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Consultants: Curtis Woodcock and Xueqiao Huang
Overview

* This research will apply remote sensing techniques to map changes in forest cover in California

* The scope of this research will be the testing and improvement of an operational FS-CDF forest change monitoring program
Objectives of the Study

Research Objective 1

Establish an operational forest cover change monitoring program based on the following project efficiency indicators:

- Change-map accuracy assessment
- Flexibility of implementation
- Interpretability of methods and results
- Consistency across phenologically diverse areas
Objectives of the Study

Research Objective 1: Related research questions

1. Which change detection techniques produce the most accurate, interpretable maps of forest cover change?

2. How do the existing FS-CDF program methods compare to those generated by state-of-the-art techniques?

3. How do results differ between southwest and northeast California study sites?
Objectives of the Study

Research Objective 2

Implement the forest monitoring program established in Objective 1 to analyze the extant data sets (1996-2000 and 1990-2000)
Objectives of the Study


1. How is forest cover change manifested in terms of
   a) geographical extent, b) cause, c) rate?

2. How does forest cover change affect landscape spatial patterns (e.g., habitat fragmentation)?

3. How are changes in forest cover associated with mapped lifeform and species categories in the region?
Scientific Implications

Cooperative Research

NASA-LCLUC

Regional Agencies

User Groups
Scientific Implications

Disturbance Monitoring

- Logging
  * Selective
  * Clearcut
- Fire
  * Wildfire
  * Prescribed
- Pest
  * Infestation
- Regrowth
  * Natural
  * Replanting
- Urban Growth
Scientific Implications

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Pest Infestation

Regrowth
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- Replanting

Urban Growth
Heritage of the Research

* San Diego State-Boston University-USDA Forest Service forest cover mapping project
Heritage of the Research

*USDA Forest Service - California Department of Forestry and Fire Protection Change Monitoring Program

Northeastern CA
Northern Sierra
North Coast
Southern Sierra
Southern CA
Methods

The research proposed presents a comprehensive, multitemporal, multistage forest cover change monitoring strategy

1. Data sets

Landsat 5 and 7, Aerial Photos, ADAR, IKONOS

Fire Perimeters, Pest Records, Logging Records
Program Methods - Phase I
Image Processing

'93 TM

MKT Transform

'98 TM

ΔBGW

Pixel-level Change Image
Methods

Program Methods - Phase I
Classify and Label Change

Segment-level Change Image → Classify Change
• Aerial Photos
• GIS Layers
• Other Imagery

Phase I Change Map
Methods

Program Methods - Phase II
Aerial Photography
Program Methods - Phase II
Machine Learning Classifier

- measured Δ canopy
- BGW signatures
- covertype
- “seasonality”
- climate (Δ precip)
- cause
- aspect
- slope
- land use zoning

Methods
Methods

Change Data
with accuracy assessment

• - 70 to - 100% CC
• - 41 to - 70% CC
• - 16 to - 40% CC
• + 15 to - 15% CC
• + 16 to + 40% CC
• + 41 to + 100% CC
• Shrub/Grass Decrease > 15%
• Shrub/Grass Increase > 15%
• Change w/in Existing Urban Area
• Terrain Shadow
• Cloud or Cloud Shadow

Cause Database

• Mortality
• Wildfire
• Harvest
• Regeneration
• Fuel Break
• Thinning
• Development
• Conversion
• Other
• Unknown
Methods

2. Field Data Collection
3. Radiometric Normalization
4. Geometric Processing
5. Image Enhancement Techniques
   - Change Vector Analysis
   - Spectral Mixture Analysis
   - Spatial Indices (Texture-Context)
6. Classification
   - Decision Tree
   - ANN-Fuzzy ArtMap
7. Evaluation
## Data Plan

