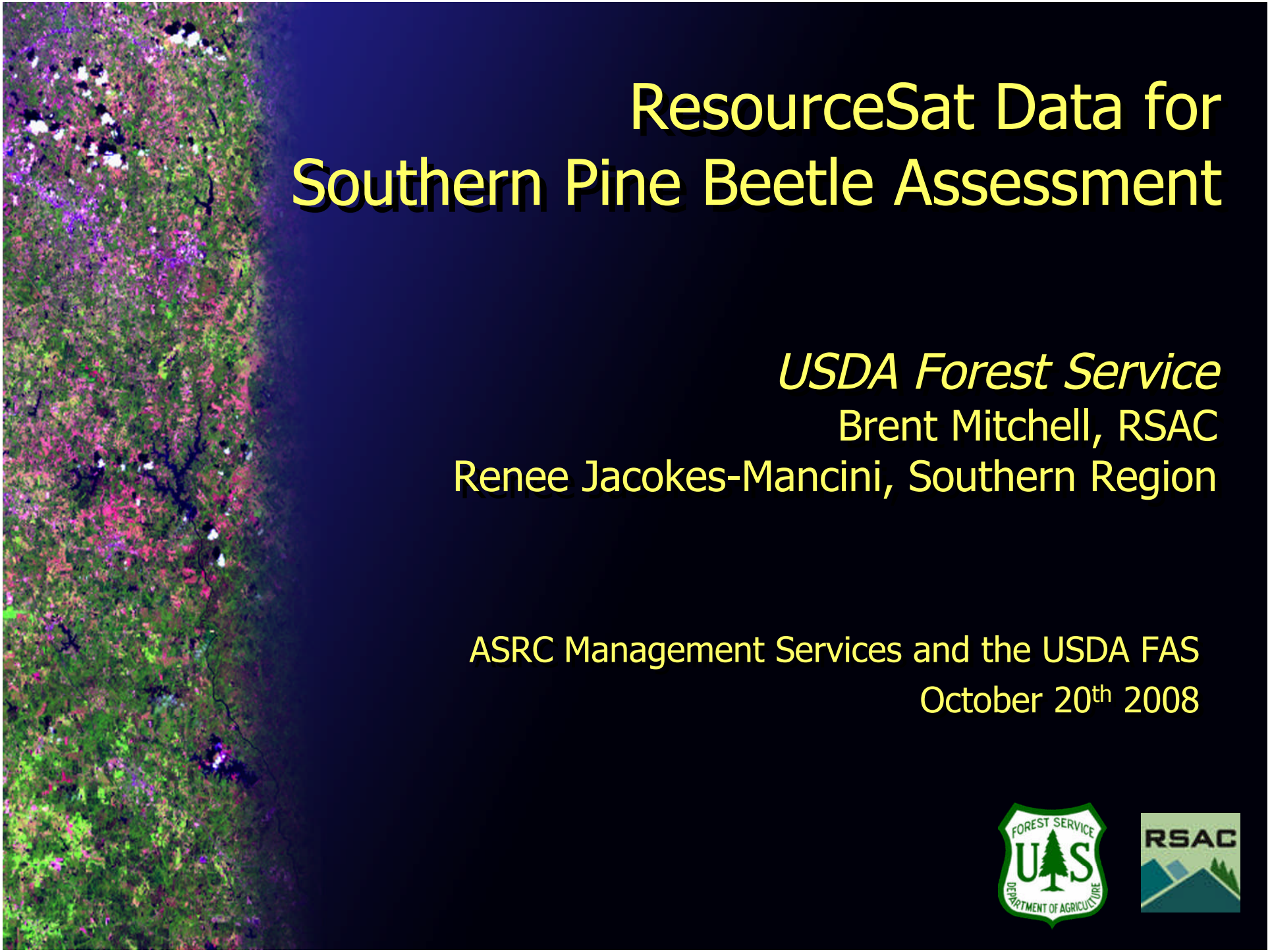

ResourceSat Data for Southern Pine Beetle Assessment

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ASRC Management Services and the USDA FAS
October 20th 2008

Outline

- Objectives of the study
- Background and Study Area
- Data Sources Used
- Analysis Techniques
- Accuracy Assessment
- Results
- Discussion and Applications

