

Application of High Resolution Multispectral Imagery for Levee Slide Detection and Monitoring

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OUTLINE

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- ❑ Objectives
- ❑ Previous Studies
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- ❑ Methods and Results
- ❑ Conclusion



INTRODUCTION

- ❑ Levee systems: primary flood protection measures for many states
- ❑ Every year sections of levee fail due to various reasons
- ❑ Levee slides are common and significant among them



INTRODUCTION

- ❑ USACE of Vicksburg District repaired about 1000 slides since 1964 (Neuner, 2002)



- ❑ Traditional method of slide detection involves a physical survey (driving along the levee), which is neither time or cost efficient.

INTRODUCTION

- ❑ Remote sensing, proven tool for detecting wetness properties of soils associated with levee failures
- ❑ Could be useful for developing levee slide detection methods if aided by spatial analysis techniques
- ❑ Methods for slide detection and monitor would assist in levee maintenance

OBJECTIVE

Develop methods to detect and monitor levee slides using commercially available high resolution multispectral imagery



PREVIOUS STUDY

Neuner (2002):

- ❑ Used high resolution multispectral imagery
- ❑ UAV imagery (3 bands: G, R, IR; 1 m res.)
- ❑ Detected slides by visual inspection
- ❑ Correlated soil moisture content with reflection data of the imagery



PREVIOUS STUDY

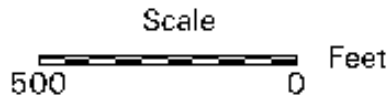
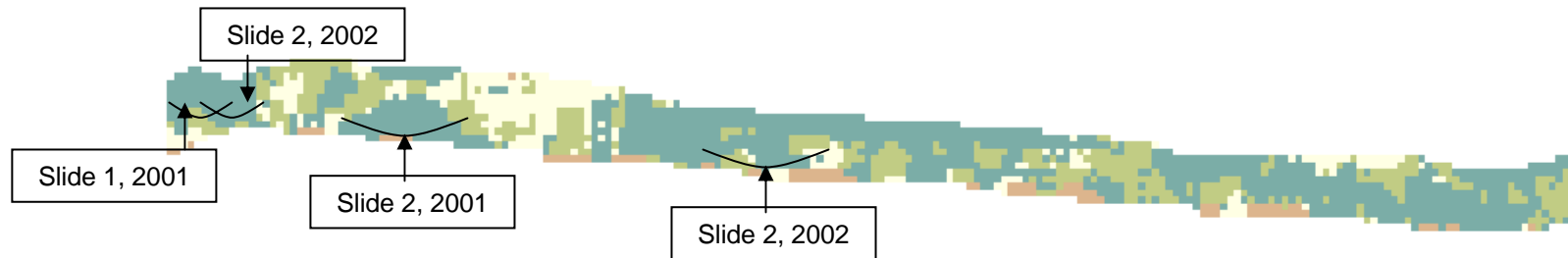
Kuszmaul and others (2004):

- ❑ Showed association of levee slides with high surface moisture content
- ❑ Used field data and multispectral imagery
- ❑ UAV multispectral imagery used for areas with limited vegetation along with direct measurements of soil moisture
- ❑ IKONOS used in more heavily vegetated sites to map relative variation of moisture across levee surface







PREVIOUS STUDY

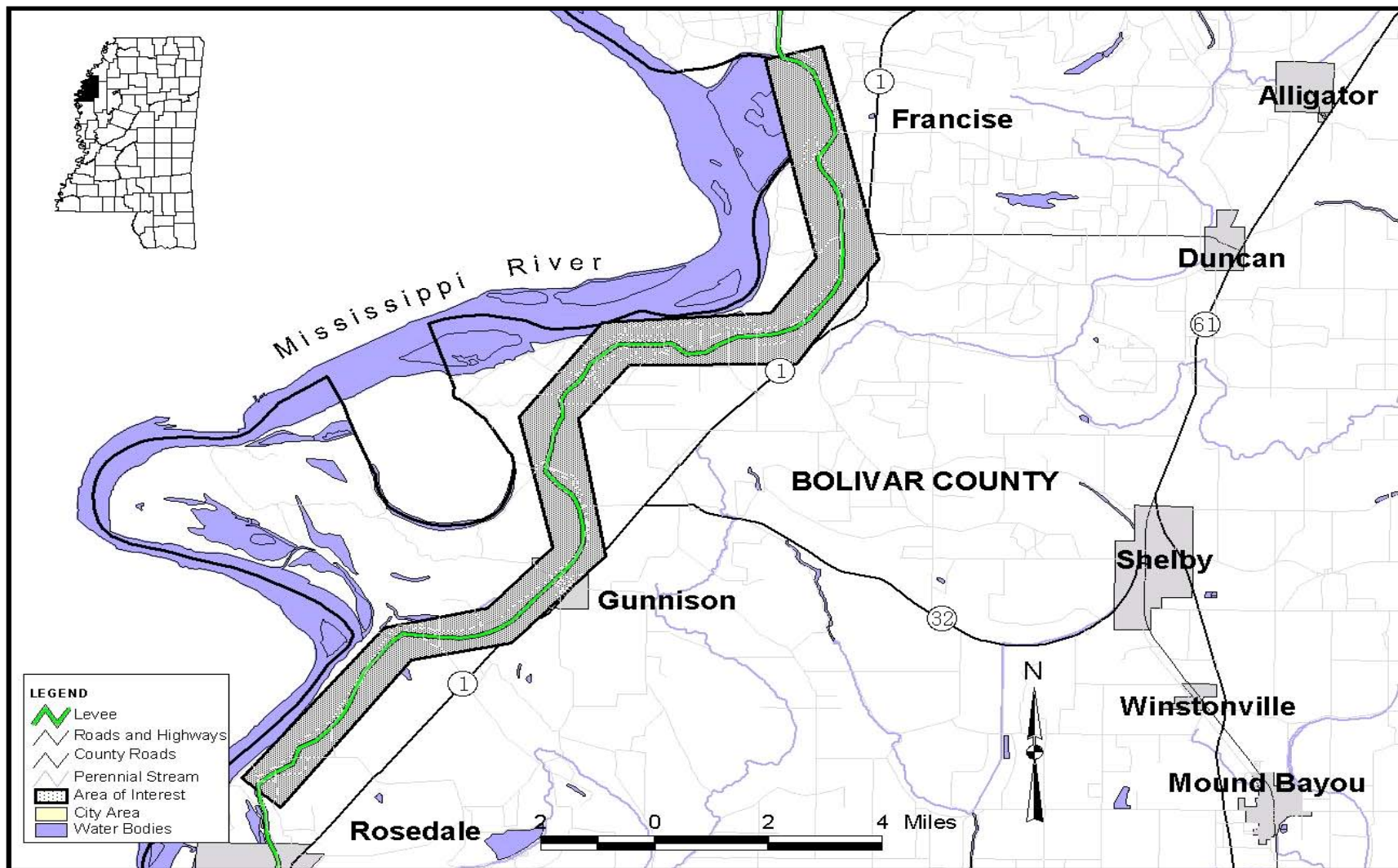
Kuszmaul and others (2004):



