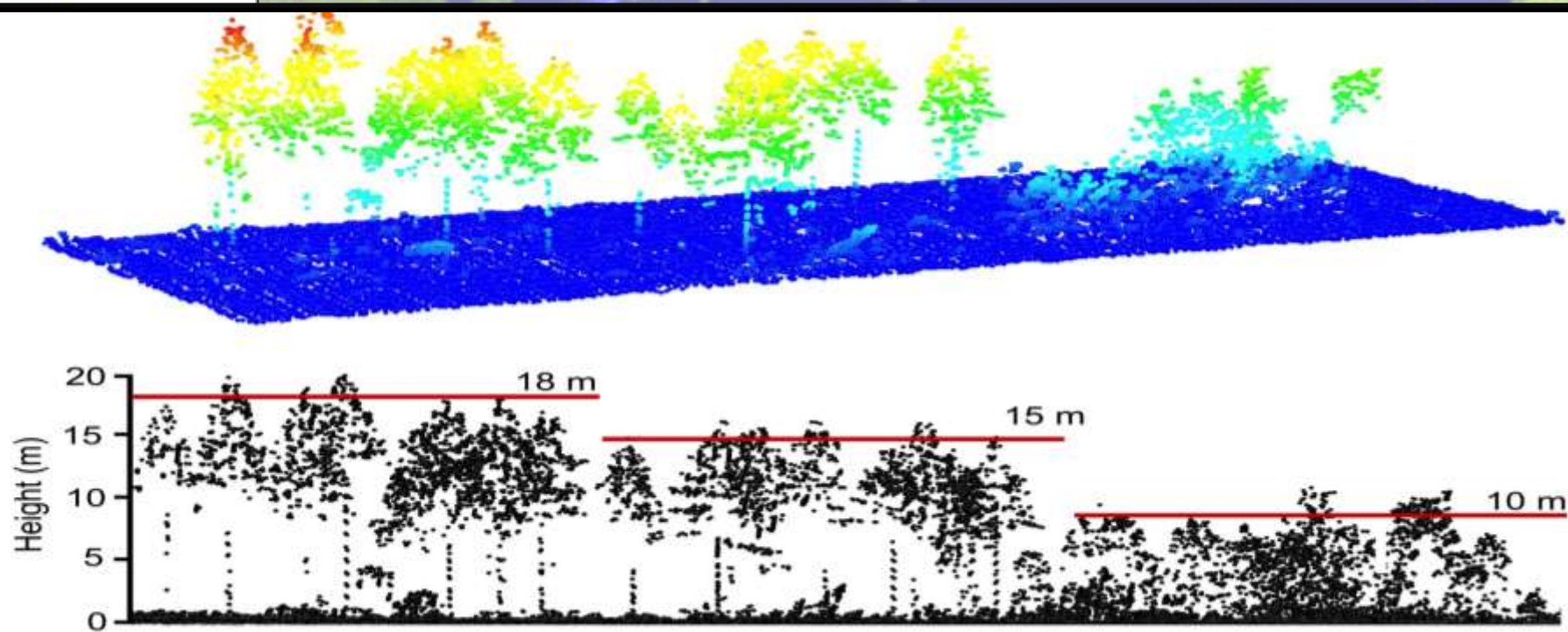
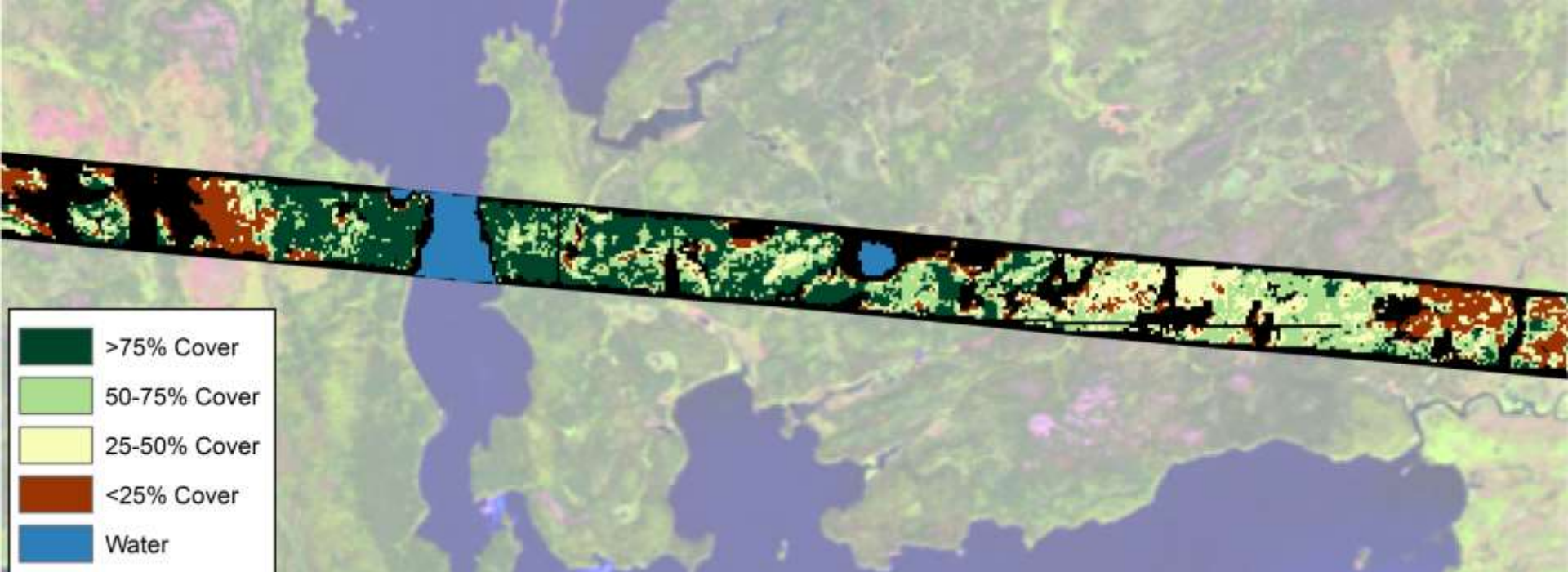
- Forested area of Saskatchewan
380,000 km²
50 individual Landsat scenes
3399 images through time

Disturbance year

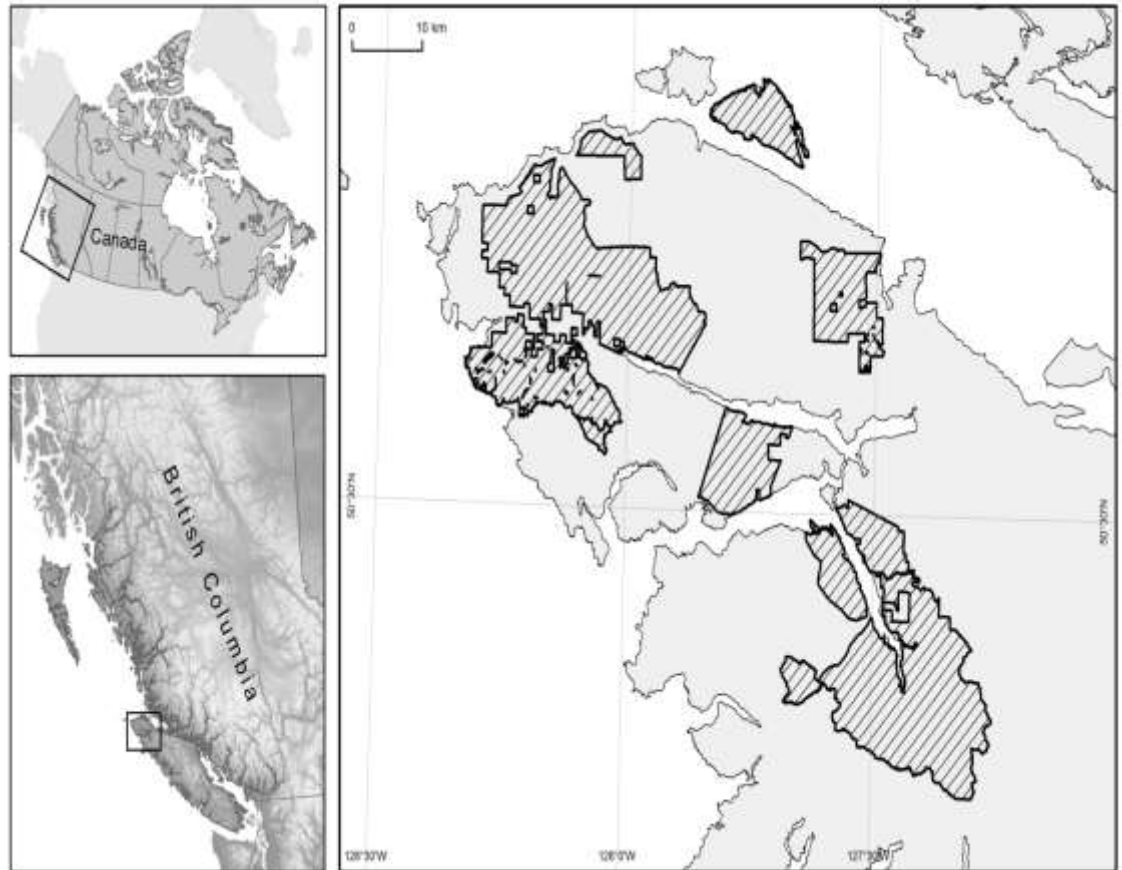
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010