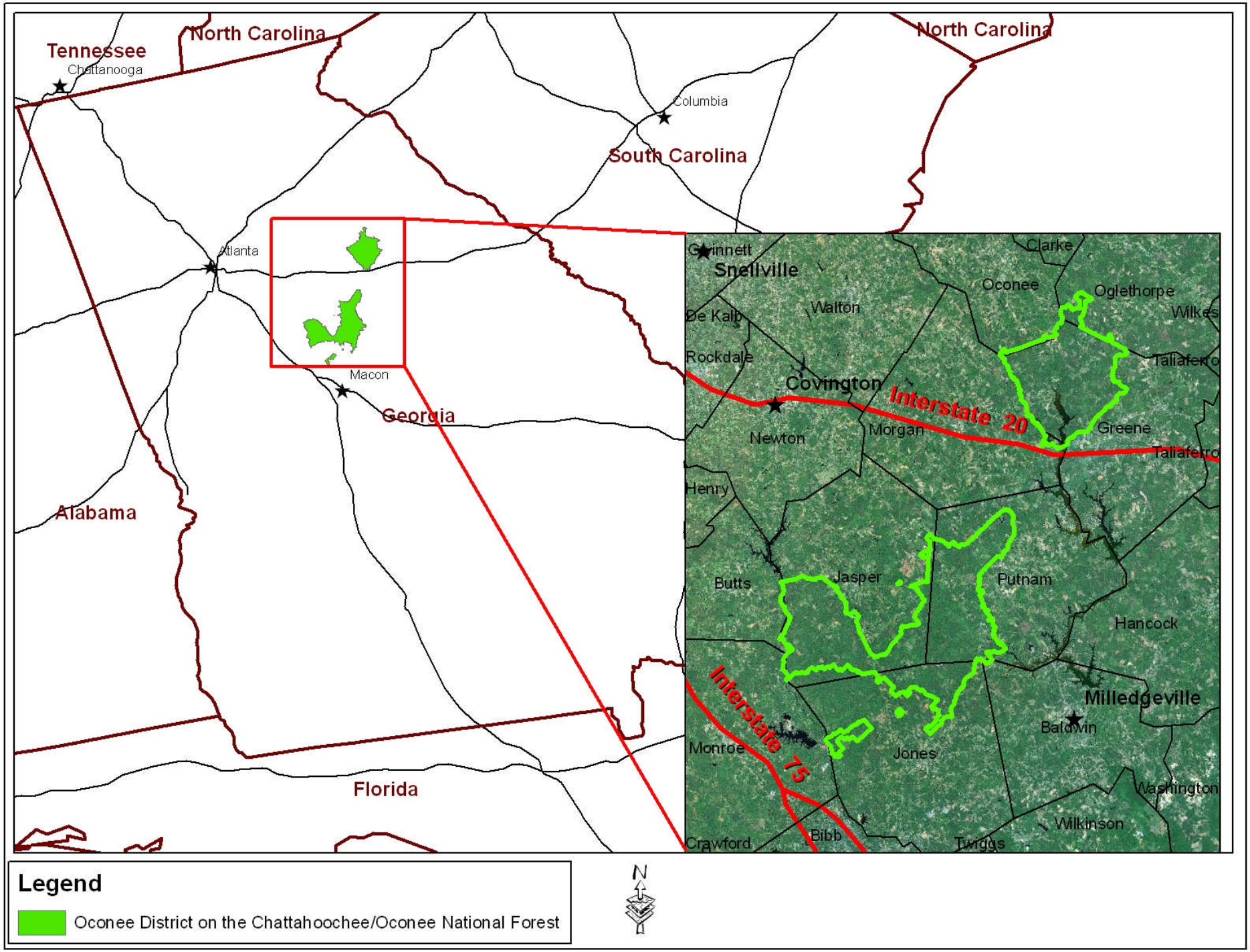
Background

The National Forests in Southeast has experienced several Southern Pine Beetle (SPB)

- Changing the Ecosystems
- Increased fuels for wildfire
- Threatening sensitive sites
- Economic impact
- Endangering the public

Background

- The Oconee District has experienced two major SPB outbreaks in the last 10 years.
- The climate has provided ideal conditions for the SPB
- The second large SPB outbreak in the spring of 2007.


Tennessee
Chattanooga
North Carolina
North Carolina
Columbia
South Carolina
Atlanta
Macon
Georgia
Alabama
Florida
Gwinnett
Snellville
Clarke
Oconee
Oglethorpe
Wilkes
Walton
De Kalb
Rockdale
Taliaferro
Covington
Interstate 20
Newton
Morgan
Greene
Taliaferro
Henry
Butts
Jasper
Putnam
Hancock
Interstate 75
Milledgeville
Baldwin
Monroe
Jones
Washington
Wilkinson
Crawford
Bibb
Twiggs
Legend
Oconee District on the Chattahoochee/Oconee National Forest
N

Purpose/Goal

- Selection of sensor(s) and develop of image process(es) for the operational monitoring of Southern Pine Beetle (SPB) outbreaks.
- Ideal operational goal of monitoring the SPB every two week cycles at a low cost and acceptable accuracy

