

# Multi-Scale Analysis of Arctic Vegetation Phenological Variability

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GRAND VALLEY  
STATE UNIVERSITY

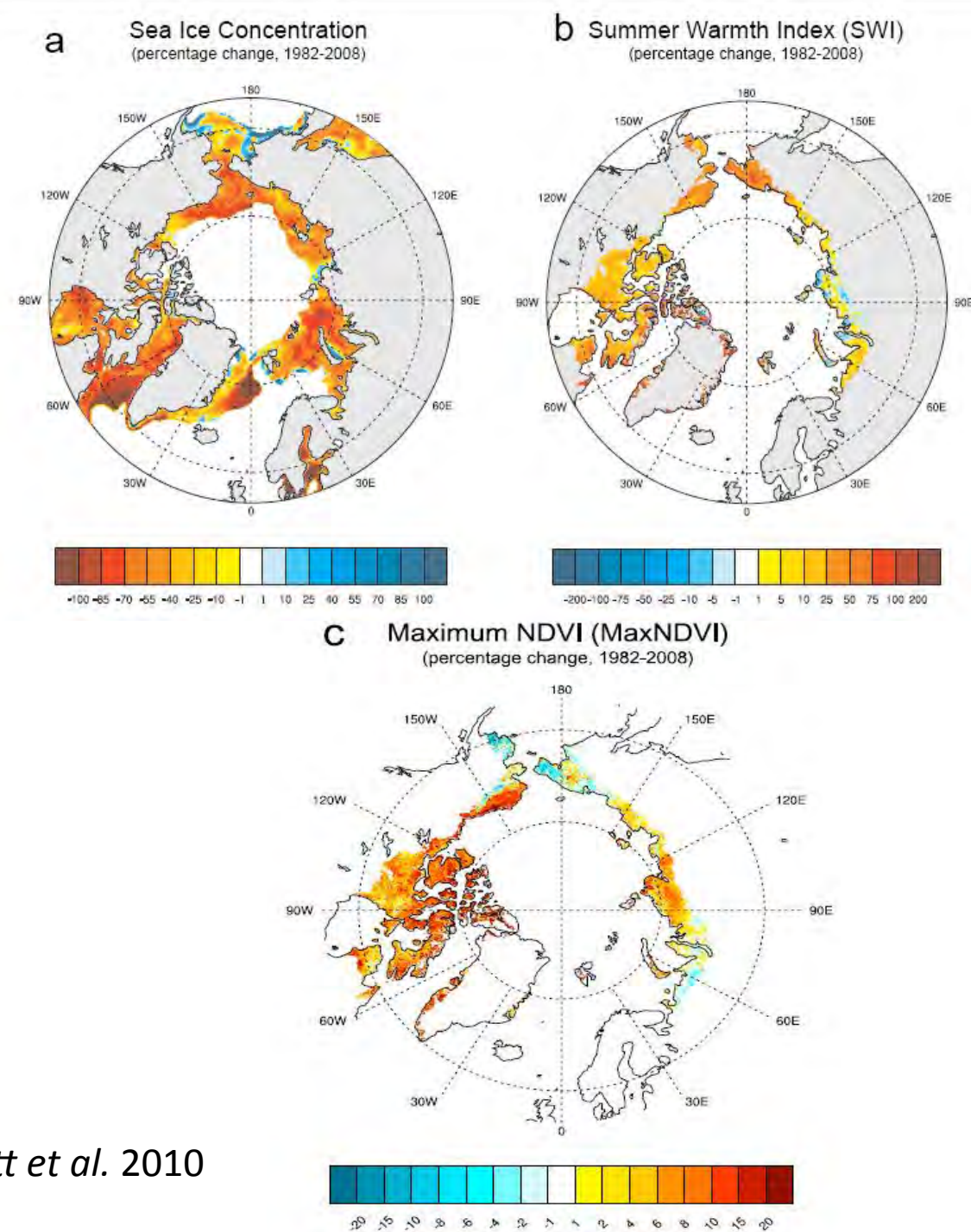
**FIU**

FLORIDA  
INTERNATIONAL  
UNIVERSITY



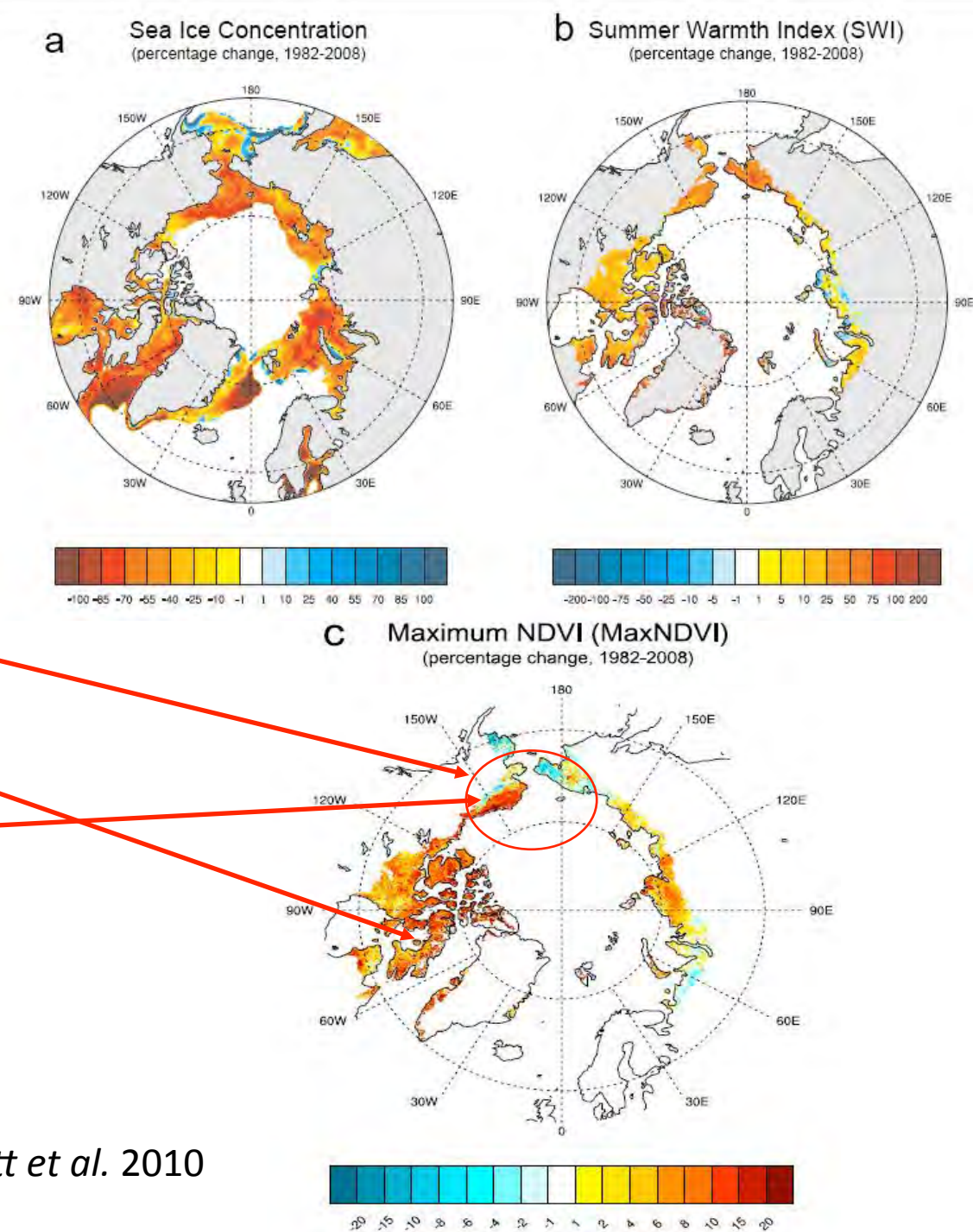
# Greening of the Arctic...

- Satellite-derived greening of the Arctic among the most recognized changes ongoing in the arctic
- ~ Increased plant biomass and productivity
- Recognized challenge interpreting relationship between satellite-derived and ground-based change.



# Greening of the Arctic...

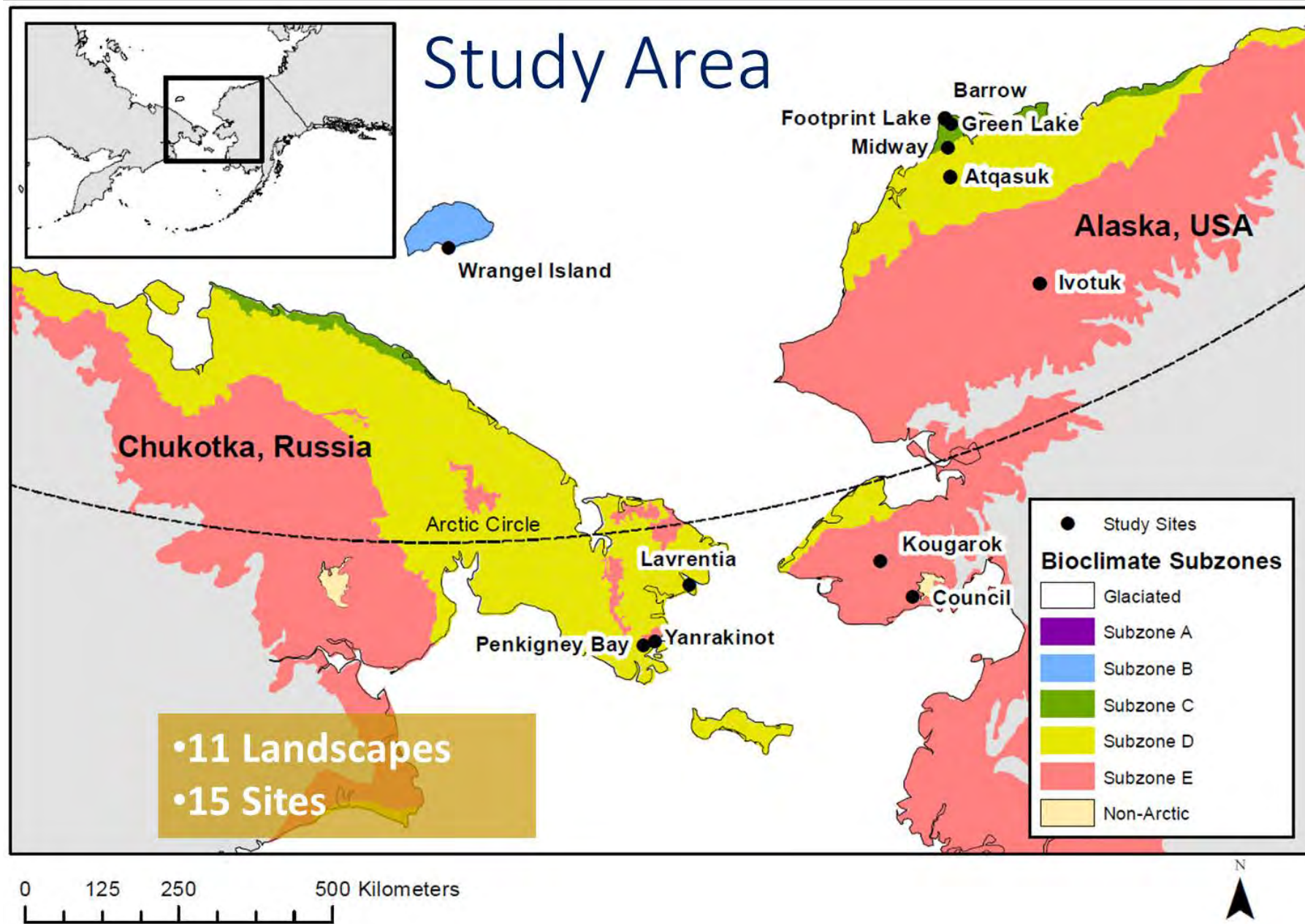
- Explored how the following impact greening
  1. Land cover change
  2. Successional change
  3. Land surface change
  4. Disturbance
  5. Spatio-temporal variability



