Ten Year Assessment of the Region 5 Land Cover Mapping and Monitoring Program (LCMMP)

Lisa Fischer, Carlos Ramirez, Zhanfeng Liu and Erik Haunreiter
USDA Forest Service, Region 5

Forest Health Protection programs were reviewed by a team convened by the Washington Office FHP director during the week of July 13, 2005. At the close of the review a set of issues, findings and recommendations were presented. This report addresses Issue 5 concerning re-assessment of the California Land Cover Mapping and Monitoring (LCMMP).

The review team found that the LCMMP needs re-assessment according to the following:

1. How does the program meets FHP mission and objectives
2. Determine the appropriate level of expenditure for this program and ascertain if other program areas should be more involved and share in its cost
3. Determine who the users and/or clients are for this information

This report is one step in response to the findings of the WO review. FHP also conducted a survey to assess how users are incorporating LCMMP data into their work.

Introduction

The LCMMP began in 1994 with a study Forest Health Protection (FHP) supported to evaluate the utility of using remotely sensed data for mapping and monitoring forest mortality (Macomber, 1994). This initial study led to FHP implementing tree mortality detection across mixed ownerships. Mortality information was used to compliment annual aerial surveys that cover only national forest system lands. LCMMP data is used to provide a base for longer-term large-area trend analysis.

Collaboration with Ecosystem Planning (EP) staff, Geometronics staff, California Department of Forestry and Fire Protection (CDF)[1], and Bureau of Reclamation (BOR) began in 1995 when these agencies needed a means of cooperative vegetation mapping and monitoring over large areas across mixed ownership. The LCMMP's collaborative approach to land cover mapping and monitoring includes the coordinated acquisition of resource photography, satellite imagery, and geo-processing on a five-year cycle (Figure 1). Baseline vegetation maps and inventory plots, change detection, cause determination, and map updates serve as the basis for assessing the State's vegetation resources.

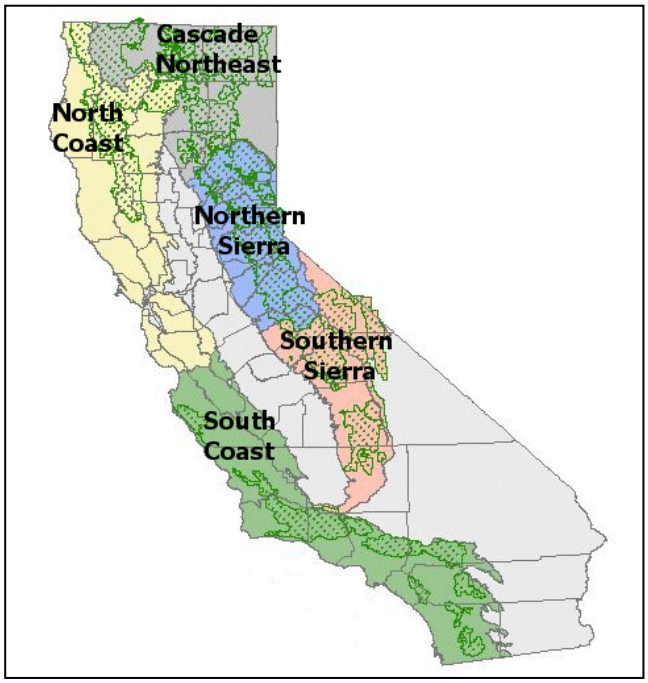

Figure1. Region 5 coordinated schedule map.

[1] Two staffs from the California Department of Forestry and Fire Protection have participated with the LCMMP including the Fire Resource and Assessment Program (FRAP) and Forest Pest Management (FPM).

The USDA Forest Service and CDF use the LCMMP data to track forest health trends, evaluate cumulative watershed impacts, model wildlife habitat, identify the hazardous build up of fuels, and examine the effectiveness of existing policies. Both agencies also use the LCMMP data to monitor the effects of sudden oak death, pitch canker disease and other forest health concerns (Mahon *et al*., 2002). The FS EP staff uses LCMMP data to update vegetation maps and target where to re-measure FIA plots. Additionally, the data is used to conduct multi-forest analyses in support of land management plans such as the Northwest Forest Plan Amendment, California Spotted Owl Environmental Impact Statement (EIS), the Sierra Nevada Framework and others. For the past 10 years, the EP staff has used the LCMMP data and recognized that it is critical for meeting the business needs for the Region's vegetation mapping program. The Bureau of Reclamation uses this data set to compliment their central valley habitat monitoring program.