Legend

-  Dry area
-  Low moist area
-  Medium moist area
-  High moist area

STUDY SITE



DATA USED

Slide Data

- ❑ Obtained from MS Levee Board: 2001 (2 slides) and 2002 (6 slides)

Field Data

- ❑ June & Sept. 2003, Feb. 2004
- ❑ GPS: slide location and GCP
- ❑ Spectral signatures of vegetation and soils
- ❑ Types and pattern of vegetation

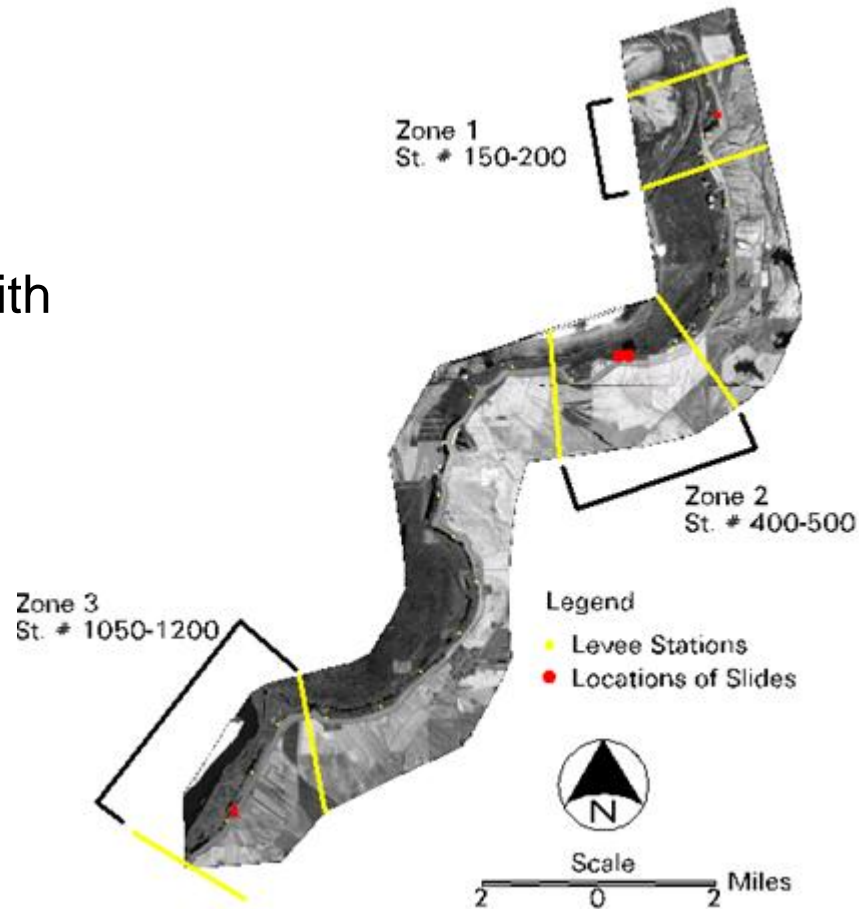
Image Data

- ❑ QuickBird, 2 scenes, 2 dates
- ❑ IKONOS, 3 scenes, 3 dates

Date	Sensor
January 15, 2001	IKONOS
June 10, 2001	IKONOS
June 21, 2002	IKONOS
August 21, 2002	QuickBird
August 26, 2002	QuickBird

METHODS & RESULTS

- ❑ Investigation focused on three zones
- ❑ Slides in different zones investigated with different images
- ❑ Zone 2:
 - QuickBird
 - IKONOS
- ❑ Zone 1 & Zone 3:
 - QuickBird



METHODS & RESULTS

- ❑ Field observations were combined with image processing techniques

- ❑ Levee slides detected using three different methods:
 - Pan-sharpening-for visual inspection

 - ISODATA clustering-for image classification

 - Spatial modeling using Tasseled Cap transformation



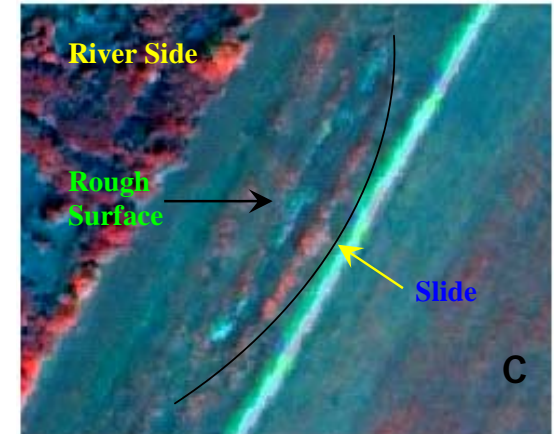
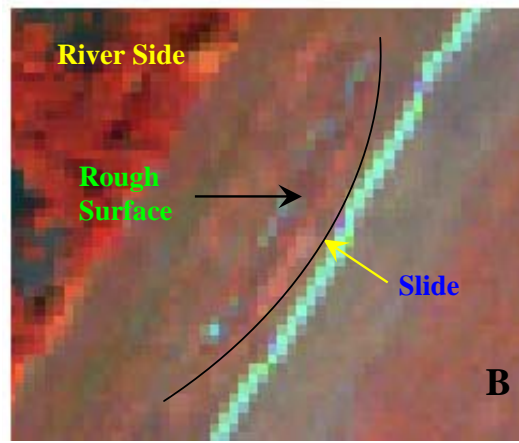
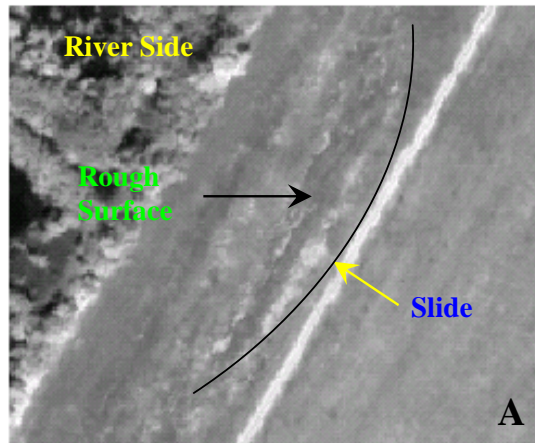
METHODS & RESULTS