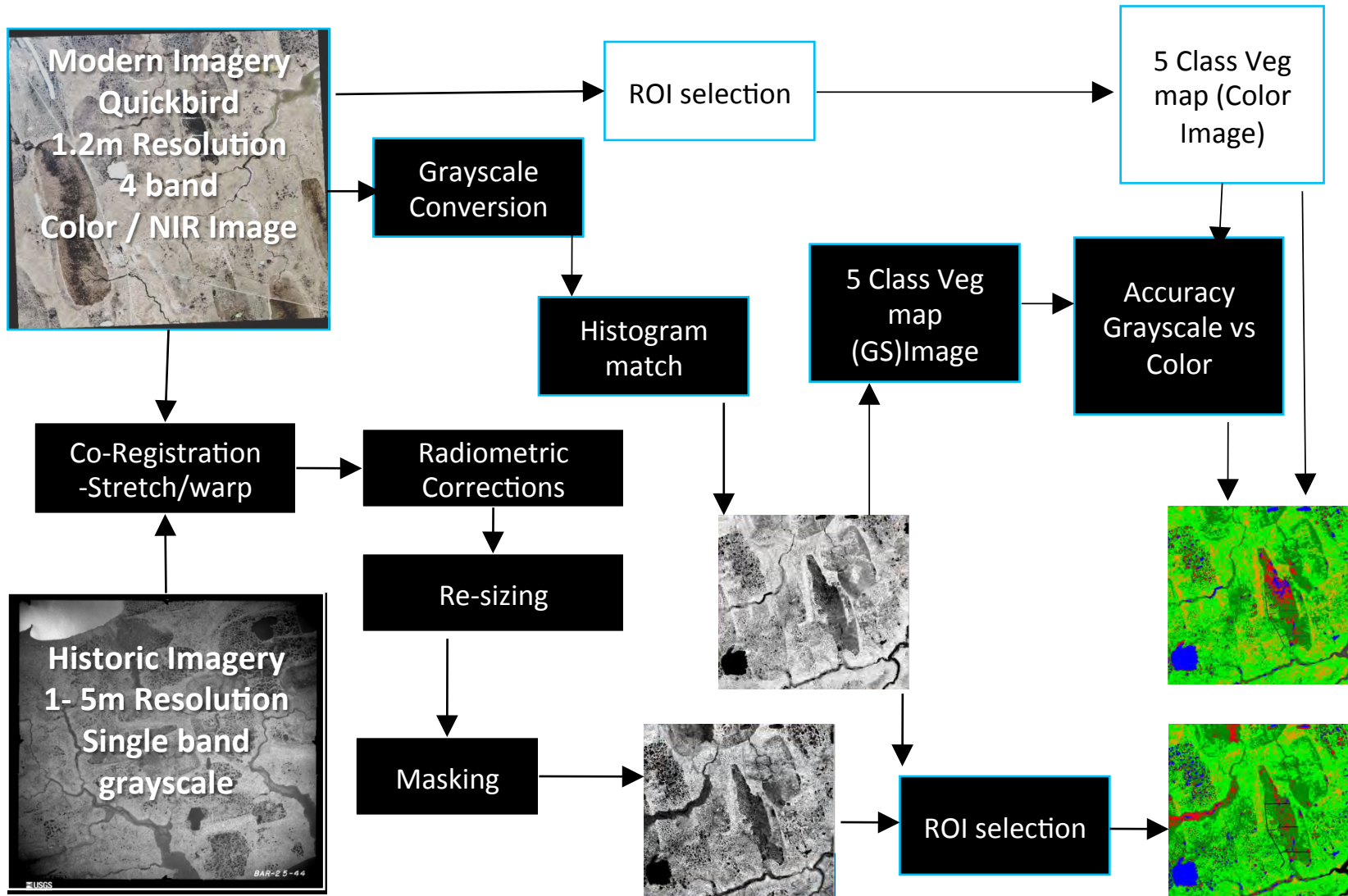
*Bhatt et al. 2010*



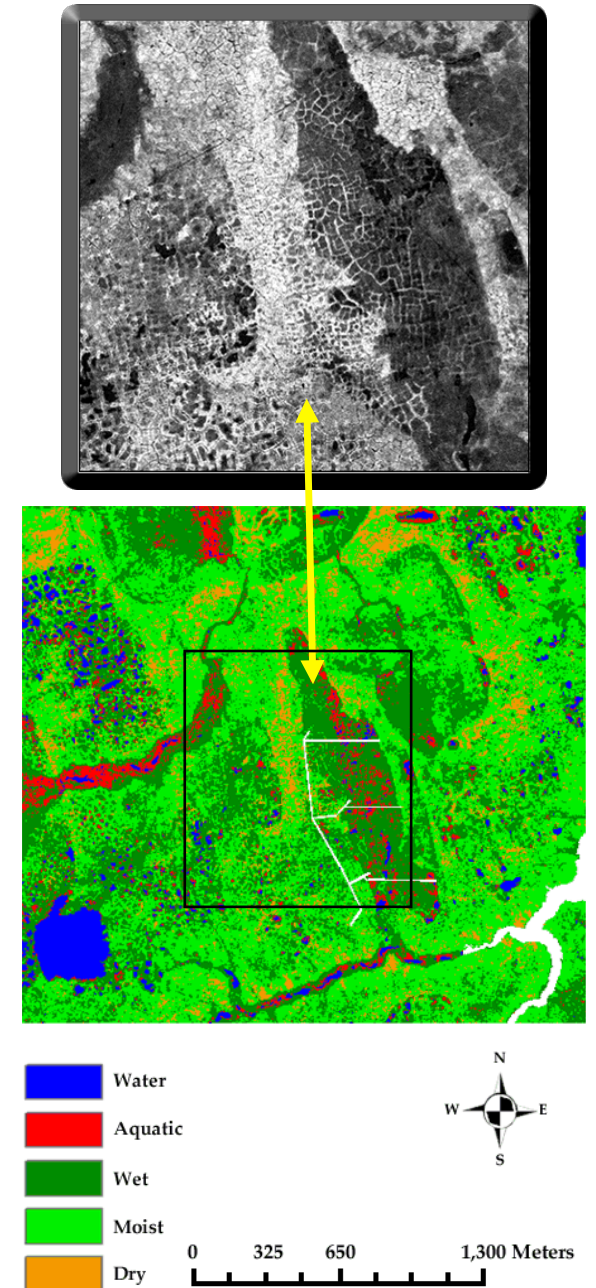
# 1. Land Cover Change ~ Lin et al. (2011) ERL



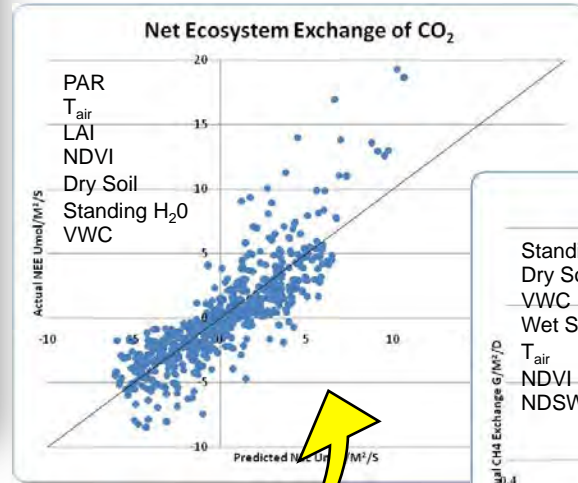
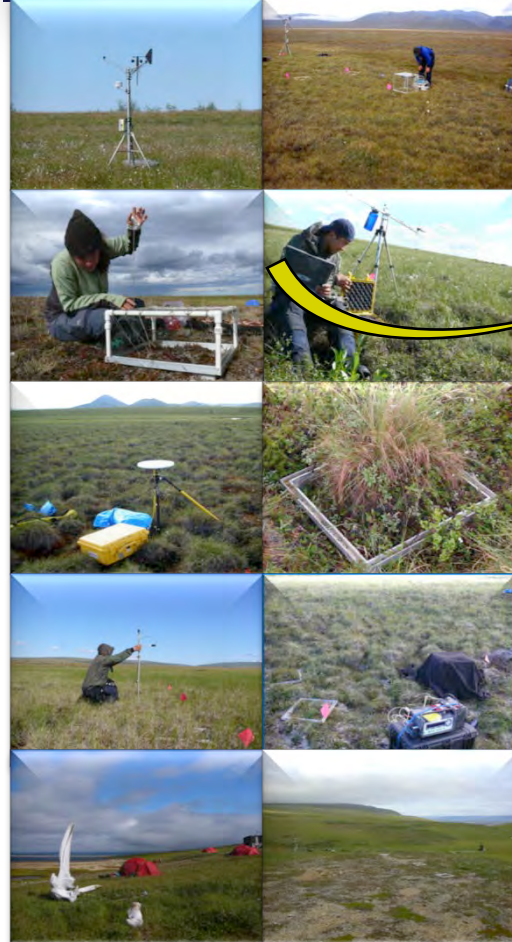
# Image Classification Workflow