- Undisturbed
- Agricultural areas

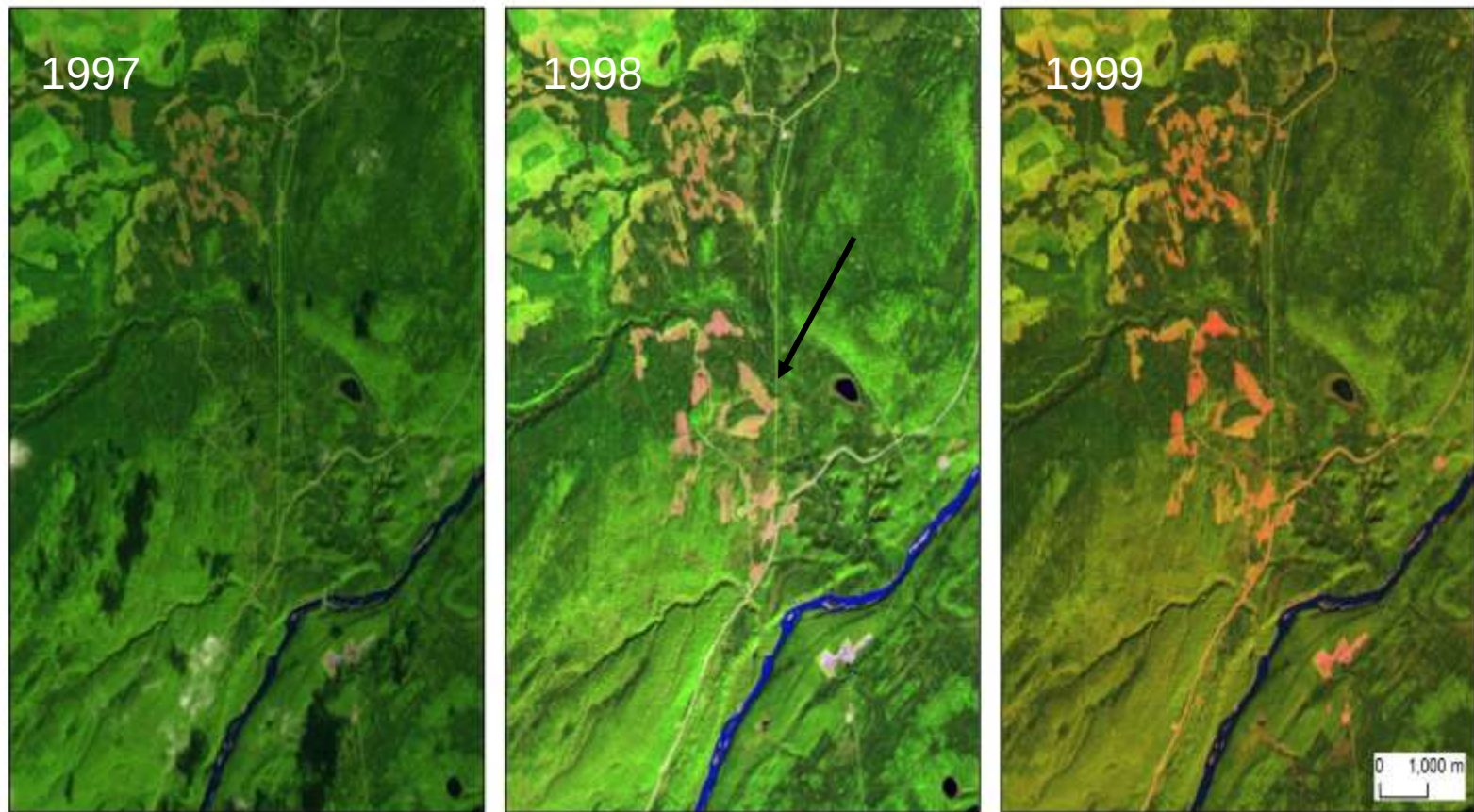
200 km



Calculating Site Index using LiDAR and Landsat



Landsat Time Series

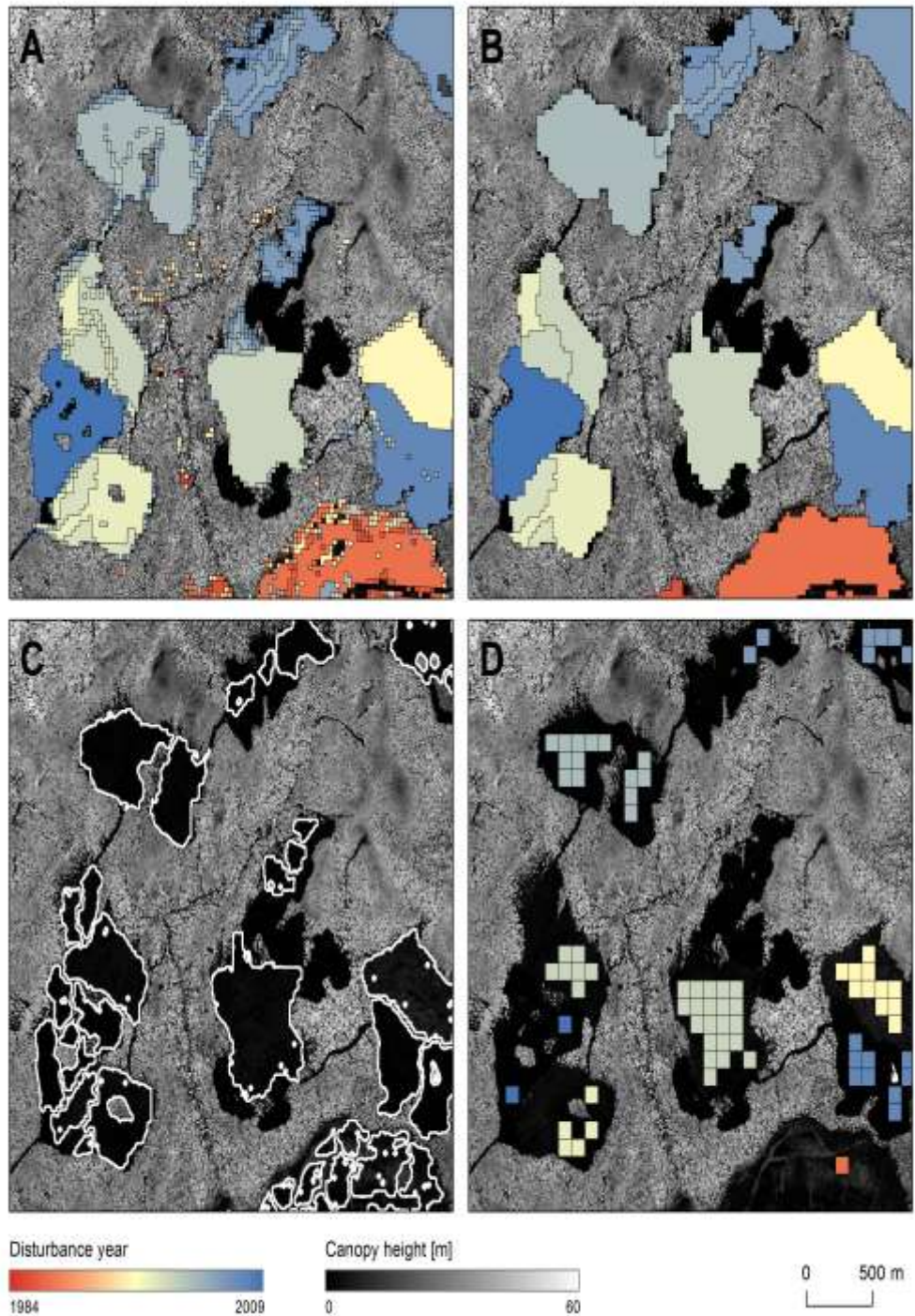


A – VCT Landsat
Change

B – Small disturbances
removed

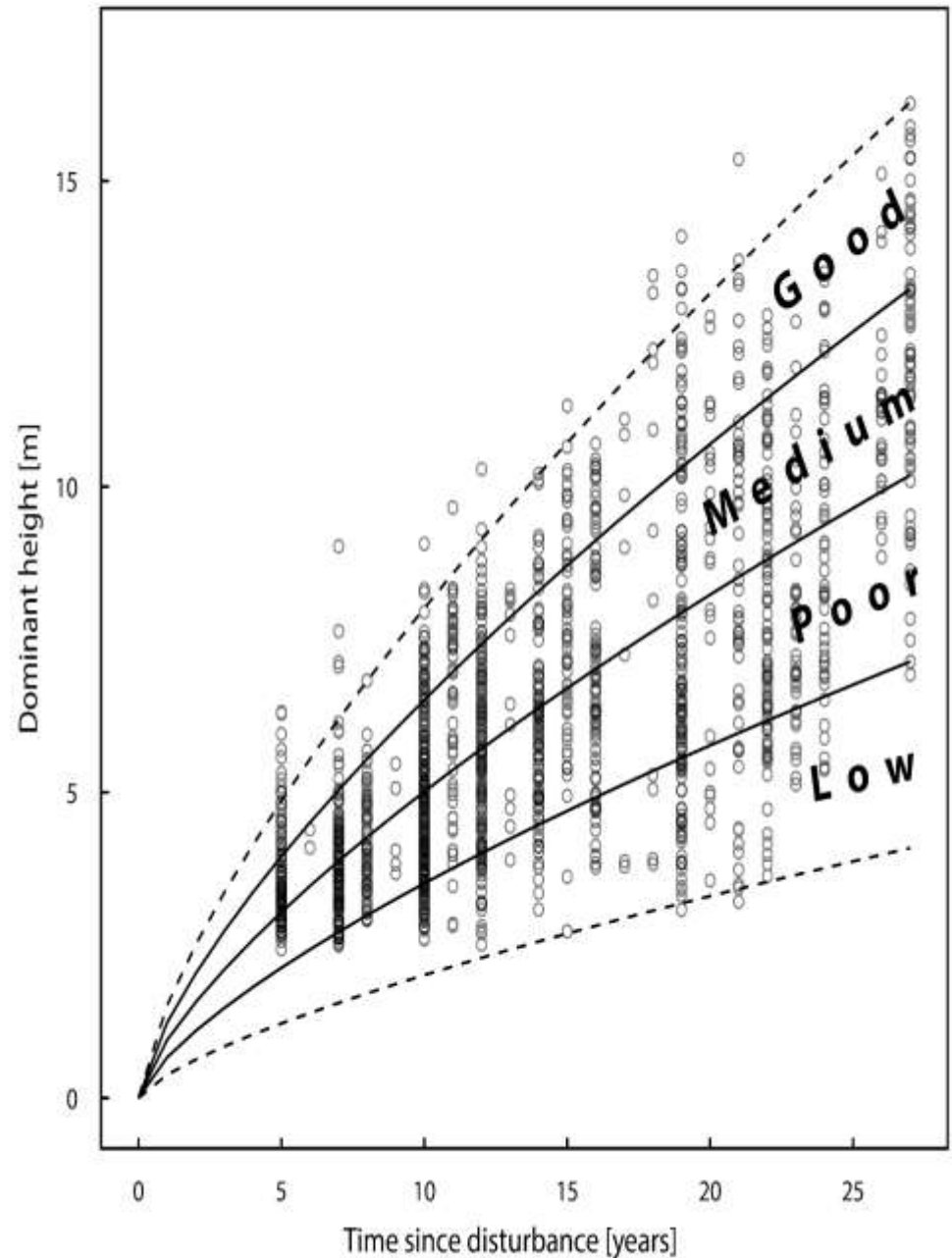
C – Shape refined with
LiDAR canopy layer

D – 1 ha sample units

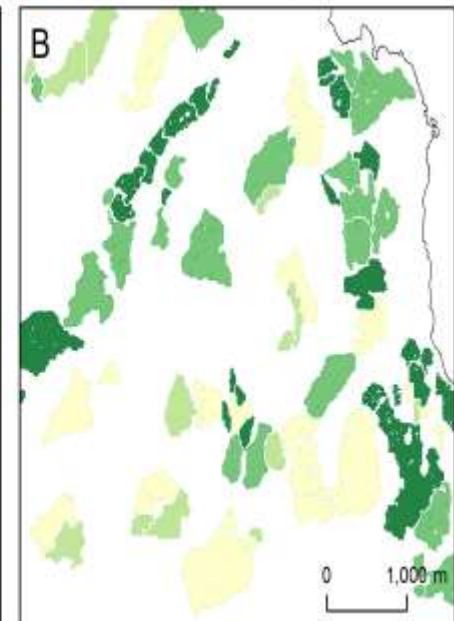
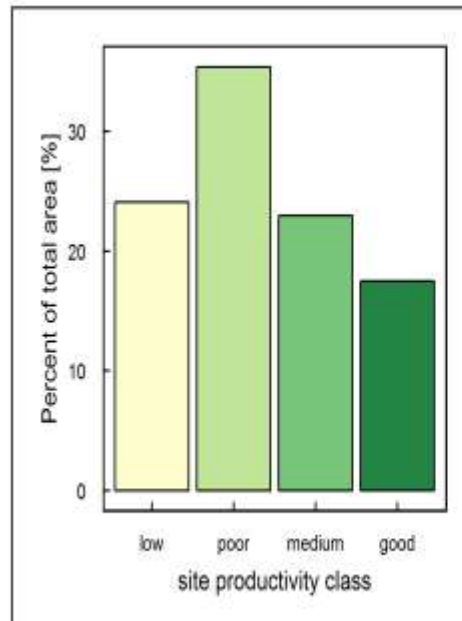
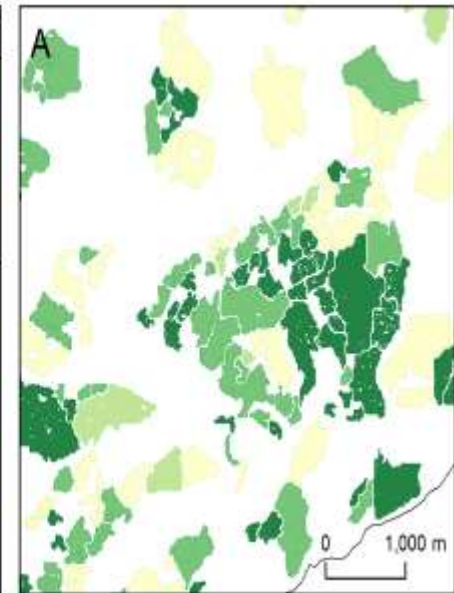
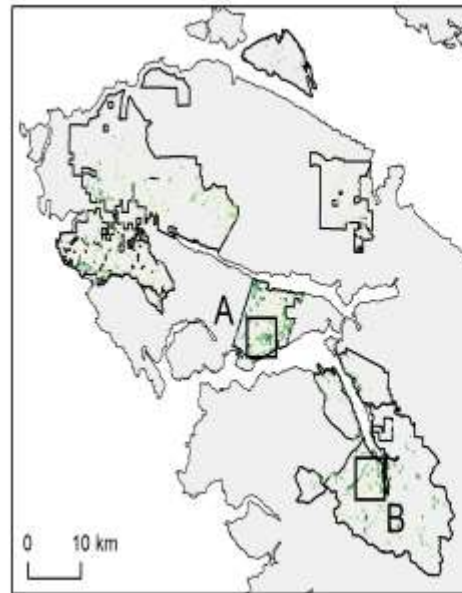


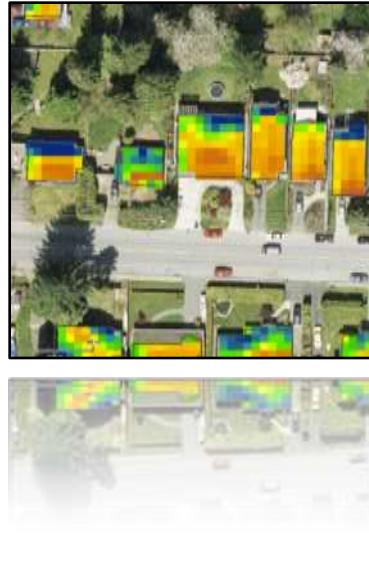
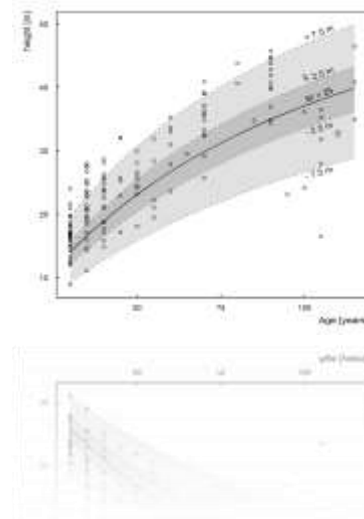
- Modelling the productivity by fitting Richards curves to the height data

Develop site curves and map



Estimated productivity





In an urban environment LiDAR can also provide unprecedented 3D information.