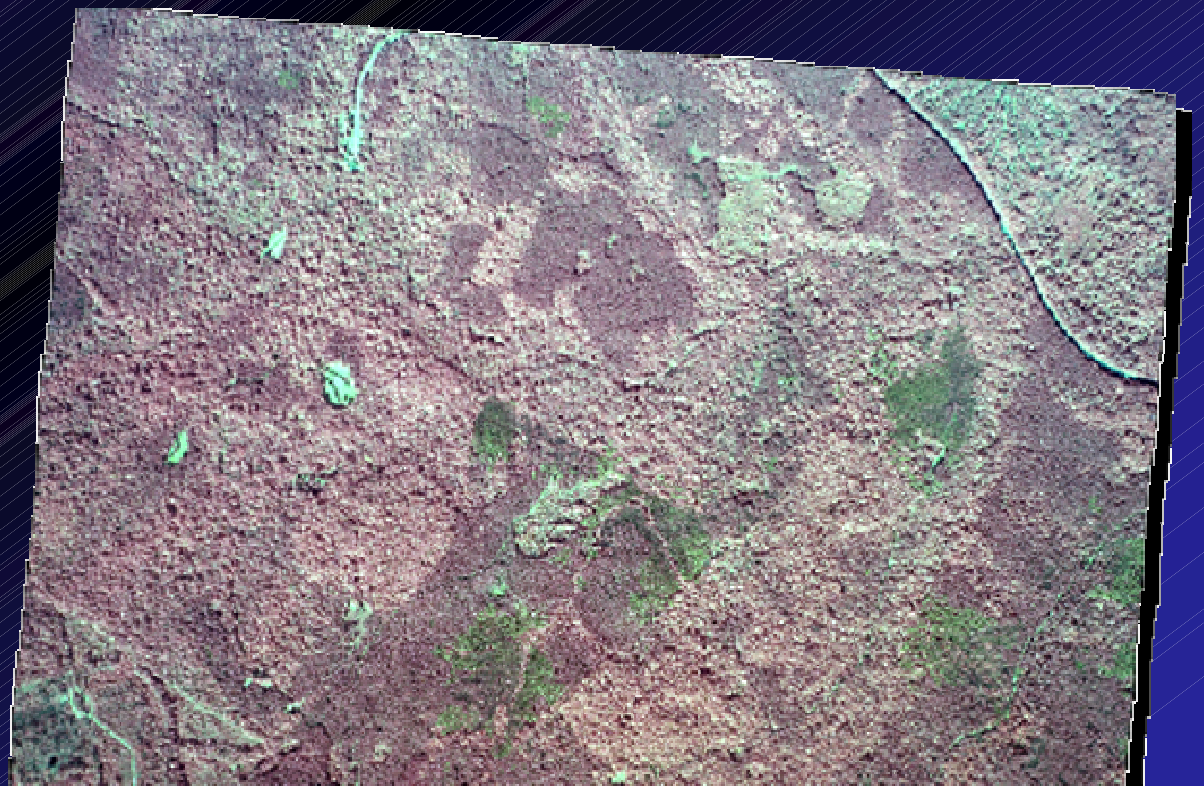
Objectives

- Determine the operational feasibility of the techniques and sensors.
- Based on cost, timeliness, and accuracies of five different image sources.
- Produce a matrix comparing the effectiveness of the various sensors for detecting SPB outbreaks.

Imaging Platform	Sensor Name	Temporal Resolution	Coverage (Swath-Width)	Spatial Res.	Minimum Detection Area	Spectral Res.	Availability	Cost of Acquisition	Per/Hours needed for Analysis, estimated at $50per/hr	Accuracy	Cost/ Acre of final product	Comments and Concerns
Fixed Wing Aircraft	Kodak DCS 645c Proback sensor (16 megapixel), 55mm lens	Dependent on need and availability	2.1km in this particular case	.5 m	1 pixel = .00006 acres, smallest recommended feature detection area is 0.00024 acre	G, R, NIR	Dependent on need.	$11,000.00 per flight	80 per/hrs ($4000.00)	Overall = 97.1% Users = 87.5% Producers = 69.01% Kappa = .7564	5.2 Cents per Acre or 12.9 Cents per Hect.	Not Operationally Feasible
Spot 5 Satellite	HRG	3-5 Days (Pointable)	60km	10m	1 pixel = .025acres, smallest recommended feature detection area is 0.1 acre	G, R, NIR, SWIR	Can be tasked at any desirable date.	$2675.00 Level 1A 10m 1/4 Scene	40 per/hrs ($2000.00)	Overall = 93.7% Users = 27.14% Producers = 61.29% Kappa = .34823	.5 Cents per Acre or 4.1 Cents per Hect.	Would benefit from performing a NDMI Differencing Analysis.
IRS-P6 Satellite	LISS3	24 Days (nadir), Liss3 only available at nadir	141km	23m	1 pixel = .13acres	G, R, NIR, SWIR	Scenes available for free from April to September for 2008.	$924.00 per scene	24 per/hrs ($1200)	Overall = 97.0% Users = 78.87% Producers =78.87% Kappa = .772	.062 Cents per Acre or .15 Cents per Hect.	Accuracy is operationally feasible, but limited by its 24 day revisit time.
IRS-P6 Satellite	AWIFS	24 Days *(nadir), 5 Days with increased viewing angles*	740km Full Scene, contains 4 tiles 370km each.	56m	1 pixel = .77acres	G, R, NIR, SWIR	Scenes available for free from April to September for 2008.	Free	24 per/hrs ($1200)	Overall = 97.6% Users = 92.59% Producers = 71.43% Kappa = .794	.004 Cents per Acre or .009 Cents per Hect.	Most Operationally Feasible.
AQUA/ TERRA	MODIS	Daily	2330km	2 at 250m 5 at 500m	1 pixel = 15 acres	B, G, R, NIR, Mid IR, Far IR, Thermal	Scenes avalable for free, archived back to 2000, available daily.	Free	24 per/hrs ($1200)	Overall = 92.1% Users = 43.75% Producers = 18.67% Kappa = .2270	.00008 Cents per Acre or .0002 Cents per Hect.	The spatial resolution isn't adequate to detect SPB infestations with any confidence.

Imagery Data Sources

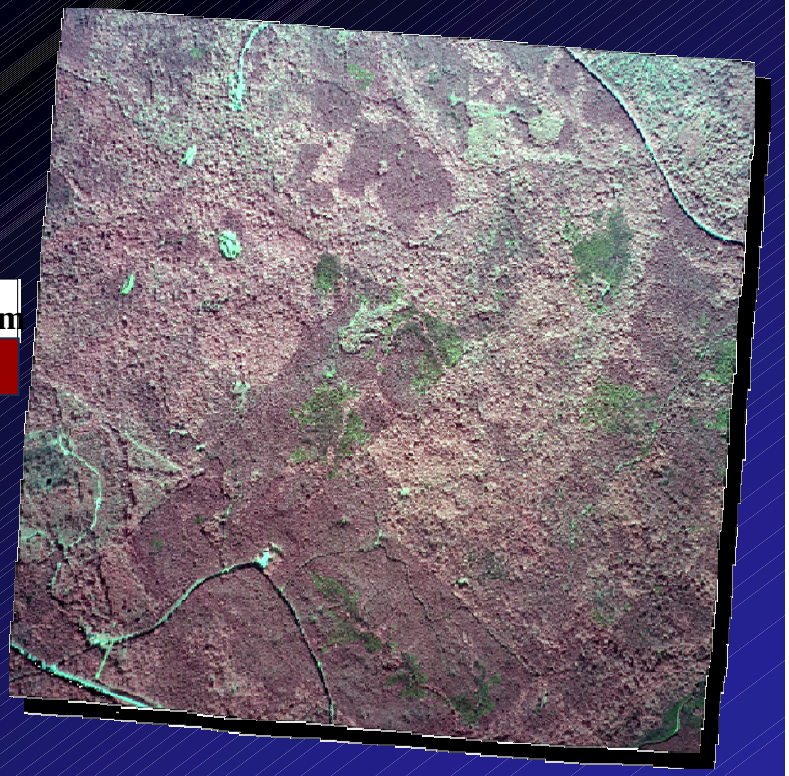
- Imagery with a variety of spatial and spectral resolutions were obtained.
  - Aerial Photography
  - SPOT5
  - LISS3
  - AWIFS
  - MODIS



