Evaluating Multi-Date Land Cover Mapping from Landsat 5 Imagery in the Northeastern US

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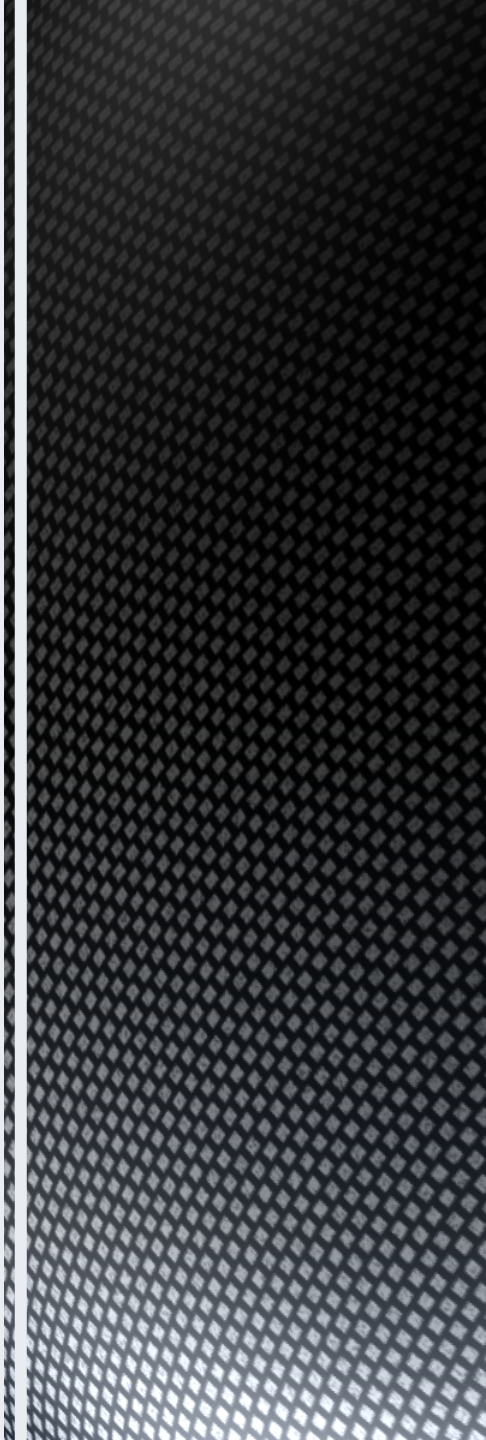
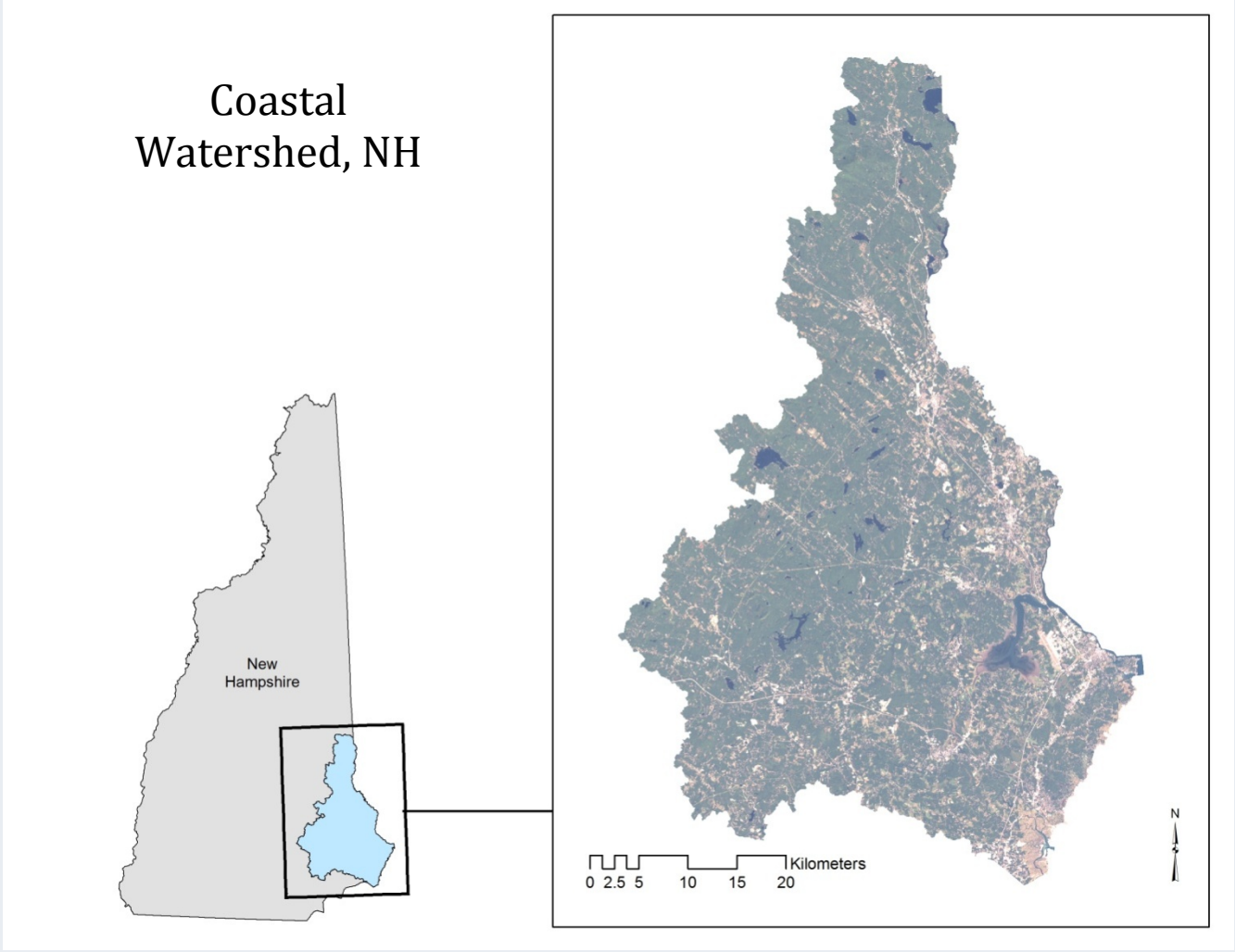


