Incorporating Data from Several Remotely Sensed Platforms to Map Current and Potentially Restorable Wetlands

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Outline

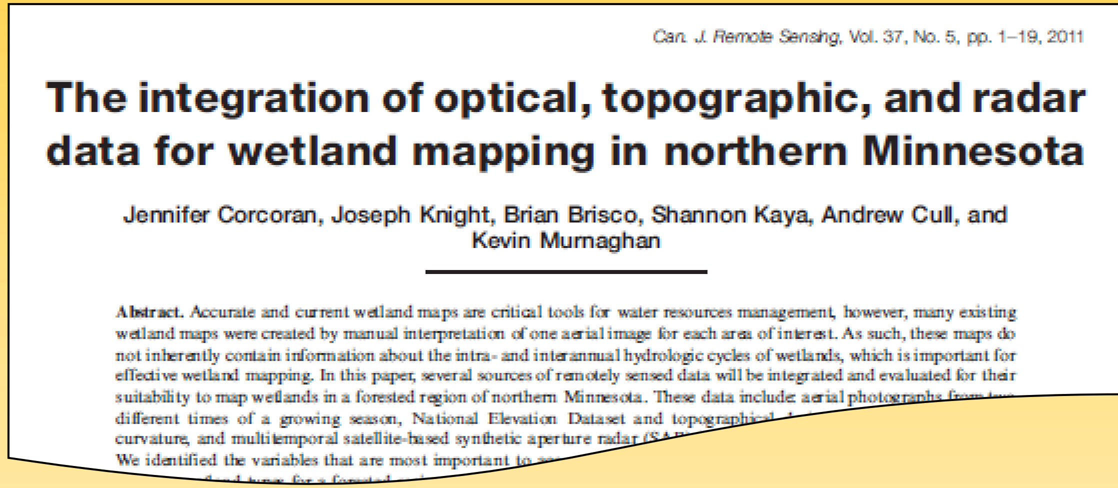
- Background, Motivation, & Previous Work
- Study Site, Data & Methodology
- Results & Conclusions
- Ongoing & Future work

Background & Motivation

- Why should we care about wetlands?
  - Water quality, wildlife habitat, runoff, flooding…
- “Can’t manage what you don’t measure”
- Radar not affected by clouds or night
- Other data representative of structure and potential of H_2O presence
- Statewide assessment and monitoring requires affordable products

Previous Work

- Previous work:
  - Aerial photos, Radarsat-2, & topo data at higher resolution
  - Best datasets included summer blue band, spring red & NIR bands, and elevation
  - Comparatively lower overall accuracy
    = 72% Optical, Topo only
    = 75% Optical, Topo, and Radarsat-2



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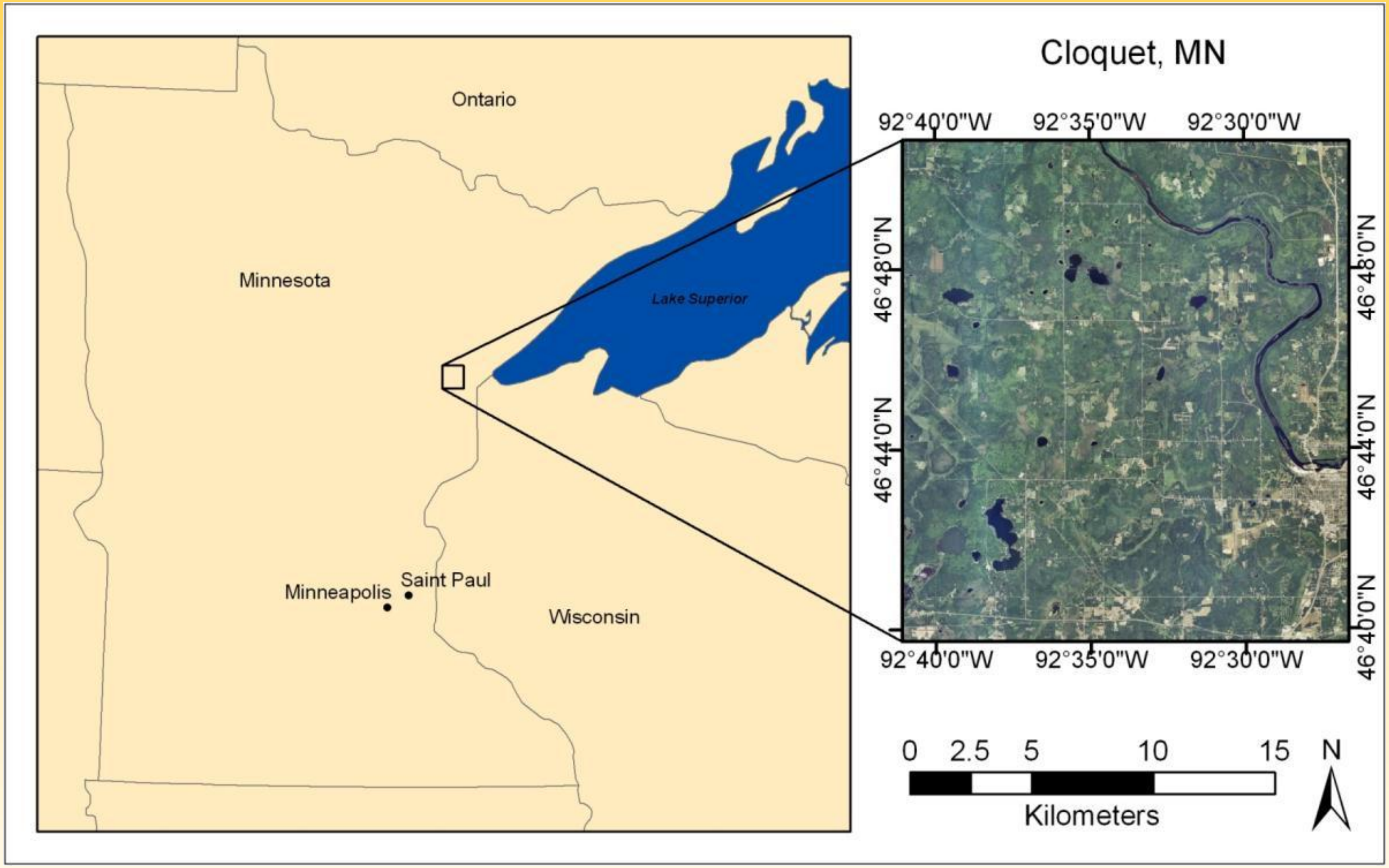
The integration of optical, topographic, and radar data for wetland mapping in northern Minnesota

Jennifer Corcoran, Joseph Knight, Brian Brisco, Shannon Kaya, Andrew Cull, and Kevin Murnaghan