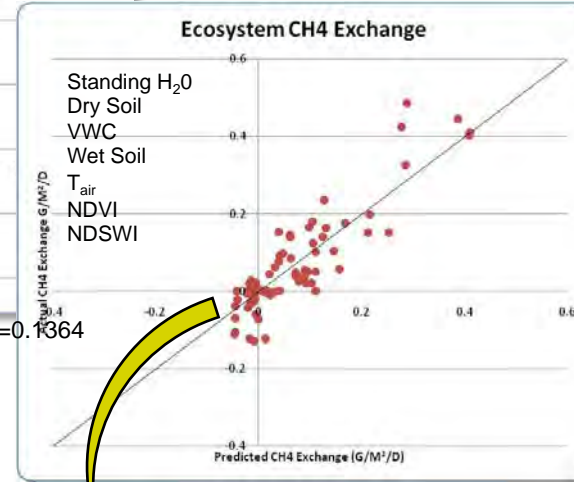
Barrow 1948-2008







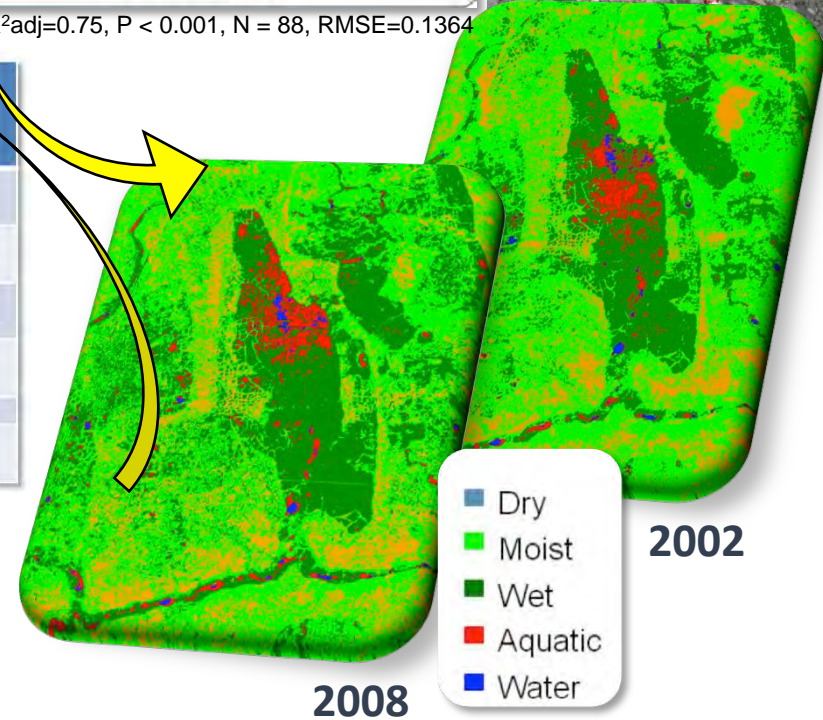
$R^2_{adj}=0.71$ ,  $P < 0.001$ ,  $N = 666$ ,  $RMSE=0.1364$



$R^2_{adj}=0.75$ ,  $P < 0.001$ ,  $N = 88$ ,  $RMSE=0.1364$

	Change in area m <sup>2</sup>	Net RF*	Change in landscape Net RF*
Dry	- 8,187	-0.49	+ 3,974.13
Moist	- 146,778	-0.43	+62,506.88
Wet	+132,052	+0.19	+ 25,158.55
Aquatic	+ 23,592	+1.70	+40,033.74
Total			+ 131,673.30

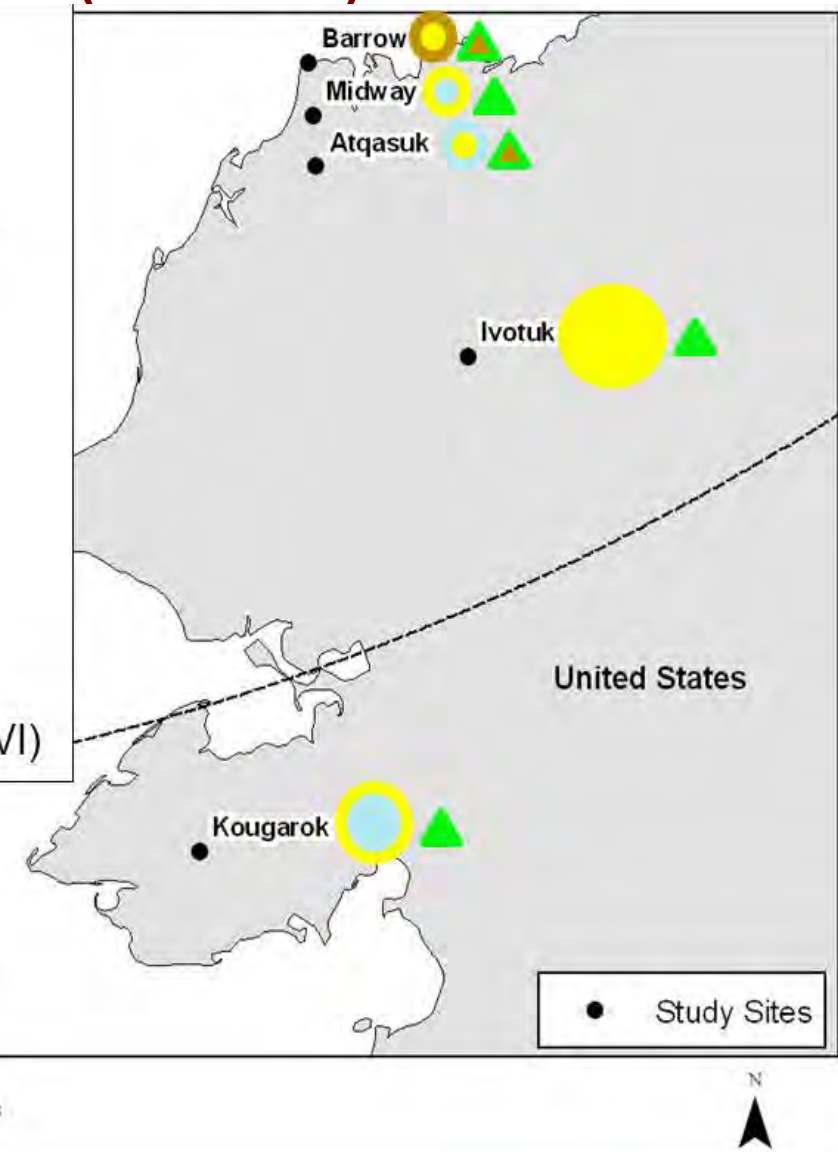
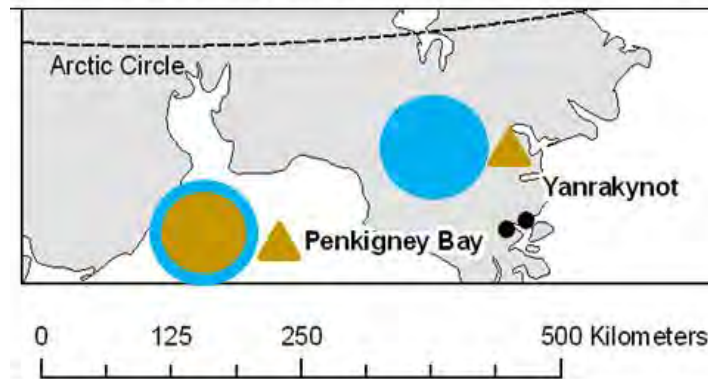
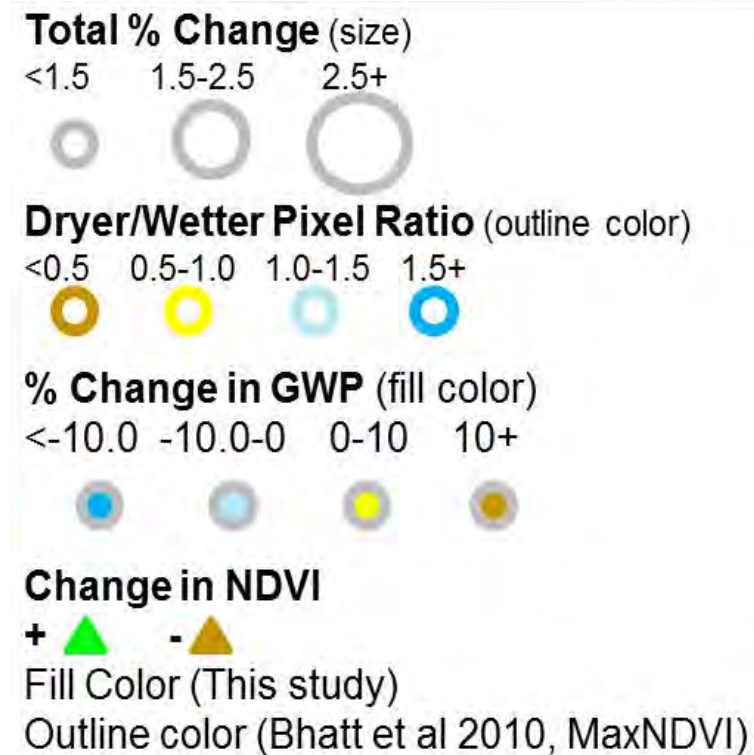
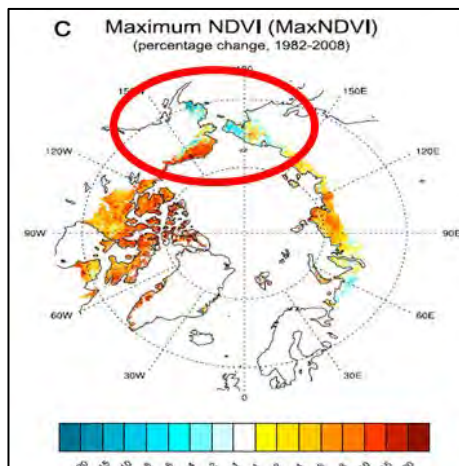
**20% increase**