Study Area


Coastal
Watershed, NH
New
Hampshire
Kilometers
0 2.5 5 10 15 20
N

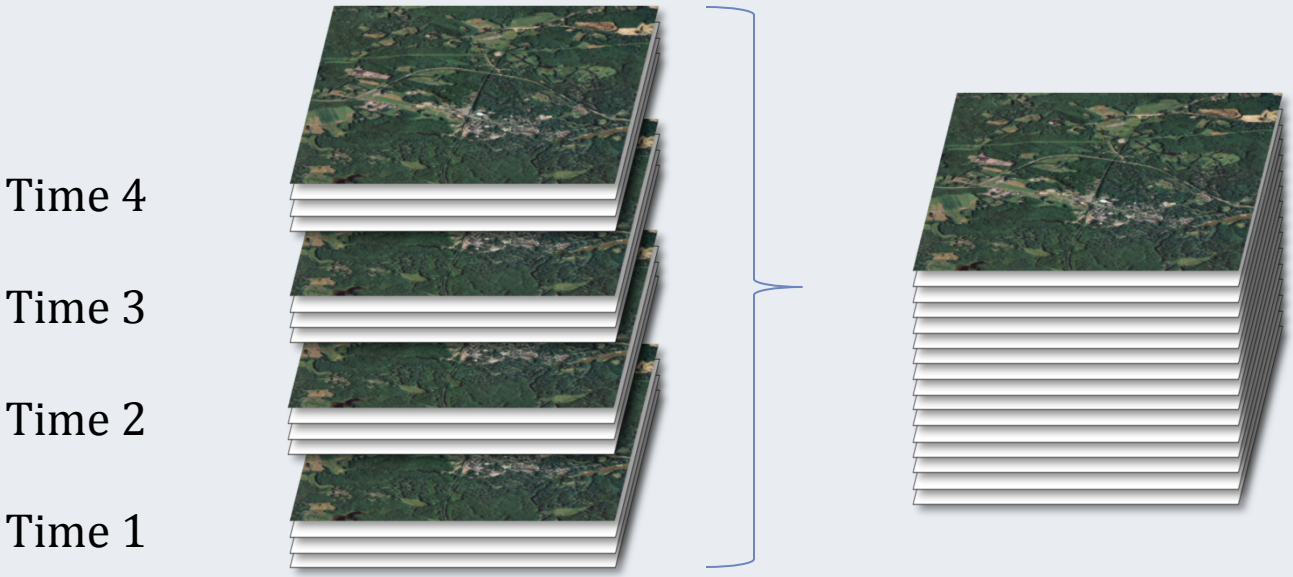
Objective: Creating a Better Land Cover Map for Use in Landscape Fragmentation Analysis

