Using a Cross Correlation Approach to Wetlands Mapping

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Questions:

- How up-to-date are my current wetland maps?
- How do you monitor wetland change?
- How can I afford to update my maps?

Answers:

- How up-to-date are my current wetland maps?
  - Not very
- How do you monitor wetland change?
  - Pay a lot of money
- How can I afford to update my maps?
  - Find a rich uncle?

The real answer…

- Our ability to do what we want is constrained by: time, budget, technology…

- What have been some of our obstacles from a remote sensing perspective?
  - Lack of available data
  - Cost of acquisition and processing
    - Data, hardware, software, speed
  - Technical limitations
    - Hardware (processing power, storage, bandwidth, etc.)
    - Software (registration, feature extraction, etc.)
  - Direct use of derived data in decision support systems

Change Detection Techniques

- Many change algorithms exist
  - Each has its own advantages/disadvantages
  - MDA Federal regularly uses all these techniques
    - Function Memory (Display)
    - Image Differencing
    - Multi-date Principal Component
    - Multi-date Composite Classification
    - Change Vector Analysis
    - Classification and Regression Tree with Image Differencing
    - Cross Correlation Analysis

CCA Introduction

- Cross Correlation Analysis (CCA) is a patented (US Patent No. 5,719,949) change detection technique
- Originally developed to determine where wetland maps were out of date based on new imagery
- It can be used in two modes
  - Thematic data to image data
  - Image data to image data
- CCA was designed for multispectral data
  - Primarily has been used with Landsat and SPOT imagery

CCA Introduction - continued

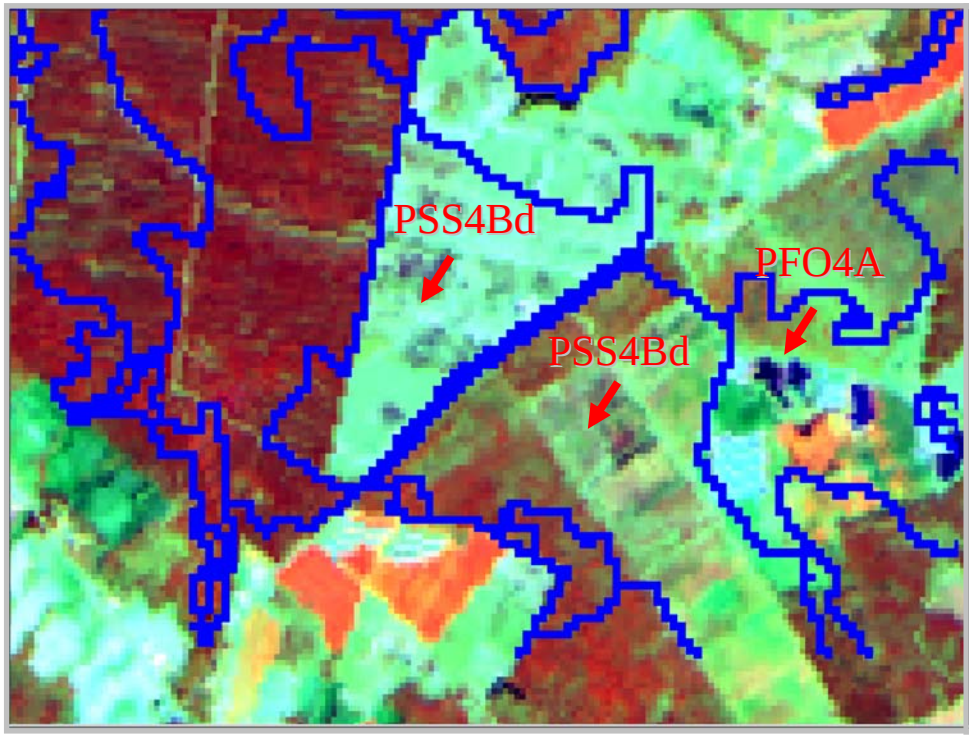
- Overcomes limitations of conventional change detection algorithms
  - Does not rely on anniversary date images
  - Works across sensors, across resolutions
  - Uses an image or map in an image normalization process
    - Minimizes false positives due to
      - Phenological differences between images
      - Climatic/atmospheric differences
- MDA uses CCA to determine where map sheets are out of date, update global land cover products, & monitoring
- Effective and economical tool for large area monitoring