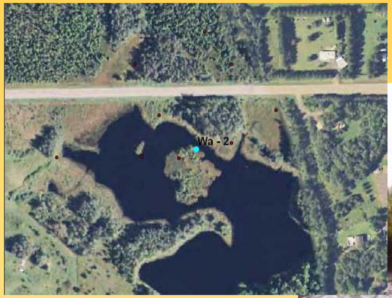
Abstract. Accurate and current wetland maps are critical tools for water resources management, however, many existing wetland maps were created by manual interpretation of one aerial image for each area of interest. As such, these maps do not inherently contain information about the intra- and interannual hydrologic cycles of wetlands, which is important for effective wetland mapping. In this paper, several sources of remotely sensed data will be integrated and evaluated for their suitability to map wetlands in a forested region of northern Minnesota. These data include aerial photographs from two different times of a growing season, National Elevation Dataset and topographical curvature, and multitemporal satellite-based synthetic aperture radar (SAR We identified the variables that are most important to

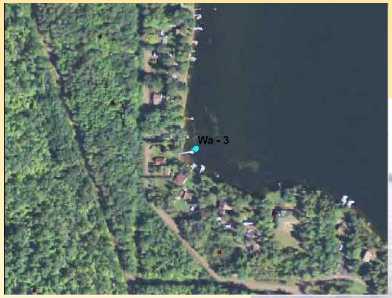
Study Site

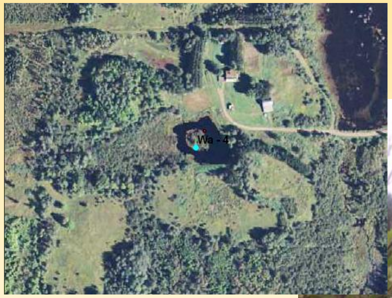


Ontario
Minnesota
Lake Superior
Minneapolis
Saint Paul
Wisconsin
Cloquet, MN
92°40'0"W
92°35'0"W
92°30'0"W
46°48'0"N
46°44'0"N
46°40'0"N
0
2.5
5
10
15
Kilometers
N

Classification - Water







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Classification – Emergent

Classification - Forested

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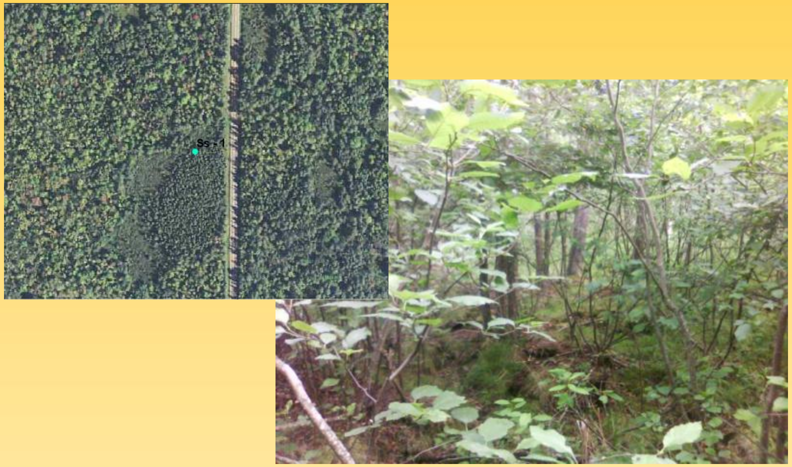
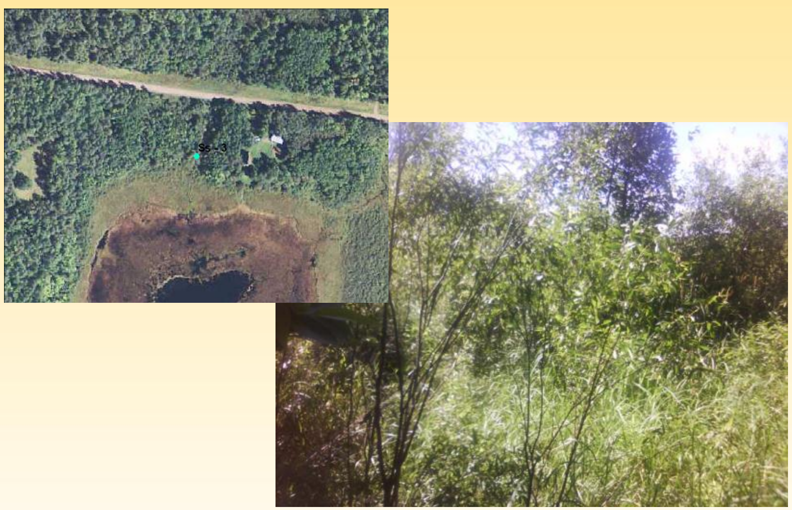
Classification - Scrub/Shrub





Objectives

- Medium resolution classification of wetland from upland & probability
- Identify key inputs for best accuracy
  - Using all available data, all season
  - Evaluate “Spring”, “Summer”, and “Fall” datasets
- Evaluate decision tree classification

Data Used

- Ground reference data:
  - Collected on the ground in 2009 & 2010
- Supplementary dataset from MN DNR
  - Wetland Status & Trends Monitoring
- 75% for training the classifier,
  25% for independent accuracy assessment

Data Used, cont

- Optical and Infrared
  - Landsat TM imagery from several dates
    - "Spring" April 17, 2010; May 19, 2010; NDVI, TC
    - "Fall" Sept 21, 2009; Oct 4, 2010; NDVI, TC
  - Color Infra-red (CIR) Aerial Orthophotos
    - "Spring" 2009 (4 bands), NDVI
    - "Summer" 2008 (4 bands), NDVI
    - "Summer" 2010 (3 bands)

Data Used, cont

- USGS National Elevation Dataset
  - Elevation; Aspect; Slope; Curvature; Flow accumulation
- Soils (USDA SSURGO)
  - Drainage class: dominant and wettest; Hydric soils; & Soil type

Data Used, cont

- RSAT-2 (HH, HV, VH, VV) C-band
  - Two dates in 2009: June 15 & Sept 19
  - Ratio HH/HV
- PALSAR (HH, HV) L-band
  - Two dates in 2009: June 29 & Sept 11, One date in 2010: June 14
- Both sets of data scaled in decibels

Data Used, cont

- Polarimetric decompositions for June 15, July 9, Aug 26, & Sept 19, 09 (July & Aug provided by Canada Centre of Remote Sensing)
  - Van Zyl, Freeman-Durden, Cloude-Pottier
- Decomps consider scatter mechanisms, i.e. single (odd), double (even), or volume (diffuse) & randomness of scattering (ex. entropy, anisotropy)