- Need a data source for entire study area that is appropriate for classes
  - Remotely sensed data
- Forest mapping can be tricky
  - Spatially heterogeneous distribution
  - Spectrally similar
  - Visually similar

- Landsat 5TM
  - Advantages:
    - Free!
    - Temporal resolution
      - Approximately every 16 days since 1984
    - 7 bands (visible, near-infrared, middle-infrared, and thermal)
    - 30 meter pixels (120 m thermal)
  - Disadvantages:
    - 30 meter pixels
    - Atmospheric effects (e.g. clouds, haze, etc.)
      - Average of 90 “clear” days in southern NH (NCDC, 2008)

Multi-temporal Image Analysis

- Uses images from different dates from throughout a single year
  - Increases available information for each land cover type
  - Uses phenological changes in vegetation to separate classes
  - Takes advantage of Landsat temporal resolution
  - Does this multi-date mapping technique work better than the traditional single-date classification method?



Available Landsat 5TM Images

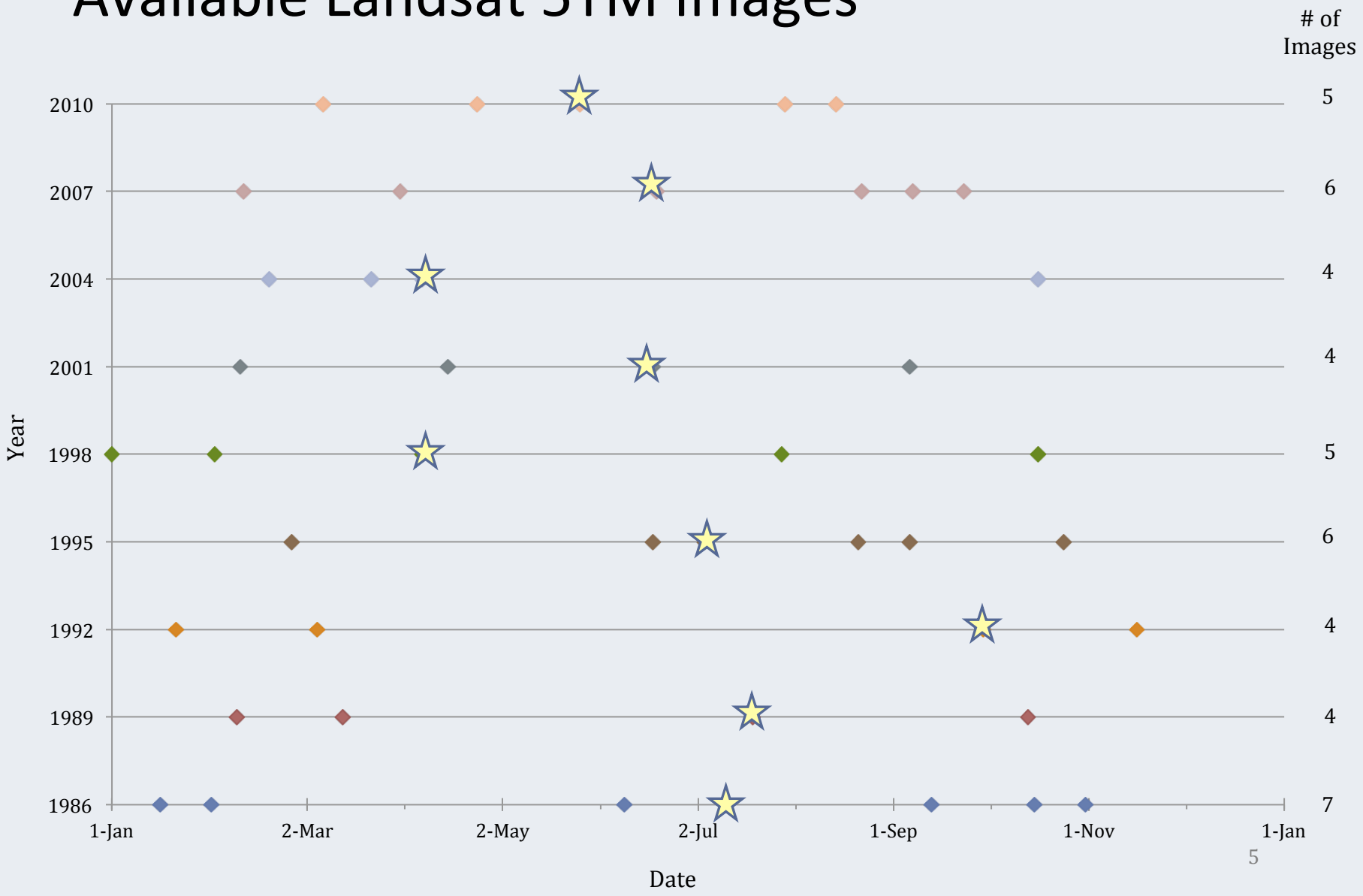
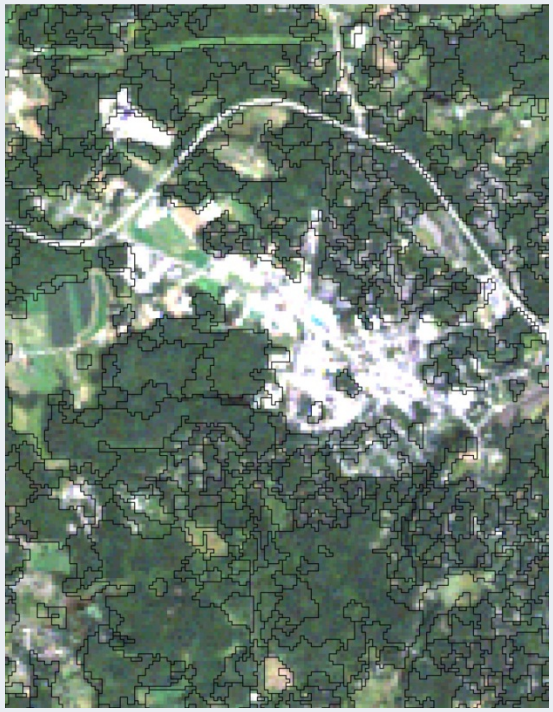