Two Pass Procedure

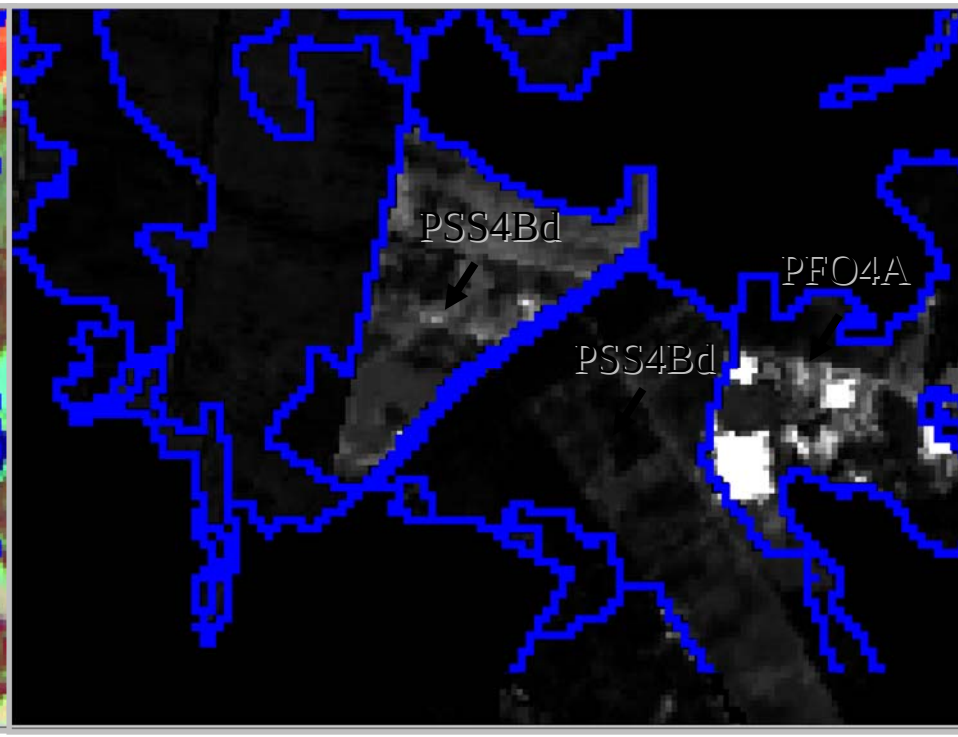
$$Z = \sum_{i=1}^{n} \left(\frac{Observed_i - Expected_i}{Std.Dev._i} \right)^2$$

where
Z = distance in n-dimensional space from the norm
i = attribute index
n = number of attributes
$Observed_i$ = observed value of the attribute with index i,
$Expected_i$ = expected or mean value of the attribute with index i,
$Std.Dev._i$ = standard deviation of the attribute with index i,

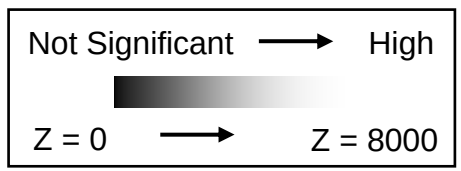
Wetland Change Example
Normalized Z Image



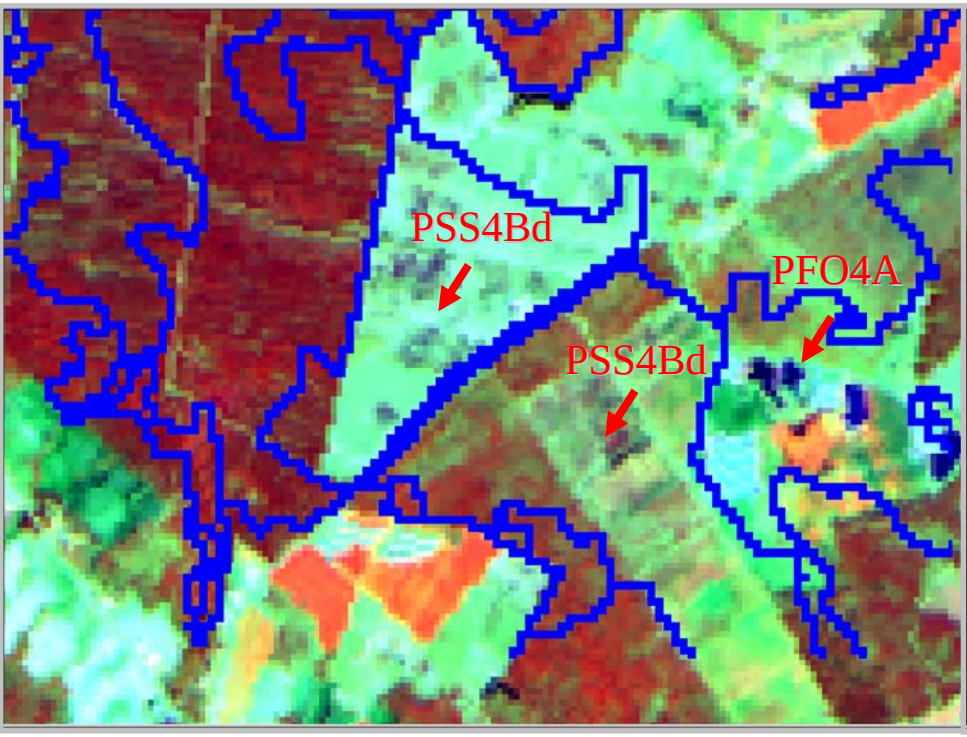
SPOT 4 XI Image from 3/16/99
with NWI Vectors