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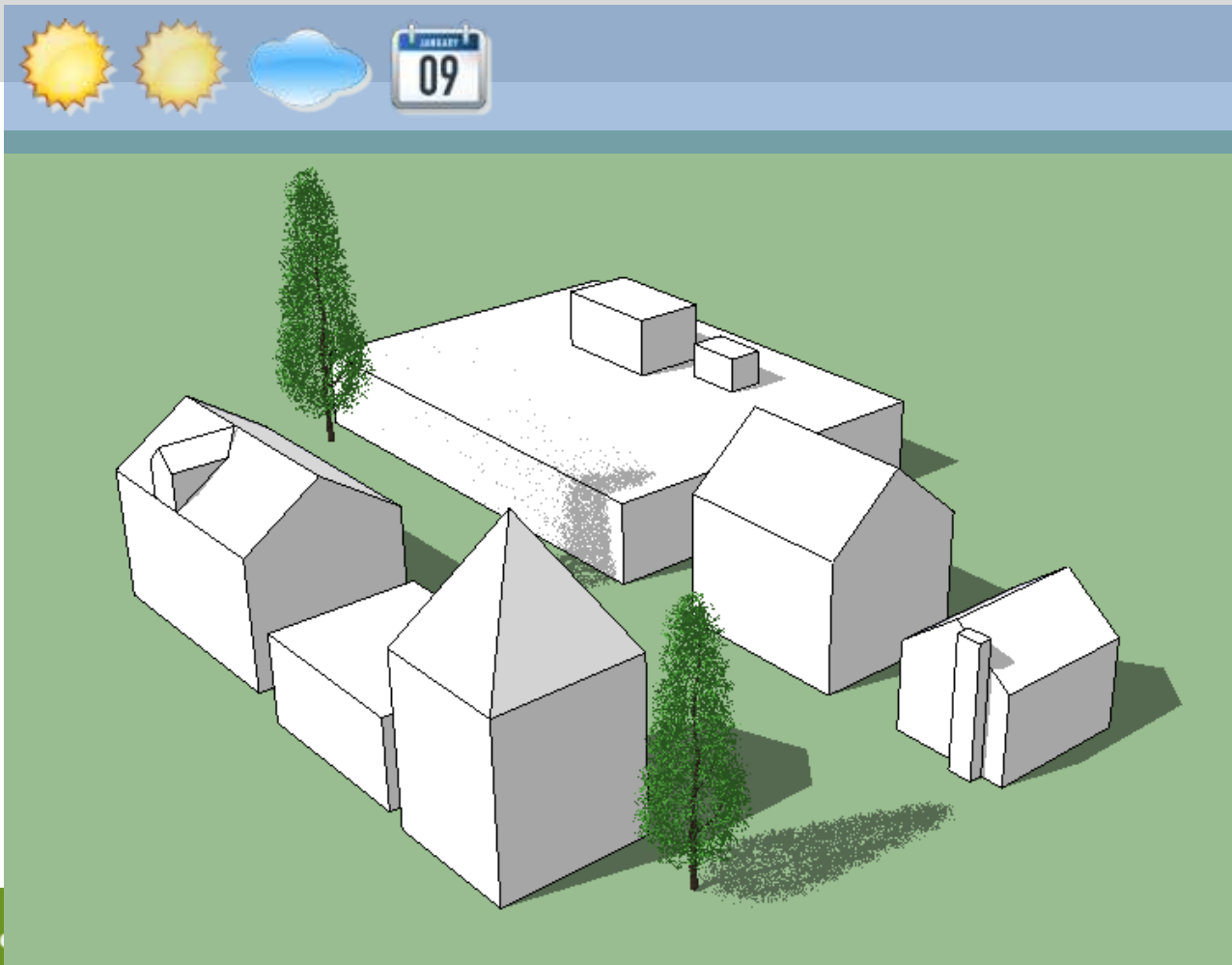


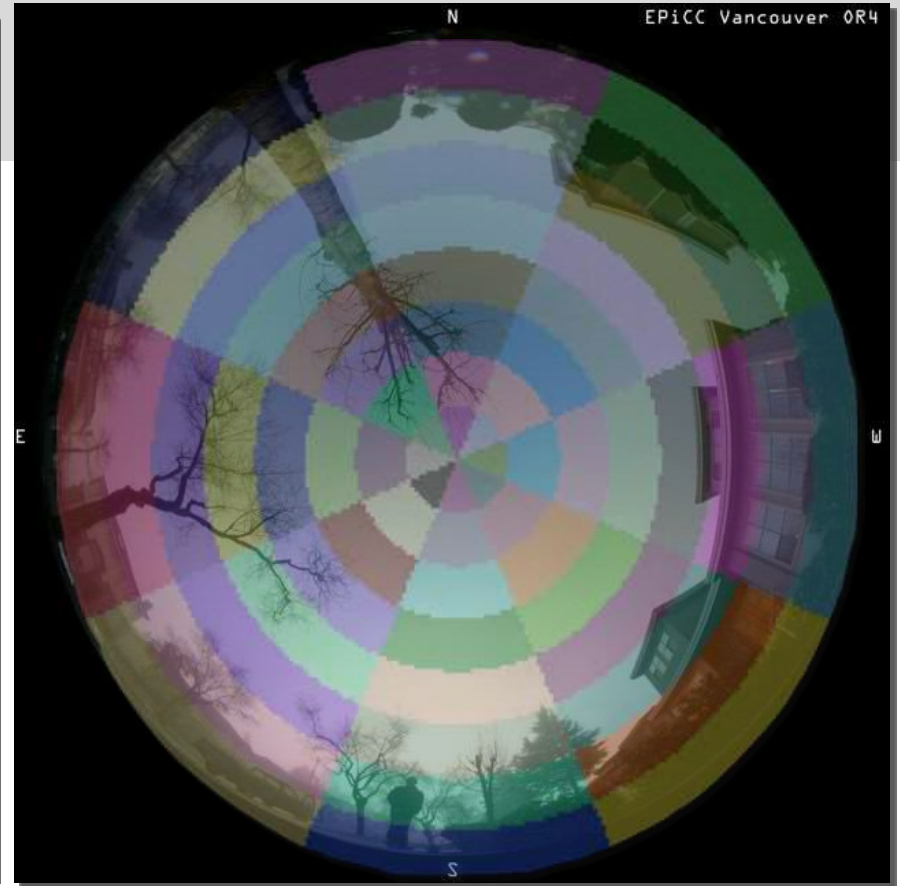
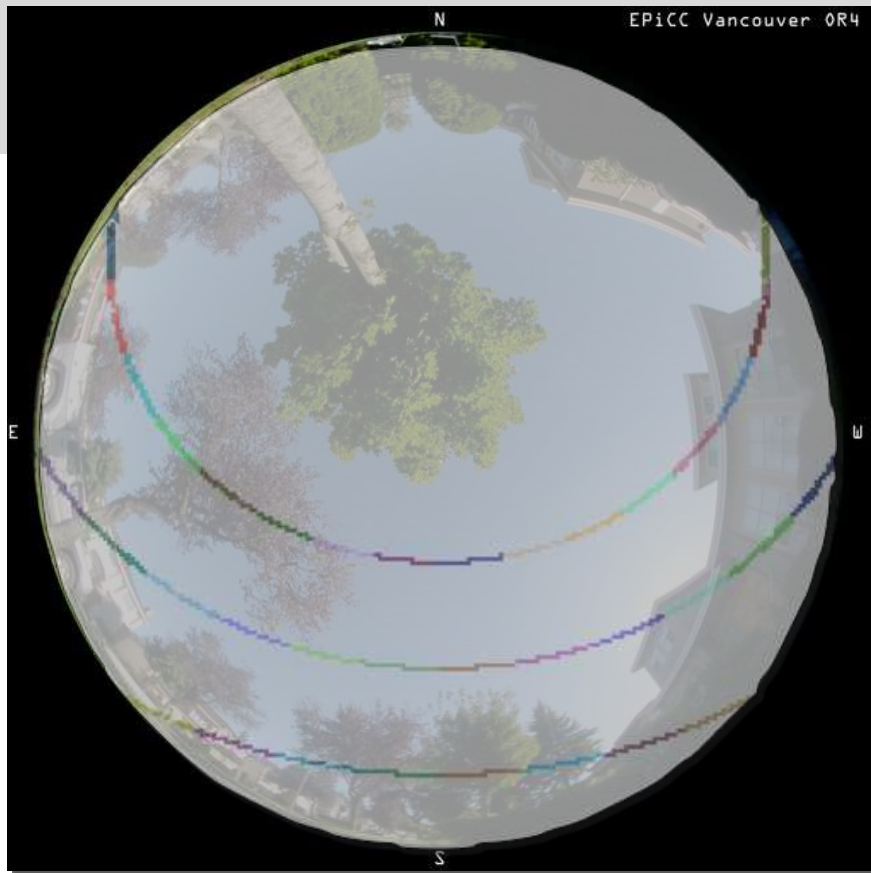




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Direct and Diffuse Components



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Tooke and Coops (2011) in review

LAYERS

TOOLBOX

FIND



Solar Calculator

Results ★★★★★

This roof is an excellent candidate for solar hot water

Heat Map

This rooftop receives an average of 1,669 MJ of solar energy daily. The optimal area of this rooftop receives an average of 39.31 MJ of solar energy daily. 20% of the rooftop faces south.



Solar Energy Graph

Average Daily solar energy values for each month



◀ 1 2 3 4 5 ▶

details

DISTRICT OF NORTH VANCOUVER, BC, CANADA

LAYERS

TOOLBOX

FIND



Solar Calculator

Savings

Calculate your potential savings

Persons in your house

1 2 3 4 5 6 7 8

Hot water fuel type

gas electric

Hot Water from Solar

66%

Estimated amount of hot water generated from a solar hot water system for this home.

Solar Savings

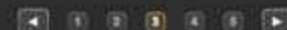
\$160

Estimated annual savings on energy costs when using a solar hot water system.