Data Sources

- Aerial Photography (High Resolution)
  - Color-infrared (CIR) small format digital camera.
  - Spatial resolution: 0.5 meters
  - Spectral bands **(Green, Red, NIR)**

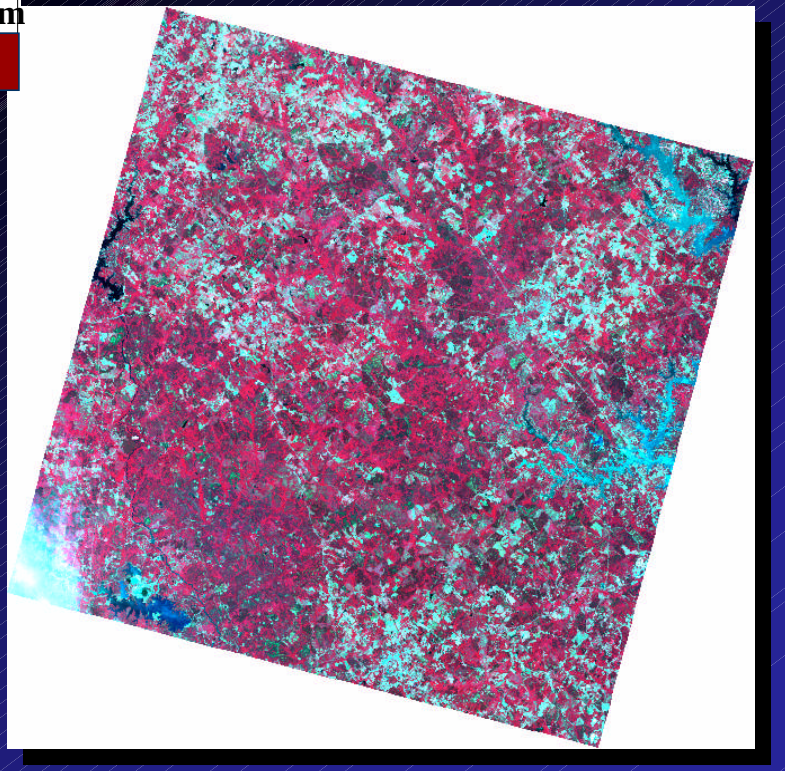
  - Collected on October 13-14, 2007



Data Sources

- Spot5 Satellite (Medium Resolution)
  - Spatial Resolution of 10 meters
  - Spectral bands: **(Green, Red, NIR, SWIR)**

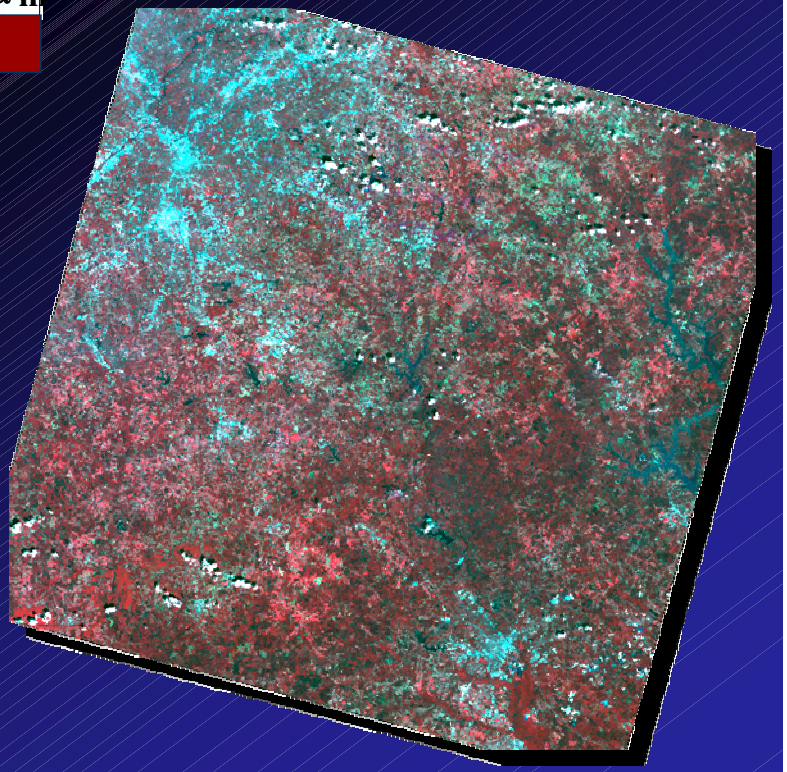
  - Imagery acquired May 15, 2008.



Data Sources

- Resourcesat-1 Satellite-LISS3 (Medium Resolution)
  - Spatial Resolution: 23 meters
  - Spectral bands: **(Green, Red, NIR, SWIR)**