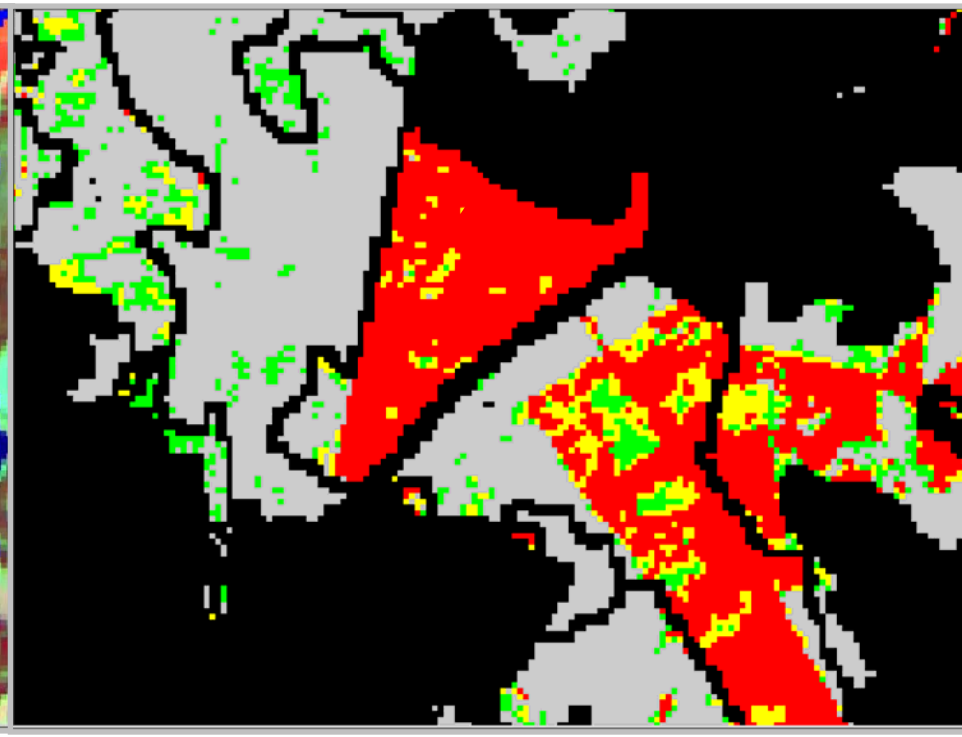
Probability of Change



Vector Wetland Change Example
Recoded Z Image



SPOT 4 XI Image from 3/16/99
with NWI Vectors



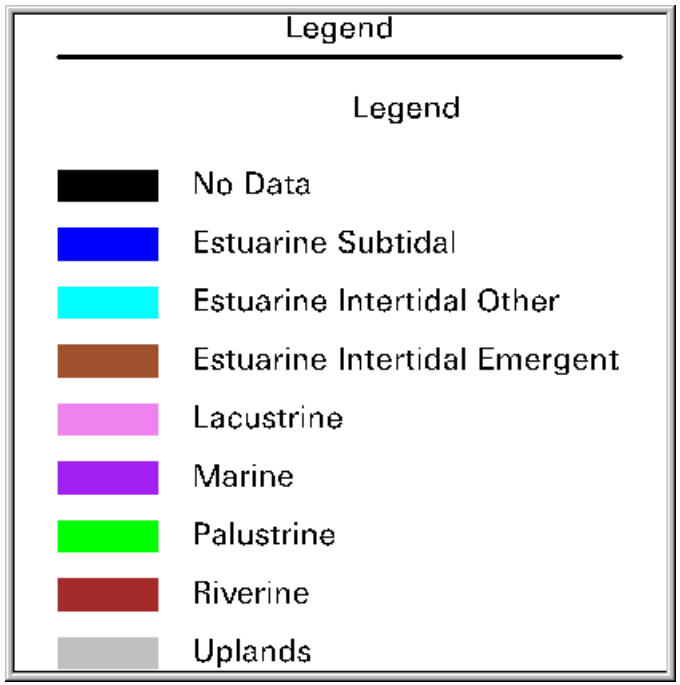
Probability of Change

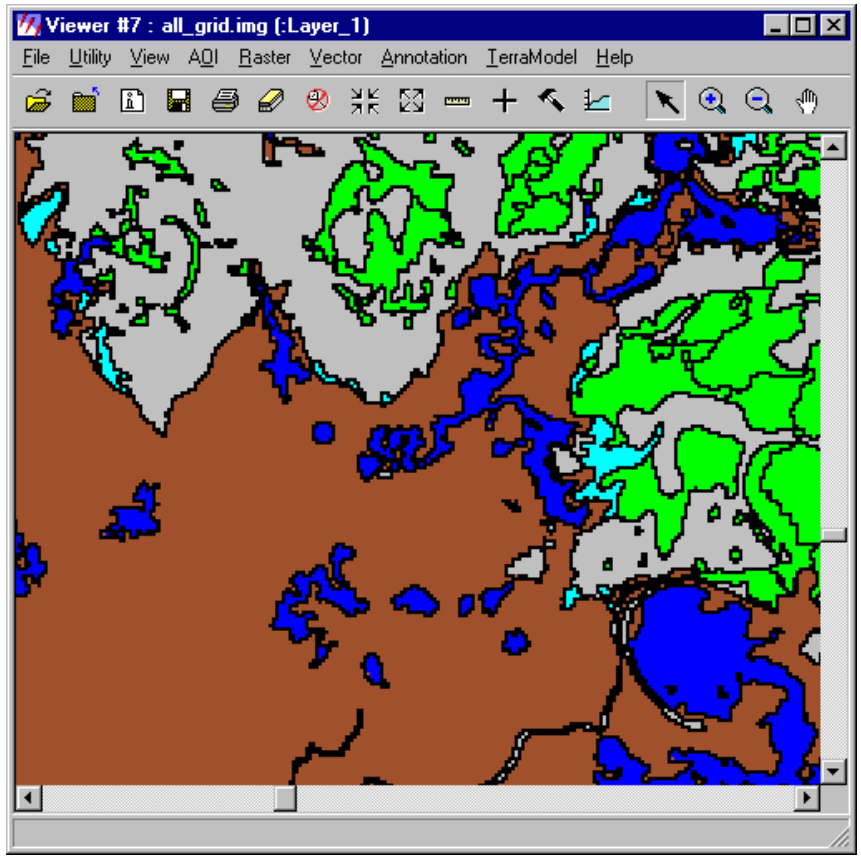
Validation of CCA Change Detection

- Wetland change validation studies conducted with
  - EPA
  - USFWS-National Wetland Inventory
  - Maryland DNR
  - USDA-NRCS

Study Area	# of Wetland Classes	Sampling Method	Accuracy