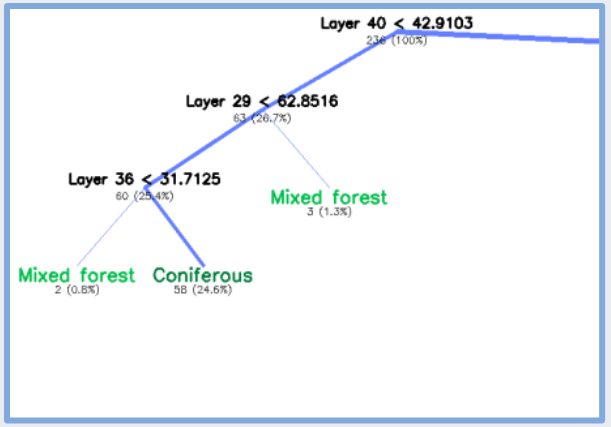
Image Preparation

- Reference image atmospherically corrected using the cosine of the solar zenith angle (COST) method (Chavez, Jr. 1996)
- All other images relatively corrected to the reference image using histogram matching
  - Thermal band disregarded for all images
- Derivative bands created for each image
  - Normalized Difference Vegetation Index (NDVI)
  - Tasseled Cap
    - Brightness
    - Greenness
    - Wetness
- Images and derivative bands layer stacked so that all of the images from a single year can be processed as a multi-date image stack