Data Used, cont

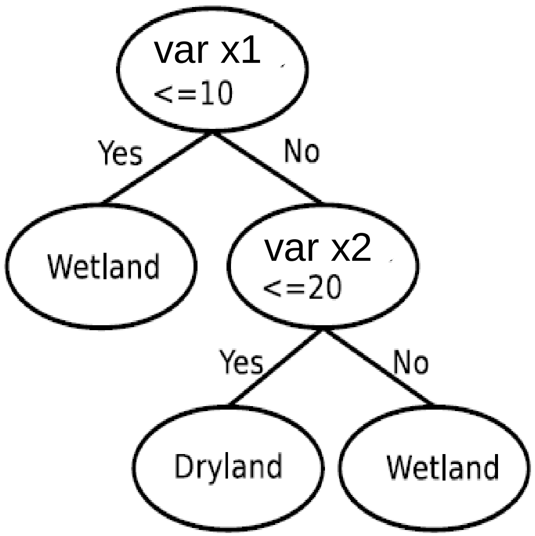
DEM Aspect Curvature Flow Accumulation
Slope Soil drainage, dominant Soil drainage, wettest Hydric Soil Type

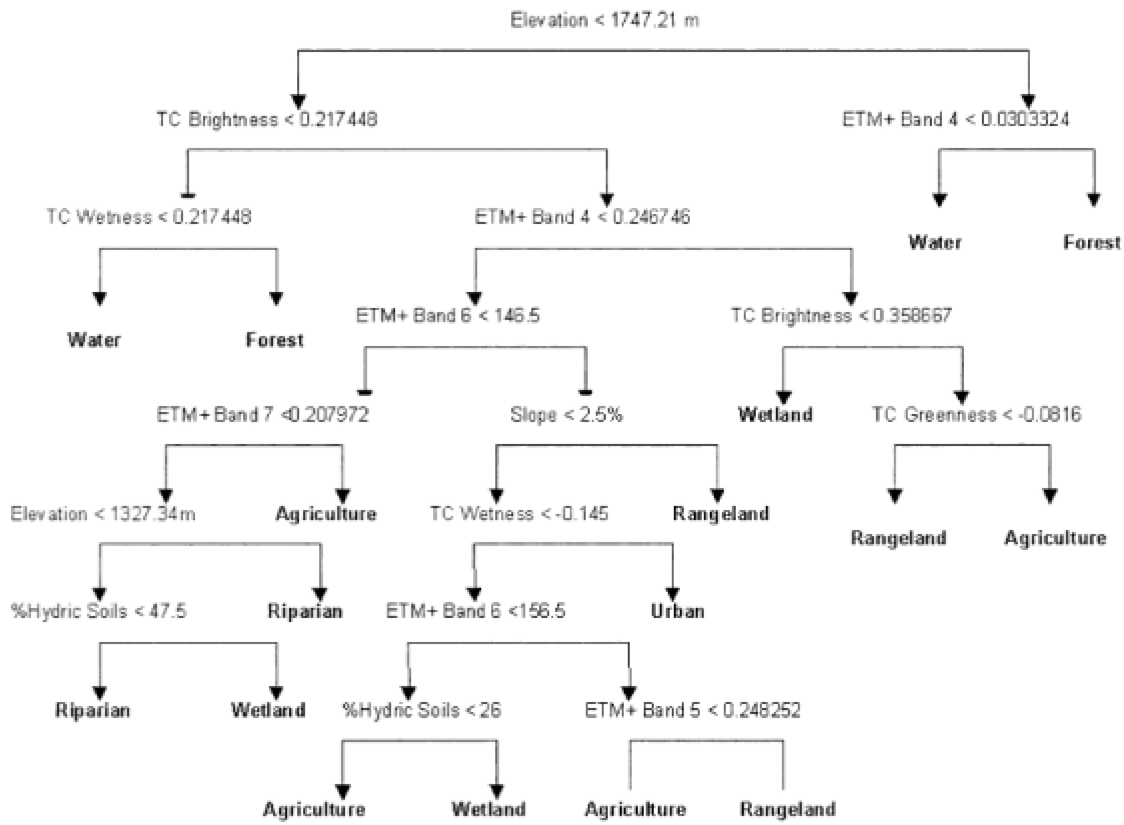
Spring	*Summer*	*Fall*
Aerial photo 2009	Aerial photo 2008 Aerial photo 2010	
TM April 17, 2010 TM May 19, 2010		TM Sep 29, 2009 TM Oct 2, 2008
Rsat-2 June 15, 2009	Rsat-2 July 9, 2009 Rsat-2 Aug 26 2009	Rsat-2 Sept 19, 2009
Palsar June 14, 2010	Palsar June 29, 2009	Palsar Sept 11, 2009

Methodology Used

- Decision tree classification
  - Rule-based technique using training data
  - Designed to reduce class variability
  - Rules applied to a set of data to classify
  - Handles continuous and discrete data

Methodology Used, cont





Methodology Used, cont

- randomForest = ‘forest’ of trees
- Each tree results in a class or ‘vote’, final classification is the most votes
- Out of bag (OOB) sampling allows for cross validation and calculating probability

Methodology Used, cont

- Outputs evaluated from randomForest
  - **Mean Decrease Accuracy:** the relative impact of including variable on accuracy
  - **Gini Index**: every time a split is made, the Gini Index value is less than the ‘parent node’ – sum indicates relative importance
  - **Classification and Probability maps**