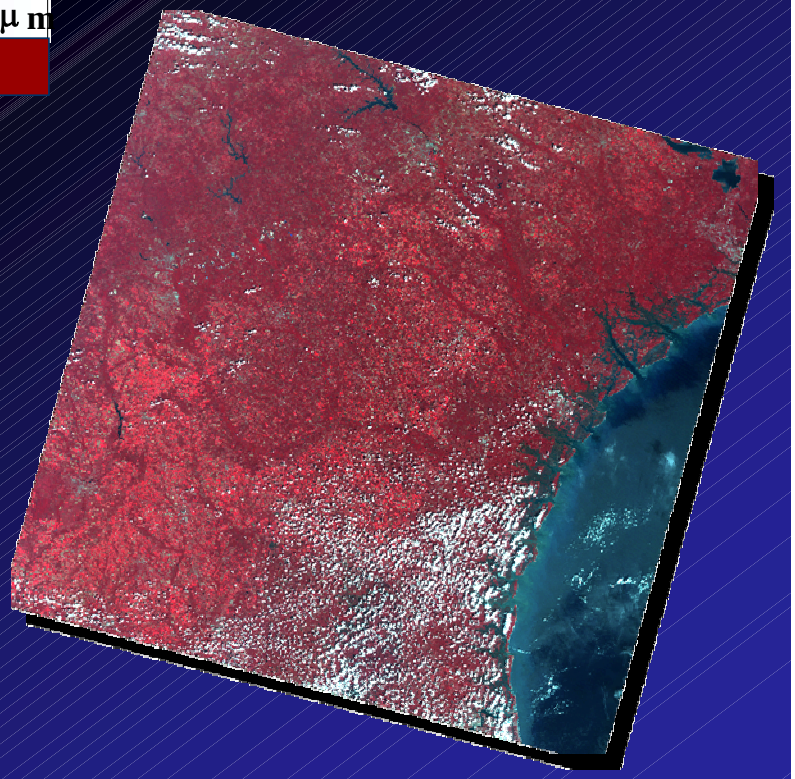
  - Acquired on August 2, 2006 and September 9, 2007.



Data Sources

- Resourcesat-1 Satellite-AWIFS (Moderate Resolution)
  - Spatial Resolution of 54 meters
  - Spectral bands: **(Green, Red, NIR, SWIR)**

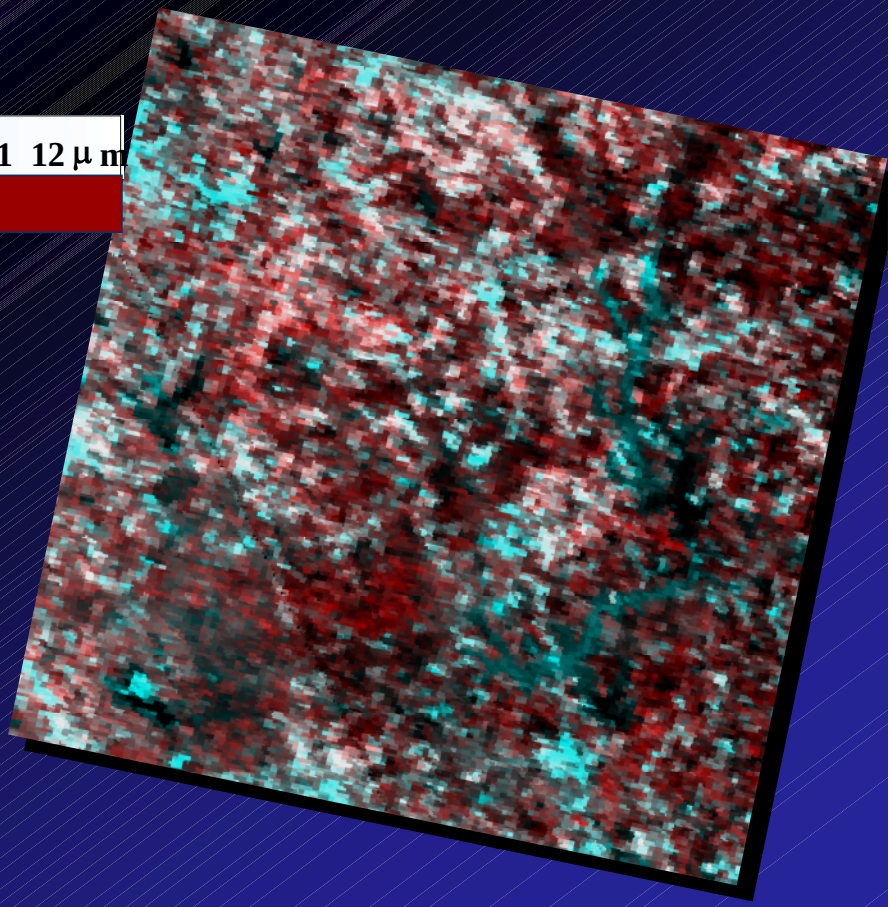
  - Acquired on September 29, 2006 and September 9, 2007.