Visual Inspection

- ❑ Pansharpened QuickBird and IKONOS imagery used
- ❑ Visual difference between slide and non-slide observed
- ❑ Criteria used:
 - pattern and shape of roughness and
 - location of special types of vegetation

METHODS & RESULTS

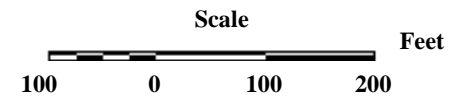
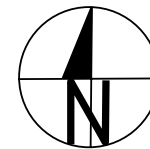
Zone-3: QuickBird Imagery



A: Panchromatic

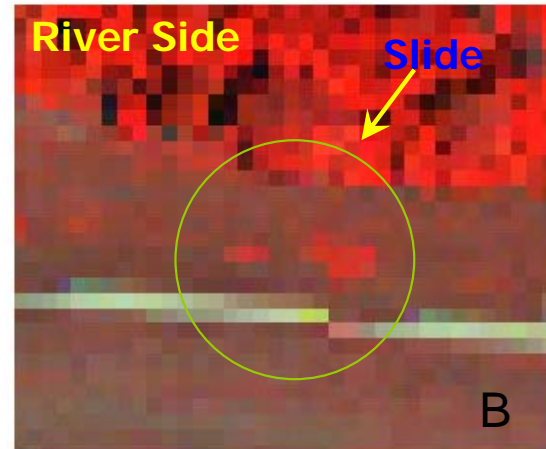
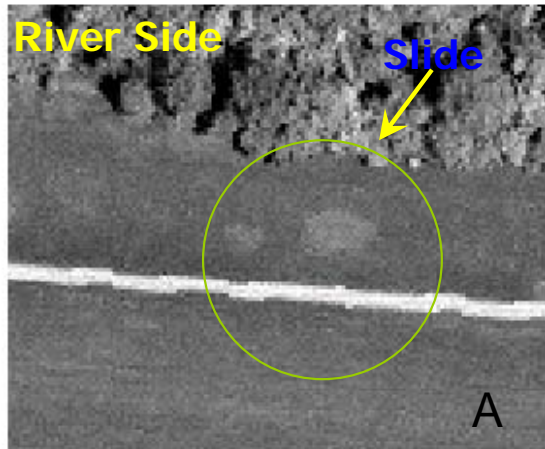
B: Multispectral