Illinois	372	Class Area	>90%
North Carolina	656	Field Observations	>90%
North Carolina	656	Change Probability Level	=90%
Maryland	1257	Class Polygon Freq.	>90%

E2EM Losses


Legend
Legend
No Data
Estuarine Subtidal
Estuarine Intertidal Other
Estuarine Intertidal Emergent
Lacustrine
Marine
Palustrine
Riverine
Uplands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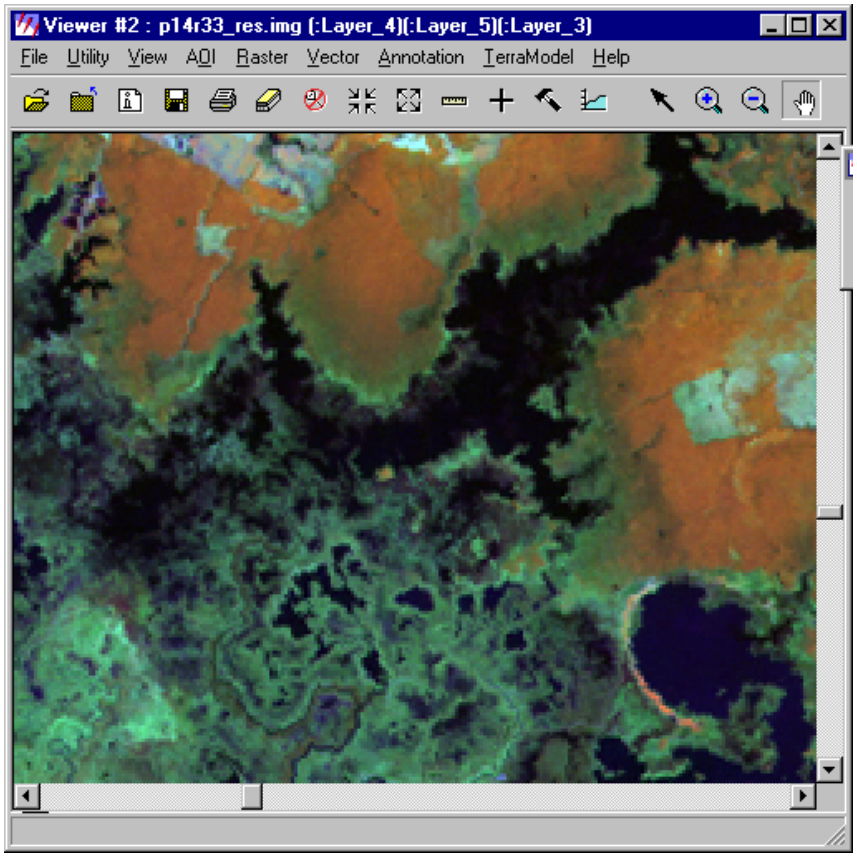
File Utility View AOI Raster Vector Annotation TerraModel Help