CO₂ Savings

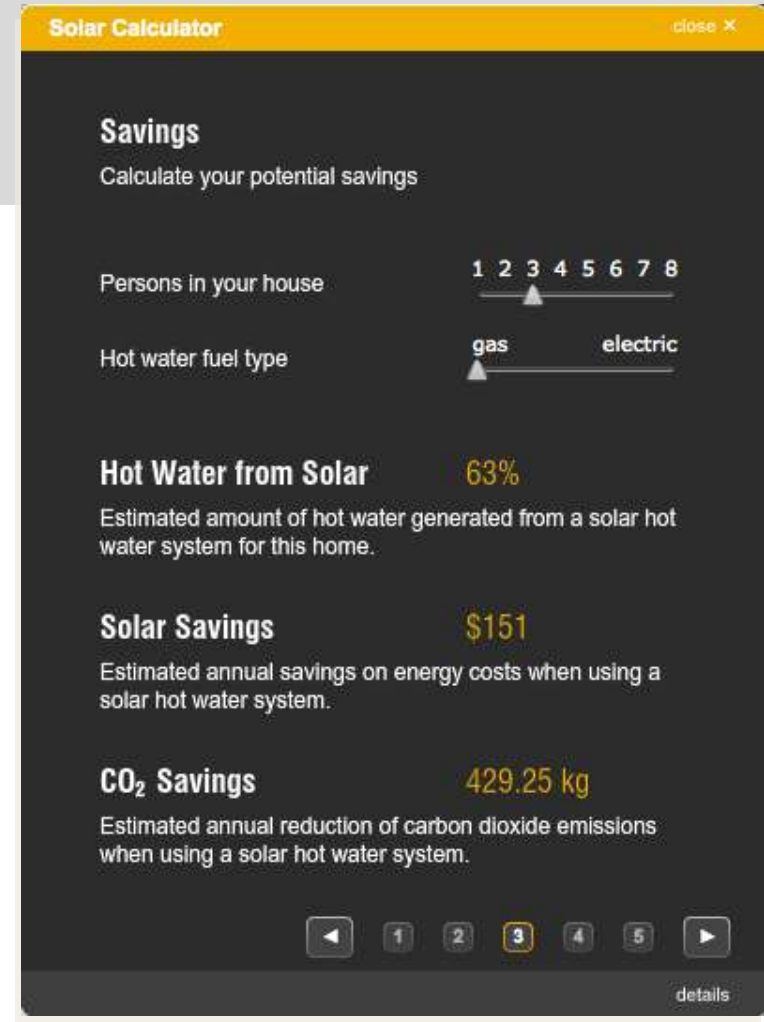
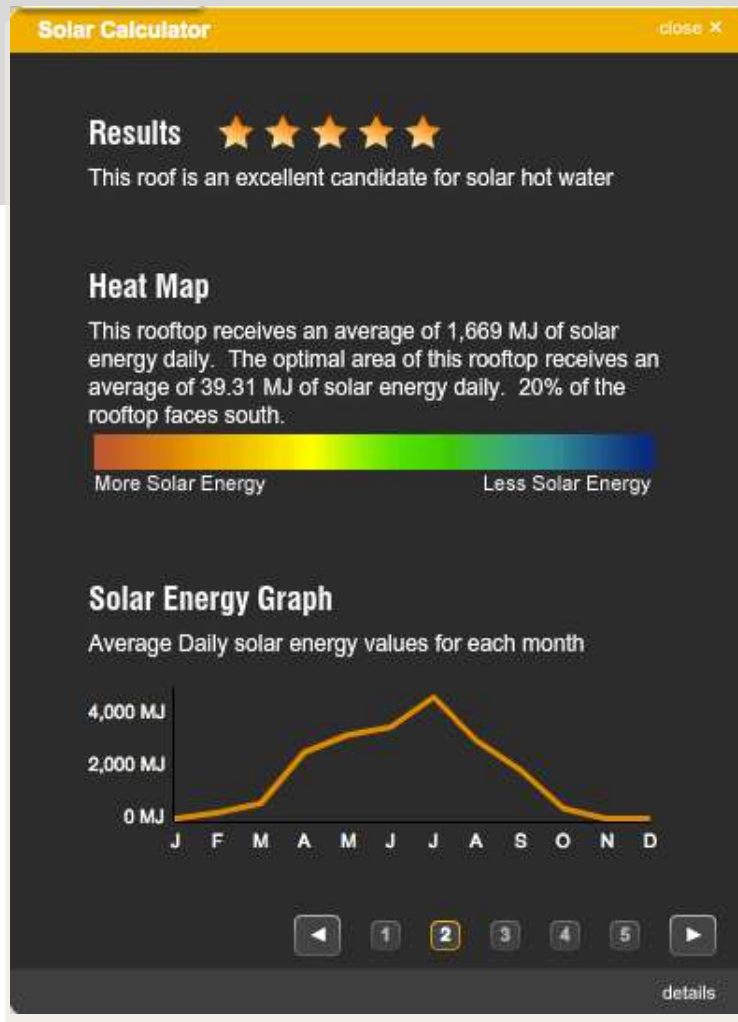
454.04 kg

Estimated annual reduction of carbon dioxide emissions when using a solar hot water system.



Details

District of North Vancouver Solar Calculator



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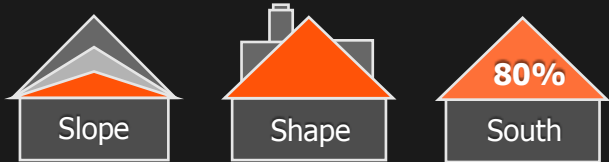
Solar Calculator

355 West Queens Rd

Address



Solar Potential



Roof Characteristics

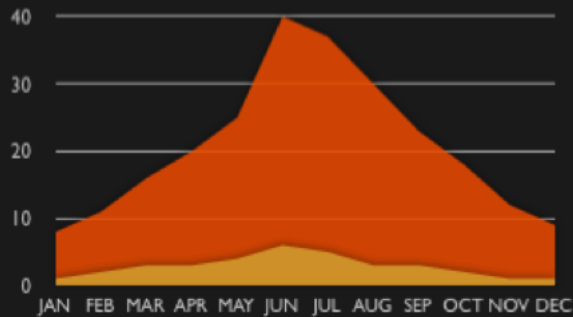
Roof Area: 2872 m²

General Building Details

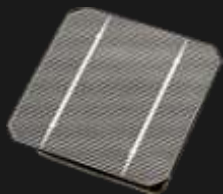
Average Height: 14.06 m

Average Daily Radiation: 16 MJ

Received Rooftop Radiation



Monthly Direct and Diffuse Radiation Graph



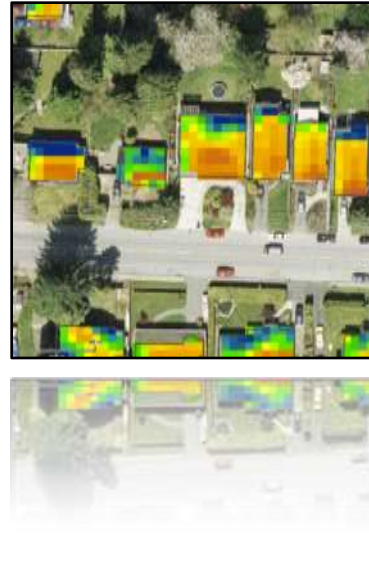
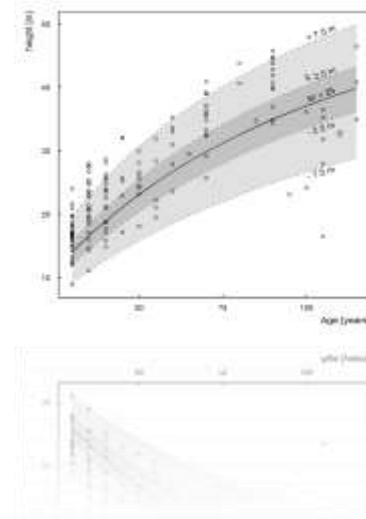
PV
500 m2
June 21 09
Report

Current Installed System (Option to Report)



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Other Information



Monitoring Vegetation Phenology for Bear Food Resources

Aim: Develop a more comprehensive understanding of the temporal onset (phenology) of key bear foods and how it changes over the landscape

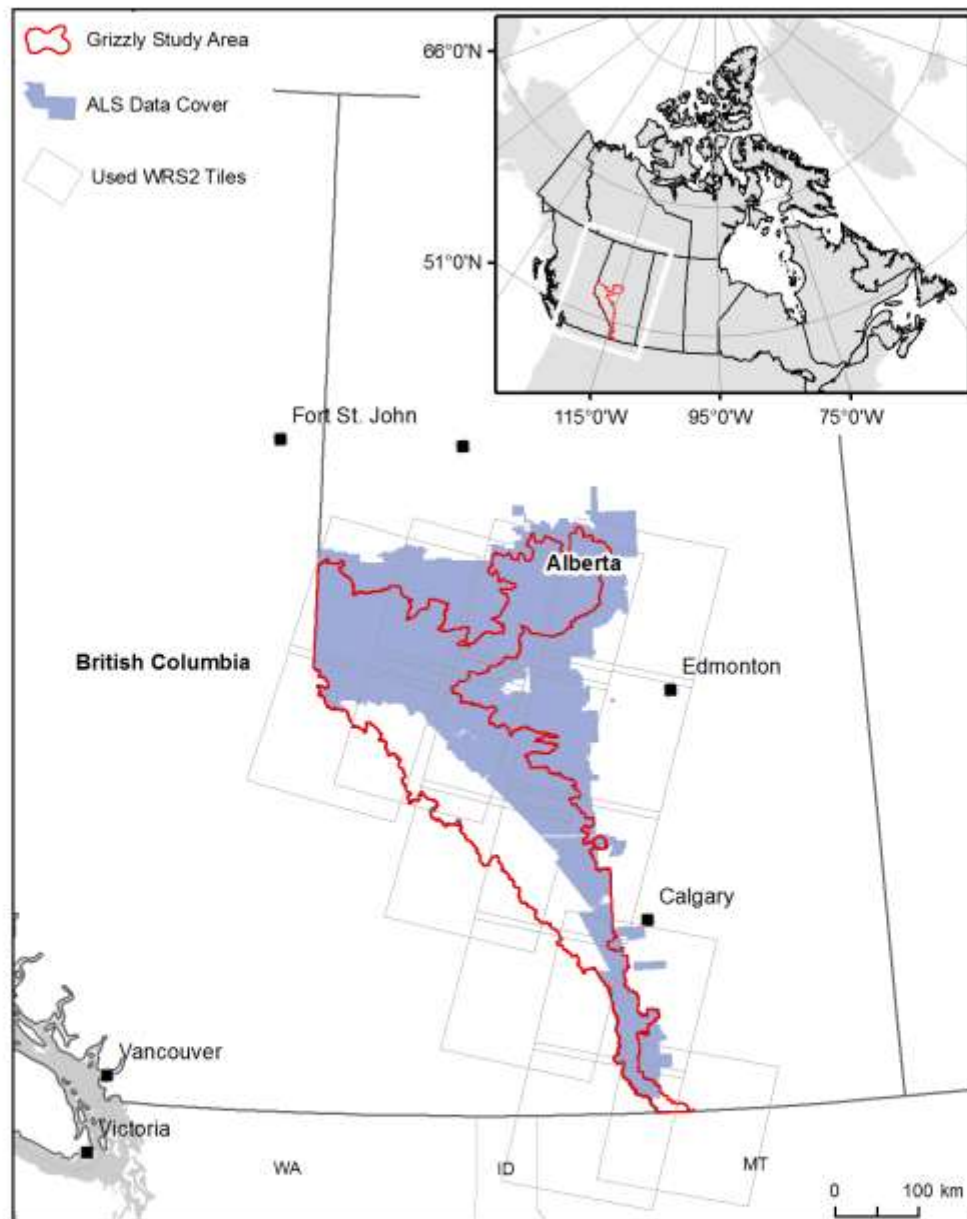
Approach: Use time lapse camera units to monitor phenology across a transect and relate to changes in satellite responses.