C: Pansharpended



METHODS AND RESULTS

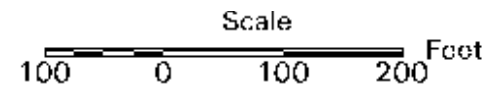
Zone-2: IKONOS Imagery



A: Panchromatic

B: Multispectral

C: Pansharpened



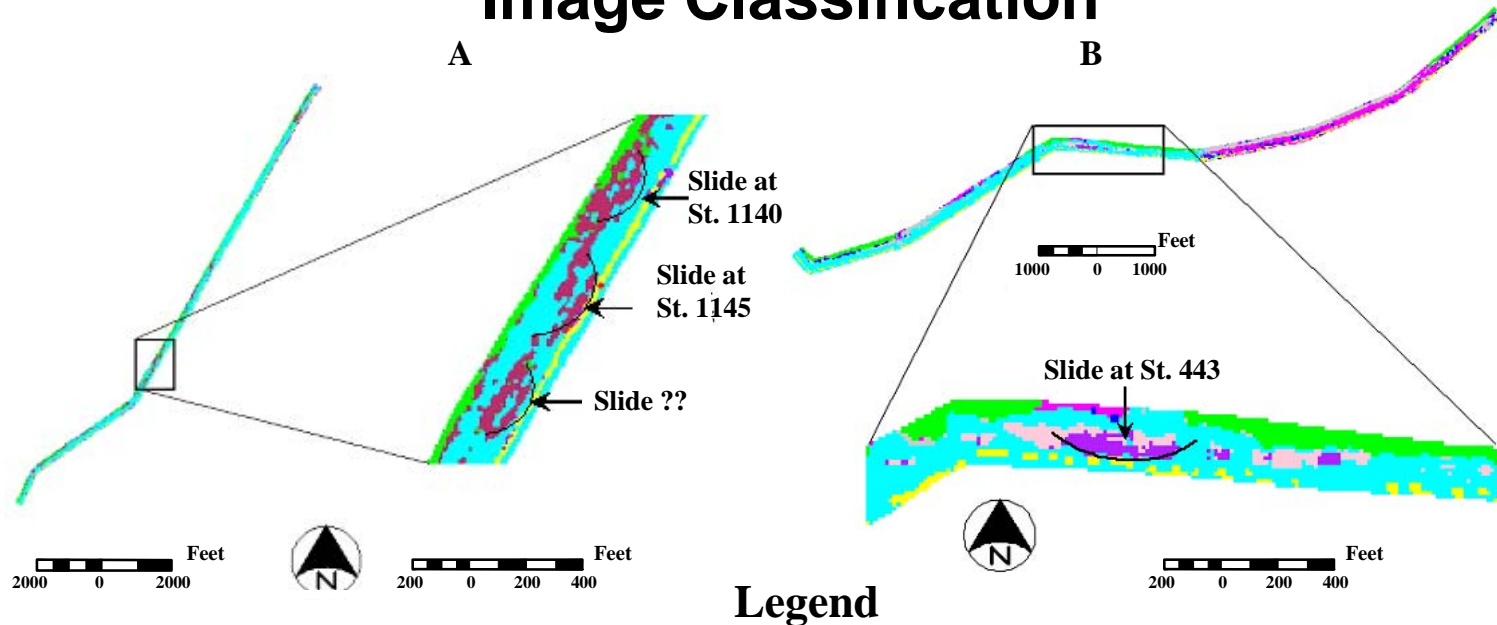
METHODS AND RESULTS











Image Classification

- ❑ Slide indicative features were classified
- ❑ Features include growth, density & types of vegetation, exposed soil, wetness of soil, and their distribution pattern
- ❑ QuickBird and IKONOS imagery were classified into 50 classes using ISODATA classification technique
- ❑ Classes were regrouped into nine (9) land cover classes of levee on the basis of field observations
- ❑ Distribution pattern (semi-circular shaped cluster) of some classification units indicate the location of slides

METHODS AND RESULTS

Image Classification



- | | | | |
|--|--|---|---|
|  | Trees |  | Exposed dry soil with little vegetation |
|  | Roads and infrastructure |  | Healthy Johnson grass with weed (not mowed) |
|  | Mowed Johnson grass with moist soil |  | Shallow water body |
|  | Mix of healthy Bermuda and Johnson grass and weed (not mowed) |  | Wet soil with little or no vegetation |
|  | Stressed grass (Bermuda and Johnson) with partial exposure of soil |  | GPS point taken in the field at slide affected area |

A: Zone-3, QuickBird, Aug. 02; B: Zone-2, IKONOS, June 01

METHODS AND RESULTS

Tasseled Cap Transformation

- ❑ Tasseled Cap transformation was applied on both IKONOS and QuickBird imagery
- ❑ Horn's (2003) Tasseled Cap transformation was applied on IKONOS
- ❑ Yarbrough and Others' (2005) Tasseled Cap transformation was applied on QuickBird imagery
- ❑ Soil Brightness Index (SBI) and Greenness Index (GI) images were classified into five classes using different thresholds
- ❑ Thresholds determined by field observations, pixel values and standard spectral curves