# Mixed models of ecosystem function

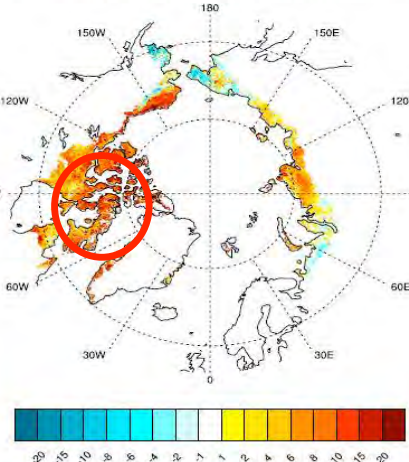


# 1. Land Cover Change ~ Lin et al. (2011) ERL





C Maximum NDVI (MaxNDVI)  
(percentage change, 1982-2008)



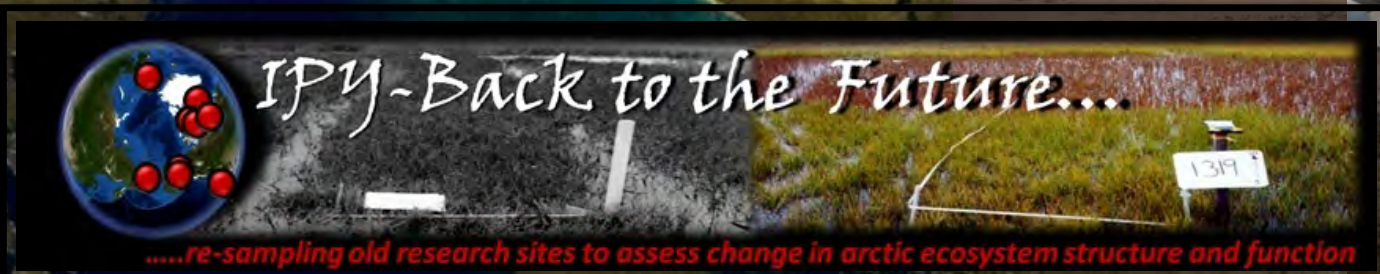
Barnes Ice Cap

Study Area

## 2. Successional change ~ Baffin Island



Pat Webber 1963/2010





1963-2009

*Bhatt et al. 2010*







1963-2009

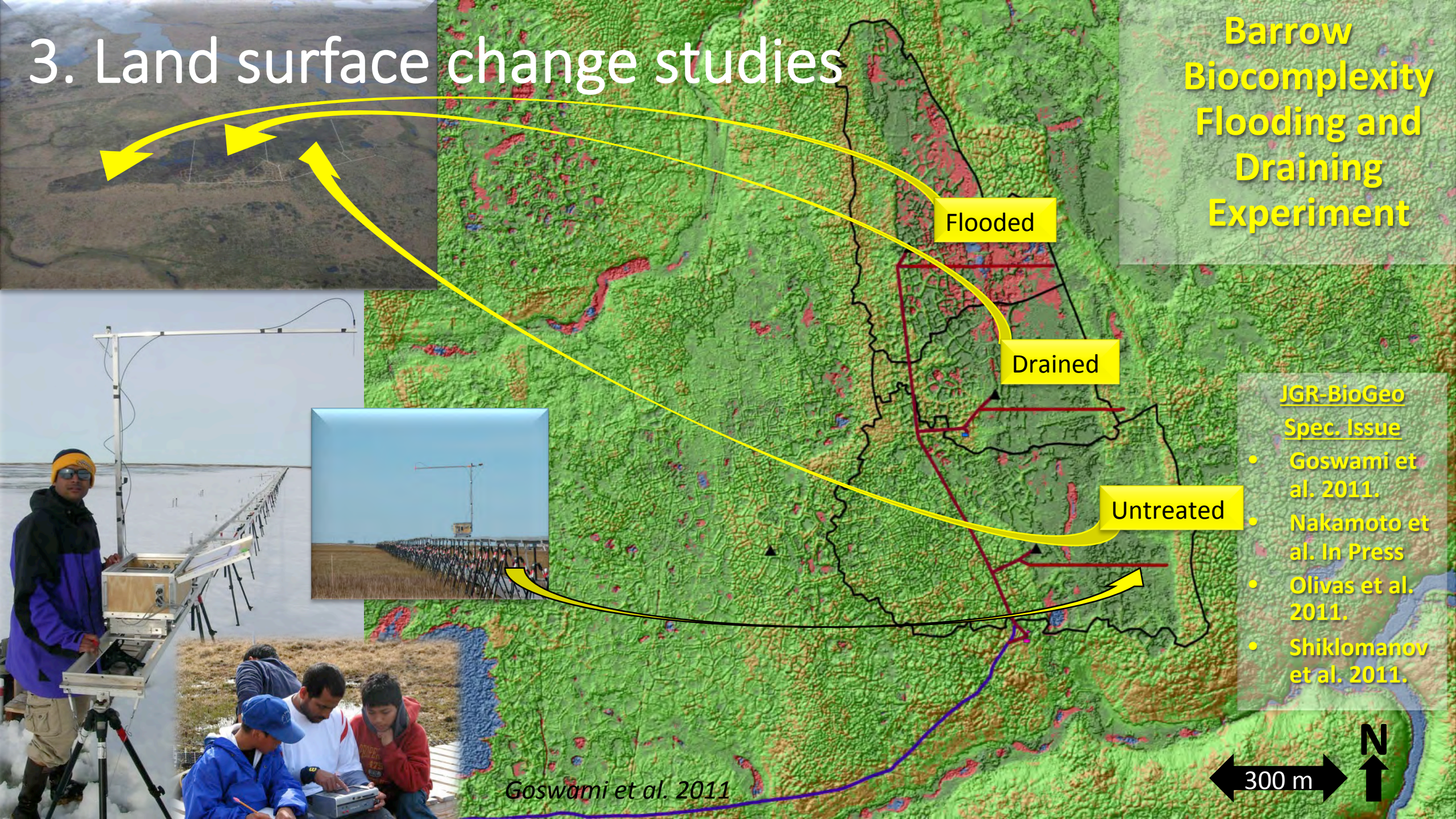


*Bhatt et al. 2010*



### 3. Land surface change studies

#### Barrow Biocomplexity Flooding and Draining Experiment



#### JGR-BioGeo Spec. Issue

- Goswami et al. 2011.
- Nakamoto et al. In Press
- Olivas et al. 2011.
- Shiklomanov et al. 2011.

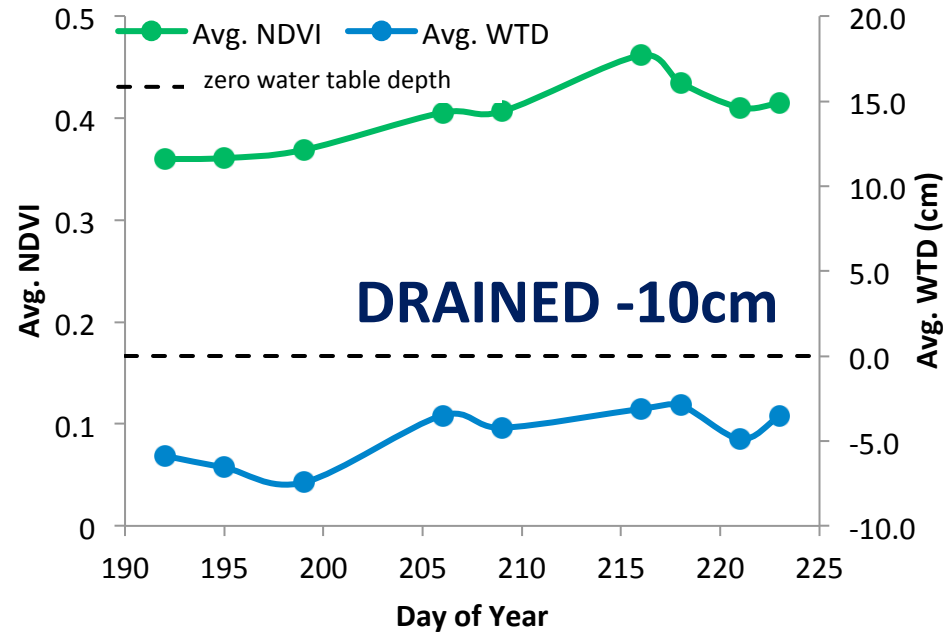
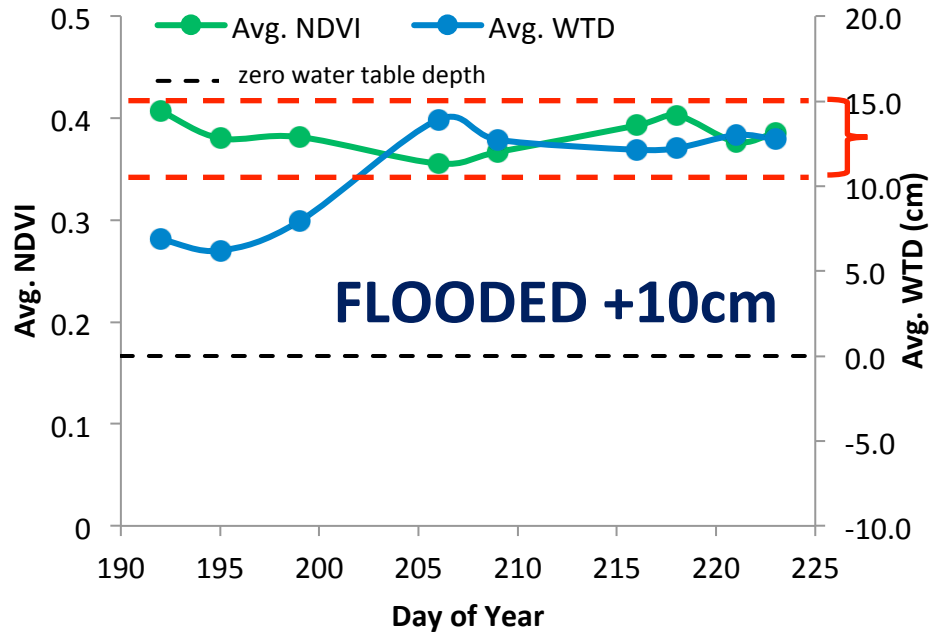
Goswami et al. 2011

