LCLUC Abstract

Operational Monitoring of Alteration in Regional Forest Cover Using Multitemporal Remote Sensing Data

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ABSTRACT

Forested ecosystems in California are undergoing accelerated change to due to anthropogenic and natural disturbances. The current Forest Service-California Department of Forestry and Fire Protection cooperative change detection monitoring strategy consists of a comprehensive, multitemporal, multistage forest cover change program established to regionally monitor these changes. The effectiveness of this program, however, has been hampered by several problems including 1) lack of funding and 2) lack of opportunity to compare data processing methods for program expansion, testing and development.

Recently, however, San Diego State researchers have developed a partnership with USDA Forest Service and California Department of Forestry (CDF) personnel to determine the best methods to incorporate into a long-term, operational forest monitoring system for California. This collaboration is needed to provide cross agency monitoring analysis for rapidly changing and fragmenting forests in California. This research will apply remote sensing techniques to map changes in forest cover in two study sites in California.

Efficiency indicators such as; map accuracy assessment, flexibility of implementation, interpretability of results, and consistency in phenologically diverse areas, will be used to test and improve the current monitoring program. Once established (by the second quarter of Year 2), the monitoring program will be applied to multiple data sets in order to derive various forest change image products. These products will be evaluated and made available for resource managers and GOFC program collaborators. Once improved and implemented, the change monitoring program should be applicable to monitoring: (1) the forested lands of California on a long-term, regional basis and (2) other forest ecosystems undergoing rapid change.

Recent results of the collaboration between USDA Forest Service/CDF and SDSU-Geography are presented in sections 1 and 2 below.

Section 1**:** Progress and accomplishments of the USDA Forest Service's Forest Pest Management Program (FPM) of Region 5 and the California Department of Forestry and Fire

Protection's Fire and Resource Assessment Program (FRAP) cooperative change detection program.

The goal of this project is to implement a long-term, low cost and high quality monitoring program to identify trends in forest health, assess changes in vegetation extent and composition, and provide data for updating regional vegetation and fire perimeter maps (Levien et al., 1999; http://frap.cdf.ca.gov). This program covers the entire state in five separate project areas on a five-year cycle http://frap.cdf.ca.gov/projects/change_detection/cdp.html).

Landscape changes are detected through two phases. In Phase I, a preliminary landscape-level change map is produced that identifies a continuum of change classes. In Phase II, the change continuum classes are correlated to canopy and ground cover measurements. This change map represents change in canopy and ground cover between two image dates that are five years apart (i.e., 1991 and 1996). The change map is then assessed for accuracy and analyzed for cause using GIS coverages, ancillary information and field work. Table 1 describes the products produced by the Forest Service change mapping program.

Table 1: Description of USFS-CDF Change Detection Products

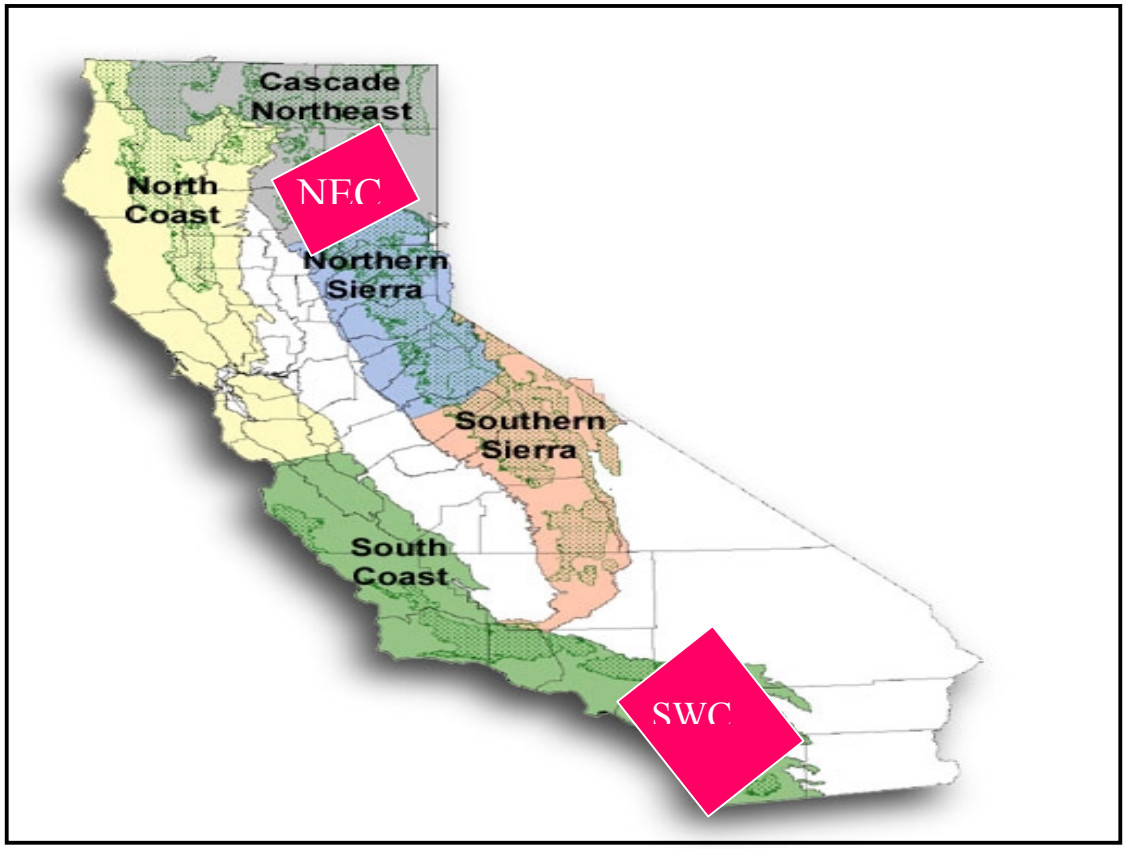
Product Name	Description	Completion Status
Change Maps	Project area change polygons showing change continuum classes. Cover change classes are available for project areas.	Completed for all areas
Cause Maps	Coverage of change polygons that have been assigned a cause through fieldwork or GIS analysis.	In progress
Statistics	Tables depicting acres of change by cover type, ownership and cause.	In progress
Project Area Reports	Discussion on the implications of detected change within a project area.	In progress