These data have been used regularly by University of California Extension programs as an educational tool on policy guidelines for oak firewood harvesting. The LCMMP data has been instrumental in providing Eldorado county with updated resource information for their general plan for two plan revisions. These data are also used regularly at the regional and statewide scale for measuring and quantifying acres of change due to mortality, harvest, fire, and other disturbance events by CDF-FRAP.

Since the inception of the Region 5 LCMMP, analysts have completed processing ten years of Landsat imagery spanning California, with the exception of the Central Valley (monitored by the U.S. Bureau of Reclamation) and the Mojave bioregions. Collectively, the LCMMP project areas cover approximately 65 million acres of land in a single cycle. To date, two cycles have been completed statewide and a third cycle has just been completed for the southern California project area. Project areas range from nine to 17 million acres and are the basis for organizing mapping and monitoring work. A total of 147 million acres have been monitored over a ten-year period. Monitored lands include Federal, State and private ownerships throughout California.

Over 20 journal papers, conference proceedings and project area reports have been published. Lectures on the collaborative program and methods have been delivered to two universities and two junior colleges over the last six years.

For a complete list of LCCMP publications and presentations see Appendix I.

More recent program collaborations include the Pacific Northwest Research Station-Forest Sciences Lab (PNW-FSL) and the California Department of Fish and Game (DFG). DFG is currently developing a bioassessment of the North Coast bioregion of California and is incorporating LCMMP data into their analysis to determine how stand-level disturbances impact biodiversity adjacent to and downstream from the disturbance origin. The PNW Research Station is using imagery from the LCCMP northern California project areas to study the effects of disturbances on the carbon budget and interactions between climate and disturbances across environmental gradients.

Addressing WO Review Findings

1) How does the LCMMP meet the FHP mission and objectives?

The Forest Service Manual 3400 (Forest Health Protection) identifies the policy of the Forest Service to:

- Cooperate with other federal agencies, state, non-governmental organizations, and other appropriate entities to protect forest and tree health.
- Include forest health considerations in forest resource management planning and decision making.
- Monitor, assess, and report on the health of the nation's forest and tree resources.

The published mission of the FHP program is

"…protects and improves the health of America's forests."

The Forest Service definition of a healthy forest is

"a condition wherein a forest has the capacity across the landscape for renewal, for recovery from a wide range of disturbances, and for retention of its ecological resiliency while meeting current and future needs of people for desired level of values, uses, products, and services."

Effective forest management requires recognition of the close ecological interrelationships between these different types of disturbances. In fact FHP states "…we monitor and report all aspects of forest health conditions (insects, pathogens, invasive plants, air pollution, storms, etc*.)."* FHP nationwide is committed to finding innovative ways to rapidly respond to forest health threats to avoid unacceptable and unnecessary loss of forest resources.

Examples of how LCMMP meets FHP mission and objectives

Cooperating with other federal agencies, state, non-governmental organizations, and other entities to protect forest and tree health

Severe tree mortality events caused by epidemic levels of *Dendroctonus, Scolytus and Ips* beetle species were exacerbated by several successive years of drought during 2001-2003**.** In order to identify and track mortality on and adjacent to the San Bernardino National Forest (BDF), change detection data from Cycle II (1997-2002) for the South Coast project area, change detection data from 2001-2003 (CDF-FRAP and FHP cooperative study), and aerial survey data were combined to develop a cumulative mortality layer for the entire project area (Figure 2). The mortality layer was used to stratify plot location by level of mortality and vegetation type for re-measurement of the plots. Volume estimates were calculated for dead trees and used to aide CDF in prioritizing their resources for harvesting. Within the project extent, approximately 13% of all conifer trees died between 2001 and 2004. This estimate represents approximately 21% (~127 million cubic feet) of the total conifer forest biomass with larger trees (DBH $\geq$ 21 inches) accounting for about 80% of the total dead biomass. The total volume loss for all tree species is estimated to be 137 million cubic feet. Plot re-measurement revealed that Coulter and Ponderosa pine (*Pinus coulteri and P. ponderosa*) were the most heavily impacted conifer species, particularly in size classes $\geq$ 21 inches DBH (Walker *et al*., 2006). For the full southern California report see Walker *et al*., 2006.