300 m

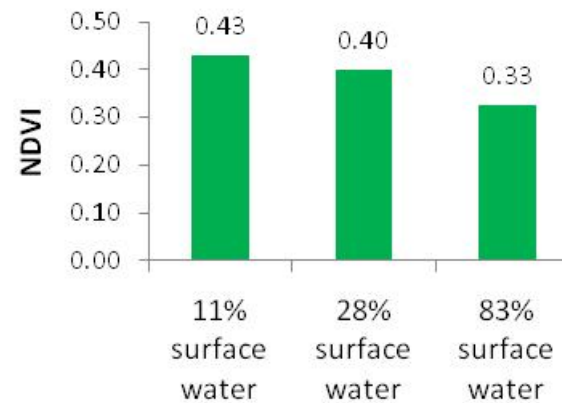




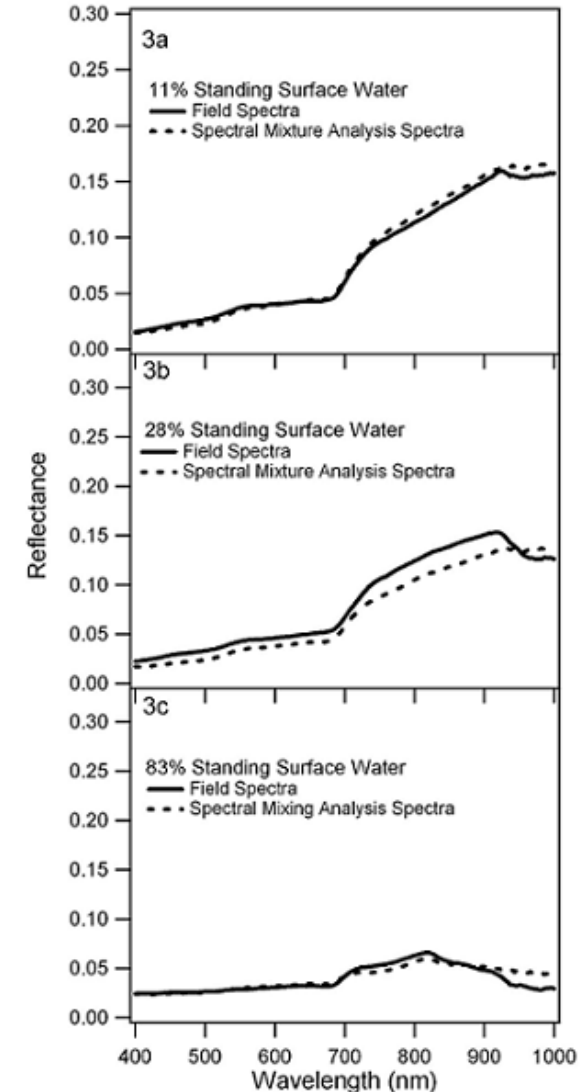
# NDVI during peak growing season 2008 (Goswami et al. 2011):



- Surface water confounds NDVI
- 70% reduction in surface water cover can increase NDVI by 25%
- Drying can increase greening
- **Are we missing the drying of the Arctic?**
- **And/or are we under-estimating greening of the Arctic?**



*NDVI decreases by almost 25% when surface water cover increases by 70%.*

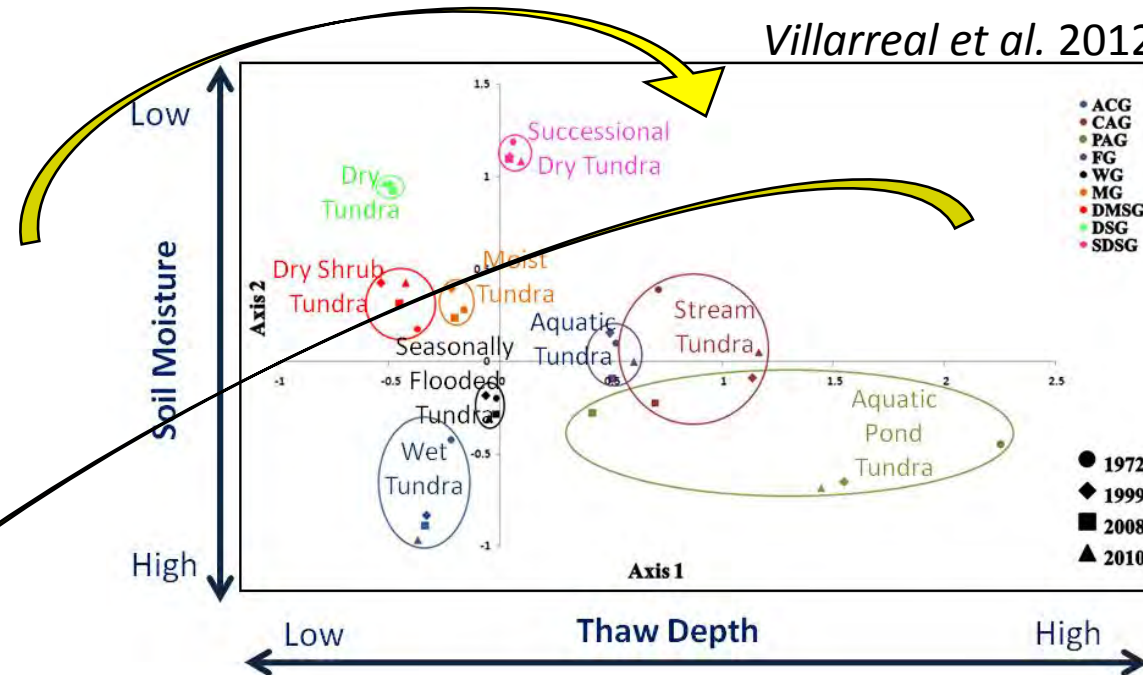




# 4. Disturbance ~ Herbivory

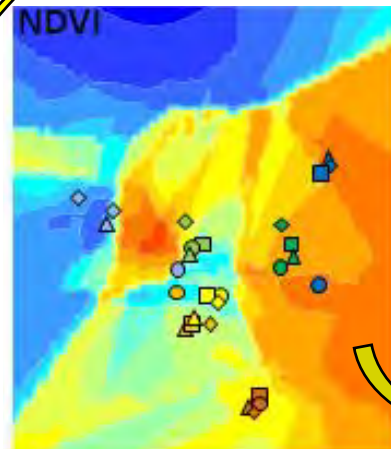
1. Measure structural and functional traits on destructive plots