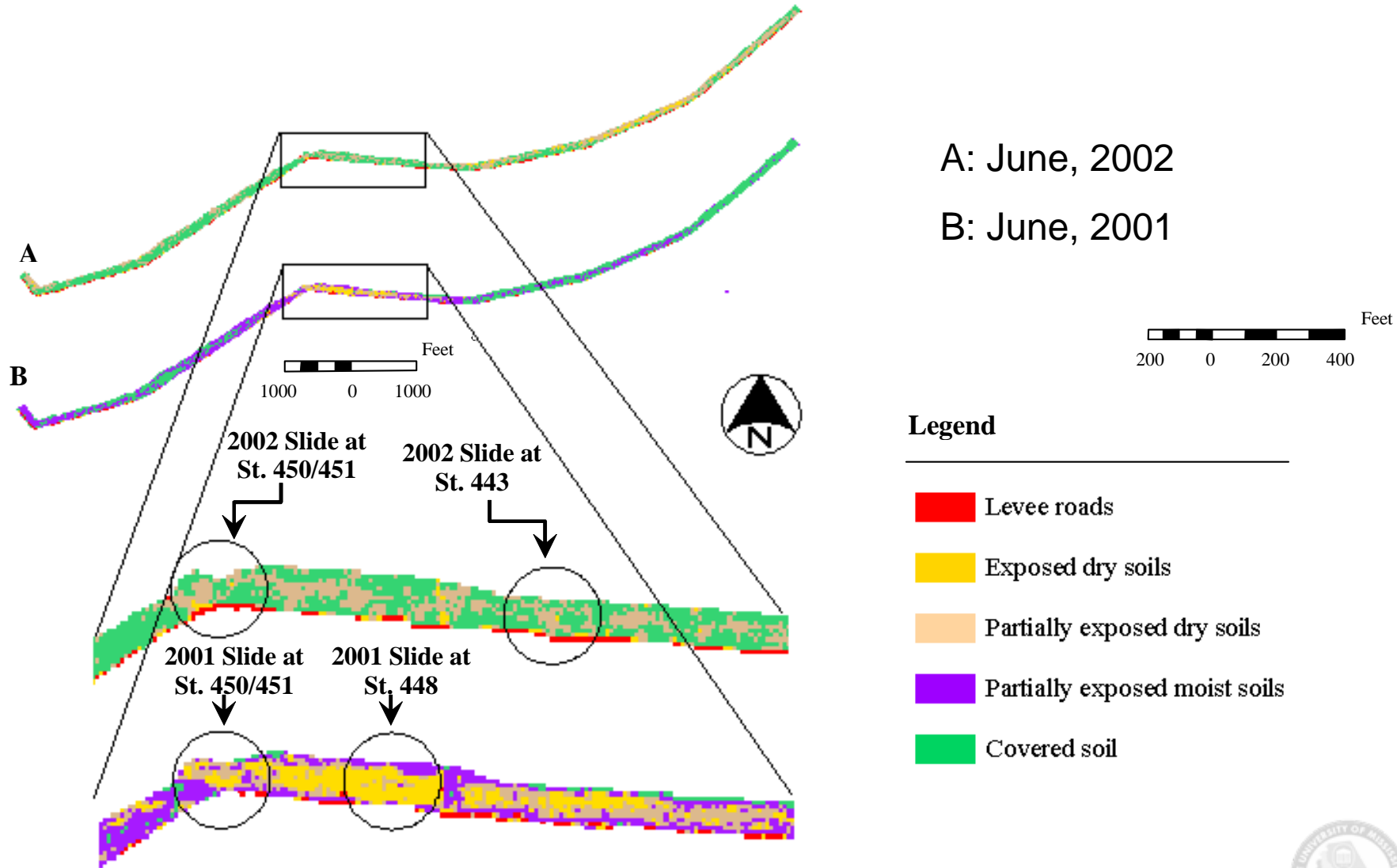


METHODS AND RESULTS

Classified Soil Brightness Index (Zone-2)-IKONOS

A: June, 2002

B: June, 2001

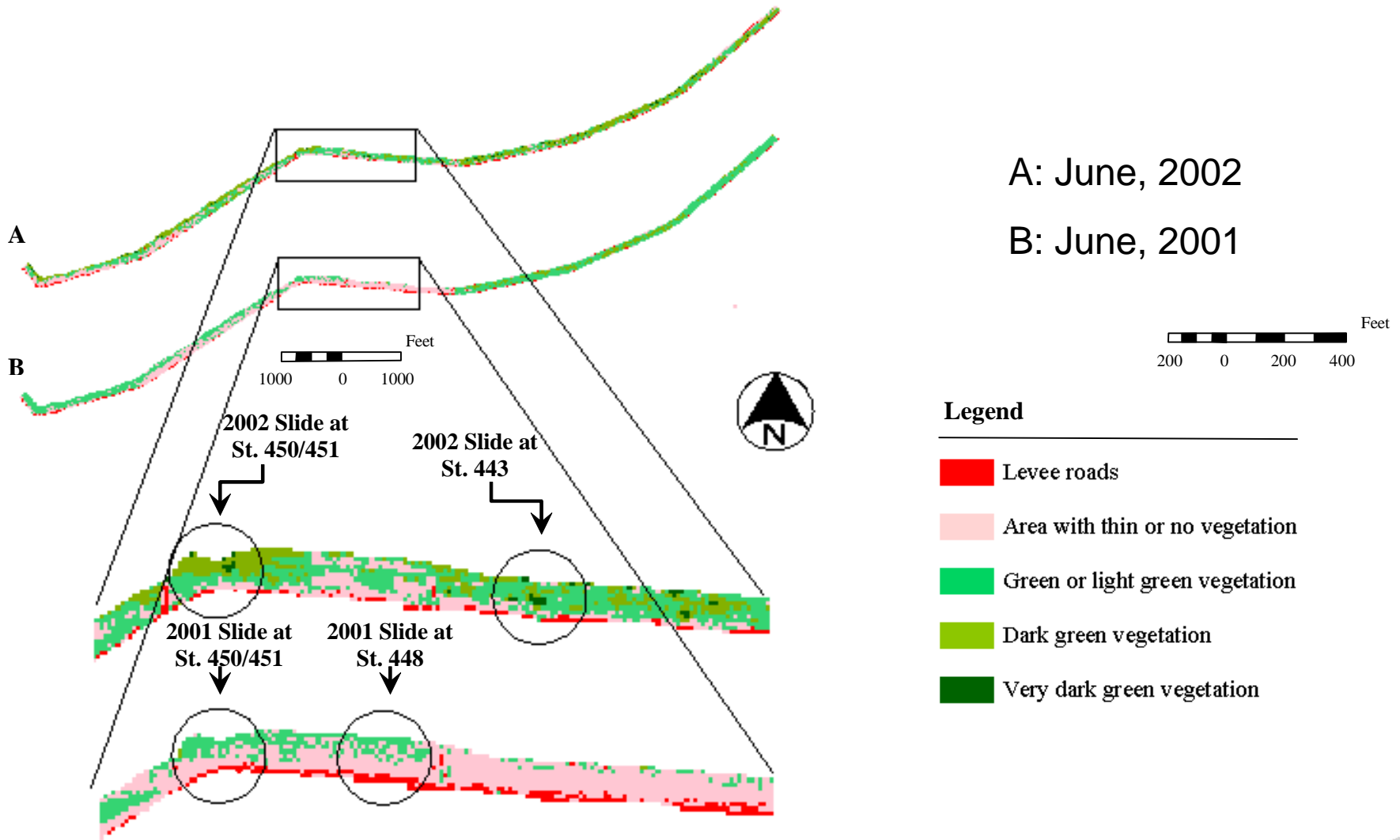


Legend

- Levee roads
- Exposed dry soils
- Partially exposed dry soils
- Partially exposed moist soils
- Covered soil