Image Classification

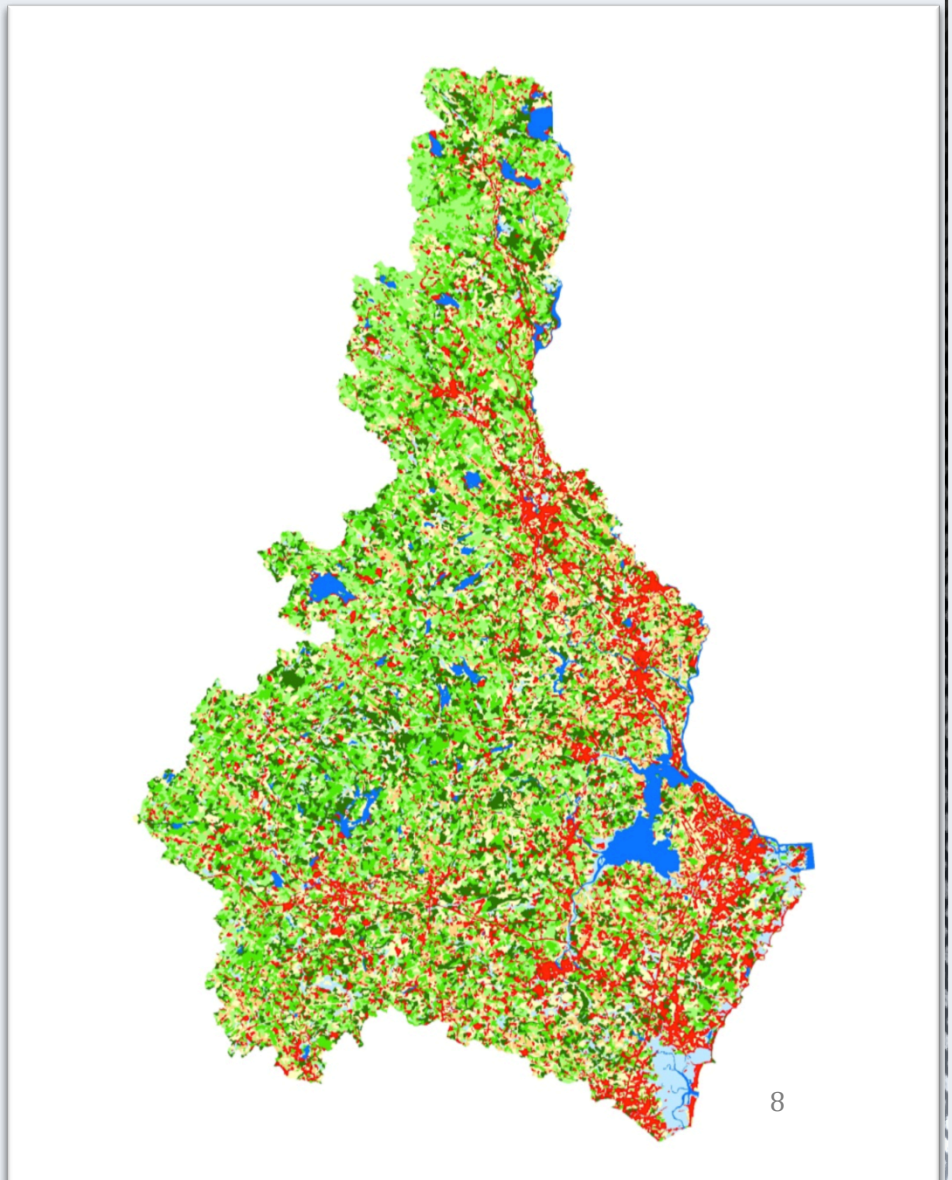
- Object-Based Image Analysis (OBIA)Segmentation – eCognition Software (Trimble®)
  - Groups pixels based on similar spectral properties
  - Variance between polygons greater than variance within polygons
  - Adds characteristics, such as:
    - Area, Shape Index, Compactness, Length/Width, Texture, Mean DN Values, Standard Deviation of Mean DN Values, etc.
- Classification and Regression Trees (CART)