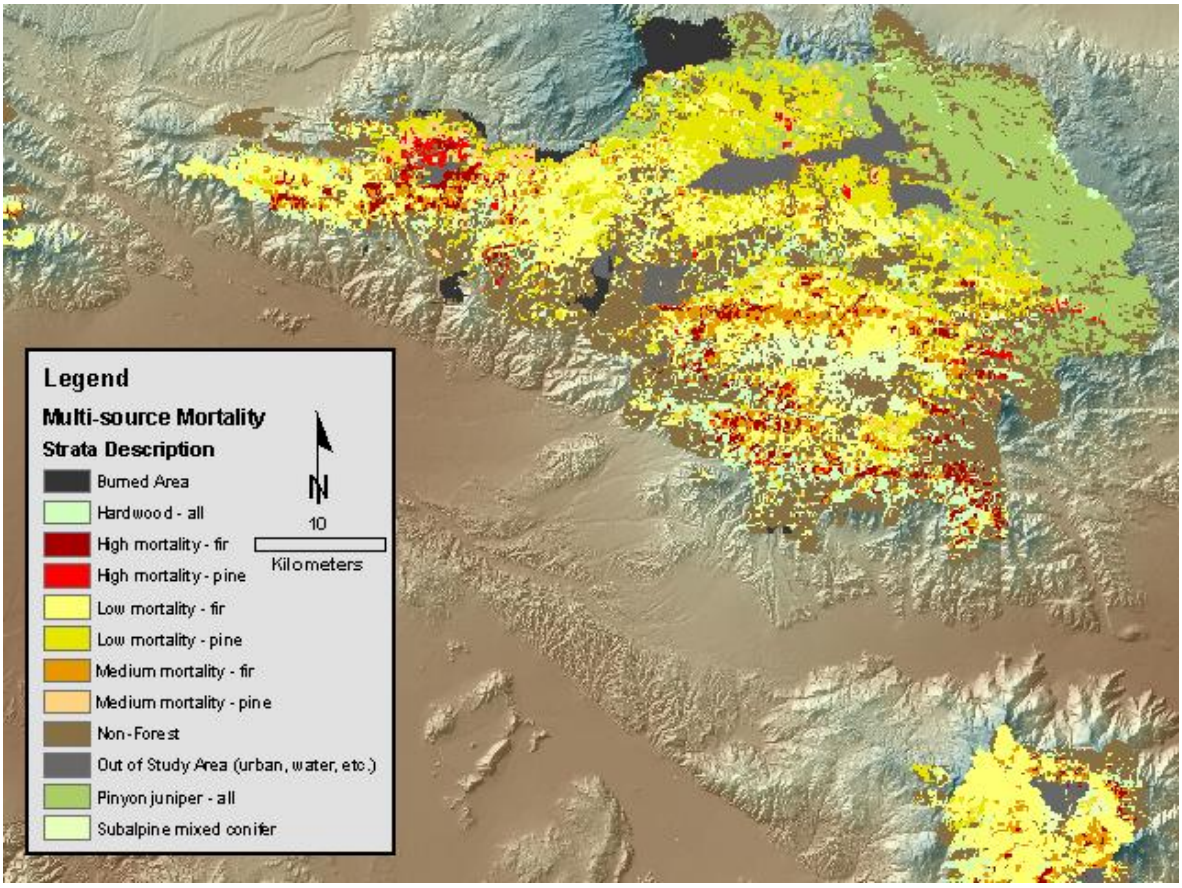

Figure 2 . Cumulative, multi-source mortality layer for the San Bernardino National Forest and surrounding areas.

Inclusion of forest health considerations in forest resource management planning and decision making

The LCMMP data is complimentary with other FHP data such as the aerial detection surveys (ADS). ADS and LCMMP data provide trend information about our forest resources over large landscapes. When used in conjunction with ADS data, mortality estimates can be refined to more closely estimate actual on-the-ground mortality rather than making gross generalizations from large polygons with a few scattered dead trees.

Figure 3 shows how the change detection data refines the ADS data. Change is from 1995-2000 overlaid onto mortality mapped through ADS for the same time period. Areas mapped as reduction in vegetation (red polygons) correspond well with areas of tree mortality mapped for multiple years (yellows). Because the change data includes reductions in vegetation due to causes other than just tree mortality, there are areas of change that fall outside of the ADS polygons. ADS data represent broad general areas of mortality, and the change detection data aids in more accurately mapping the mortality, providing a spatially and quantitatively more accurate representation of mortality over time.