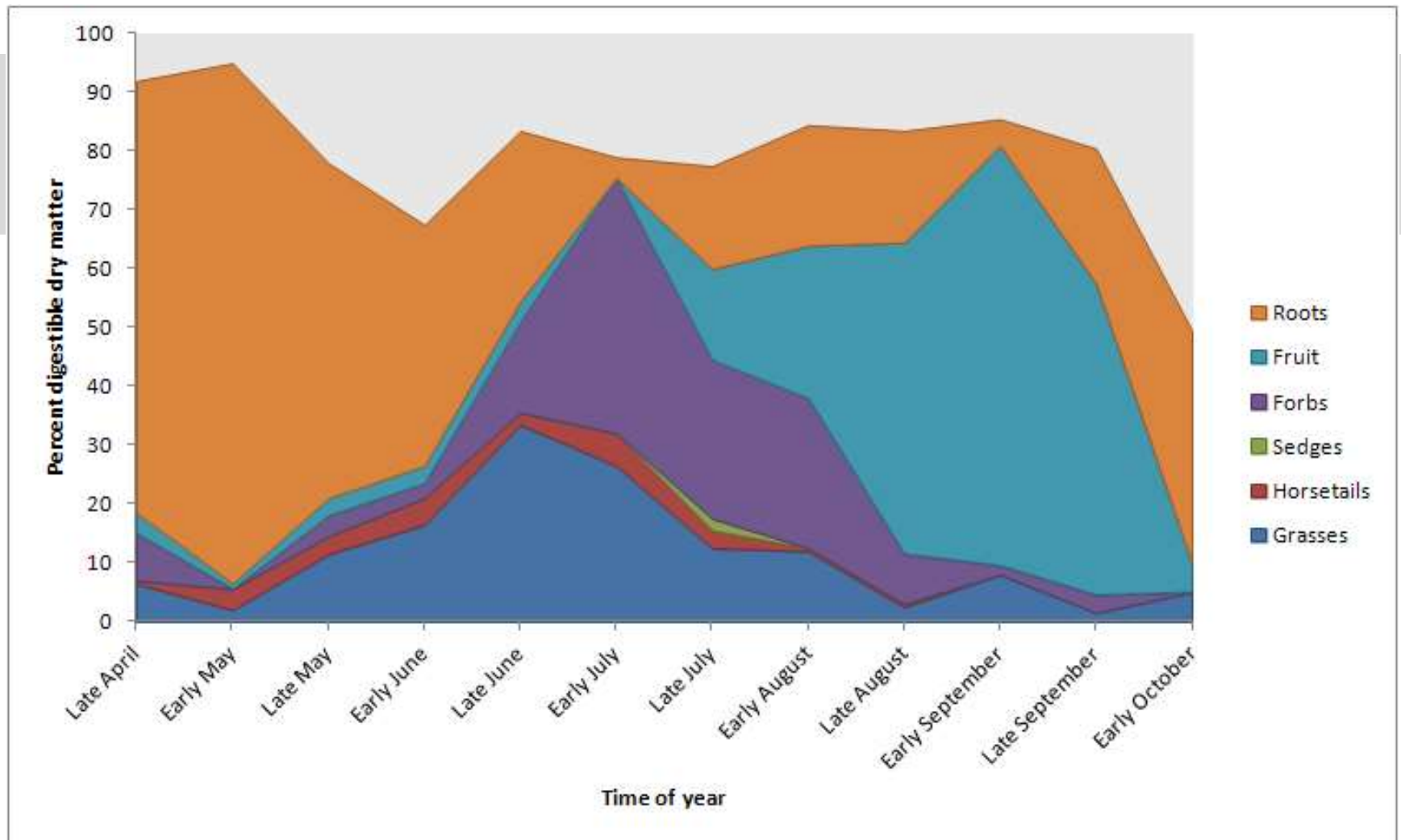


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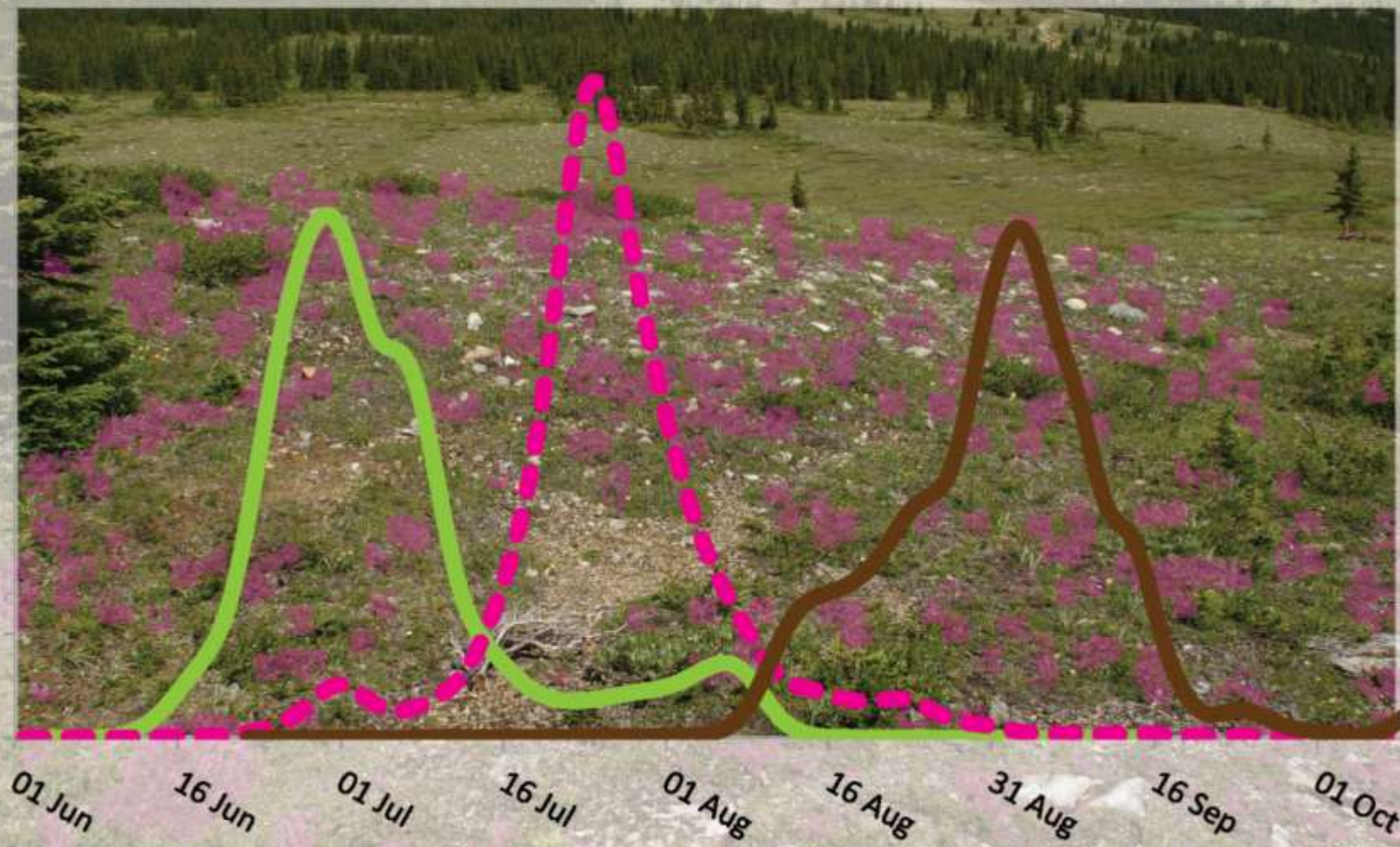






— Green-up — Flower — Senescence

Proportion H.alpinum area





Seven Pentax digital 6 mega-pixel cameras installed with intervalometer and solar panel in weather sealed case

Daily images captured between 12 - 1:00 pm

Network of cameras along an elevation transect with mixed deciduous and coniferous pairs.



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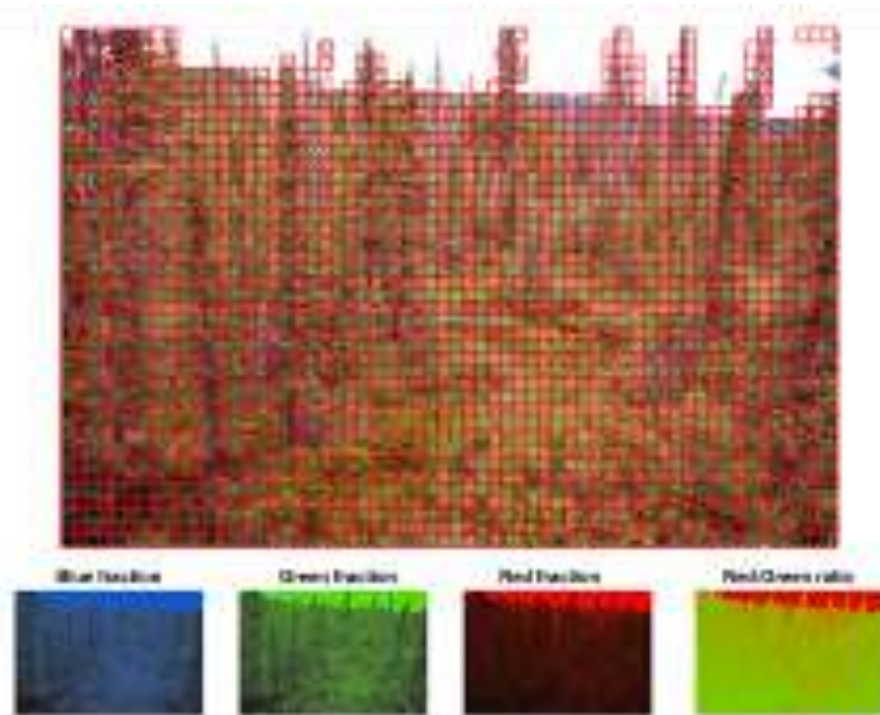
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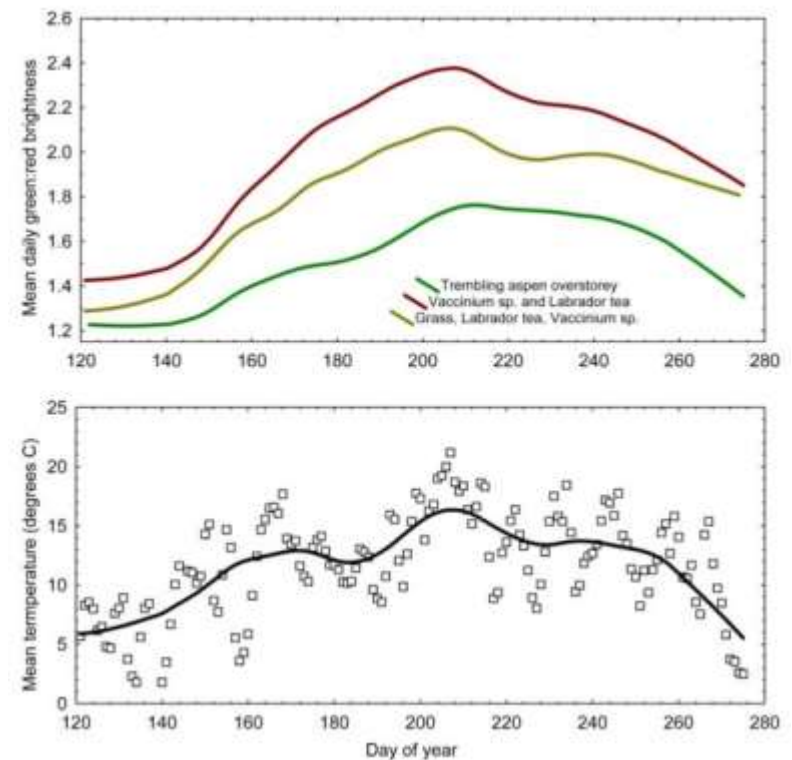
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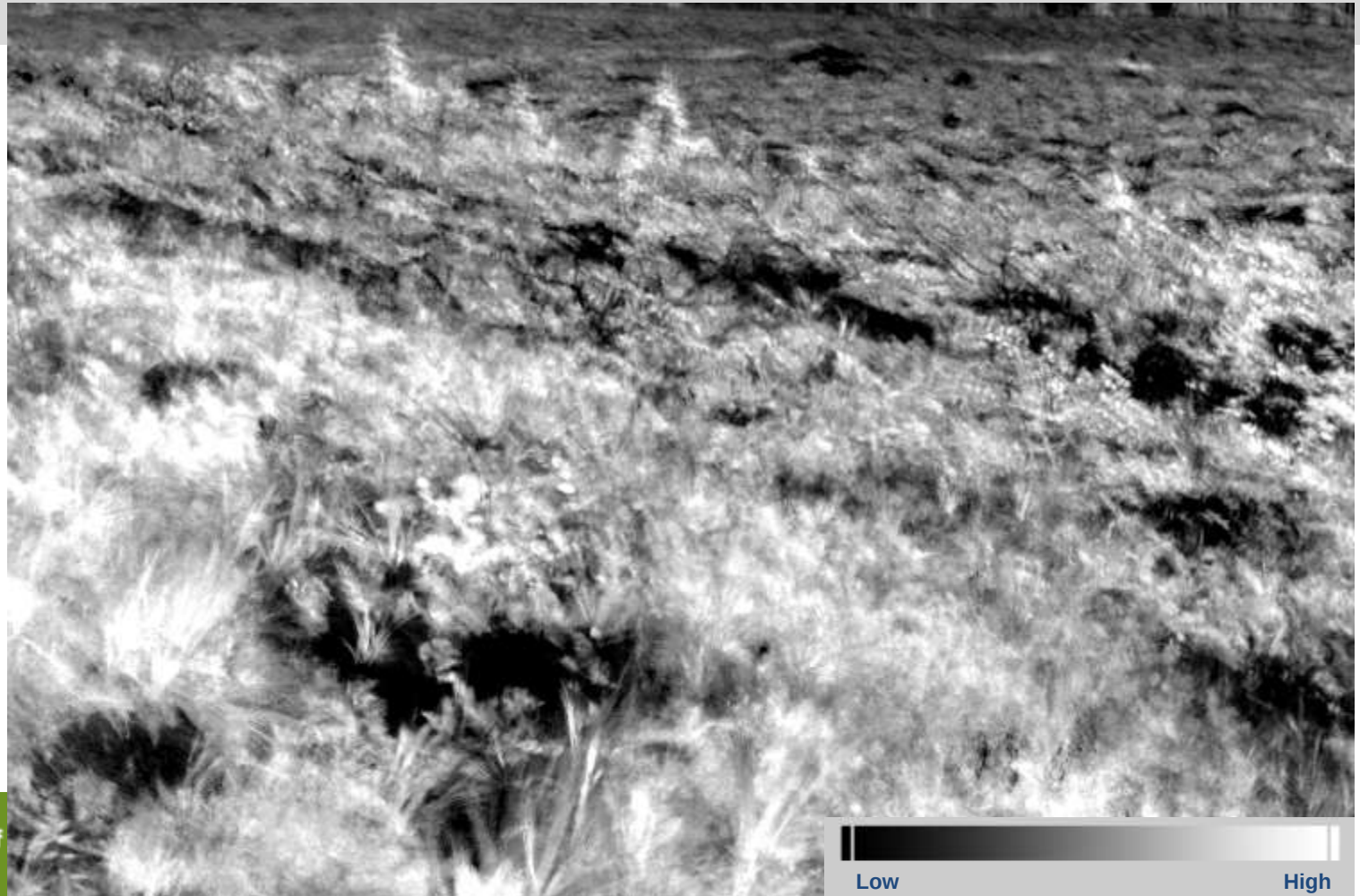