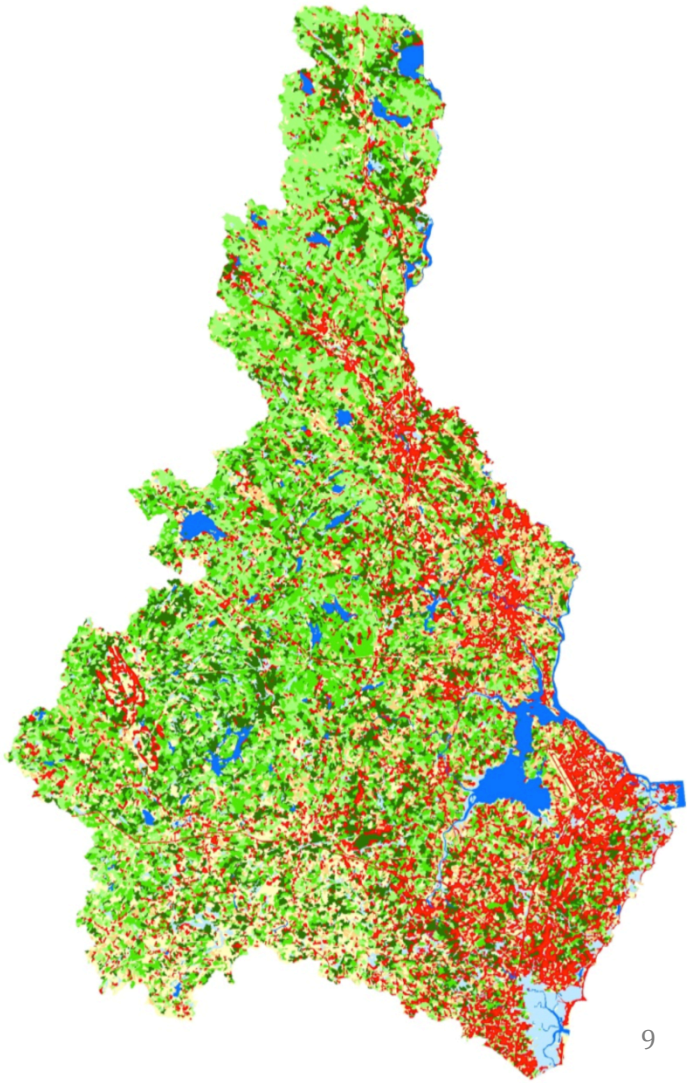
Single- vs. Multi-Date Maps

- 2010 Maps
  - Single-Date – Overall Accuracy: 69%
  - Multi-Date – Overall Accuracy: 70%
    - *Not significantly different (p=0.05)*