Villarreal et al. 2012

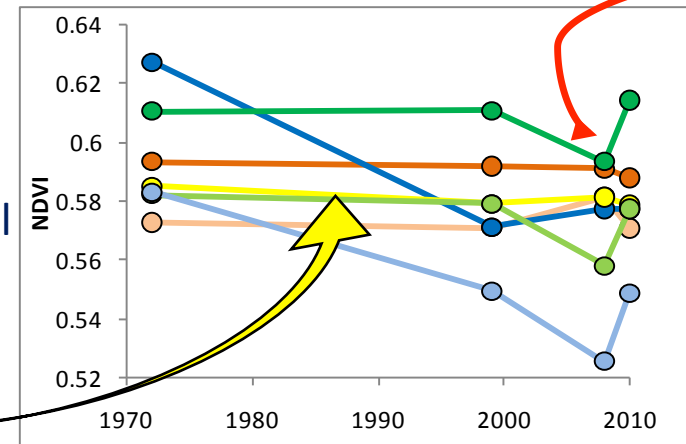


2. Ordination of historic and destructive plots

3. Surface plots of ecosystem functional traits



4. Time series of functional traits

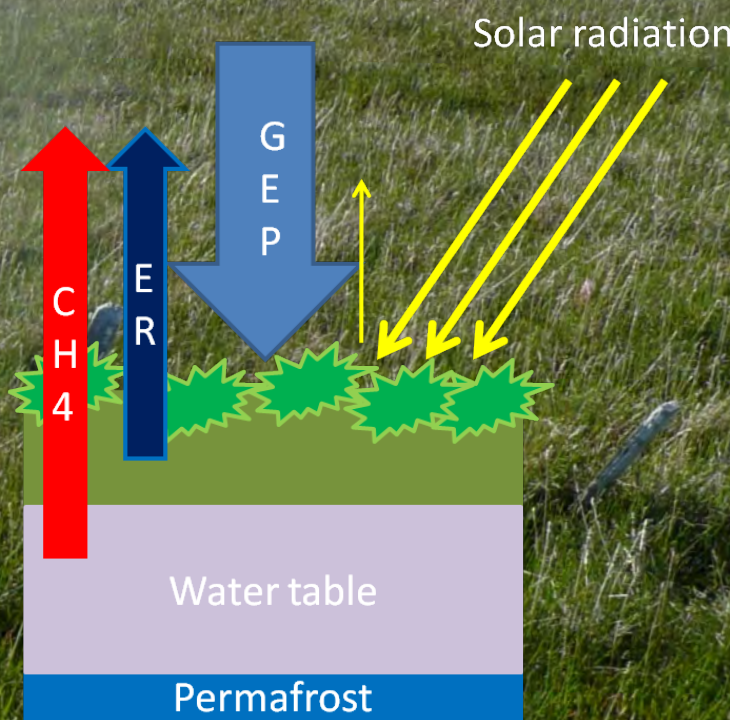
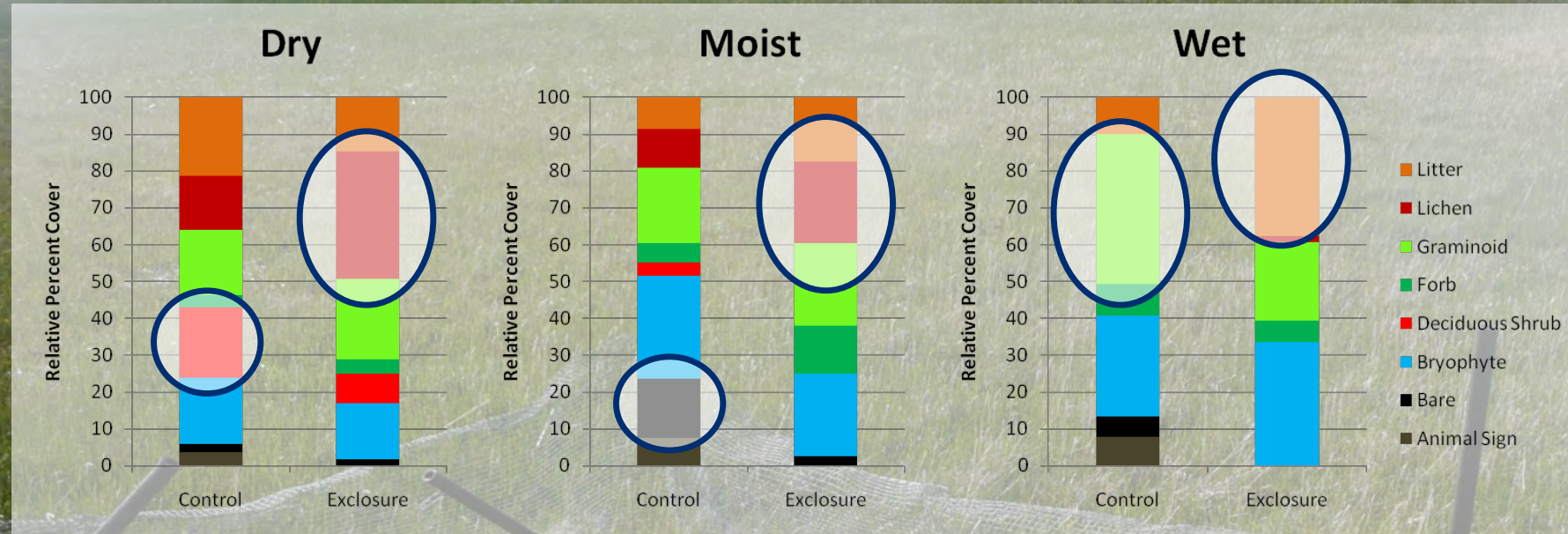


Lara et al. 2012

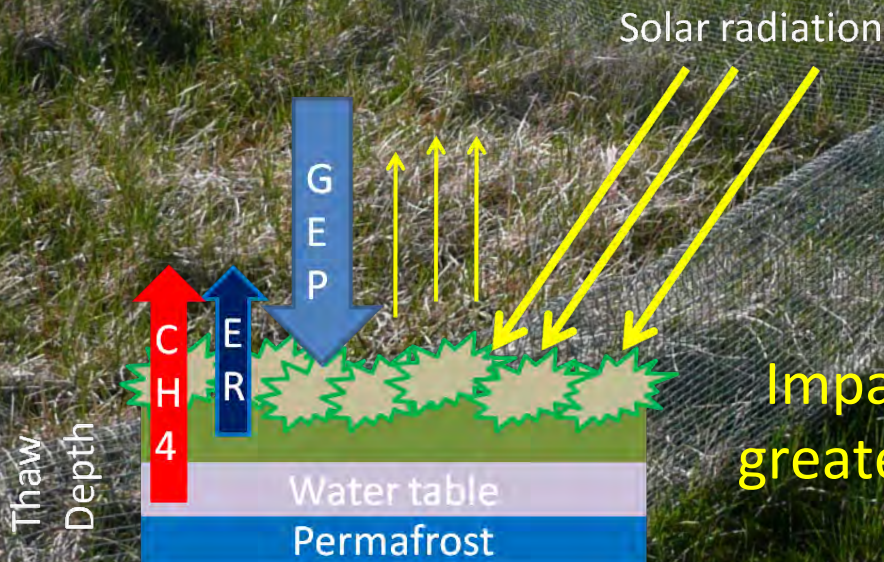




Tundra ecosystem structure and function is altered by a sustained absence of herbivory (Johnson et al. 2011; Lara et al. 2017)



Not Grazed  
Since 1950's

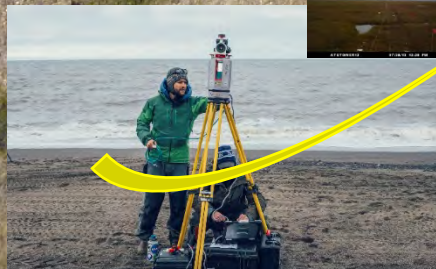
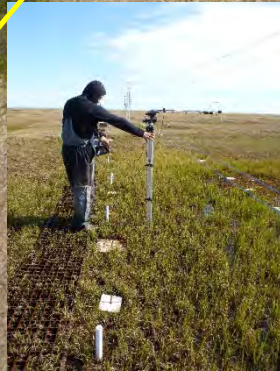
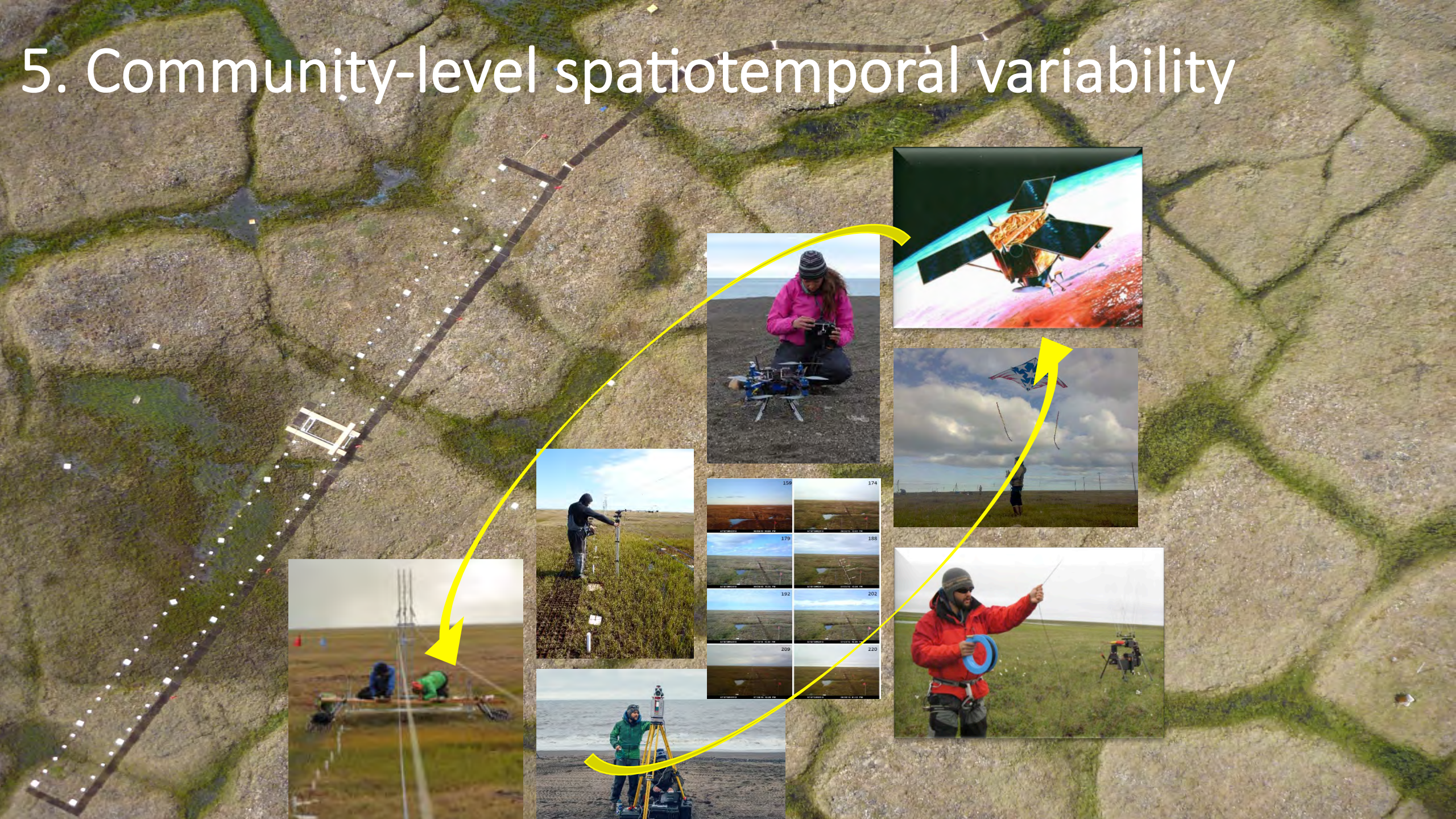