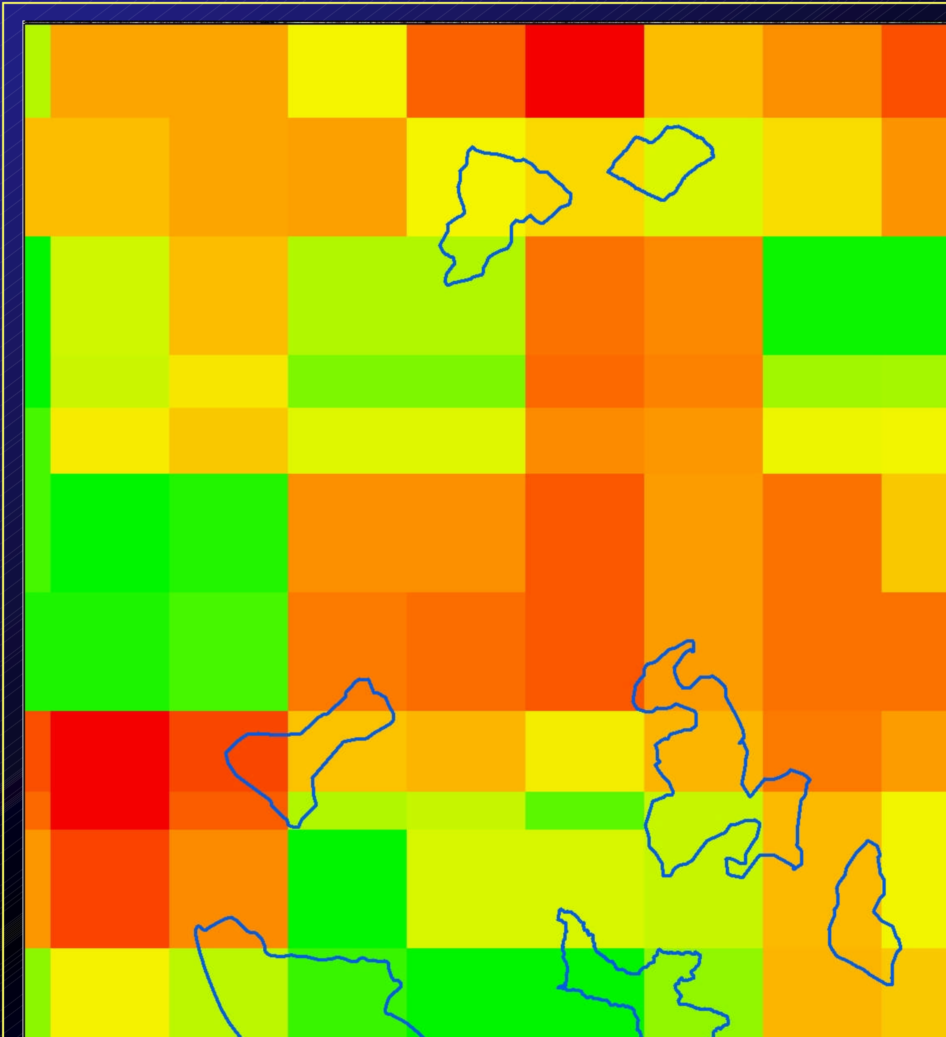
Data Sources

- Aqua/Terra Satellite-MODIS (Moderate Resolution)
  - Spatial Resolution of 250 meters
  - "Land use" Spectral bands:
    (Blue, Green, Red, NIR, SWIR and 2 MIR)

  - Acquired on October 14, 2006 and October 14, 2007.



Spatial Resolution Comparison



- NDVI difference image (meter spatial resolution) covering approximately 1000 acres of the Oconee National Forest. (Red=decrease, Yellow=no change, and Green=increase).

Detection Methods

- Feature Extraction
  - Used when no previous imagery was available to perform change detection analysis.
    - CIR Photography
    - SPOT5 Imagery
- Change Detection
  - Used in the moderate resolution imagery where multiple dates of images are more readily available.
    - LISS3
    - AWIFS
    - MODIS

Feature Extraction

- CIR photos and SPOT5
- Feature Analyst™ (FA)
  - A user assisted, automated feature extraction application offered as an extension to ArcGIS.
  - FA uses spatial association, size, shape, texture, pattern and shadow in user-defined feature examples or "Training Sets".

Training site samples over-laid on CIR photography

Change Detection

- LISS3, AWIFS, and MODIS
  - Autumn anniversary dates were used for all sensors
  - Normalized Difference Moisture Index (NDMI) performed on each image pair
    - NDMI = NIR-SWIR / NIR + SWIR

      * Chosen because of increased ability to detect lighter disturbances within the forest canopy.
  - Resulting 2006 NDMI image subtracted from the 2007 NDMI image.
  - Conifer mask applied
  - Ground truth data referenced to extract NDMI change values that correlated to the SPB infestations.

Typical Results

Legend

- SPB Infestation Spots (Ground Truth)
- CIR/Feature Analyst Extraction Polygons
- Spot5/Feature Analyst Extraction Polygons
- LISS3/Change Detection Polygons
- AWIFS/Change Detection Polygons

*All results are displayed over the CIR aerial photography for visual comparison. (RGB=NIR, Red, Green)