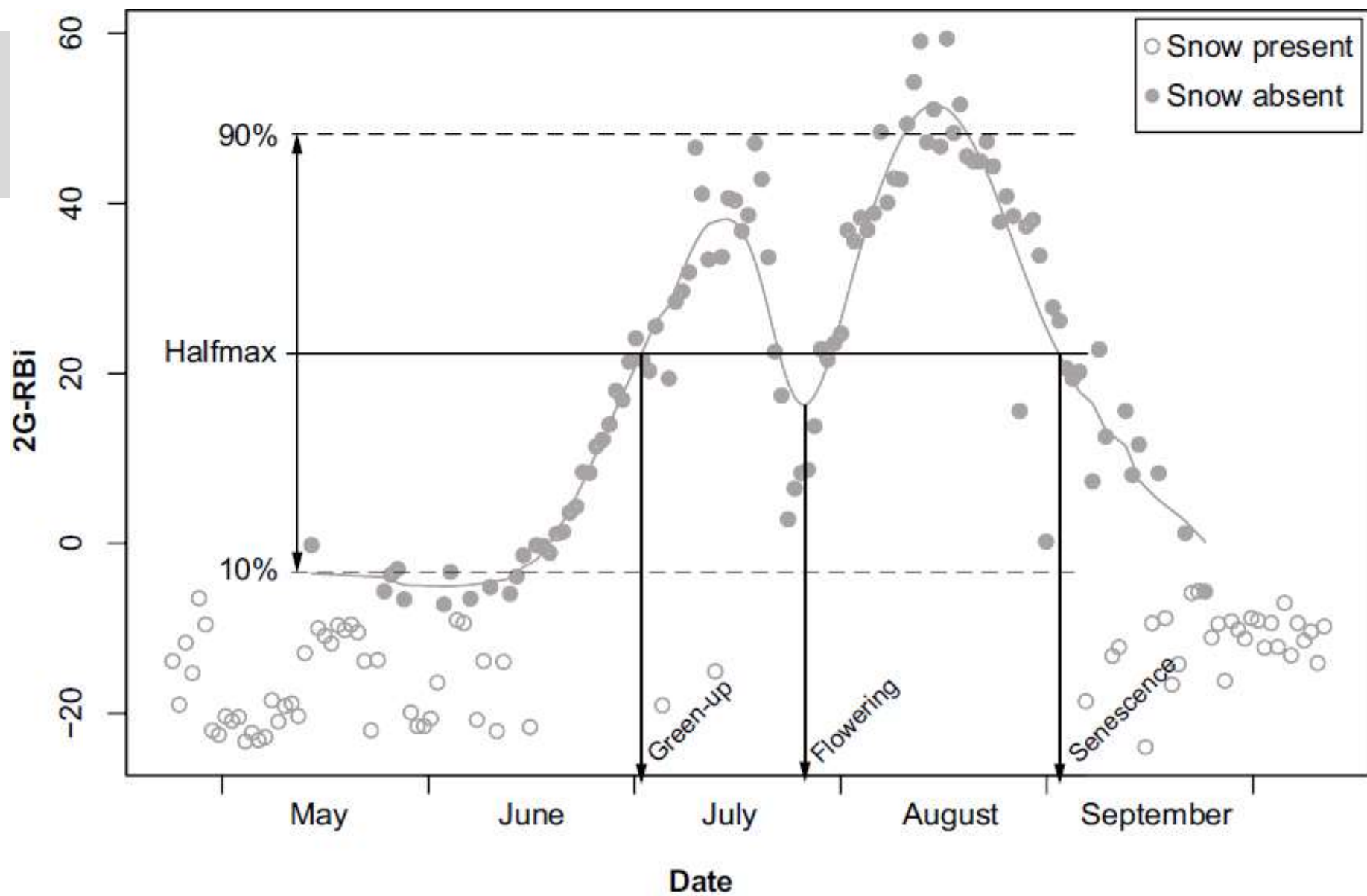
1.5 full years of data collected (2009 growing season) over 6,800 images



Greenness (2G - RB)

(Richardson et al. 2007)