Impact of sustained herbivory  
greater than most experimental  
manipulations

Grazed

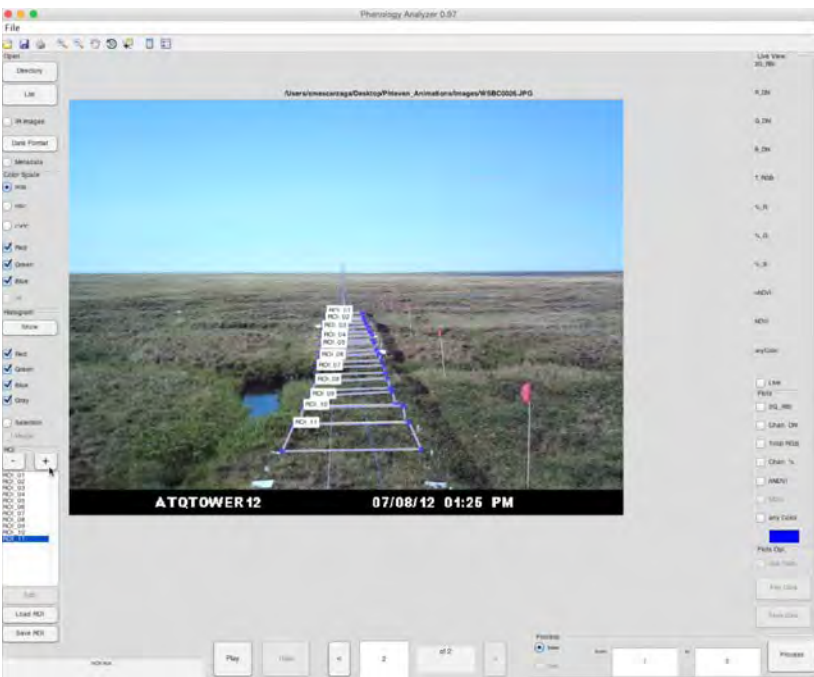
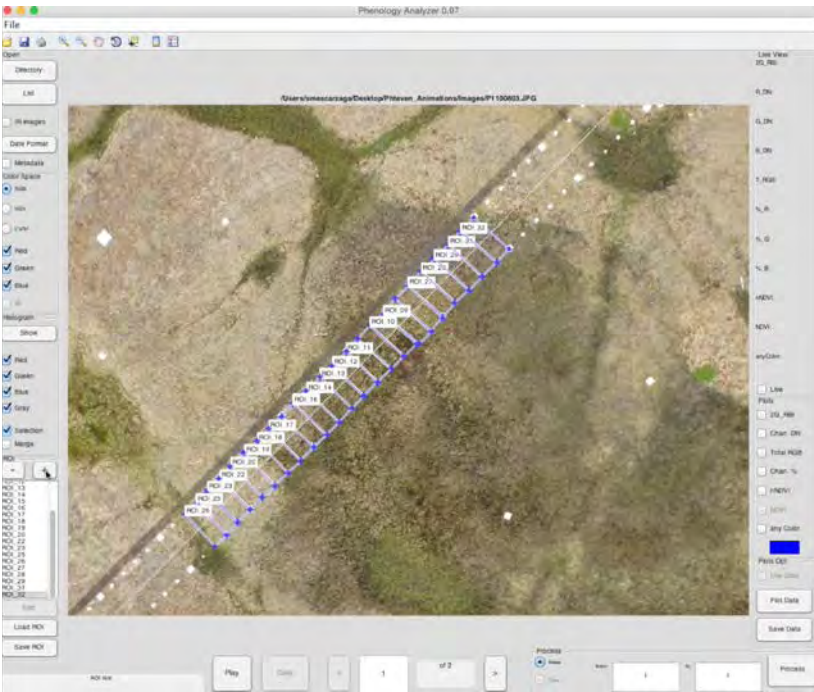
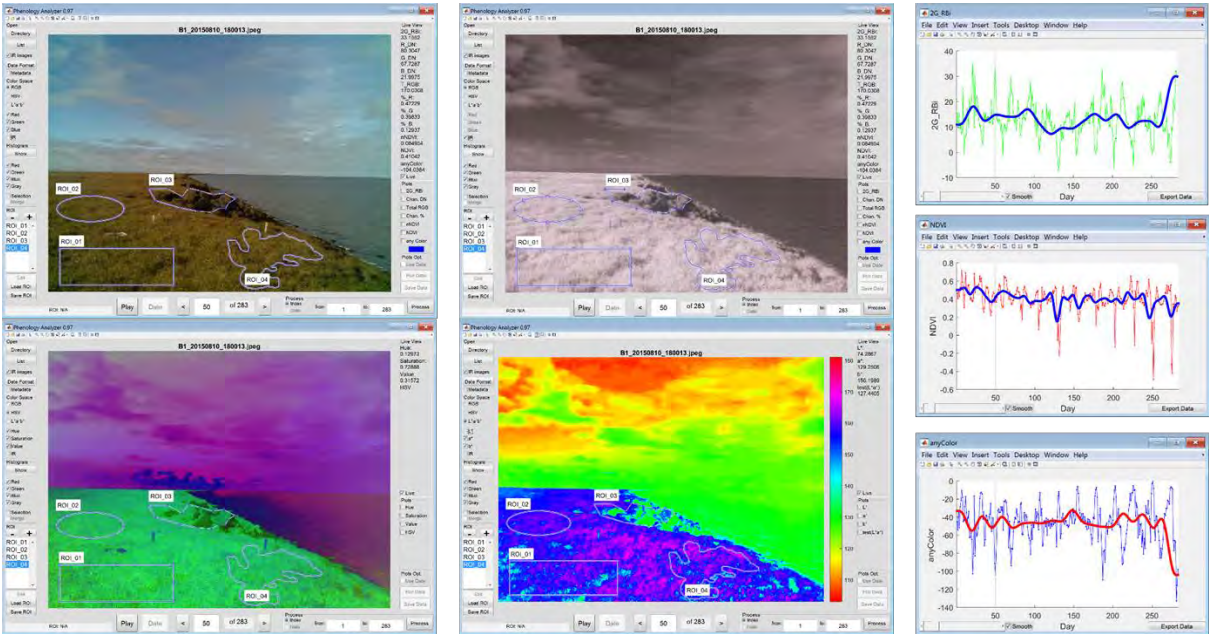


# 5. Community-level spatiotemporal variability



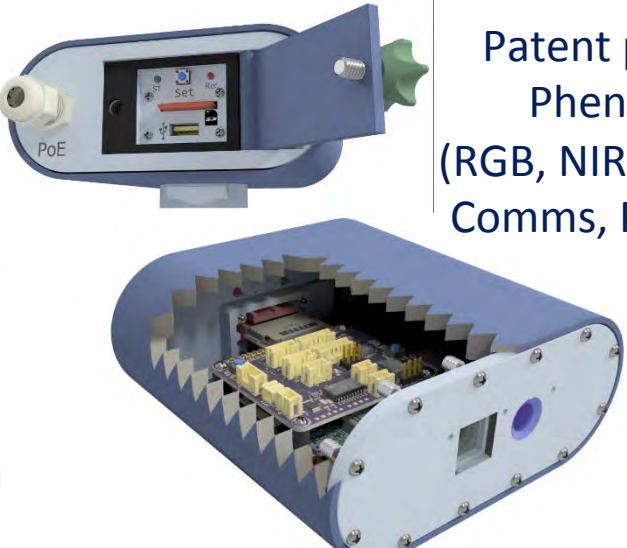
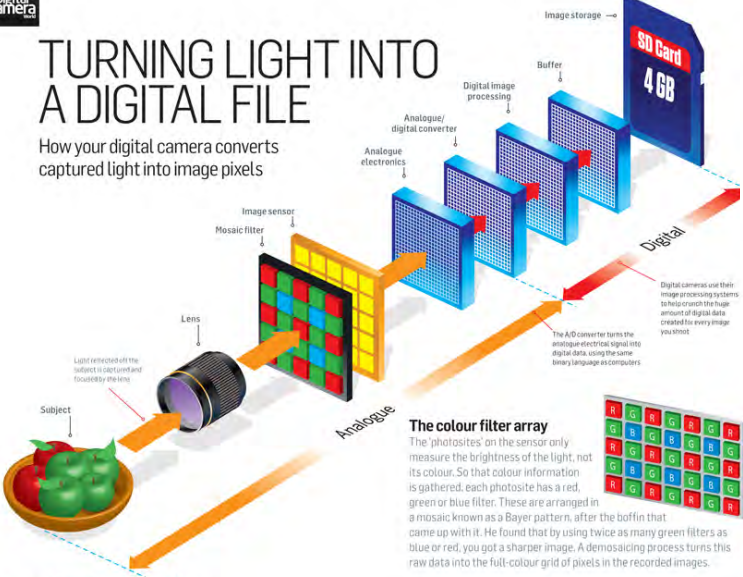


# Digital Image Analysis



## TURNING LIGHT INTO A DIGITAL FILE

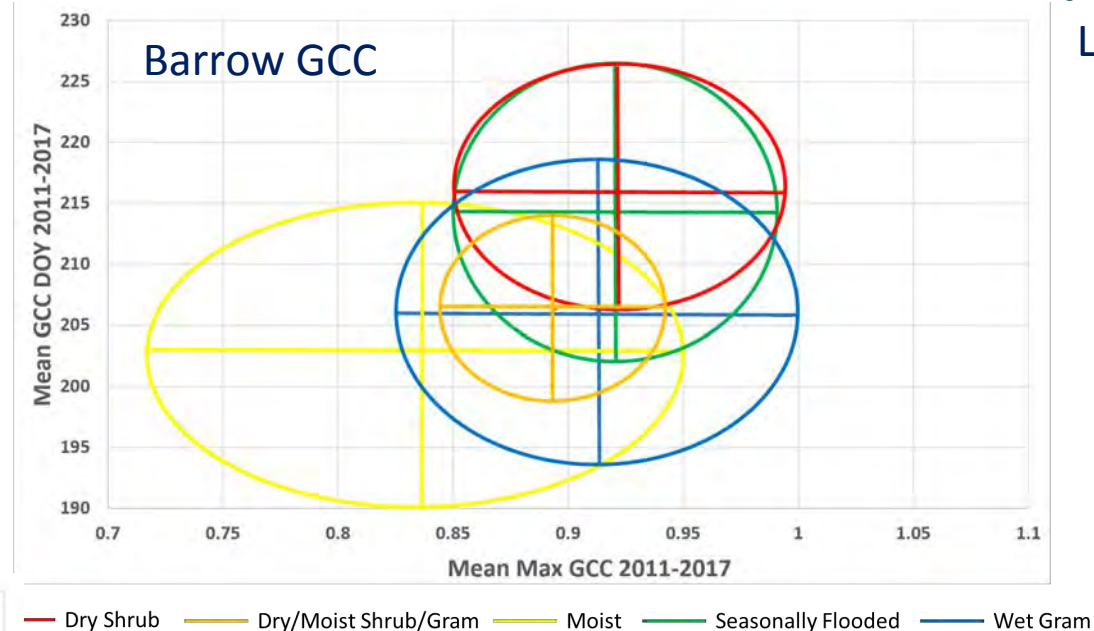
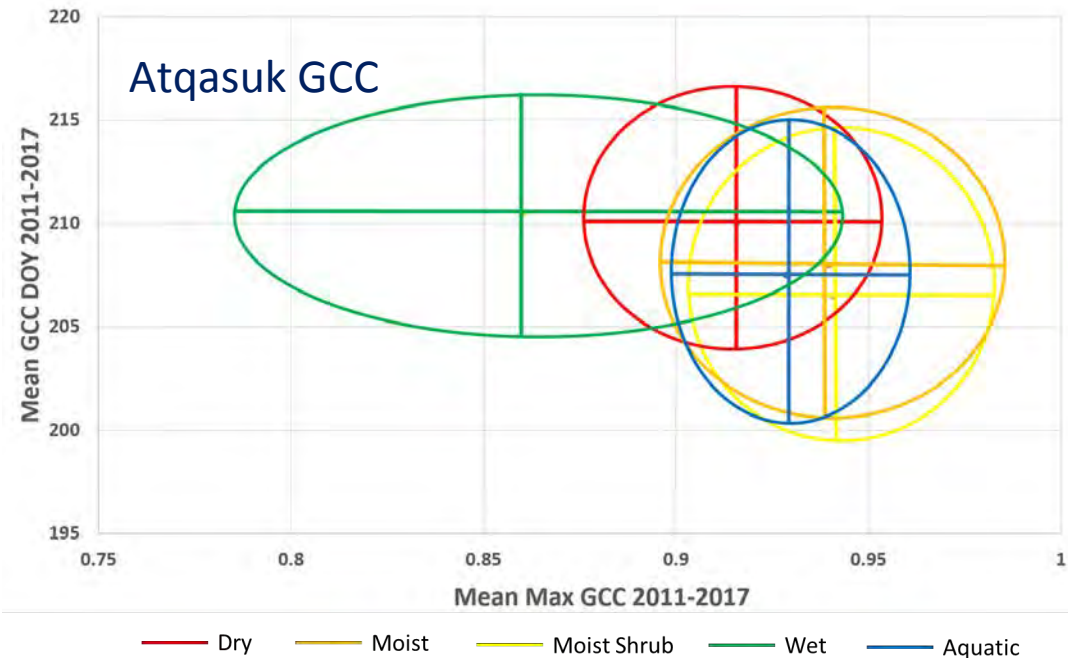
How your digital camera converts captured light into image pixels