E2EM Losses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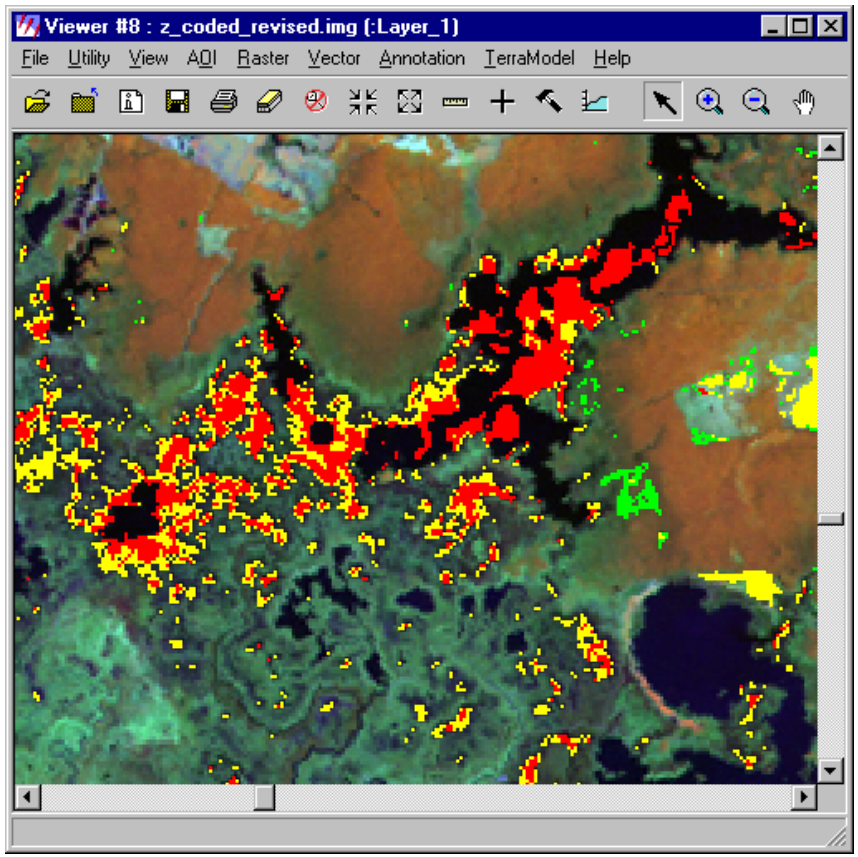
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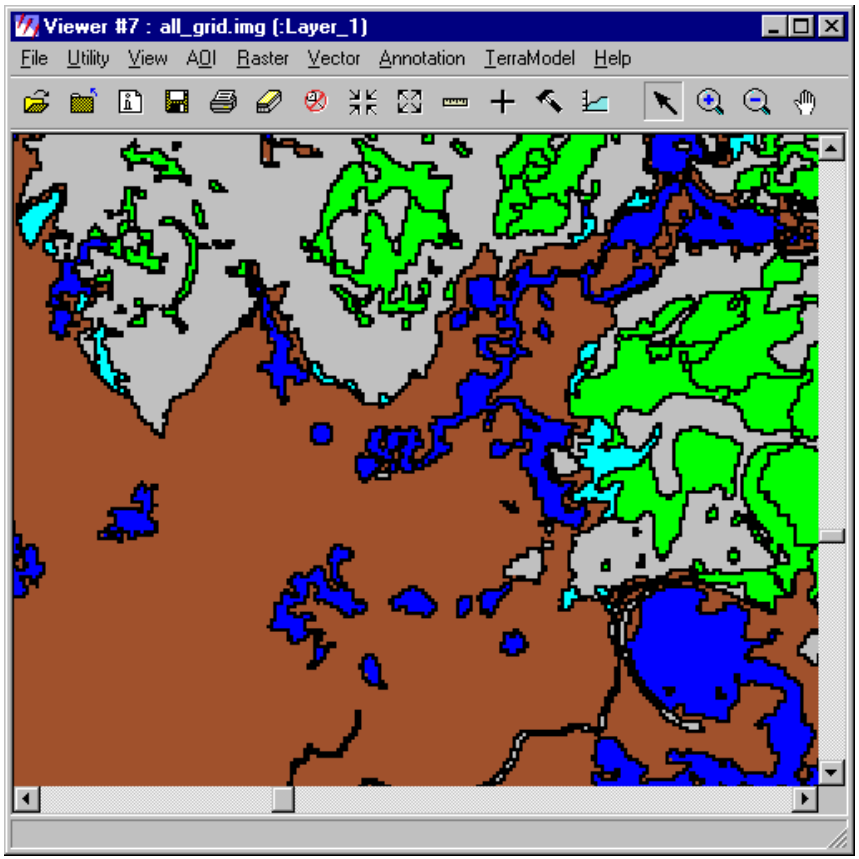
File Utility View AOI Raster Vector Annotation TerraModel Help