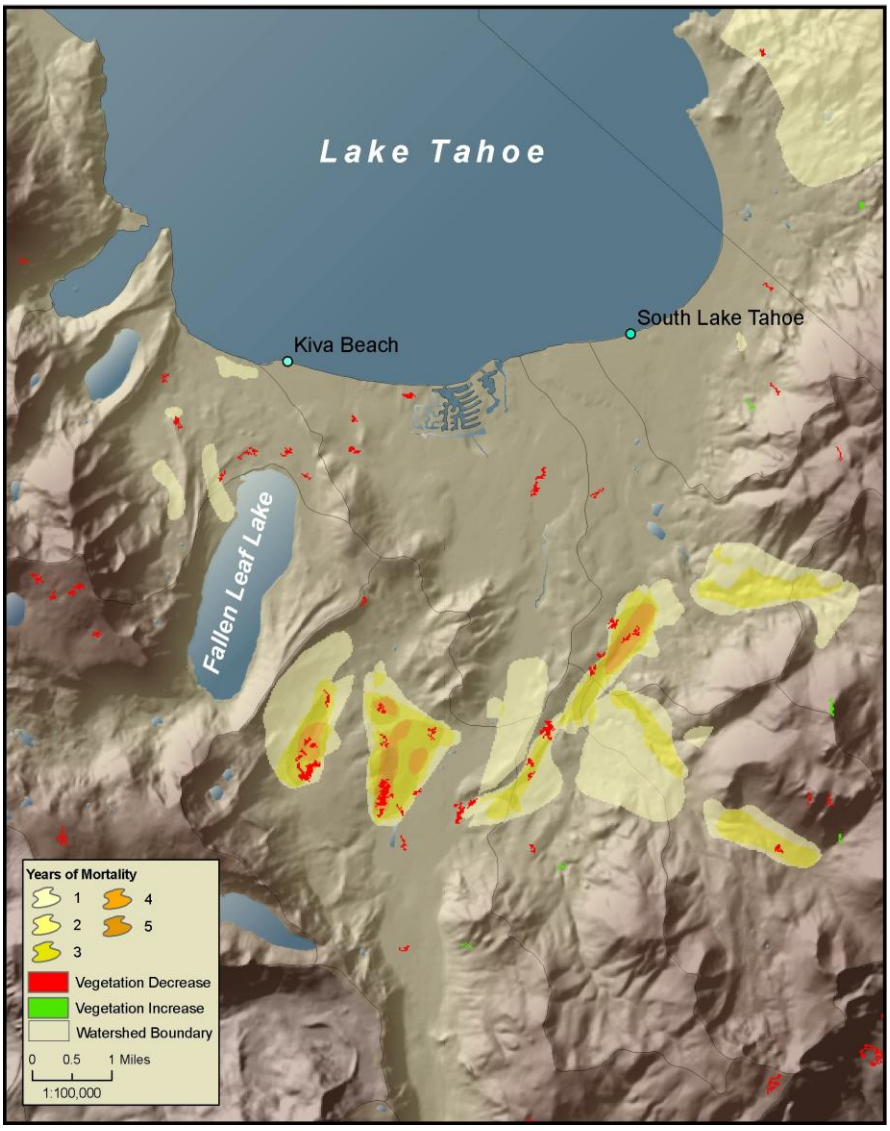

Figure 3 Multi-year ADS data overlaid with LCMMP data.

Monitor, assess, and report on the health of the nation's forest and tree resources

Fragmentation of the landscape can affect a wide range of species and have detrimental impacts on ecosystem processes (Staus *et al*., 1992). Landscape fragmentation has also been shown to increase the risk of insect outbreaks (Roland, 1993). Spatial patterns in vegetation can be linked to insect and disease risk, and changes in these patterns over time can help to assess change in risk across the landscape (Hessberg *et al*. 2000). For example, insects that favor shade tolerant conifers will be favored if this vegetation type becomes more aggregated and dominant across the landscape by replacing less favorable or historic vegetation types (Hessberg *et al*. 2000). Using this information can help managers by identifying potential areas at risk of insects or diseases that can then be managed to improve overall forest health.