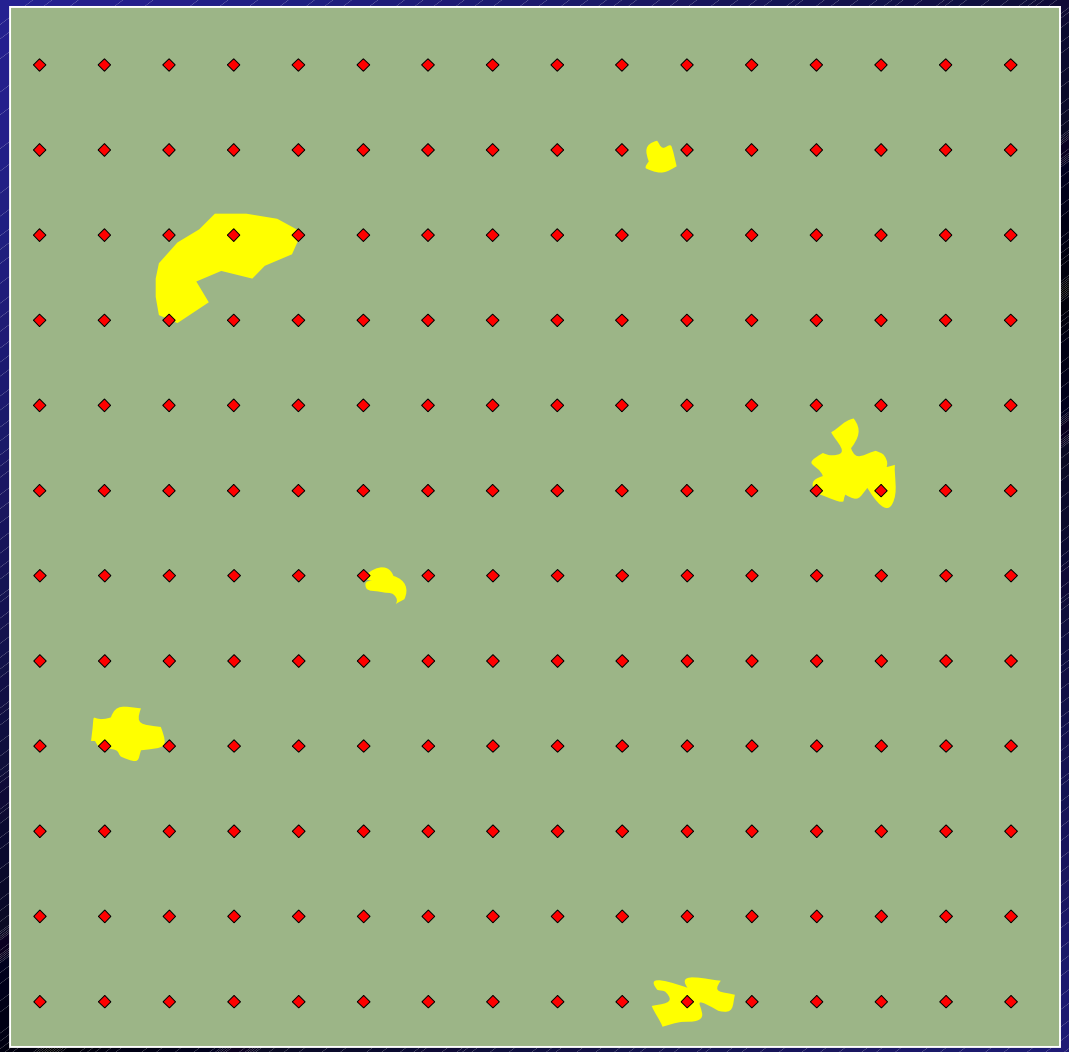
Accuracy Assessment

- SPB infestation maps compared to ground truth data.
  - Used Image Sampler Extension for ArcGIS v9.2
    - 1000 random sampling points
    - Attributed into 4 categories
      - Actual SPB on the ground-mapped as SPB in the imagery (correct)
      - Actual SPB on the ground-not mapped as SPB in the imagery (error of omission)
      - Not actual SPB mapped on the ground-mapped as not SPB in the imagery (correct)
      - Not actual SPB mapped on the ground-mapped as SPB in the imagery (error of commission)

Accuracy Assessment Results

	Overall Accuracy	SPB Users Accuracy	SPB Producers Accuracy	Kappa
CIR	97.6%	92.59%	71.43%	.794
SPOT5	93.7%	27.14%	61.29%	.348
AWIFS	97.1%	87.5%	69.01%	.756
LISS3	97%	78.87%	78.87%	.772
MODIS	92.1%	43.8%	18.7%	.227

Overall Accuracy "Spatially Skewed"



- Overall accuracy measures how well we mapped both SPB infestations and areas that are not SPB infestations.
  - Oconee District=114,851 acres
  - SPB areas=3,243 acres
- Overall accuracy will be biased, because areas that are not SPB infestations represent 98% of the study area and are easier to map.

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Results - Kappa/K-Hat in Context

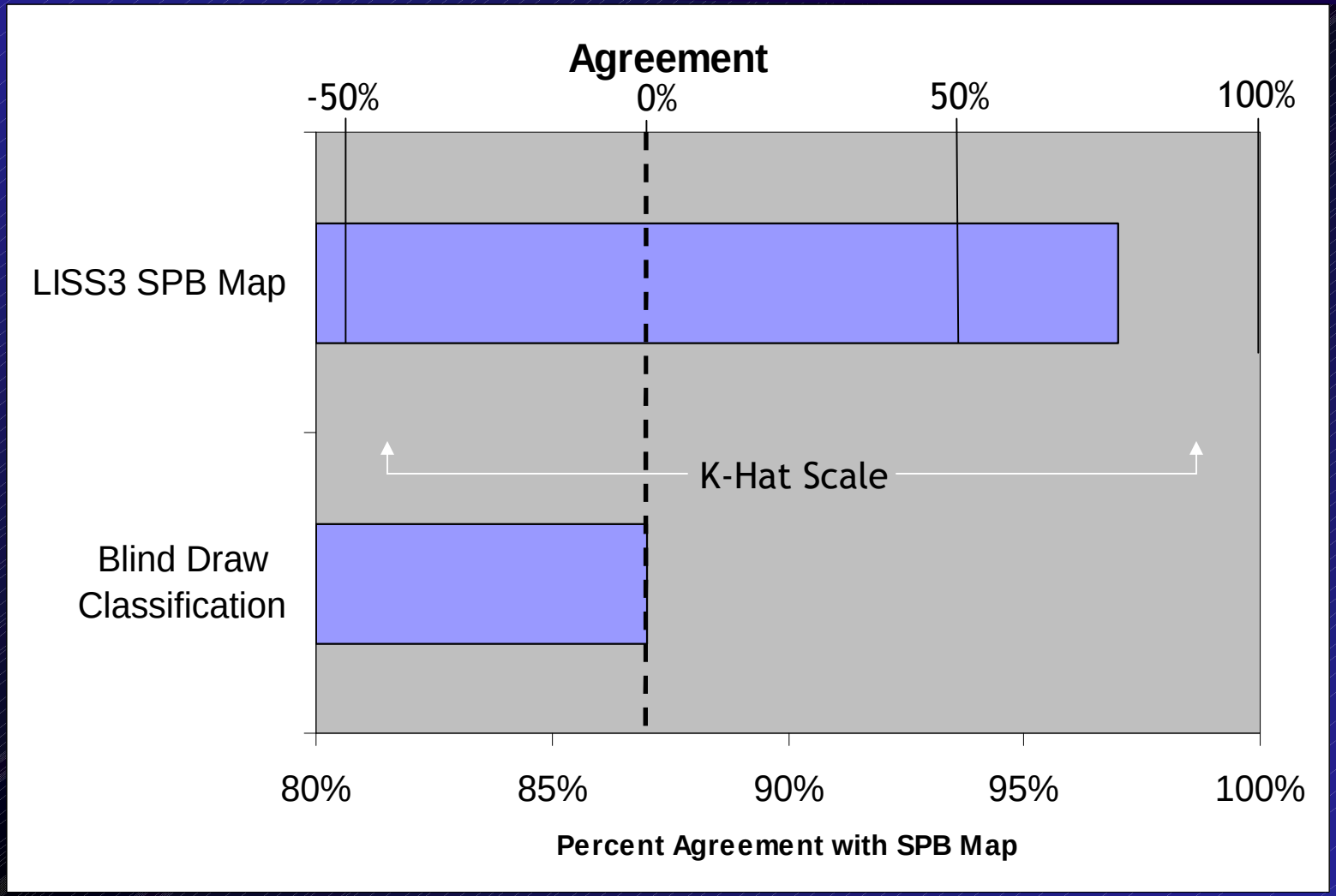

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Image Evaluation Matrix

- Summarizes the results of the study.
- Quick reference guide.
  - Characteristics of sensors
  - Accuracies
  - Costs involved
  - Operational feasibility