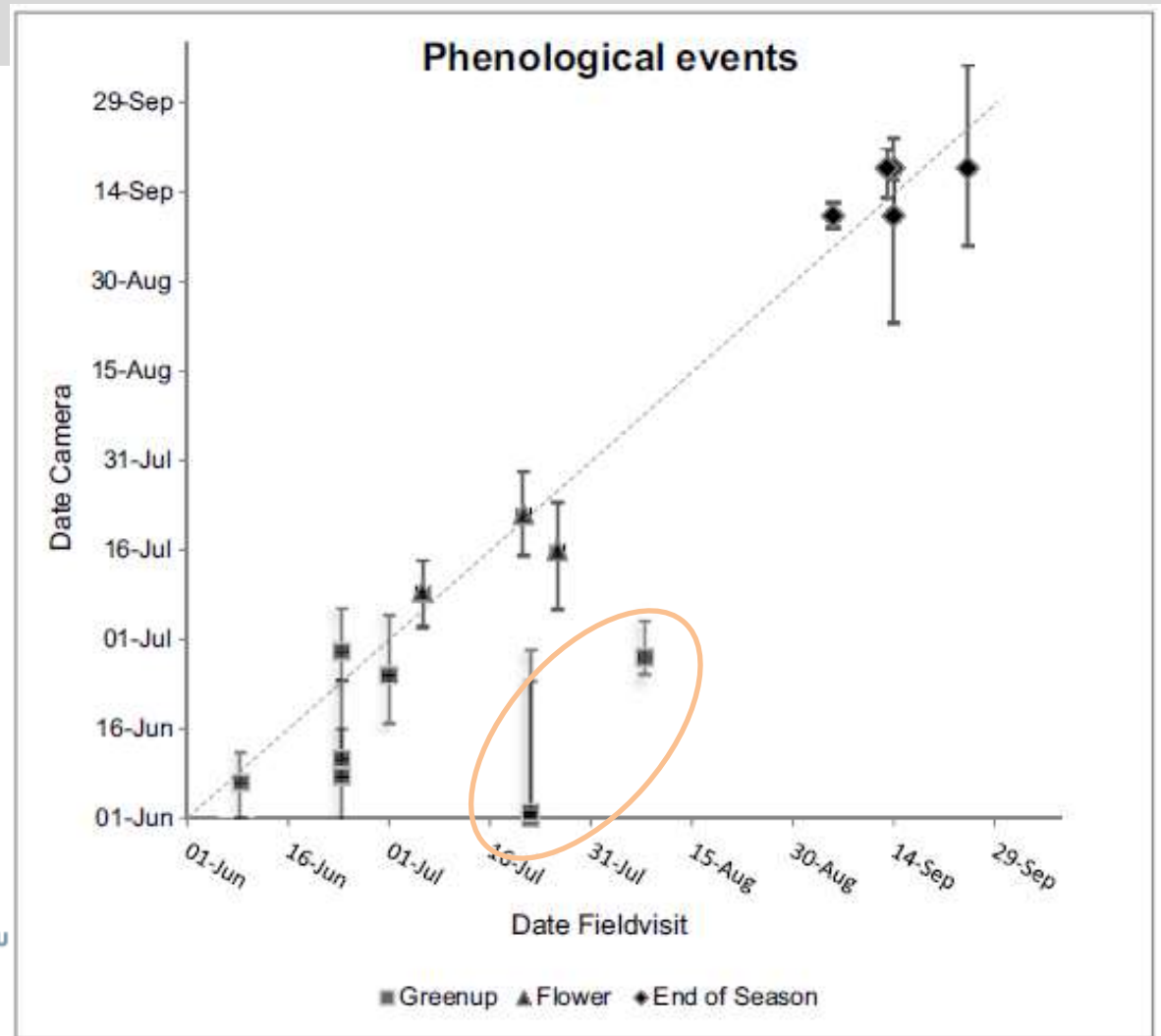
Green-up date



Senescence date



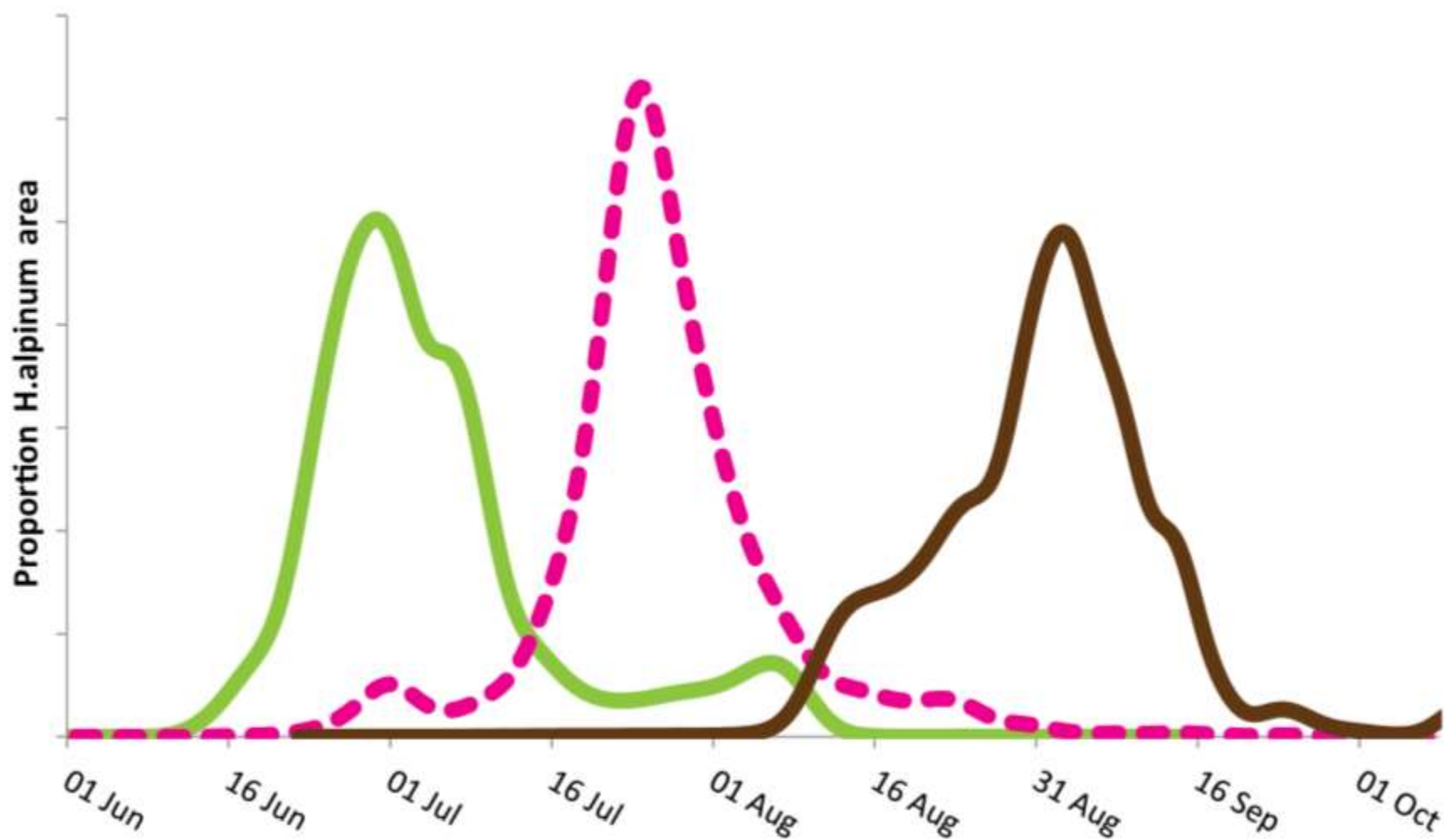
Phenological events

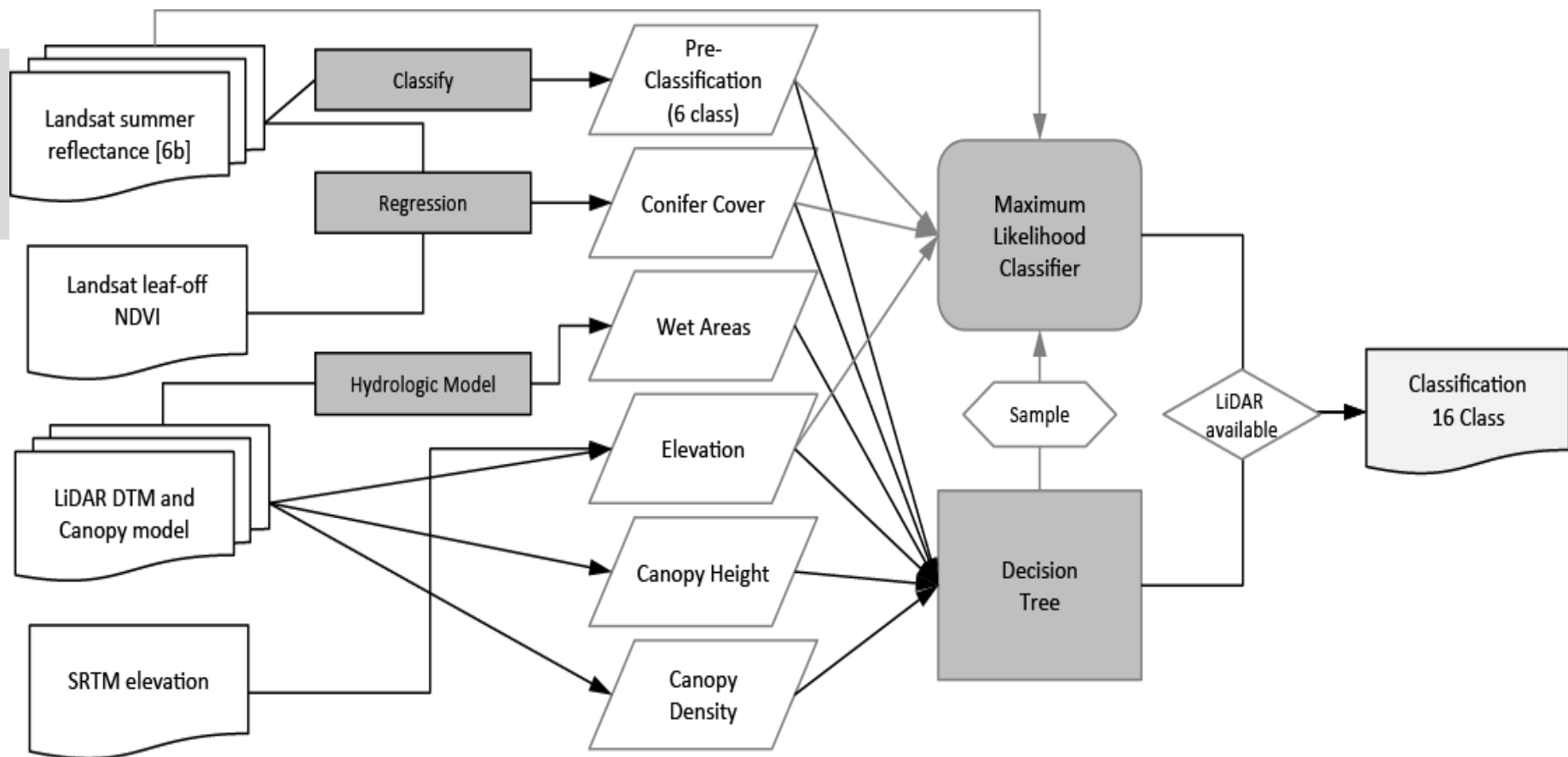


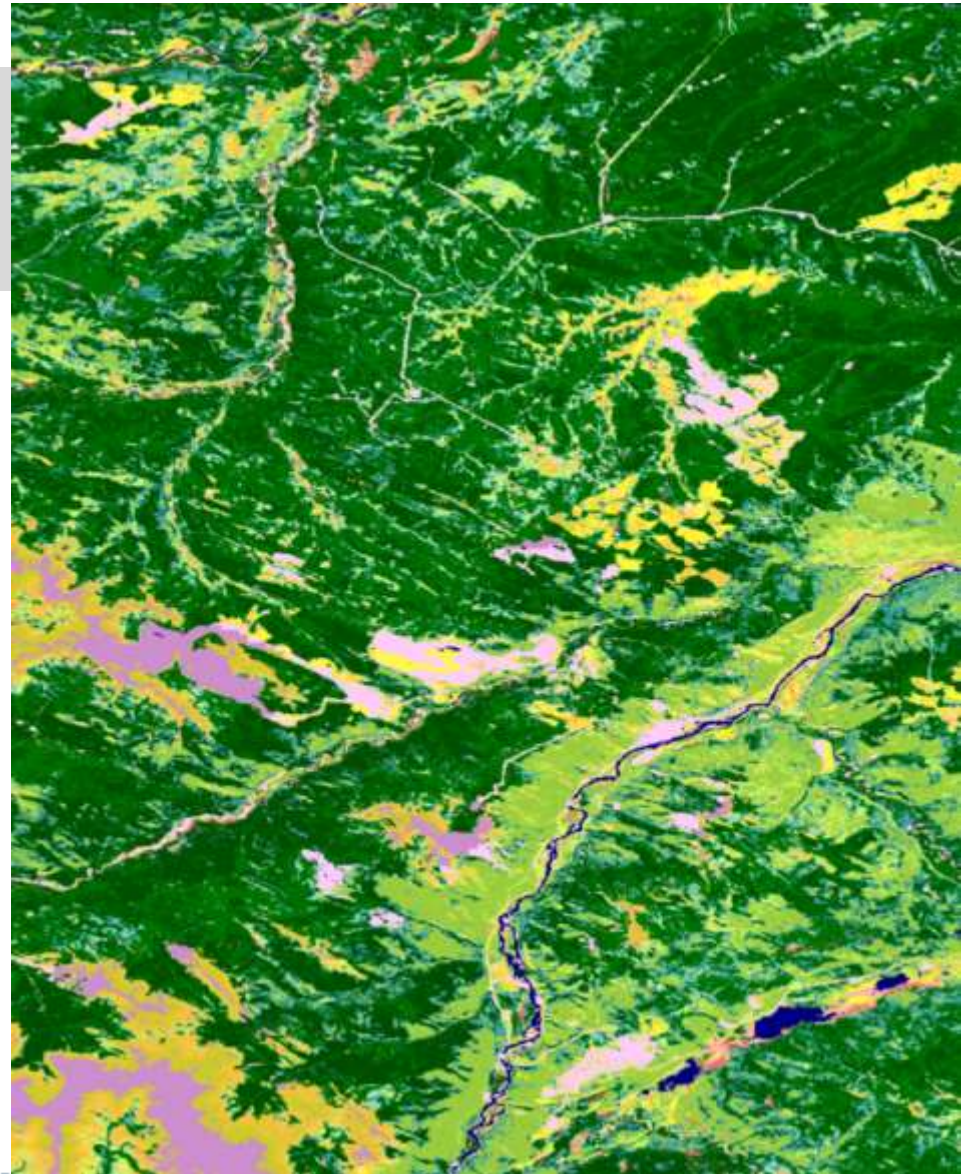
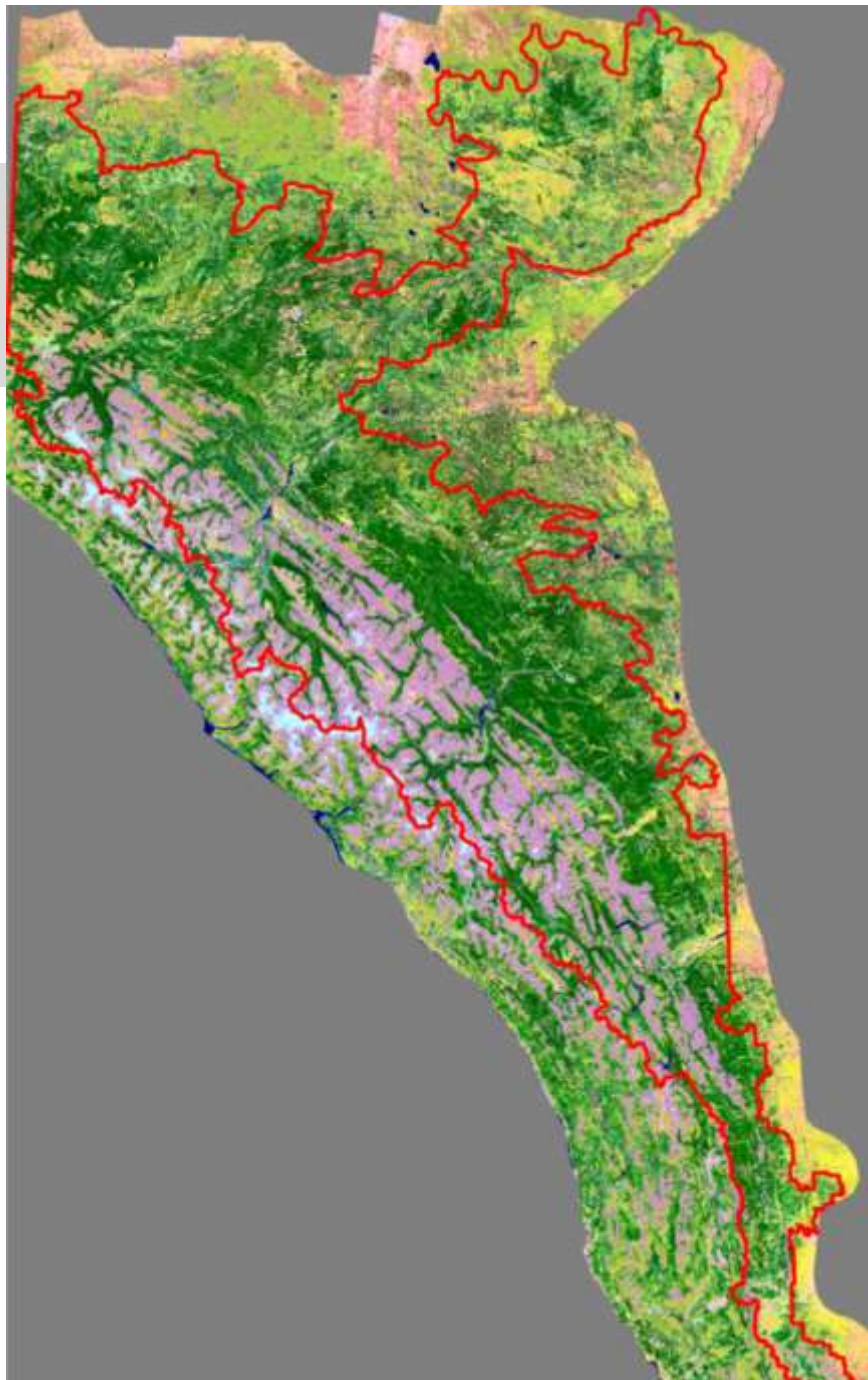