E2EM Losses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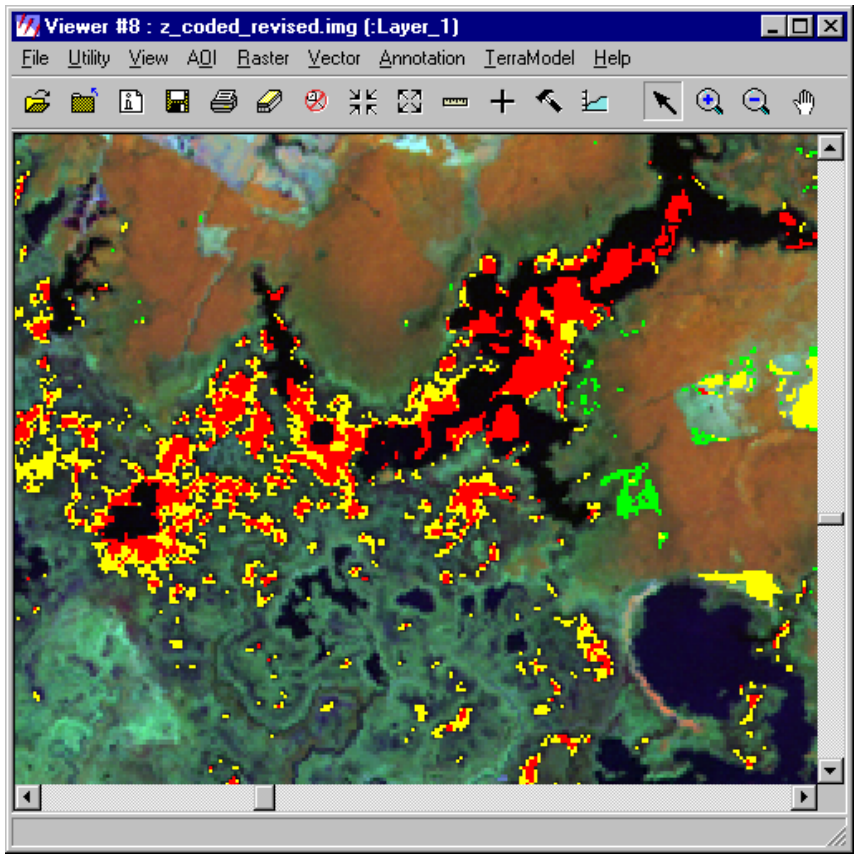
File Utility View AOI Raster Vector Annotation TerraModel Help