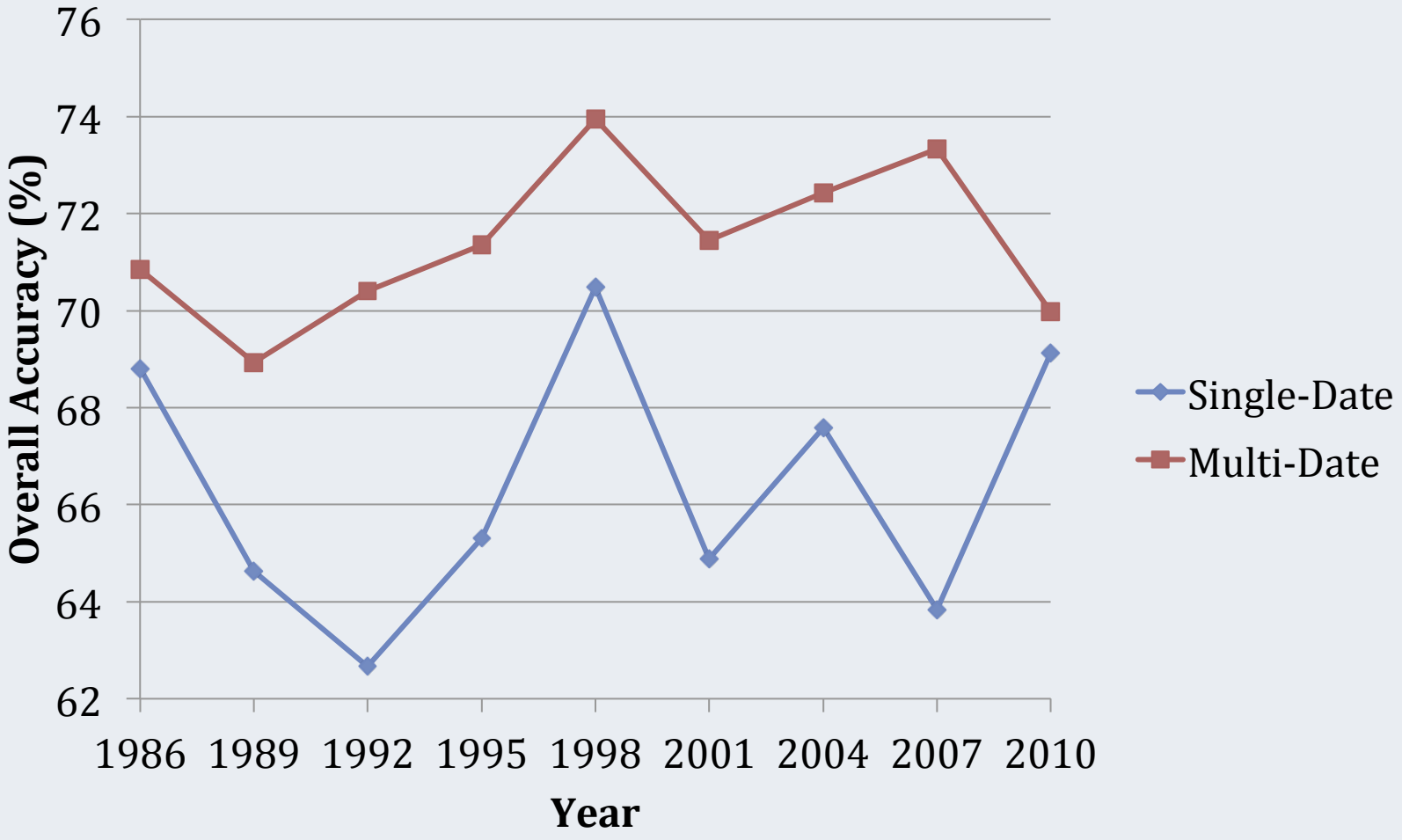


Single- vs. Multi-Date Maps

- 2007 Maps
  - Single-Date – Overall Accuracy: 64%
  - Multi-Date – Overall Accuracy: 73%
    - *Significantly better (p=0.05)!*



Overall Accuracies of All Maps



Differences in Accuracies using Kappa Analysis

Year	Traditional Error Matrix			Area-Based Error Matrix			Z-statistic **
	Single-Date Accuracy	Multi-Date Accuracy	Difference	Single-Date Accuracy	Multi-Date Accuracy	Difference	
1986	68.81 %	70.85 %	2.04 %	70.68 %	73.07 %	2.39 %	0.75
1989	64.63 %	68.93 %	4.30 %	67.41 %	72.79 %	5.38 %	1.52
1992	62.66 %	70.40 %	7.74 %	63.98 %	74.27 %	10.29 %	**2.68***
1995	65.31 %	71.35 %	6.04 %	65.31 %	74.22 %	8.91 %	**2.11***
1998	70.48 %	73.94 %	3.46 %	73.71 %	75.85 %	2.14 %	1.29
2001	64.89 %	71.45 %	6.56 %	68.78 %	76.12 %	7.34 %	**2.27***
2004	67.59 %	72.43 %	4.84 %	72.41 %	75.02 %	2.61 %	1.78
2007	63.84 %	73.33 %	9.49 %	66.05 %	76.04 %	9.99 %	**3.36***
2010	69.13 %	69.98 %	0.85 %	70.64 %	74.79 %	4.15 %	0.37

**the Z-statistic was computed using traditional error matrices, where Z_c = 1.96 at the 95% confidence interval and the single-date and multi-date error matrices are significantly different when $Z>Z_c$ (Congalton et al., 1983). Any Z-statistics with an asterisk indicates a significant difference between single-date and multi-date classifications.

What Factors Best Predict the Differences Between Single- and Multi-Date Map Accuracies?

- A forward elimination stepwise regression analysis was performed using a standard least squares estimator to using minimum AICc values to find the best explanatory model (Burnham and Anderson, 2002)
- Four explanatory variables were included in the best model for predicting the difference between single-date and multi-date accuracies (minimum ΔAICc = 169.6714)

Explanatory Variable	Coefficient	SE
Intercept	65.829	14.426
Single-date accuracy	-0.992	0.193
% of images in the fall	4.501	2.970
Senescence captured	1.384	0.466
Average date	0.037	0.021

- Single-date accuracy was the most helpful in predicting the difference between single-date and multi-date accuracies!

Summary and Conclusions

- **Why some years need multiple dates and others not**
  - The effects of clouds in a single date
  - Some needed to use information from throughout the year
    - Not limited to a single date in the growing season
    - Both early and late growing season images were used in the CART analyses
    - Fall images were important in improving classification (senescence)
  - 1992 had no good growing season image so multi-date needed
  - 1995 single image in late July with some clouds so multi-date needed
  - 2001 the May image significantly improved the classification
  - 2007 had big cloud issues so multi-date needed
  - 1986, 1989, 1998, 2004, and 2010 single date was as good as multi-date
- **Is it worth the extra processing?**
  - Maybe:
    - If a single-date map with acceptable accuracies cannot be produced: Yes!
    - Makes sense to start with single date and add multiple dates, if needed