Figures 3 and 4 show patterns of vegetation loss from 1985-2000 adjacent to and within the Eldorado National Forest. Figure 3 shows LCMMP data, while figure 4 shows a National Agriculture Image Program (NAIP) image from 2005 for the same area. These

figures show fragmented landscapes and are the types of patterns that the LCMMP can detect. Using fragmentation analysis software such as FRAGSTATS (McGarigal and Marks, 1995) to generate various metrics (such as patch size and connectivity), these patterns can be quantified, helping to provide an ecologically meaningful interpretation of vegetation patterns across the landscape. These metrics can then be used as indicators of biological diversity when assessing and monitoring forest health (Montreal Process, 1999).

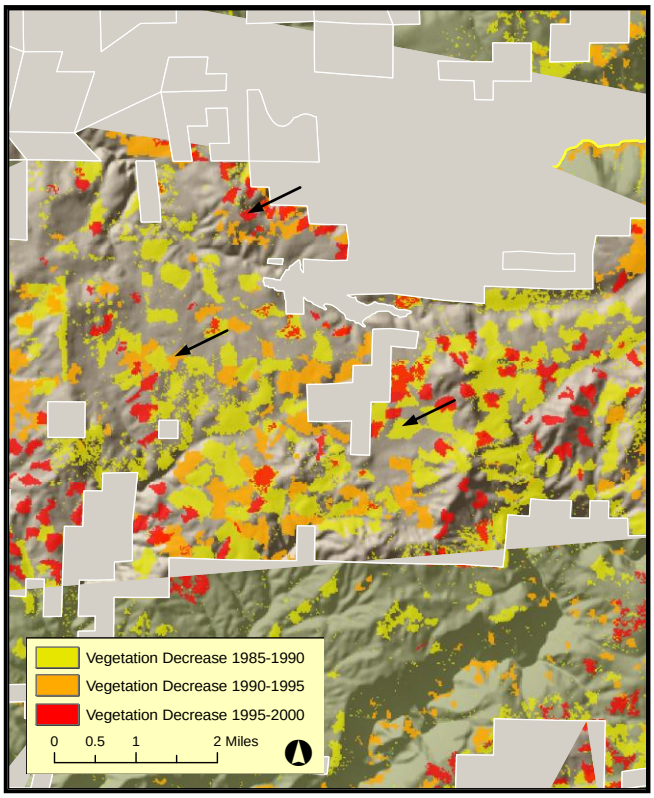

Figure 4. Vegetation loss from 1985-2000.

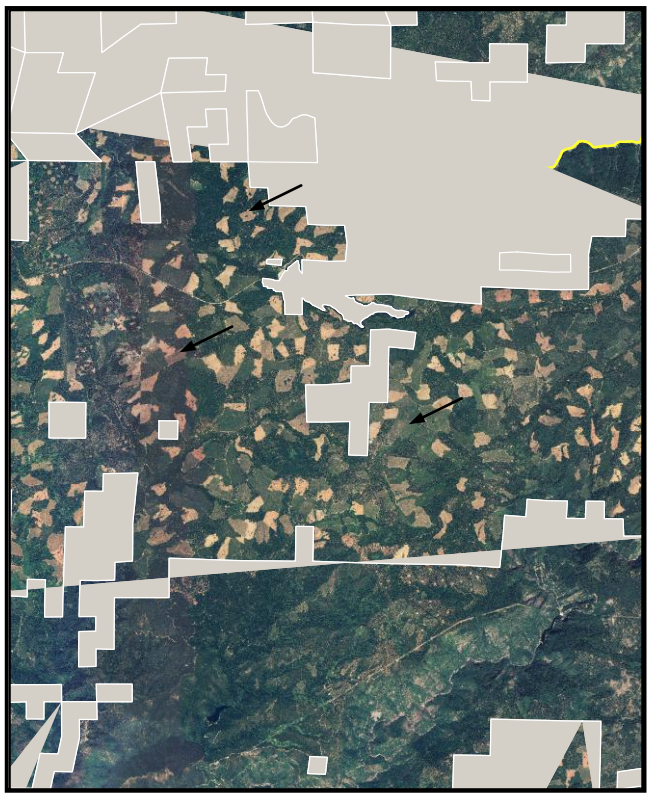

Figure 5. 2005 NAIP image.

2) Determine levels of expenditure for this program and ascertain if other program areas should be involved and share in the costs.