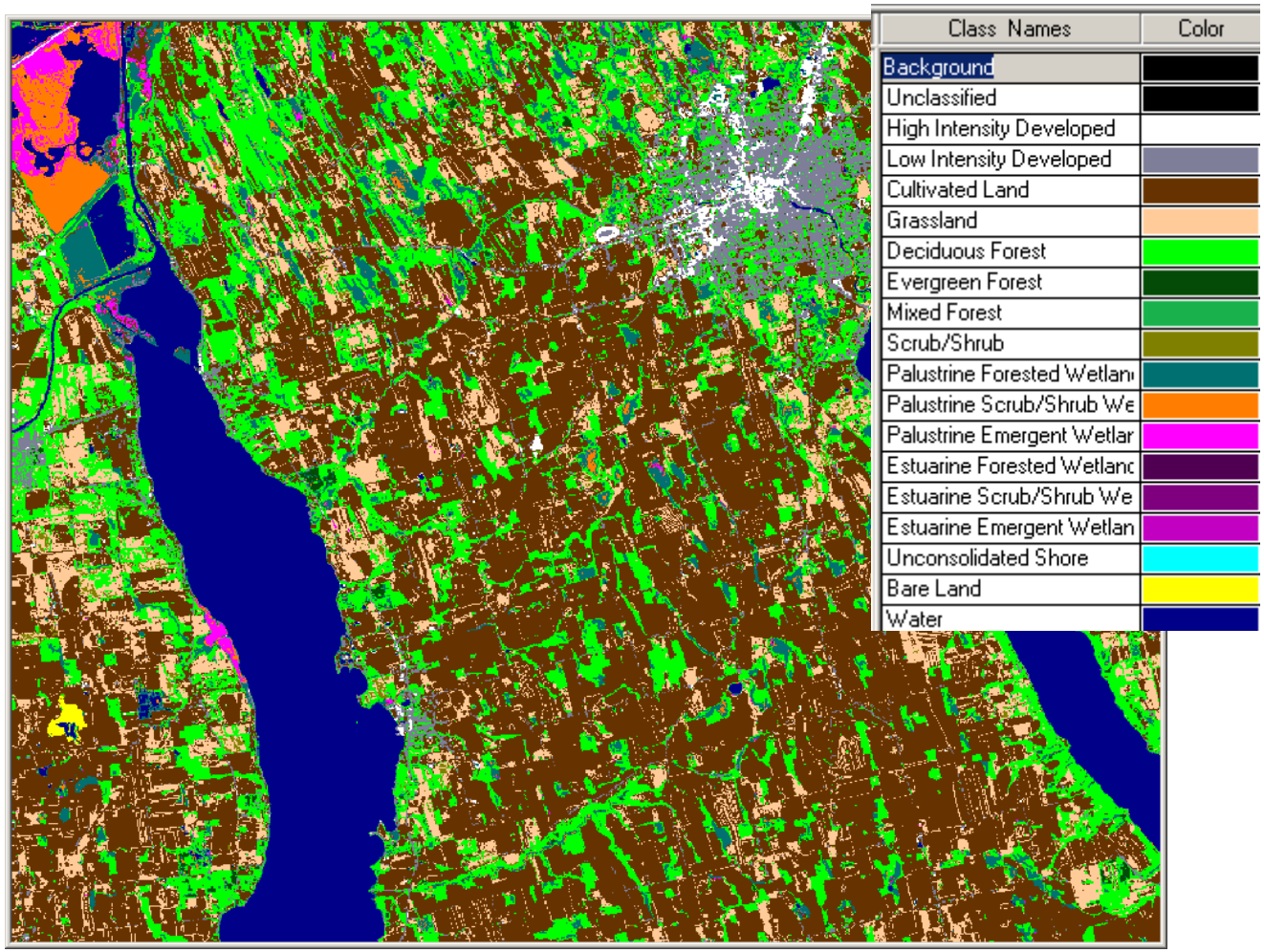

Viewer #8 : z_coded_revised.img (:Layer_1)
File Utility View AOI Raster Vector Annotation TerraModel Help

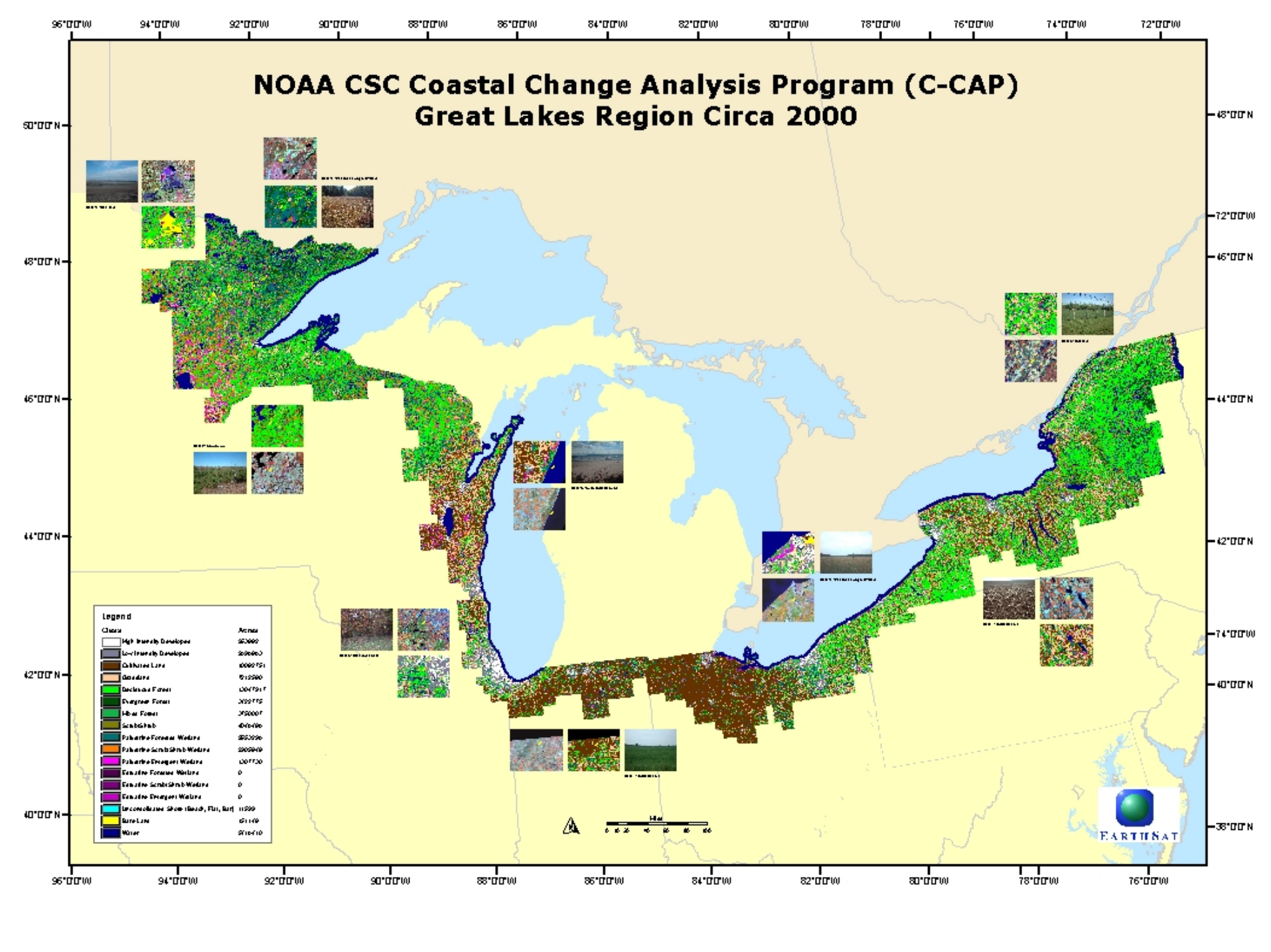
NOAA Coastal Change Analysis Program

- Creates land cover classification for the US coastal zones and change information
- Goal is to update every 5 years
- Program based at NOAA-CSC (Coastal Services Center, Charleston, SC)