<table>
<thead>
<tr>
<th>DATA TYPE</th>
<th>NOMINAL SPATIAL RESOLUTION</th>
<th>SPATIAL EXTENT</th>
<th>TEMPORAL COVERAGE</th>
<th>ACQUISITION STATUS</th>
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<tbody>
<tr>
<td>Landsat TM 5</td>
<td>30 m</td>
<td>NE California</td>
<td>June 1990</td>
<td>Acquired</td>
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<tr>
<td></td>
<td></td>
<td>SW California</td>
<td>June 1996</td>
<td></td>
</tr>
<tr>
<td>Landsat 7 ETM</td>
<td>30m</td>
<td>NE California</td>
<td>June 2000</td>
<td>Acquired</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SW California</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IKONOS</td>
<td>1m</td>
<td>NE California</td>
<td>Sept 2000</td>
<td>To be acquired</td>
</tr>
<tr>
<td></td>
<td>4m</td>
<td>SW California</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCL</td>
<td>25m Horizontal 1m Vertical</td>
<td>NE California</td>
<td>2000?</td>
<td>To be acquired</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SW California</td>
<td>2001?</td>
<td></td>
</tr>
<tr>
<td>MODIS MVI (MOD 13)</td>
<td>250m</td>
<td>California State</td>
<td>June 2000</td>
<td>To be acquired</td>
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<tr>
<td>MODIS Aerosol Product (MOD 08)</td>
<td>10 km</td>
<td>California State</td>
<td>June 2000</td>
<td>To be acquired</td>
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## Work Schedule

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<tr>
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<tr>
<td></td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
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<tr>
<td>These general task categories apply to Phases I and II</td>
<td>Program Prototyping and Testing for 1996-2000 and 1990-1996 Data</td>
<td>Program Implementation for all Data</td>
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<tr>
<td>1. Acquire Image Data</td>
<td></td>
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<tr>
<td>2. Acquire Collateral Data</td>
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<td></td>
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<tr>
<td>3. Image Preprocessing</td>
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<tr>
<td>4. Field Data Collection</td>
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<td>5. Enhancement and Classification</td>
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<td>6. Meetings</td>
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<td>7. Presentations</td>
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Current Findings

* Forest cover change mapping
* Research Question:
  Can Multitemporal Spectral Mixture Analysis techniques be effectively used to accurately map forest cover changes in southern California?
* Specifically:
  - What categories of forest cover change can be mapped using MSMA techniques?
Endmembers used to Model 90-96 Scenes

Soil

GV

NPV

Shade

Rescaled Reflectance

TM Band
FRACTION ANALYSIS

Regrowth and Deforestation

No Change

Regeneration

Deforestation

Red = GV 1990
Blue, Green = GV 1996

GV 1990

GV 1996
## Results

### Contingency Matrix: Decision Tree Classification

<table>
<thead>
<tr>
<th></th>
<th>REF TOTALS</th>
<th>CLASS TOTALS</th>
<th>CORRECT</th>
<th>PRODUCER’S ACC.</th>
<th>USER’S ACC.</th>
<th>KAPPA</th>
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</thead>
<tbody>
<tr>
<td><strong>Water Recharge</strong></td>
<td>33</td>
<td>30</td>
<td>26</td>
<td>78.79%</td>
<td>86.87%</td>
<td>0.82</td>
</tr>
<tr>
<td><strong>No Change</strong></td>
<td>44</td>
<td>30</td>
<td>23</td>
<td>52.27%</td>
<td>76.67%</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>Vegetation Increase</strong></td>
<td>27</td>
<td>30</td>
<td>20</td>
<td>74%</td>
<td>66%</td>
<td>0.59</td>
</tr>
<tr>
<td><strong>Vegetation Decrease</strong></td>
<td>25</td>
<td>30</td>
<td>23</td>
<td>92%</td>
<td>76.67%</td>
<td>0.72</td>
</tr>
<tr>
<td><strong>Change in Non-vegetated areas</strong></td>
<td>21</td>
<td>30</td>
<td>16</td>
<td>76%</td>
<td>53%</td>
<td>0.45</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>150</td>
<td>150</td>
<td>108</td>
<td>72%</td>
<td>0.65</td>
<td></td>
</tr>
</tbody>
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