Funding History

FHP funding that has supported the LCMMP change detection work averaged $100,875 per year over the 12 year period beginning in 1994, and ending in 2006 (Figure 5). Funding from FHP peaked at $175,000 in 2003 with a peak in funding from contributing agencies as well. In total, FHP has invested $1,210,500 covering approximately 140 million acres over 12 years. Since the program's inception in 1995, this work has been coordinated with other forest service staffs, CDF and other federal agencies. The maximum amount of funding from CDF was $75,000 in 2002–2004. The funding for CDF-FPM stayed constant through the past 10 years. Funding leveraged from the CDF, BOR and other Forest Service staffs reduced the costs of conducting change detection to ***$.01/acre***. The intent of a coordinated approach was to leverage funding across program

areas, staffs and agencies to acquire consistent baseline data to monitor forested ecosystems, wildlife habitats, and map and measure trends in forest health.

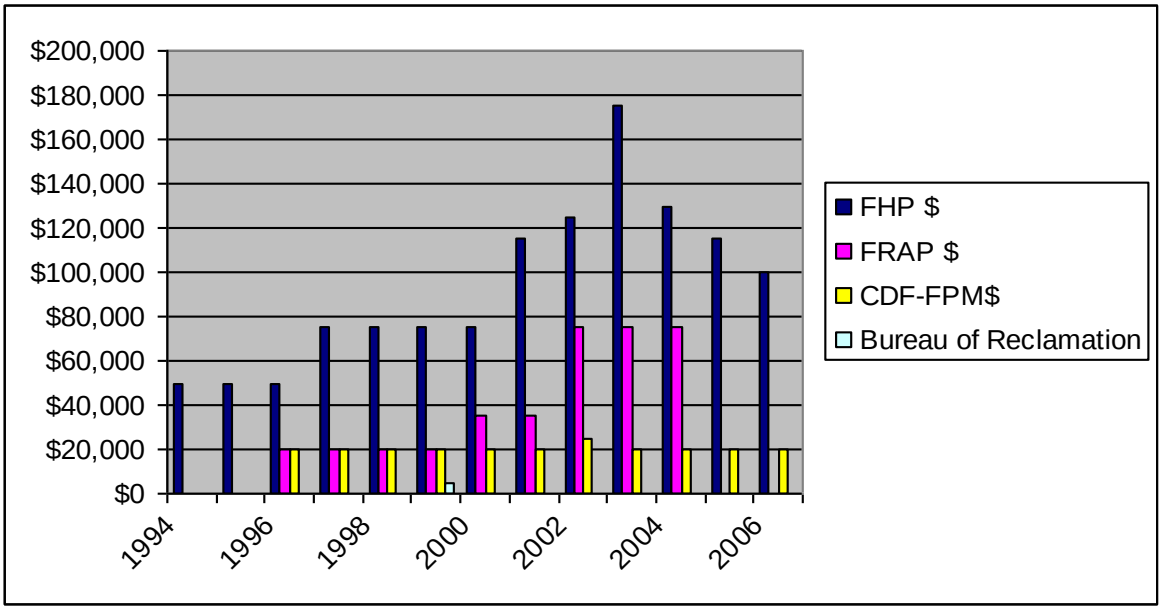

Figure 5. Funding by organization and year.

It should be noted that the funding represented here does not include in-kind contributions from CDF-FRAP or other forest service staffs. During the seven year period covering 1996 to 2003 when CDF-FRAP was fiscally committed to this program, in-kind contributions included office space for two employees, two computer workstations with image processing and GIS software, 1 full-time CDF-FRAP employee as a co-project manager, 1 full-time student, and the equivalent of 1 full-time contractor for data processing and analysis. It is estimated that in-kind contributions from CDF-FRAP totaled $750,000 for the seven year period.

In–kind contributions from other forest service staffs include resource photography coordinated with the acquisition of satellite image data, vegetation data layers for stratification of the change data and the continual exchange of knowledge. The latter being a priceless contribution toward multiple programs, the former including acquisition of resource photography over all National Forest lands totaled approximately $60,000 per year for 12 years.

The unique co-location of FHP, other forest service staffs and CDF for 13 years provided a true model of collaboration of agencies with varying yet complimentary missions. Even though our overall program goals differed we all saw the need for statewide data layers that were updated on a regular basis to provide trend information on our forested resources. Continuing with a statewide program will require cost-sharing.

Appendix II contains further breakdown of FHP funding by program area.