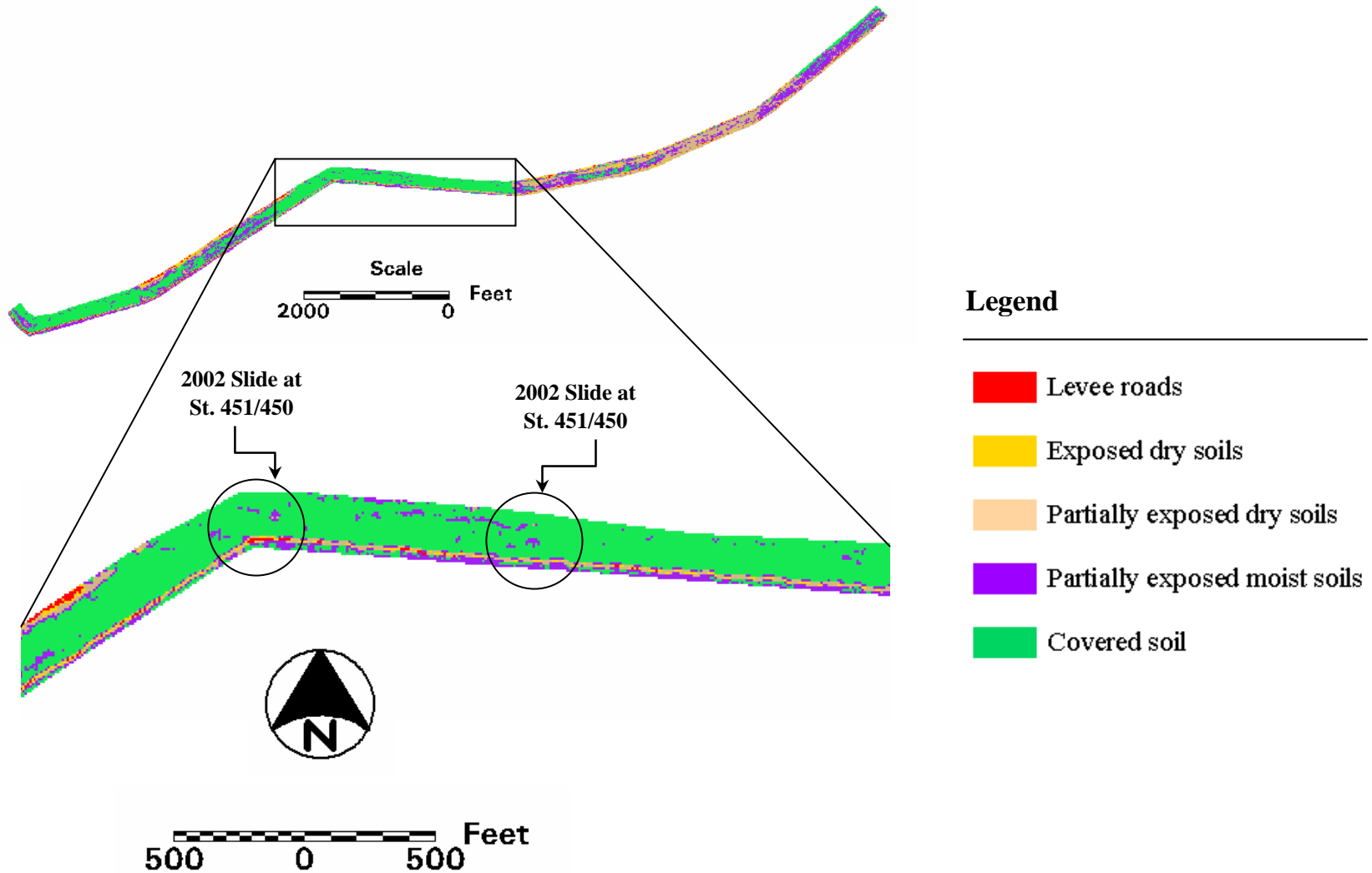
METHODS AND RESULTS

Classified Greenness Index (Zone-2)-IKONOS



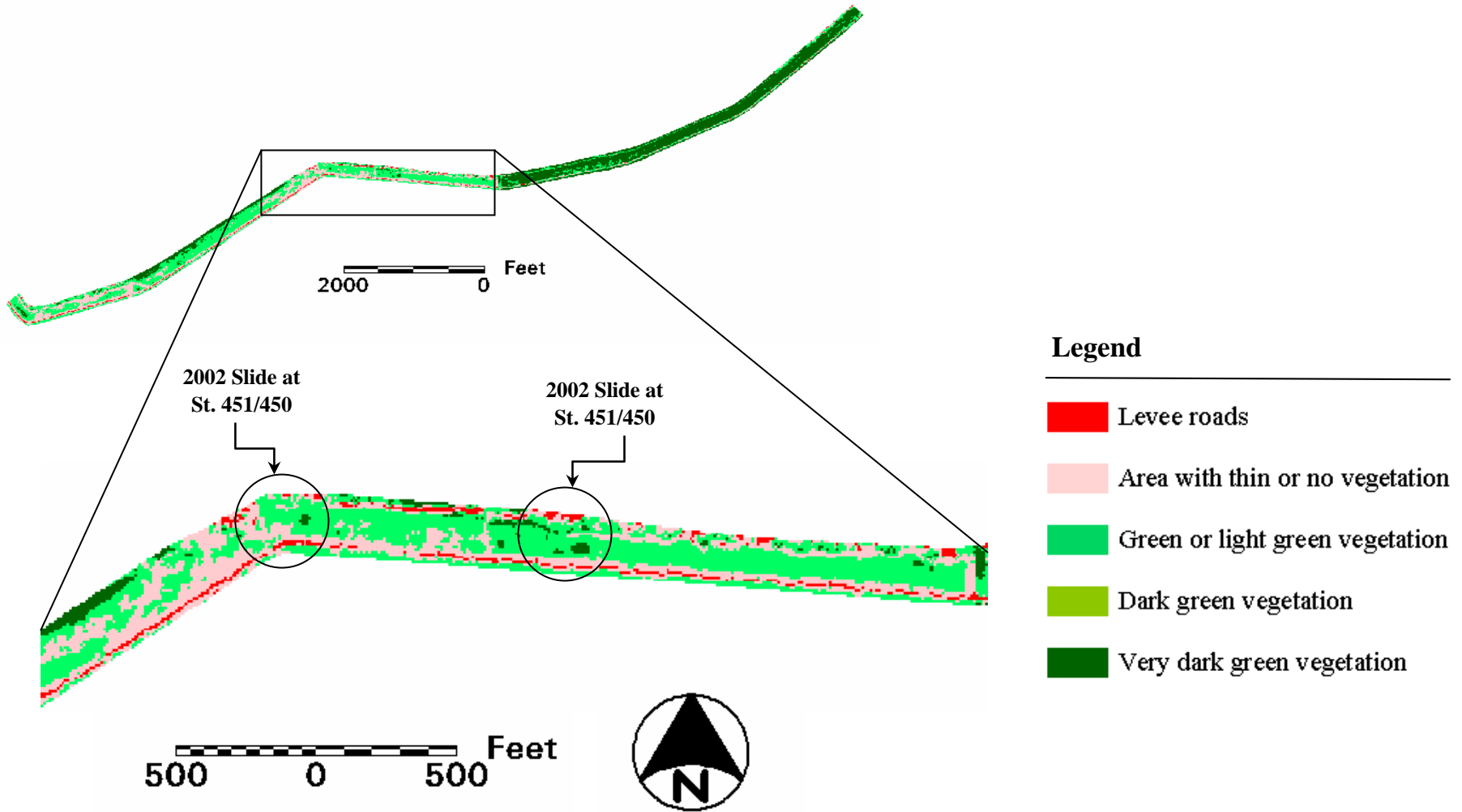
METHODS AND RESULTS

Classified Soil Brightness Index (Zone-2)-QuickBird



METHODS AND RESULTS

Classified Greenness Index (Zone-2)-QuickBird

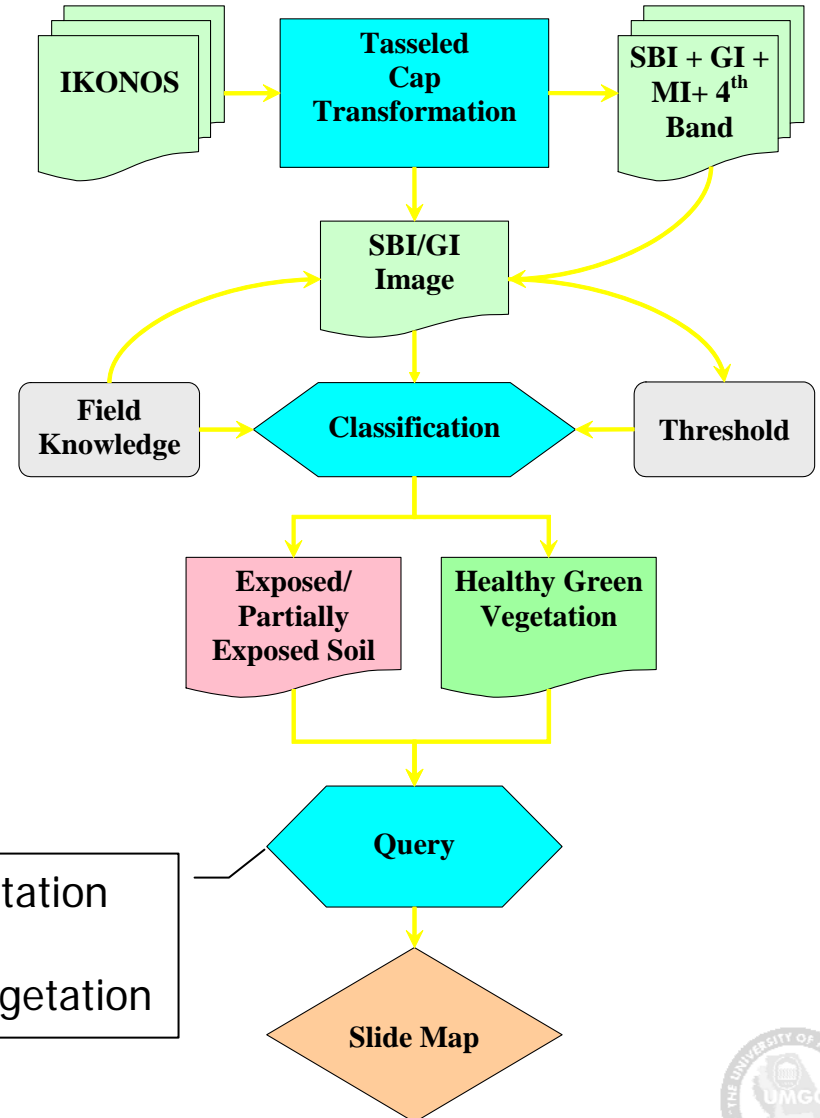


METHODS AND RESULTS