C-CAP Classification Scheme

High Intensity Developed
Low Intensity Developed
Cultivated Land
Grassland
Deciduous Forest
Evergreen Forest
Mixed Forest
Scrub/shrub
Palustrine Forested Wetland
Palustrine S/S Wetland
Palustrine Emergent Wetland
Estuarine Forested Wetland
Estuarine S/S Wetland
Estuarine Emergent Wetland
Unconsolidated Shore
Bare Land
Water
Palustrine Aquatic Bed
Estuarine Aquatic Bed
Tundra
Snow/Ice




NOAA CSC Coastal Change Analysis Program (C-CAP)
Great Lakes Region Circa 2000
Legend
Class
Acres
High Intensity Developed
Low Intensity Developed
Cultivated Land
Grassland
Deciduous Forest
Evergreen Forest
Mixed Forest
Scrub/Shrub
Palustrine Forested Wetland
Palustrine Scrub/Shrub Wetland
Palustrine Emergent Wetland
Estuarine Forested Wetland
Estuarine Scrub/Shrub Wetland
Estuarine Emergent Wetland
Unconsolidated Shore (Beach, Flat, Bar)
Bare Land
Water
Hilo
EARTHSAT

Coastal California

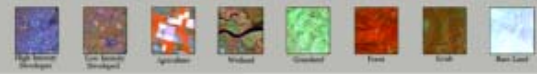
California's coastal region hosts a rich diversity of plant life and topography, ranging from towering coastal redwoods to bountiful agricultural valleys and vineyards to dramatic coastal mountain ranges. The state's coastal zone is also one of the nation's fastest growing areas – home to most of California's 35 million residents and two of the world's largest metropolitan areas, San Francisco and Los Angeles.

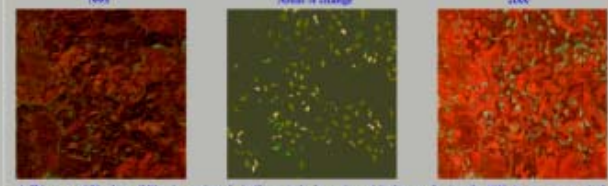
Its 4th 22-class land cover map produced as part of the Coastal Change Analysis Program (C-CAP), we can see California's incredible natural diversity are the impact of human development. Plentiful rainfall and coastal fog in the northern part of the state have created ideal conditions for growing some of the tallest trees in the world, a setting for a natural resource and a recent timber industry. The state's vast inland agricultural valleys are some of the most productive anywhere, providing numerous crops including fruits, vegetables, nuts and grapes.

Along California's coast, wetlands serve as a vital interface between land and open water. These natural systems act as buffers against the damaging effects of coastal storms and shoreline erosion and improve water quality and aquatic habitat for numerous birds and other species, many endangered or threatened.

The rapidly developing areas around Los Angeles, San Francisco and Sacramento stand in stark contrast to the coastal forests, grasslands, scrublands and coastal estuaries and wetlands. One extraordinary feature is the large natural wetland of the Suisun Marsh Estuary, the largest contiguous brackish water marsh remaining on the west coast of North America.

The C-CAP land cover map is based on Landsat 7 satellite imagery acquired between March 2000 and May 2002 on three different seasons. Satellite imagery provides the data necessary to identify land cover features over large areas. The image mosaic covers the extent of the coastal zone, an area determined by county boundaries, coastal drainage areas and state coastal management jurisdictions. This land cover map and others like it are used to monitor changes to the Earth's landscape, as highlighted by the three examples shown below that illustrate changes to the California landscape occurring between 1995 and 2000.





1. This area of Northern California experienced significant timber harvesting activity between the time the 1995 imagery was acquired and 2000. Post processing of satellite data highlights the areas of change and enable the mapping of the impact of logging. The data are a vital tool for natural resource managers monitoring logging zone and the impact of sediment loading in adjacent creeks and rivers.

2. The Butte Sink and the Gray Lodge Waterfowl Management Areas are located in the Colusa Basin, between the Sierra Nevada and Coastal Ranges and are managed to provide wintering habitat for waterfowl. These wildlife areas are composed of intensively managed wetland units created by more than 50 miles of levees and ditches directing water into the pools where water levels are controlled. These units provide complex wetland habitat for migratory waterfowl while new wetlands are being restored on private lands within the corridor. As can be seen above, the seasonal/yearly changes in water regimes in the Central Valley can result in fluctuations of wetland area.

1. These two images starkly illustrate the rapid suburban development typical of Southern California since 1995. High and low intensity development in the Antioch and Brentwood areas south of the San Joaquin River caused losses of natural and managed grasslands and pastures.

Answers:

- How up-to-date are my current wetland maps?
  - Not very
- How do you monitor wetland change?
  - Change detection process
- How can I afford to update my maps?
  - How can you afford not to update your maps?
  - Landsat data free, processing cheap

Contacts

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