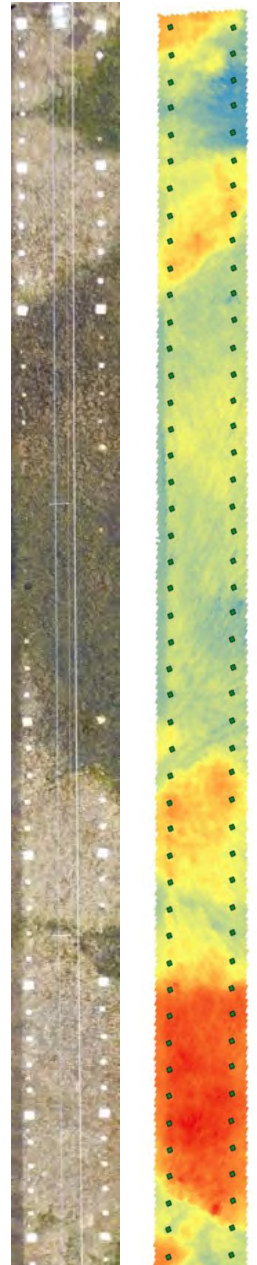
Patent pending  
Phenocam  
(RGB, NIR, Thermal;  
Comms, Rugged...)



# Variability in Max Green Chromatic Content (GCC) between plant communities and locations 2011-2017



Barrow MISP Grid & LiDAR Elevation



- Wet and moist plant communities demonstrate greatest variability
- Classification not joined between Barrow and Atqasuk... evidence of variation nonetheless



# Take Home Messages

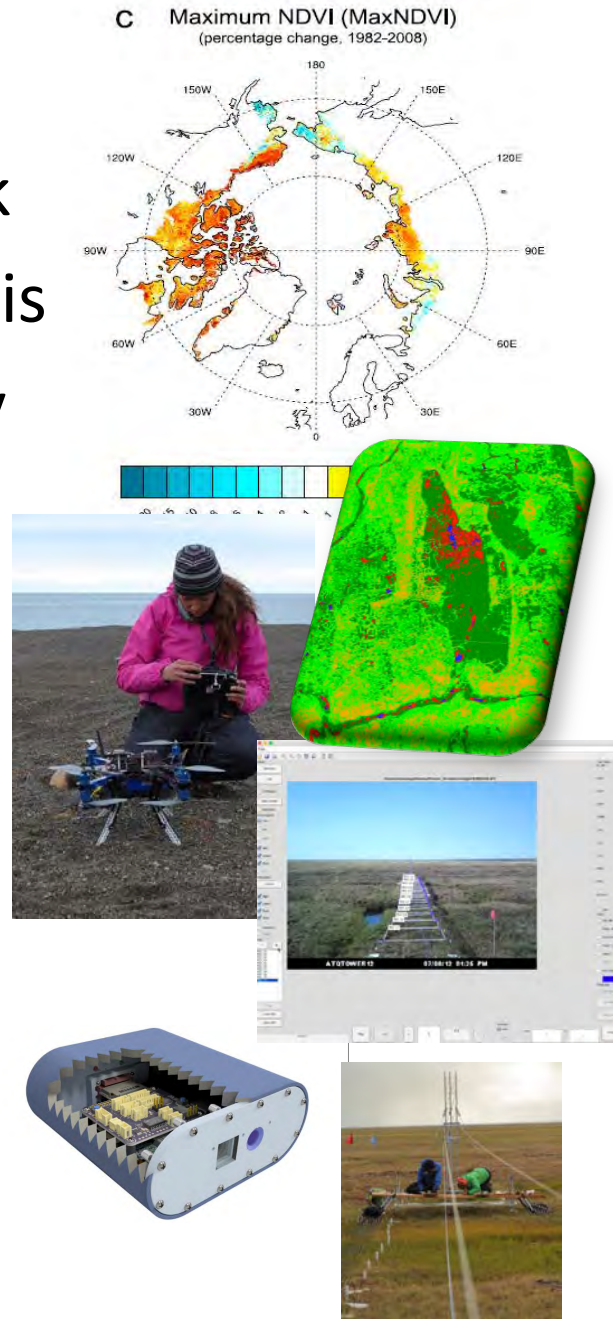
- Multiple interacting ecosystem properties and processes impact greening trends
- Need for new and/or multi-index analyses and other RS approaches to isolate and identify relative importance of different drivers of change
- Ground and mid-scale remote sensing platforms key to success
- New lost-cost low-tech solutions increasingly available
- ITEX sites and partners uniquely poised to catalyze advances in scaling studies



# New synthesis?

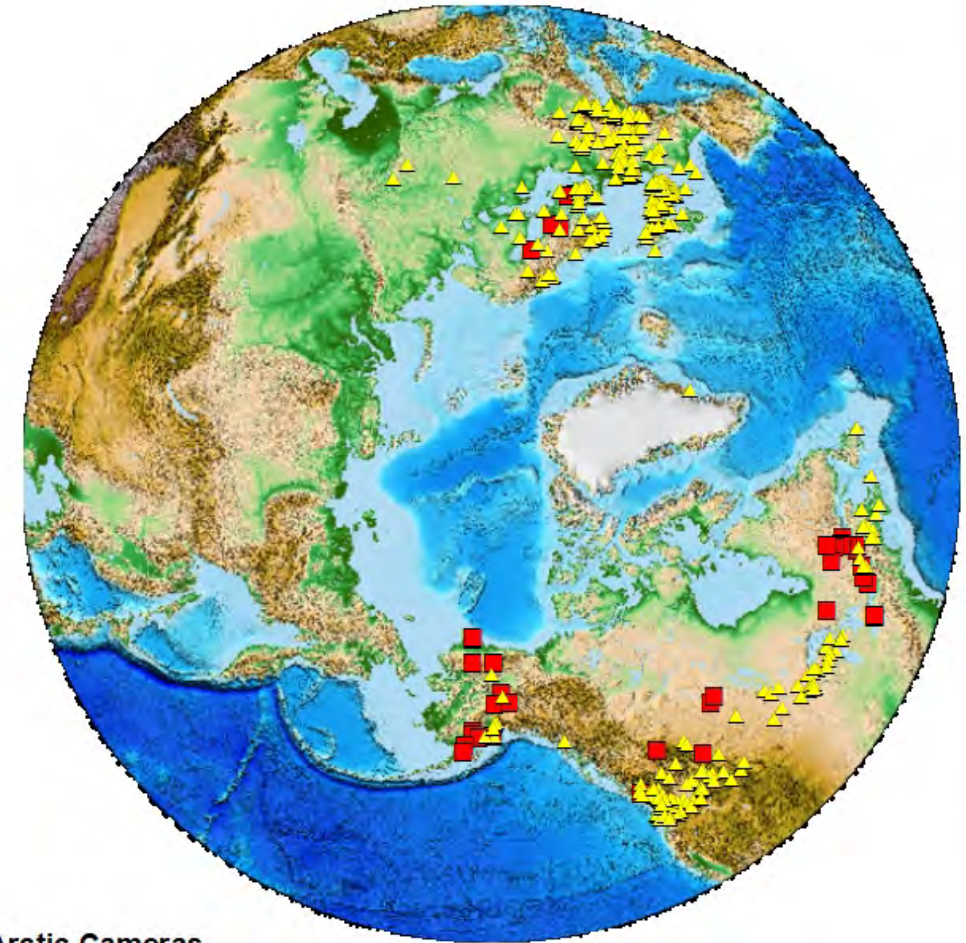
- Build phenocam network
- Share capacity for analysis
- Acquire high-res imagery
- Scale to landscape
- Synthesize findings

Advance understanding of  
lower scale ecosystem  
properties and processes  
manifest as large scale  
change



## Arctic Webcam and Phenocam Locations

(Approx. 45 Science, 400 public)

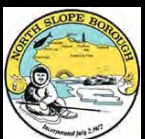


A.G. Gaylord, A. Kassim, W.F. Manley, R. Cody, M. Dover, R. Score, and C.E. Tweedie, 2014. Arctic Research Mapping Application (ARMAP). Englewood, Colorado USA: CH2M HILL Polar Services. Digital Media. <http://www.armac.org> Amante, C. and B. W. Eakins, ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis. NOAA Technical Memorandum NESDIS NGDC-24, 19 pp, March 2009.





CIAP



UMIAQ



Thanks for Watching!

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