Imaging Platform	Sensor Name	Temporal Resolution	Coverage (Swath-Width)	Spatial Res.	Minimum Detection Area	Spectral Res.	Availability	Cost of Acquisition	Per/Hours needed for Analysis, estimated at $50per/hr	Accuracy	Cost/ Acre of final product	Comments and Concerns
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Image Evaluation Matrix

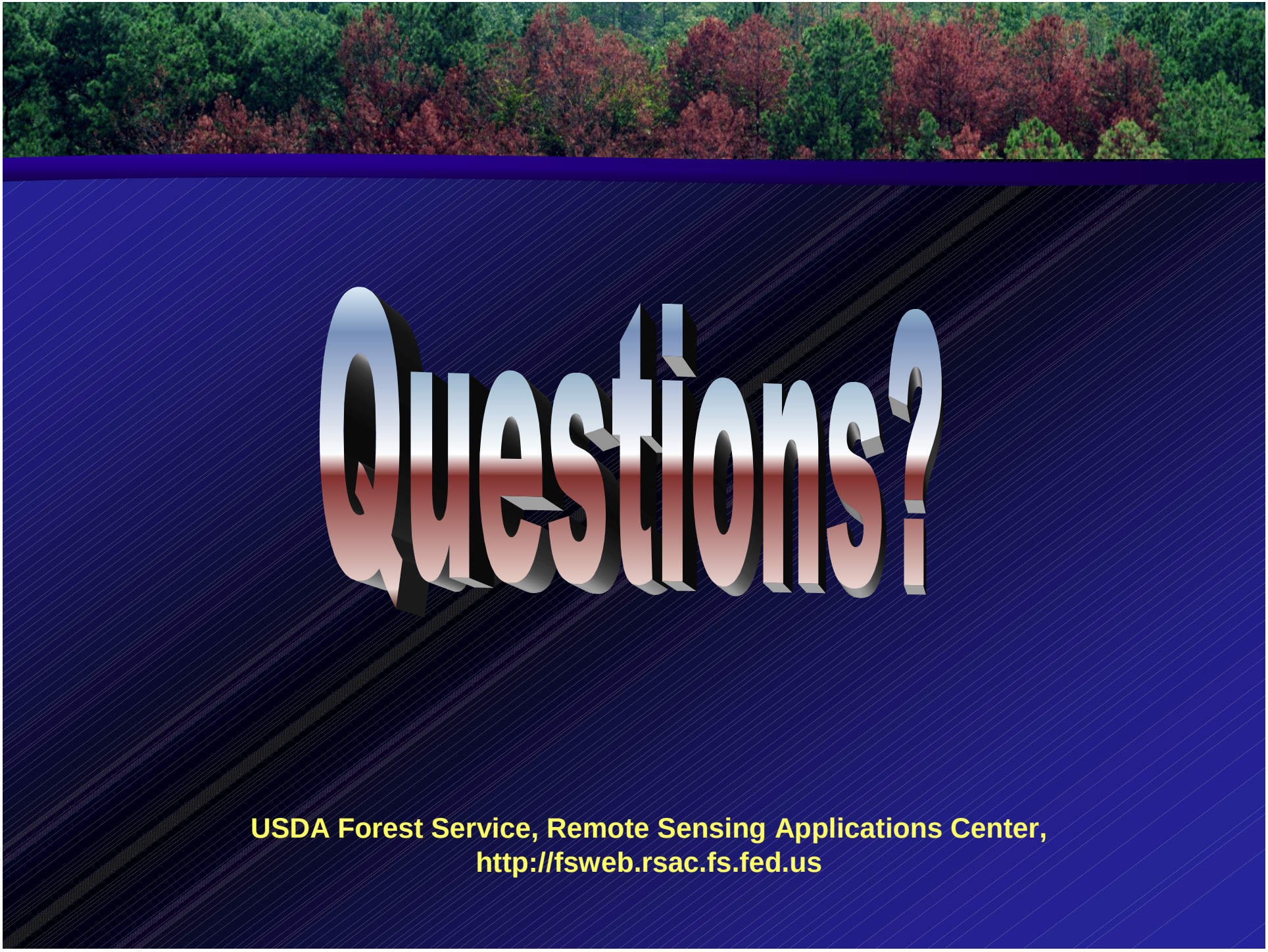
Discussion

- CIR aerial photography
  - Accurate
  - Costly and acquisitions have to be scheduled
  - Cost ~ 17 cents/acre
- Spot5
  - Accuracy not proven
  - Logistics of acquiring data could be difficult
  - Cost ~ 8 cents/acre
- LISS3
  - Accurate
  - Revisit time of 24 days not operationally feasible
  - Cost ~ 4 cents/acre
- AWIFS
  - Accurate
  - Revisit time of 5 days—possibly operationally feasible*
  - Cost ~ 3 cents/acre
- MODIS
  - Poor Accuracy
  - Free daily coverage
  - Cost ~ 3 cents/acre

*All estimates based on $50 per/hour analyses cost and cost of imagery.
*The cost for collecting ground truth data is not accounted for.

Applications

- The combination of accuracy, cost, revisit time and ease of analysis suggests that AWIFS could act as an operational monitoring tool for SPB infestations and possibly other forest health issues in the future.



USDA Forest Service, Remote Sensing Applications Center,
http://fsweb.rsac.fs.fed.us