Data Used, review

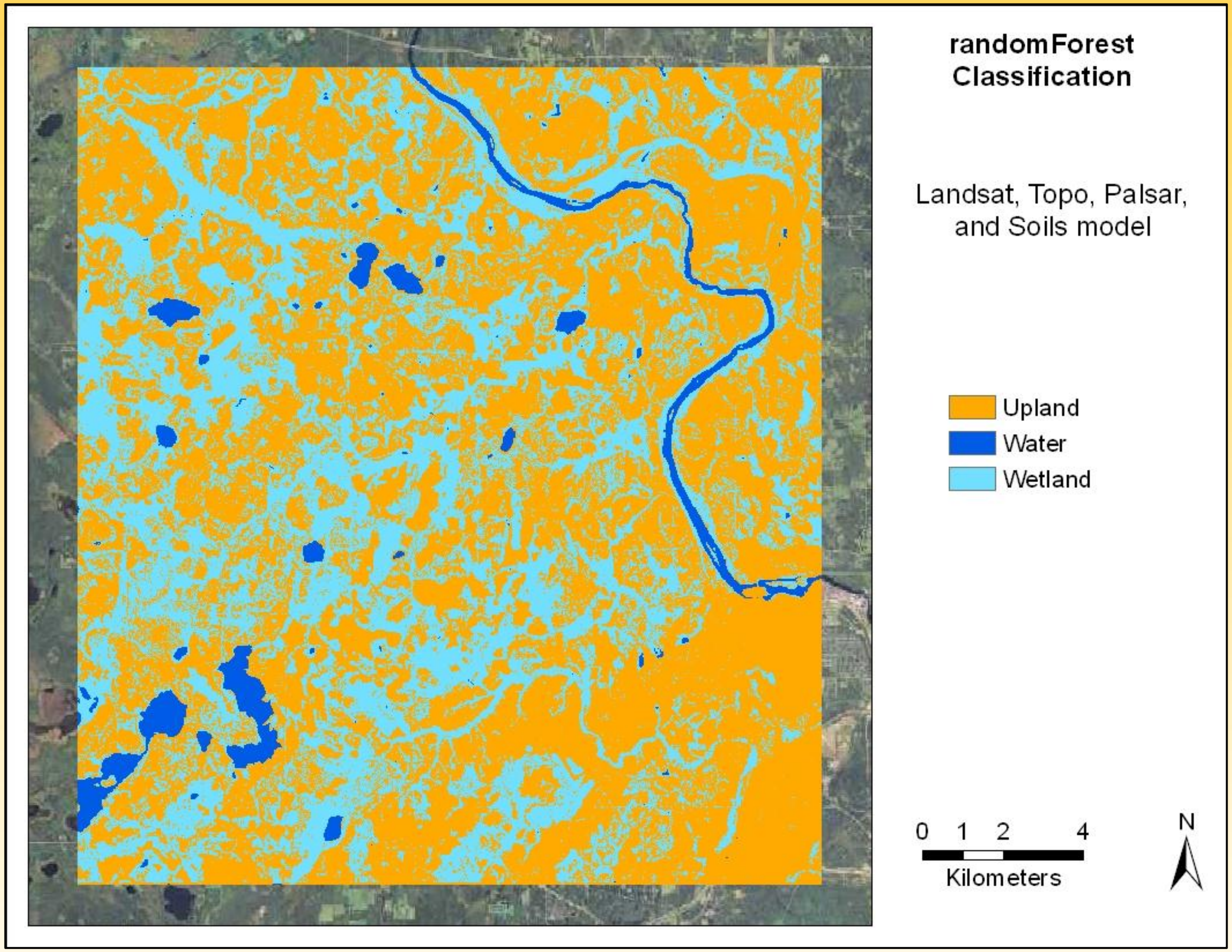
Total = 118 input rasters, 60 combos

- Aerial Orthophotos
- Landsat TM & Derivatives
- NED & Derivatives
- RADARSAT-2 Quad-pol
- Polarimetric Decompositions
- PALSAR Dual-pol
- SSURGO Soils & Attributes

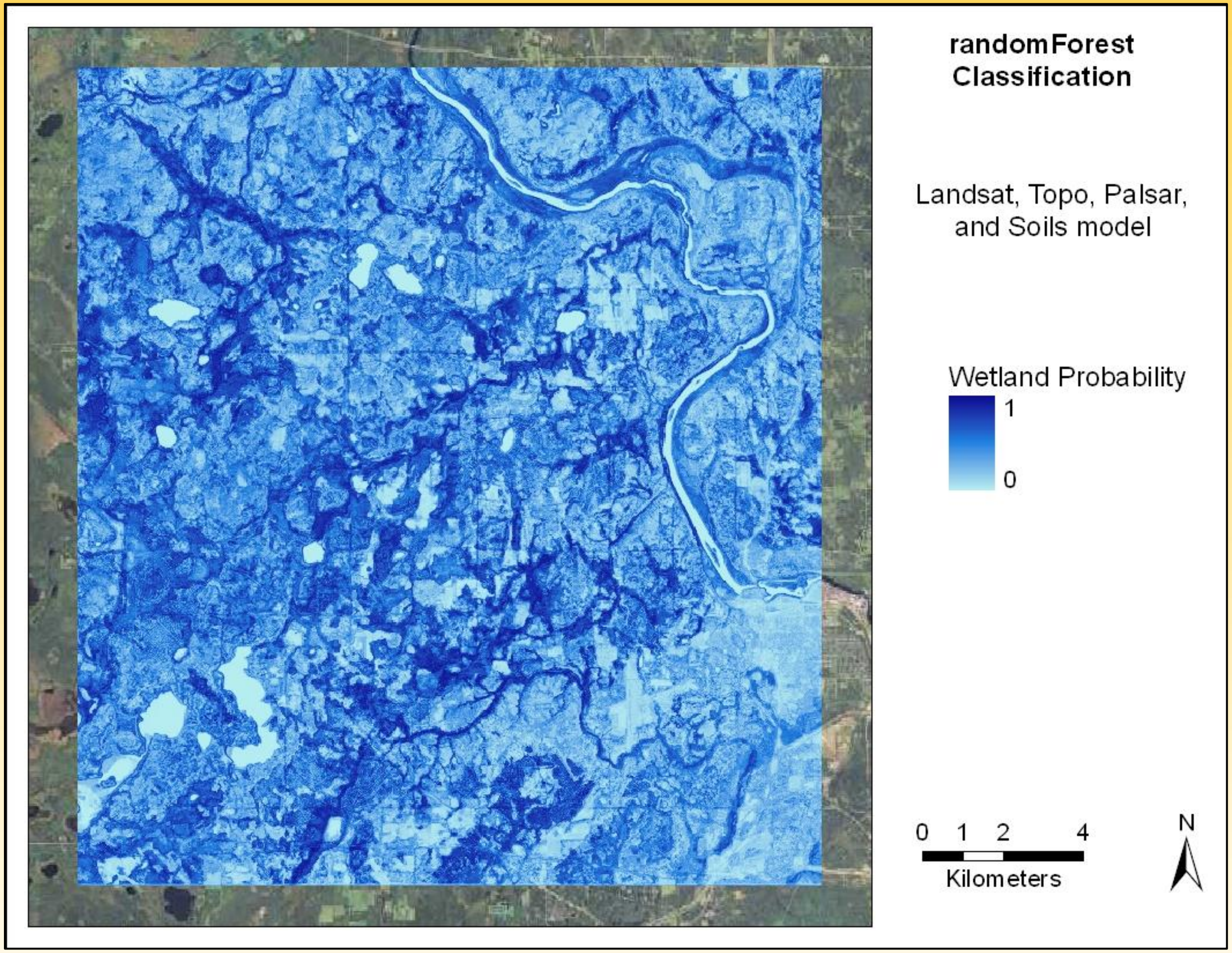
Results: Outline

- Full Season Upland/Wetland Classification
- Probability maps
- Key input data layers/variables
- Data reduction classification
- Accuracy Assessment
- Data available in different seasons