Slide Detection Model-IKONOS

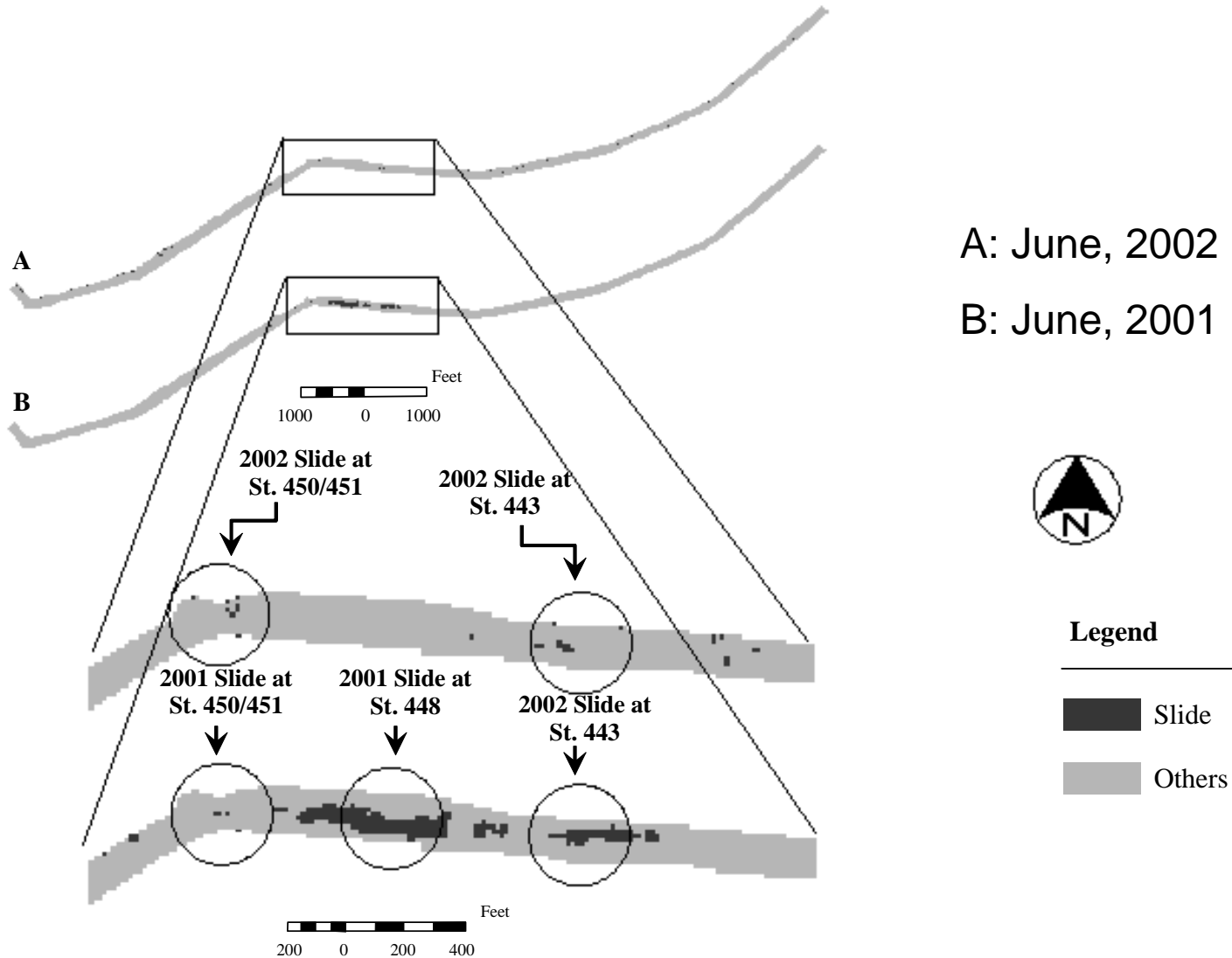
- It was observed that SBI and GI images can be used independently for slide detection, but the results may not be precise
- Classified exposed soils in SBI and healthy green vegetation in GI include areas not associated with slide.
- Classified SBI and GI images used to create a model for slide detection.