If we continue to conduct this program as it has been conducted for the past ten years the amount of funding from FHP must remain at a minimum of $120,000 (covers 1 ½ contractors). It must also have contributions from other program staffs and cooperating agencies that match the amount FHP contributes. This is necessary to maintain an accurate product statewide. In Region 5 many business needs are driven by accurate

vegetation data. Region 5 has invested millions of dollars over 15 years to create a vegetation mapping program. Over the past 12 years FHP has been coordinating with the vegetation mapping program to provide essential information about what has changed so that baseline vegetation maps can be quickly updated. In addition, FIA plots that fall within changed areas are also re-visited and re-measured on a 5-year cycle, providing an easy way to prioritize field data collection. The region has decided to move to a 10-year cycle for vegetation mapping. The EP staff has primary responsibility for vegetation mapping in the Region and has determined this change data to be a critical component of their map refresh process. EP should remain a partner and contributor in this program. CDF should also contribute to this program and other staff units including CDF-Division of Fish and Game should become resource sharing partners.

3) Determine who the users and/or clients are for this information

LCMMP Survey Summary

In response to the outcome of the WO review (July 2006), a survey was conducted to identify who are the users of the data and how they incorporate the LCMMP data into their work. The survey was sent to approximately 70 individuals and we received 21 responses. Twenty responses were used in the results compilation with 12 from the Forest Service, 5 from Universities and the remaining 3 from state and federal agencies. Of these responses, 13 are regular users, 3 limited/occasional users and 3 do not use the data for their projects. Several of the responses recognized the usefulness of the LCMMP data to provide long-term trend/monitoring data for ecological studies and planning purposes. The survey results revealed the various implementations of the LCMMP data. Uses include countywide planning, watershed level planning, updating vegetation maps, incorporation into wildlife habitat modeling, and determination of changes in mortality patterns on the ground, to name a few. Thirteen of the responses stated that the data is relevant to their program's mission and that the loss of these data would impact their work.

Users were also asked to identify potential impacts on their work if this data is no longer available. Several users identified the loss of monitoring management activities. Other notable impacts include difficulty in monitoring impacts of global climate change, prevention/suppression activities, fire severity and pest disturbances. One notable response from a user mentioned losing litigation or appeals because of the loss being able to make informed decisions about current conditions.

For complete results of the LCMMP user survey see Appendix III.

Future Directions

In the short-term (over the next 3-5 years) the R5 FHP staff will focus on small projects driven by catastrophic forest health events, e.g. southern California mortality event, for applying change detection to trend analyses. We will also continue to look for additional partners and collaborators that can share in the resources required to conduct monitoring with remotely sensed data across all ownerships.

Currently our collaboration with PNW- Forest Sciences Laboratory is providing a historic look over the northern portion of California. We intend to look historically at the southern bioregions of California to conduct analyses that will be integrated into existing

regional level programs such as the Stewardship Fireshed Assessment program. We also hope to provide a broader picture of forest health to support past conditions to aid in determining future conditions and forest health risk.

We would like an advisory group to evaluate this assessment as a response to the WO findings of the July 2005 WO FHP review and advise on a strategy for the long term direction of the program and the needs of the Region for monitoring data.

References

California Department of Forestry and Fire Protection, Fire and Resource Assessment Program (FRAP), 2003. *The Changing California: Forest and Range 2003 Assessment, Assessment Summary*, October 2003, http://www.frap.cdf.ca.gov/assessment2003.

Macomber, S., and C.E. Woodcock, 1994. Mapping and Monitoring Conifer Mortality Using Remote Sensing in the Lake Tahoe Basin. *Remote Sensing of Environment*, 50, 255-266.

McGarigal, K., and B.J. Marks. 1995. *FRAGSTATS: spatial pattern analysis program for quantifying landscape structure*. Gen. Tech. Report PNW-GTR-351, USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Mahon, L.C., Fischer, C., Levien, L. and Mai, J. 2002. *The Use of Remotely Sensed Data for the Detection, Mapping and Monitoring of Sudden Oak Death*. Proceedings of the 9th Biennial Forest Service Remote Sensing Conference. San Diego, CA. April 8-12.

Roland, J. 1993. Large-scale forest fragmentation increases the duration of tent caterpillar outbreak. *Oecologia*, 93, 25-30.

Staus, N.L., Strittholt, J.R., DellaSala, D.A., Robinson, R. 2002. Rate and pattern of forest disturbance in the Klamath-Siskiyou ecoregion, USA between 1972 and 1992. *Landscape Ecol*., 17, 455-470.