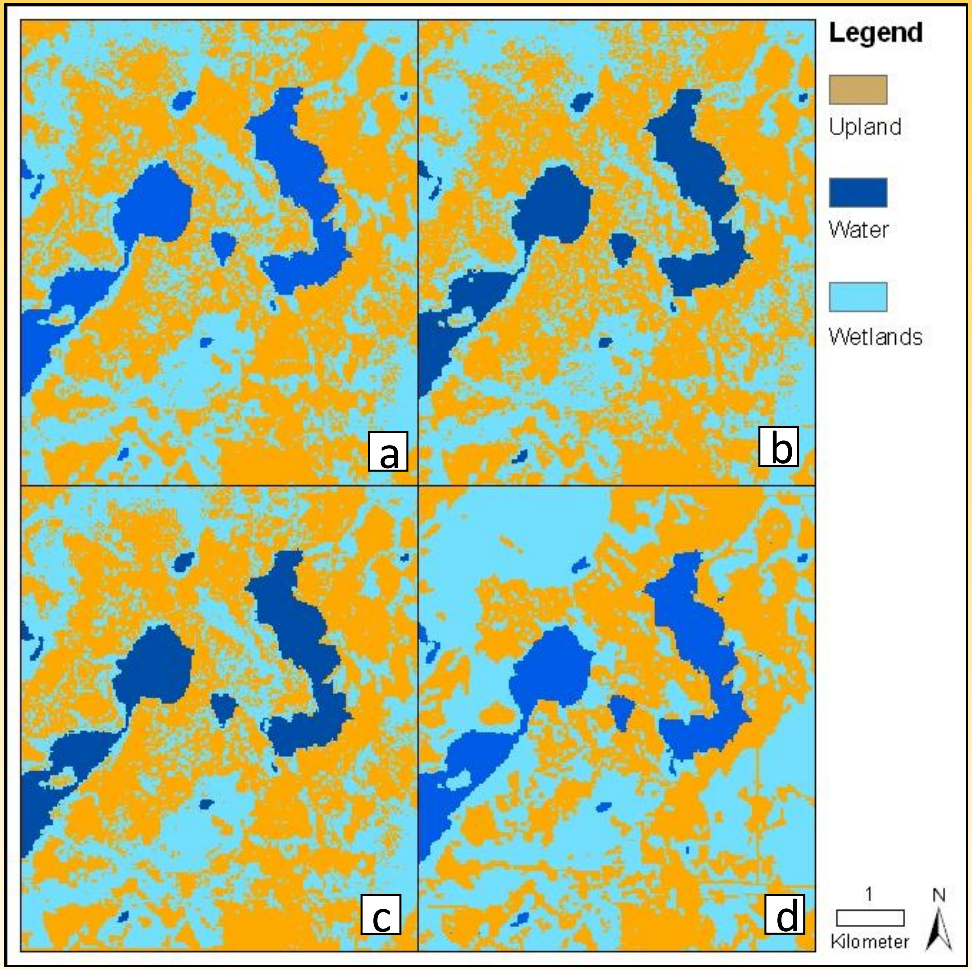
Results: Full season, cont



Results: Full season, cont



Results: Full season, cont



a. TM, topo, palsar, soils (#1)

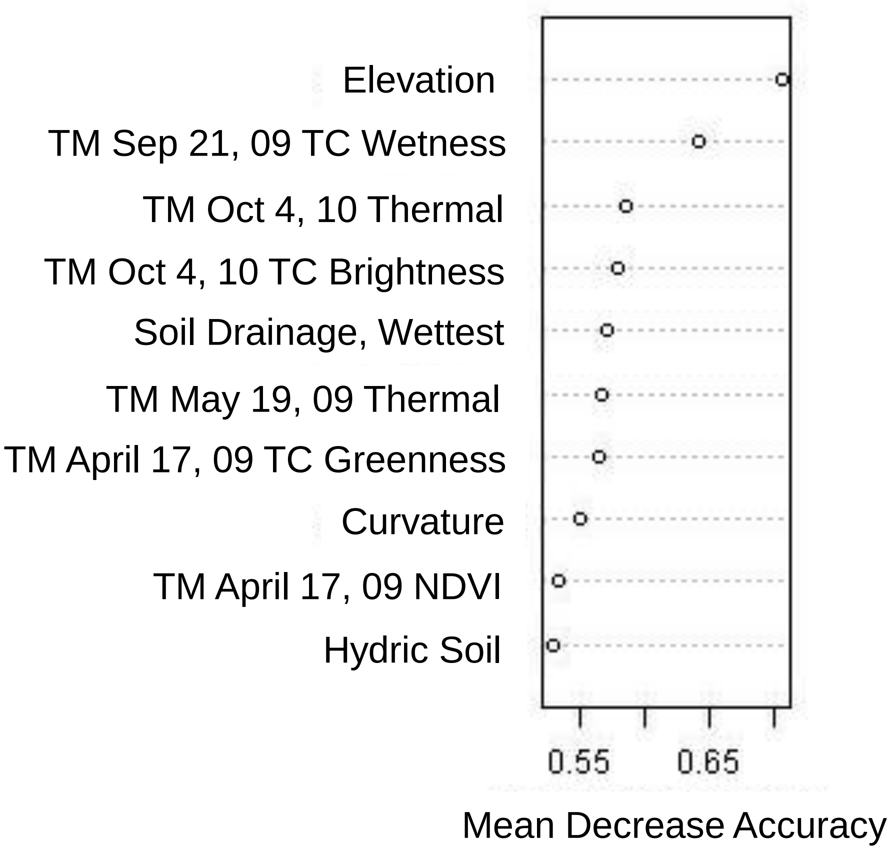
b. TM, topo, Rsat, soils (#2)

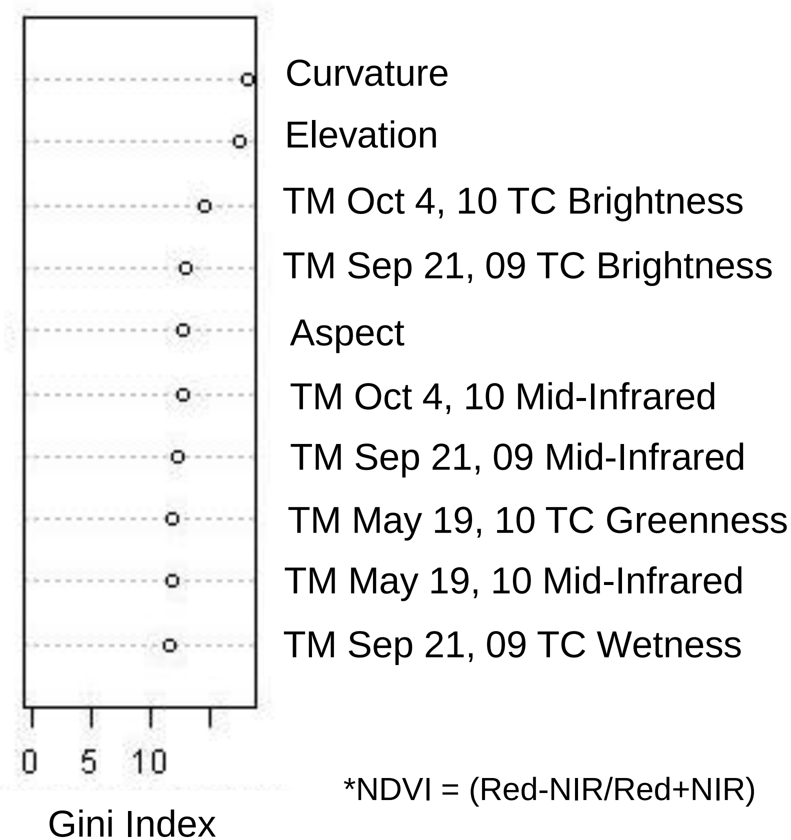
c. TM, topo, soils (#3)