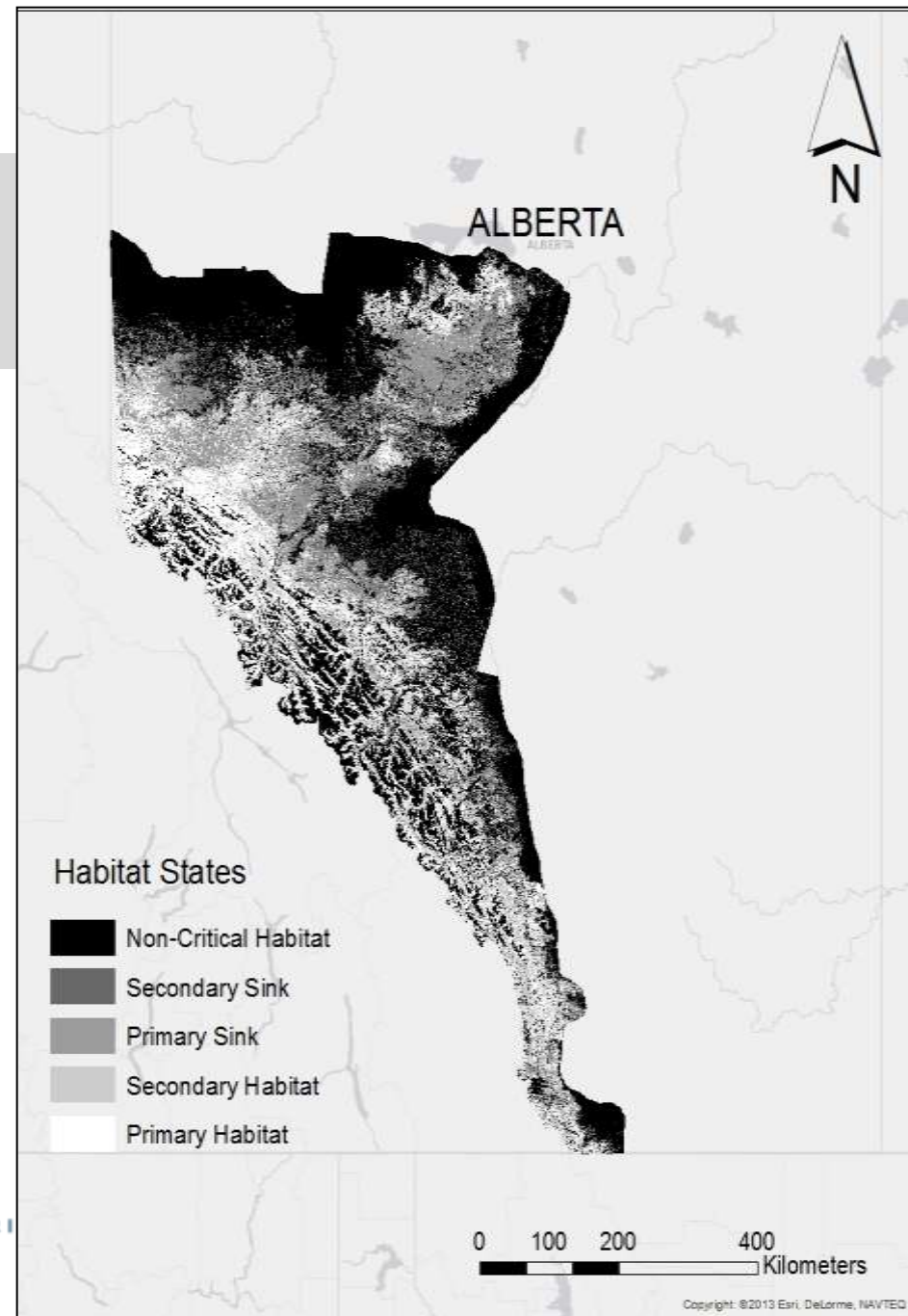
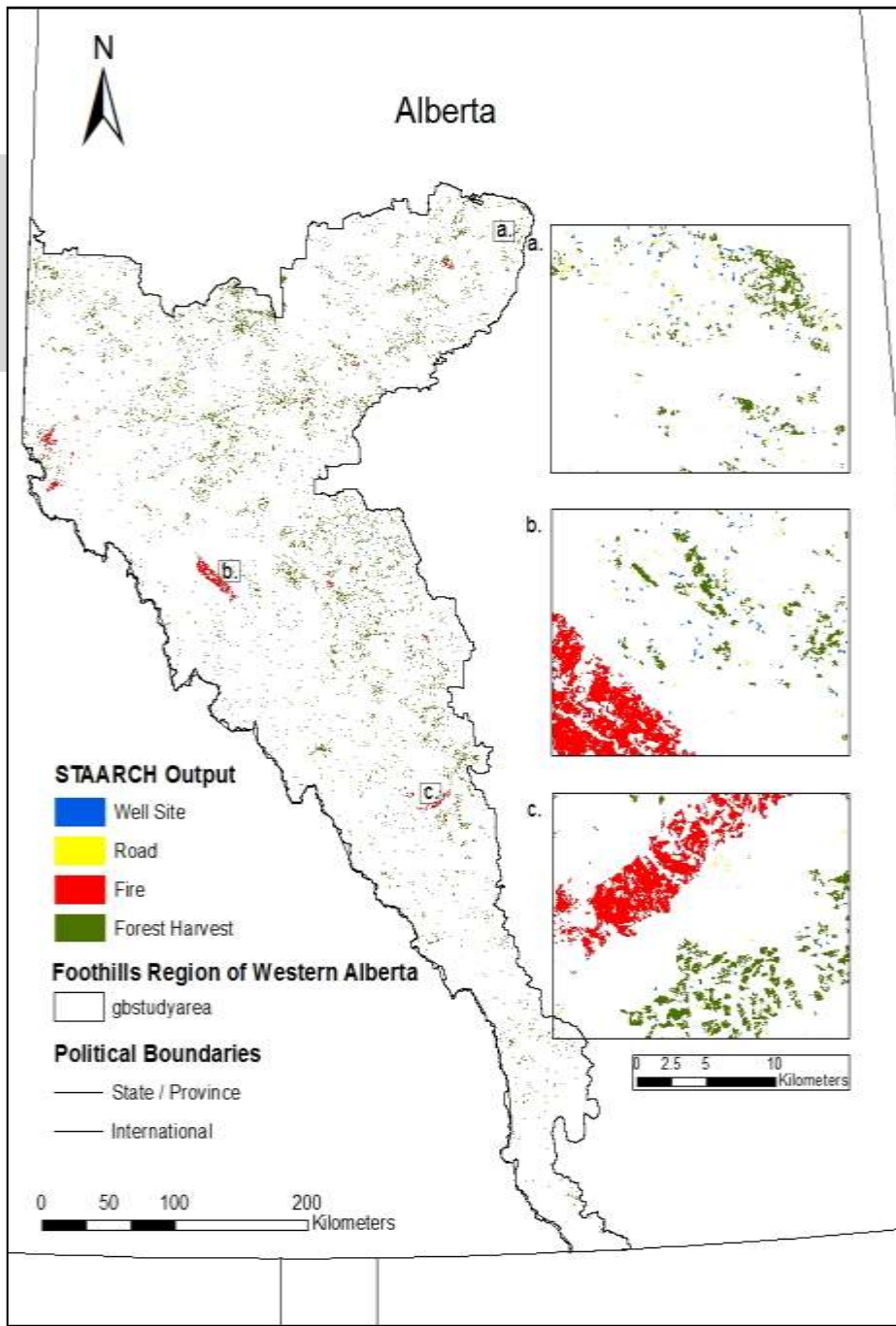
Green-up **Flower** **Senescence**

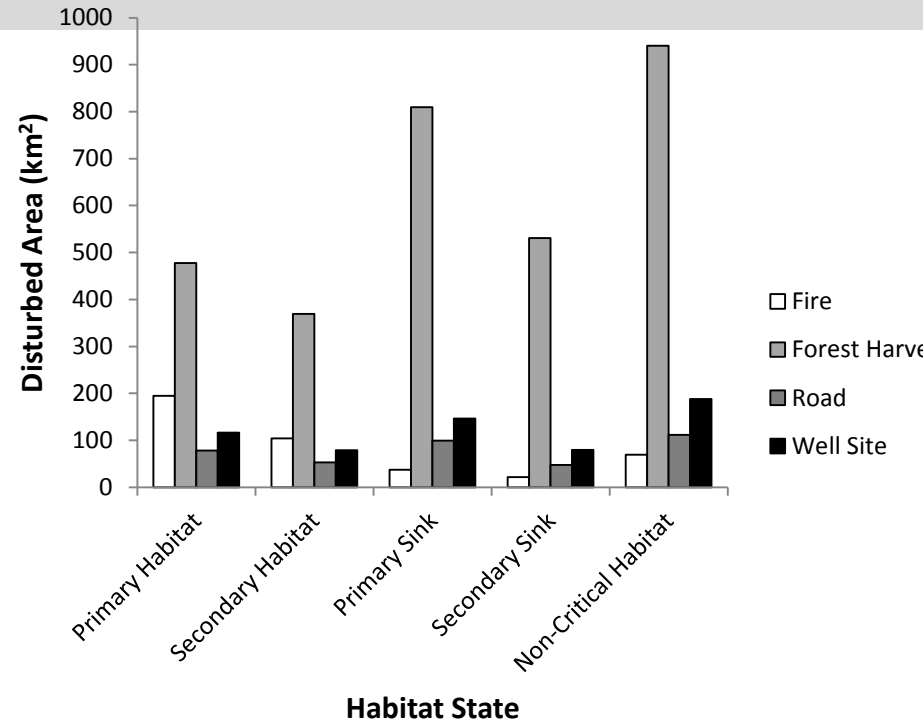
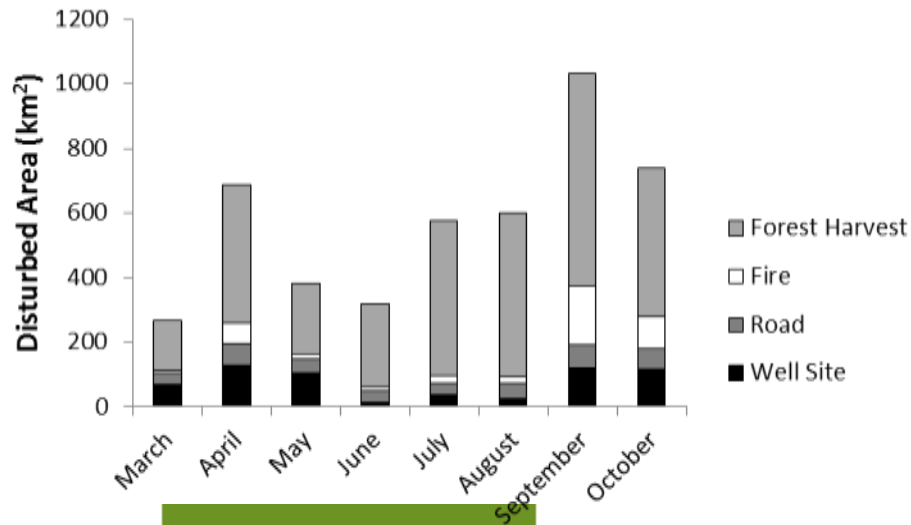
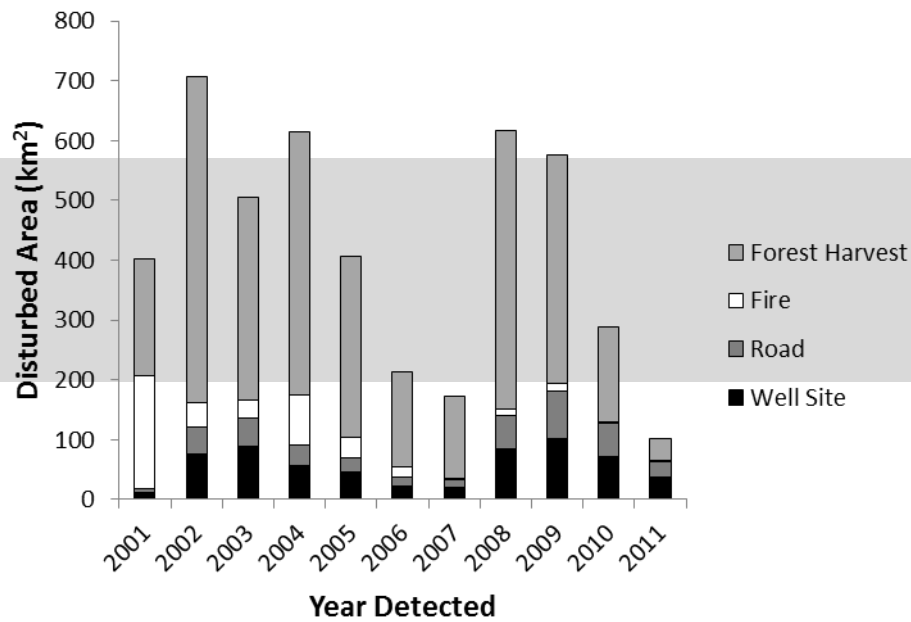






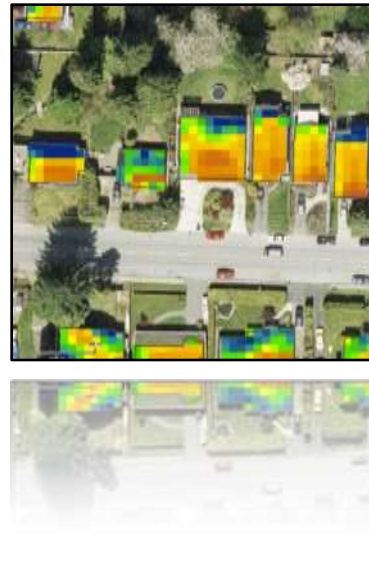
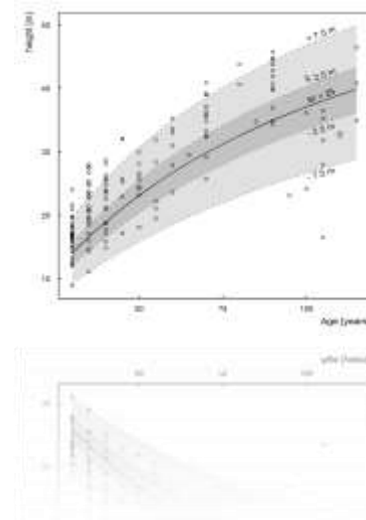
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- Research presented within undertaken by Dr Rory Tooke, Dr Colin Ferster, Dr Txomin Hermosilla, Dr Piotr Tompalski, Dr Wiebe Nijland
- Ryan Powers , Doug Bolton, Lin (Tony) Cao, Ryan Frazier, Paul Pickell, Greg Rickbeil (PhD Candidates)
- Michael Wulder and Joanne White (CFS)



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**That's
amazing...
I did not know
remote
sensing could
do that**

Dr. Nicholas Coops



Nicholas Coops,

Canada Research Chair in Remote Sensing
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