Exposed dry soil + Area with less vegetation
OR
Partially exposed soil + Healthy green vegetation



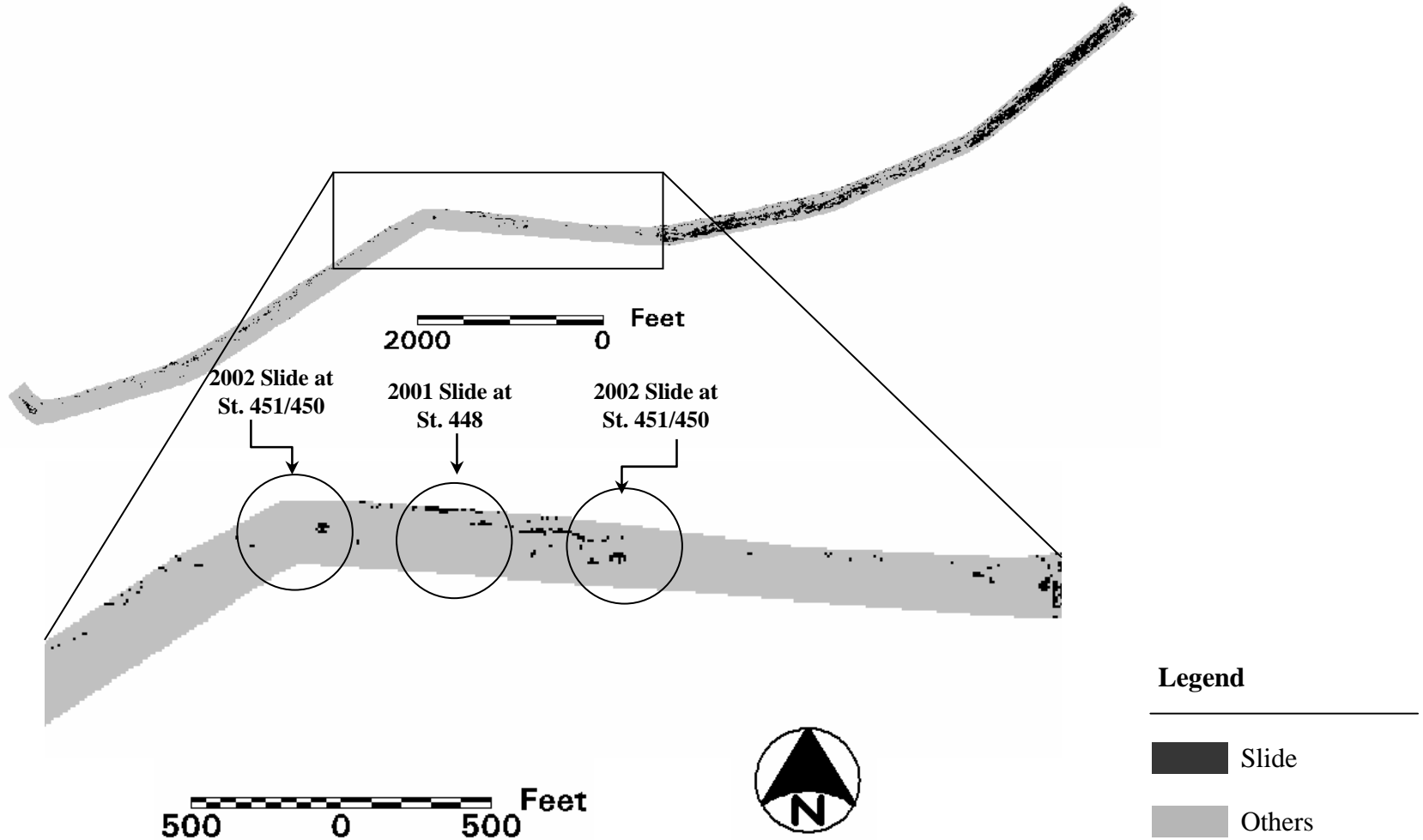
METHODS AND RESULTS

Slide Detection Model-IKONOS



METHODS AND RESULTS

Slide Detection Model-QuickBird



METHODS AND RESULTS

Slide Detection Model-QuickBird

- ❑ Showed capability to detect slide affected areas
- ❑ Also identified non-slide areas as slides
- ❑ Did not work like IKONOS based model
- ❑ Tasseled Cap transform co-efficient derived for QuickBird and IKONOS in different way

CONCLUSION

- ❑ High resolution multispectral imagery like IKONOS and QuickBird are suitable for detecting and monitoring levee slides
- ❑ IKONOS suitable for:
 - Visual inspection
 - image classification and
 - Tasseled Cap transform based slide detection model
- ❑ QuickBird suitable for:
 - Visual inspection and
 - Image classification
- ❑ Tasseled Cap based model was found to be the best method to detect slides

REFERENCES

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- ❑ Neuner, J. A., 2002, Detection of surficial failures in high plasticity, compacted clay slopes using remote sensing along the Mississippi River levee, University of Mississippi, M.Sc. thesis, 131p, 90 figs.
- ❑ Yarbrough, L. D., Easson, G., and Kuzmaul, J. S., 2005, QuickBird 2 Tasseled Cap Transform coefficients: a comparison of derivation method, Pecora 16 “Global Priorities in Land Remote Sensing” October 23 – 27, 2005
* Sioux Falls, South Dakota.



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- UMGC-Funded the project
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