d. National Wetland Inventory

Results: Full season, cont

Most Important Variables for Upland/Wetland Classification





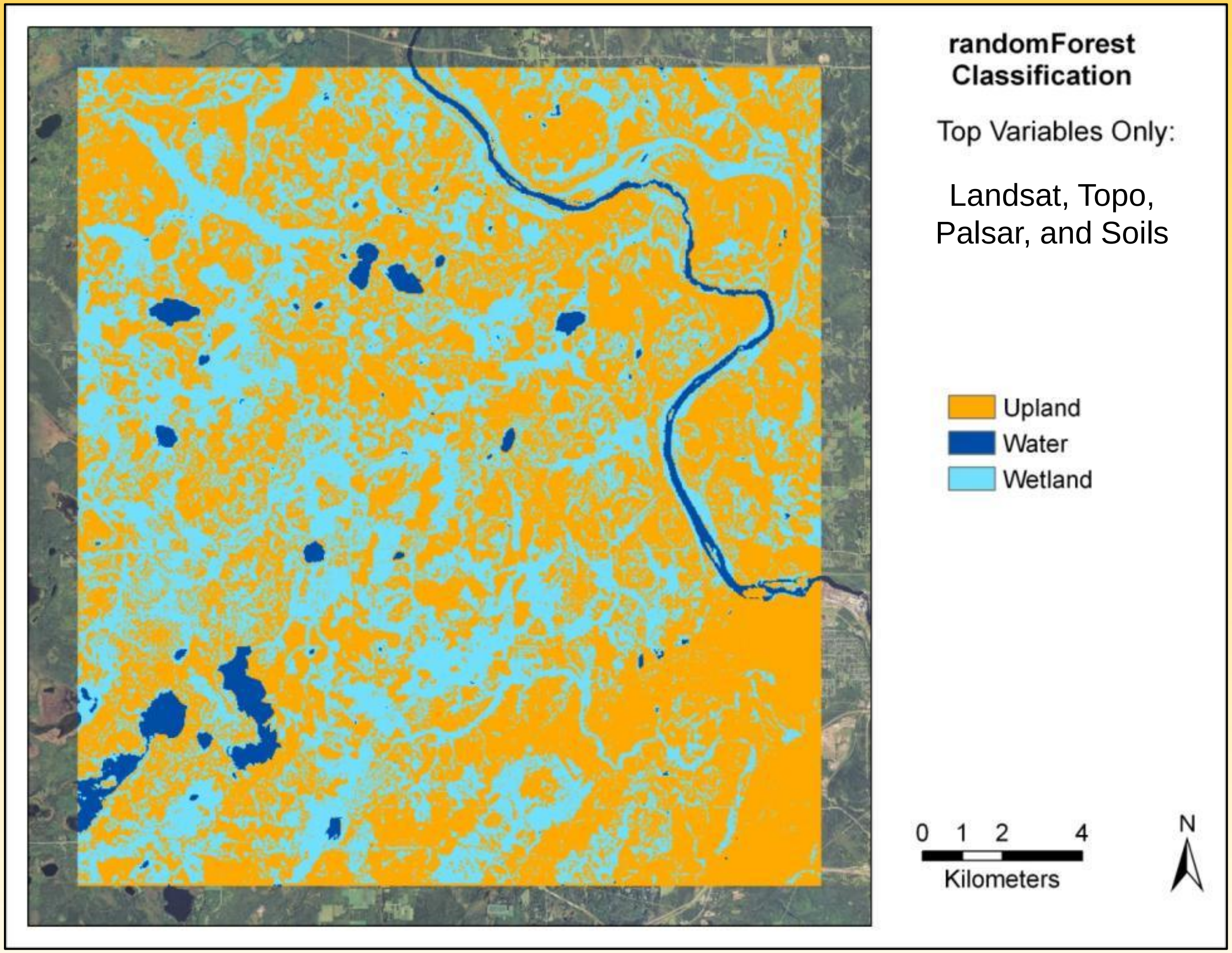
*NDVI = (Red-NIR/Red+NIR)

Results: Full season, cont

DEM
Aspect
Curvature
Flow Accumulation
Slope
Soil drainage, dominant
Soil drainage, wettest
Hydric
Soil Type

Spring	*Summer*	*Fall*
Aerial photo 2009	Aerial photo 2008 Aerial photo 2010	
TM April 17, 2010 **TM May 19, 2010**		**TM Sep 29, 2009** **TM Oct 2, 2008**
Rsat-2 June 15, 2009	Rsat-2 July 9, 2009 Rsat-2 Aug 26 2009	Rsat-2 Sept 19, 2009
Palsar June 14, 2010	Palsar June 29, 2009	Palsar Sept 11, 2009