In each of the research study regions, (i.e., southwestern California (SWC), and northeastern California (NEC)), the USFS-CDF work has resulted in completion of Phase I and Phase II of the program (Figure 1). As table 1 suggests, however, cause information and subsequent statistical outputs have still to be produced for the study areas (Lisa Levien, pers comm.). The change detection accuracy assessment results for the South Coast region are presented in table 2.

The contingency matrix results show that the Phase I and Phase II change detection methods produced highly accurate measures of forest cover change (Table 2). The overall classification accuracy of the study was 89.2 %. Change classes that exhibited dramatic inter-

date change (i.e., classes 1, 2, 5, and 6) were accurately mapped, whereas those classes used to describe 'slight' inter-changes were less accurate (i.e., classes 3, 7, and 8).

Figure 1: Location of NWC and SWC study areas within USFS-CDF Statewide Change Detection Framework.



Section 2**:** Summary of the Descanso Ranger District (DRD) Pilot Study conducted by SDSU-Geography and the USDA-Forest Service.

The objective of this research was to compare the performance of two change enhancement techniques (i.e., Multitemporal Kauth Thomas (MKT) and Multitemporal Spectral Mixture Analysis (MSMA)), and two classification techniques (i.e., maximum-likelihood (ML) and decision-tree (DT)), in terms of accuracy, for identifying changes in vegetation cover in a southern California study area between 1990 and 1996.

The study area was Descanso Ranger District (DRD), located in Cleveland National Forest, San Diego County. The 1,142 km^2 DRD was considered ideal for this study due to the diversity of vegetation types, and the presence of multiple, and frequent, change-causing disturbance events. This research also presented an opportunity to compare both image enhancement techniques and image classification techniques, with those operationally used in the USFS-CDF approach (i.e., DT classification and MKT change enhancement).

Table 2: Southern California Change Detection Accuracy Assessment

SOCDP ACCURACY ASSESSMENT (SITE LEVEL)

Reference Class

Classified As	1	2	3	4	5	6	7	8	9	15	Sites
1	7										7
2		12									12
3			5	2							7
4			1	148	1		3	7	2		162
5					4						4
6						1					1
7				4			15		1		20
8				1	1			15			17
9				4					25		29
15										1	1
Sites	7	12	6	159	6	1	18	22	28	1	260

Input Layers:

1. Phase I change
2. Covertype
3. Cause (fire)
4. Seasonality

Class Description

Class	
1	-71 to -100% CC
2	-41 to -70% CC
3	-16 to -40% CC
4	+15 to -15% CC (Little or No Change)
5	+16 to +40% CC
6	+41 to +100% CC
7	Shrub/Grass Decrease > 15%
8	Shrub/Grass Increase > 15%
9	Change within Existing Developed Area
15	Cloud or Cloud Shadow

Producer's Accuracy

Class				
1	= 7 / 7 =	100%	Tree Decr	
2	= 12 / 12 =	100%	96%	
3	= 5 / 6 =	83%		
4	= 148 / 159 =	93%		
5	= 4 / 6 =	67%	Tree Incr	
6	= 1 / 1 =	100%	71%	
7	= 15 / 18 =	83%		
8	= 15 / 22 =	68%		
9	= 25 / 28 =	89%		
15	= 1 / 1 =	100%		

(inverse is error of omission)

User's Accuracy

Class				
1	= 7 / 7 =	100%	Tree Decr	
2	= 12 / 12 =	100%	92%	
3	= 5 / 7 =	71%		
4	148 / 162 =	91%		
5	= 4 / 4 =	100%	Tree Incr	
6	= 1 / 1 =	100%	100%	
7	= 15 / 20 =	75%		
8	= 15 / 17 =	88%		
9	= 25 / 29 =	86%		
15	= 1 / 1 =	100%		

(inverse is error of commission)

Training sites:	135	34%
AA sites:	260	66%
TOTAL sites:	395	

Overall Accuracy = 89.2%

Classification accuracy results (based on the kappa statistic) were high (i.e., >80%) and showed that, 1) the DT classification approach outperformed the ML classification approach, by ~10%, regardless of the input enhanced imagery, and 2) using DT classification, MSMA-change fractions (i.e., green vegetation, non-photosynthetic vegetation, shade and soil) outperformed MKT change-features (i.e., change in brightness, greenness and wetness) by ~5%. These results appear to show promise for applying MSMA techniques to larger areas for the prototyping phase of the forest monitoring system. We expect to submit a manuscript, describing these results, in May 2000 (Rogan and Franklin in prep.).

In summary, the USFS-CDF change-detection work should be completed by June 2000. Our fieldwork will then begin in order to provide more extensive validation data for the *prototyping* phase of the change detection project. This work phase will address the challenge of mapping forest cover change between 1990 and 1996 in NEC and SWC, respectively.

Relevant references

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