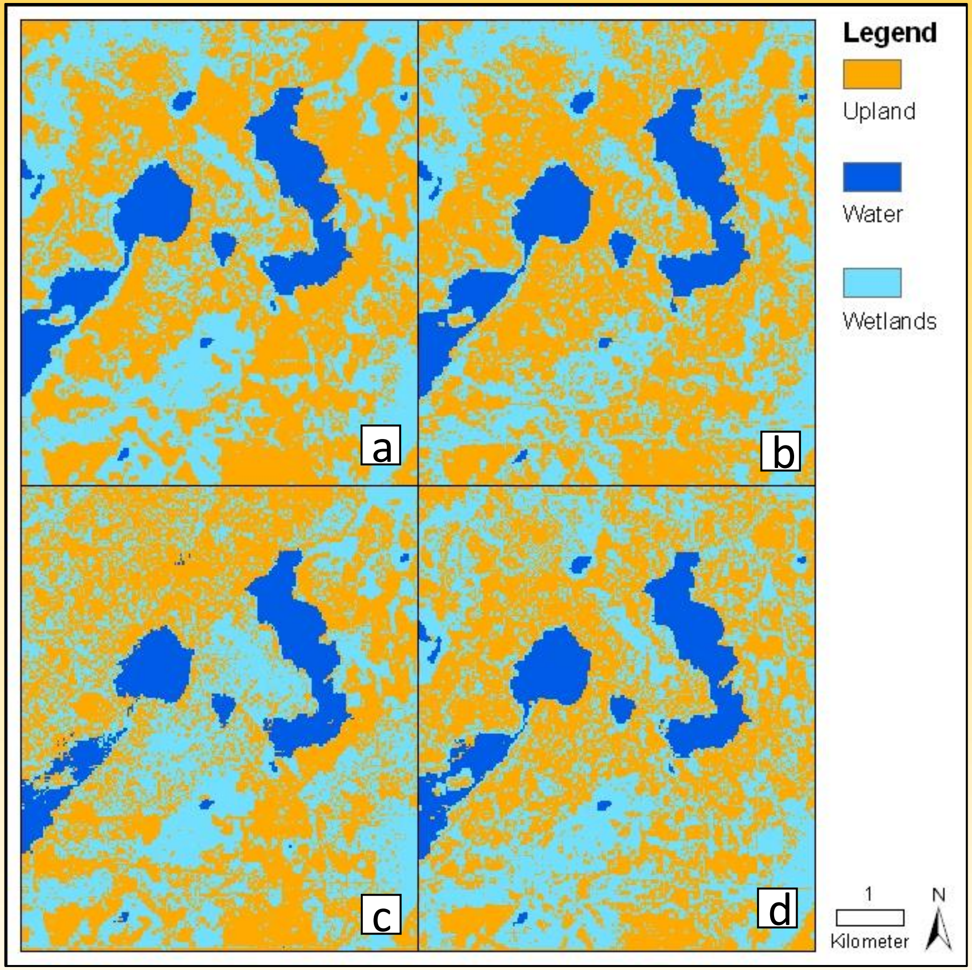
Results: Full season, cont



Results: Full season, cont

Upland, Water, Wetland Classification	*Total Accuracy (%)*	*Kappa-hat Statistic*	*Z Statistic*
Landsat, Topo, Palsar, Soils	**79**	**0.65**	**16.02**
Only Top Variables in #1 Model	**77**	**0.64**	**16.01**
Landsat, Topo, **Rsat,** Soils	78	0.62	15.10
Landsat, Topo, Soils	77	0.61	14.44
National Wetland Inventory	70	0.46	9.64

Results: Seasons, cont



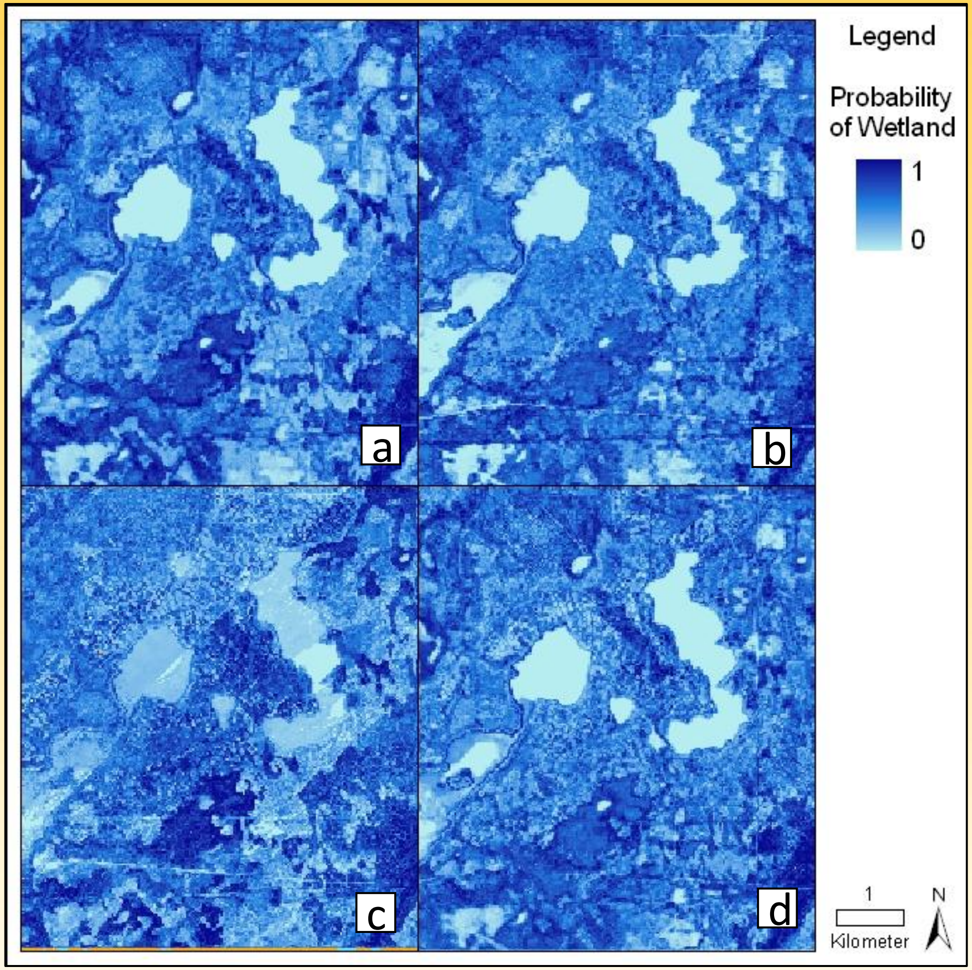
a. Full Season

b. Spring

c. Summer

d. Fall

Results: Seasons, cont



a. Full Season
b. Spring
c. Summer
d. Fall

Results: Season - Spring

Spring

- Elevation
- Curvature
- TM May Thermal
- TM May NDVI
- TM April NDVI
- Rsat HH June 15

DEM
Aspect
Curvature
Flow Accumulation
Slope
Soil drainage, dominant
Soil drainage, wettest
Hydric
Soil Type

Spring	*Summer*	*Fall*
Aerial photo 2009	Aerial photo 2008 Aerial photo 2010	
TM April 17, 2010 **TM May 19, 2010**		TM Sep 29, 2009 TM Oct 2, 2008
Rsat-2 June 15, 2009	Rsat-2 July 9, 2009 Rsat-2 Aug 26 2009	Rsat-2 Sept 19, 2009
Palsar June 14, 2010	Palsar June 29, 2009	Palsar Sept 11, 2009

Results: Season - Summer

Summer

- Aerial 2010 Green
- Soils, Hydric
- Curvature
- Soils, Drainage Wettest
- Aerial 2010 Red
- Palsar HV July

DEM
Aspect
Curvature
Flow Accumulation
Slope
Soil drainage, dominant
Soil drainage, wettest
Hydric
Soil Type

Spring	*Summer*	*Fall*
Aerial photo 2009	Aerial photo 2008 **Aerial photo 2010**	
TM April 17, 2010 TM May 19, 2010		TM Sep 29, 2009 TM Oct 2, 2008
Rsat-2 June 15, 2009	Rsat-2 July 9, 2009 Rsat-2 Aug 26 2009	Rsat-2 Sept 19, 2009
Palsar June 14, 2010	**Palsar June 29, 2009**	Palsar Sept 11, 2009

Results: Season - Fall

Fall

- TM Oct Thermal
- Curvature
- TM Sep Mid-Infrared
- TM Sep Far-Infrared
- Rsat HV Sep 19
- TM Oct Red

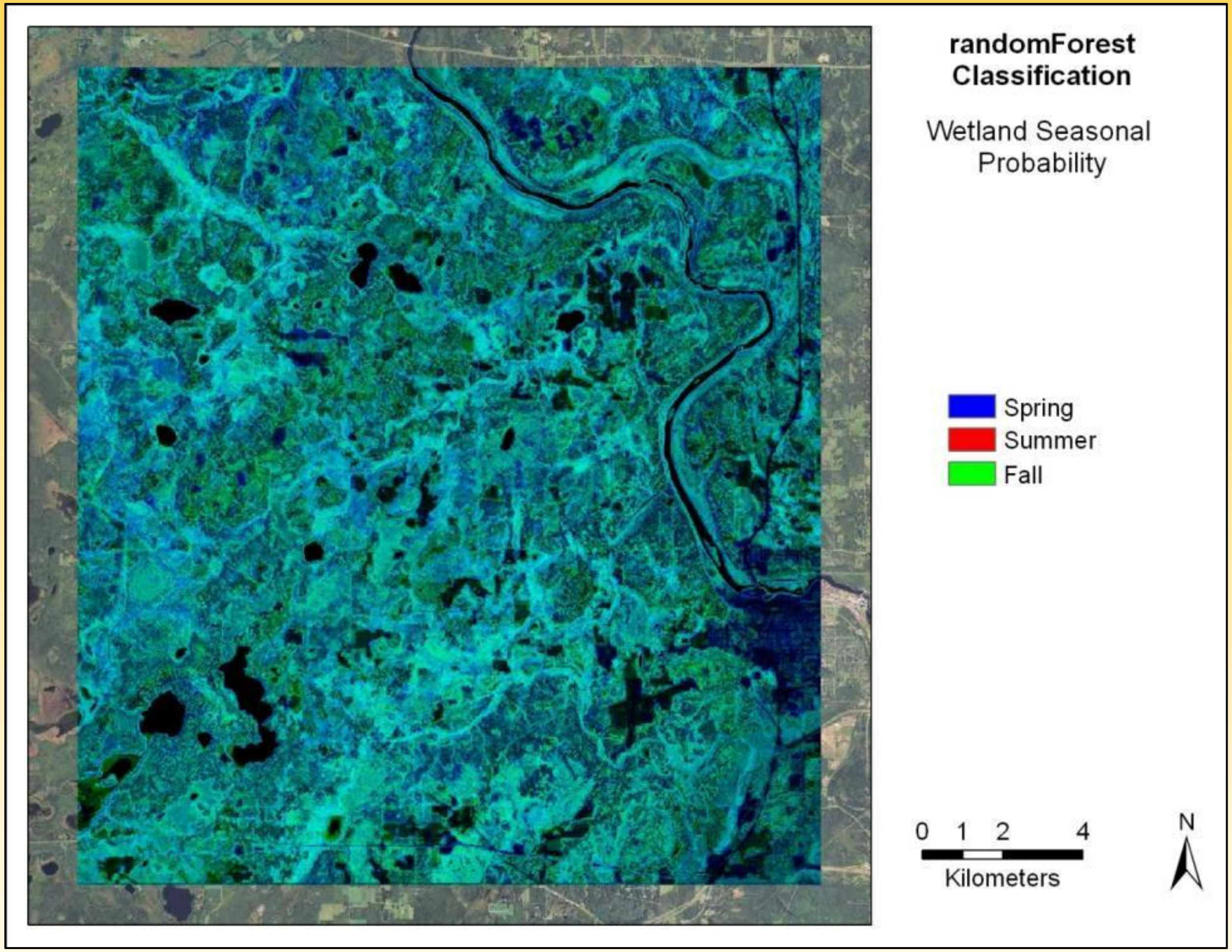
DEM
Aspect
Curvature
Flow Accumulation
Slope
Soil drainage, dominant
Soil drainage, wettest
Hydric
Soil Type

Spring	*Summer*	*Fall*
Aerial photo 2009	Aerial photo 2008 Aerial photo 2010	
TM April 17, 2010 TM May 19, 2010		**TM Sep 29, 2009** **TM Oct 2, 2008**
Rsat-2 June 15, 2009	Rsat-2 July 9, 2009 Rsat-2 Aug 26 2009	**Rsat-2 Sept 19, 2009**
Palsar June 14, 2010	Palsar June 29, 2009	Palsar Sept 11, 2009

Results: Seasons, cont

Upland, Water, Wetland Classification	***Total Accuracy (%)***	***Kappa-hat Statistic***	***Z Statistic***
Spring: TM, Topo, **Rsat**	79	0.62	15.10
Summer: AP, Topo, **Palsar**, Soils	77	0.58	13.59
Fall: TM, Topo	77	0.60	14.04
Full Season: TM, Topo, Palsar, Soils	79	0.65	16.02

Results: Seasons, cont



Conclusions, cont

- With the moderate resolution data in this study site:
  - It is more accurate to classify wetland from upland by integrating Landsat TM, Palsar, topo, and soils data from different dates throughout the year
  - Classifying wetlands during different seasons is more feasible with aerial photos, Radarsat-2, and Palsar included
  - Data reduction does not sacrifice much in accuracy
  - Statewide wetland classification is achievable with relative efficiency and affordability

Conclusions, cont

- The key input layers for decision tree classification of annual wetlands and wetlands during different seasons:

"Annual Snapshot"

- Elevation, curvature, aspect
- Fall & Spring TM TC, thermal, Mid-IR
- Hydric Soils & Drainage, wettest time

Spring

- Elevation, Curvature
- TM NDVI, Thermal

Summer

- Aerial Green Band
- Soils, Hydric
- Soil Drainage, Wettest time

Fall

- TM Mid-IR, Thermal
- Curvature

Ongoing & Future Work

- LiDAR intensity and vegetation structure
- Spatially explicit decision trees
- Integrate with object oriented analysis
- Additional study areas: Minnesota River
- Other parameters for restoration ID
- Applications for emergency response (flood water retention)

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US Forest Service - Forest Remote Sensing Applications Center
American Society for Photogrammetry and Remote Sensing

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Thank you for your attention!

Any questions?

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