USDA Forest Service. *Forest Service Manual (FSM) 3400 – Forest Pest Management WO Amendment 3400-90-1*. June 1, 1990. USDA Forest Service. June 25, 2006 <http://www.fs.fed.us/cgi-bin/Directives/get_dirs/fsm?3400!..>.

USDA Forest Service-Forest Health Protection Staff. *Forest Health Protection Mission Statement*. October 2003. USDA Forest Service. June 25, 2006 <http://www.fs.fed.us/foresthealth/briefs/MissionVision10_03.pdf>.

USDA Forest Service-Forest Health Protection Staff. *Forest Health Management Program*. June 25, 2004. USDA Forest Service. June 25, 2006 <http://www.fs.fed.us/foresthealth/forest_health_management.shtml>.

Walker, R., Rosenberg, M., Warbington, R., Schwind, B., Beardsley, D., Ramirez, C., Fischer, L., Frerichs, B. 2006. *Inventory of conifer mortality in southern California mountains (2001-2004) due to bark beetle impacts*. Report to MAST/FAST

Appendix I - LCCMP Publications and Presentations

Project area reports, conference proceedings and peer-reviewed articles

Fischer, L., C. Ramirez, and B. Maurizi. In progress. *Monitoring land cover changes in California, a USFS and CDF cooperative program, North Coast Project Area - Cycle II*.USDA Forest Service, State and Private Forestry, Forest Health Protection, McClellan, CA.

Fischer, L., C. Ramirez, and B. Maurizi. In progress. *Monitoring land cover changes in California, a USFS and CDF cooperative program, South Coast Project Area - Cycle II*.USDA Forest Service, State and Private Forestry, Forest Health Protection, McClellan, CA.

Walker, R., Rosenberg, M., Warbington, R., Schwind, B., Beardsley, D., Ramirez, C., Fischer, L., Frerichs, B. 2006. *Inventory of conifer mortality in southern California mountains (2001-2004) due to bark beetle impacts*. Report to MAST/FAST.

Fischer, L., M. Rosenberg, L. Mahon, Z. Liu, B. Maurizi, and P. Longmire. 2005. *Monitoring land cover changes in California, a USFS and CDF cooperative program, Southern Sierra Project Area - Cycle II*.USDA Forest Service, State and Private Forestry, Forest Health Protection, McClellan, CA.

Levien, L., C. Fischer, L. Mahon, S. Parks, B. Maurizi, J. Suero, P. Longmire, and P. Roffers. 2003. *Monitoring land cover changes in California, a USFS and CDF cooperative program, North Coast California Project Area*. State of California, Resources Agency, Department of Forestry and Fire Protection, Sacramento, CA.

Levien, L., C. Fischer, P. Roffers, B. Maurizi, and J. Suero. 2002. *Monitoring land cover changes in California, a USFS and CDF cooperative program, Northeastern California Project Area*. State of California, Resources Agency, Department of Forestry and Fire Protection, Sacramento, CA.

Fischer, L., M. Rosenberg, L. Mahon, Z. Liu, B. Maurizi, P. Longmire, S. Shupe. 2004. *Monitoring land cover changes in California, a USFS and CDF cooperative program, Northern Sierra Project Area - Cycle II*. State of California, Resources Agency, Department of Forestry and Fire Protection, Sacramento, CA.

Levien, L., C. Fischer, L. Mahon, S. Parks, B. Maurizi, P. Longmire, and J. Suero. 2003. *Monitoring land cover changes in California, a USFS and CDF cooperative program, Cascade Northeast Project Area - Cycle II*. State of California, Resources Agency, Department of Forestry and Fire Protection, Sacramento, CA.

Levien, L., B.D. Schwind, C. Fischer and M. Rosenberg. 2002. *California Land Cover Mapping and Monitoring Program: A Cooperative*. USDA Forest Service and California Department of Forestry, Sacramento, CA.

Mahon, L.C., Fischer, C., Levien, L. and Mai, J. 2002. The Use of Remotely Sensed Data for the Detection, Mapping and Monitoring of Sudden Oak Death. In *Proceedings of the Ninth Biennial Forest Service Remote Sensing Conference, RS2002*. San Diego, CA. April 8-12.

Maurizi, B., P. Longmire, and L. Levien. 2002. Enhanced methods for separation of landsat TM derived vegetation change classes. In *Proceedings of the Ninth Biennial Forest Service Remote Sensing Applications Conference, RS2002*. April 8-12.

Levien, L., C. Fischer, S. Parks, B. Maurizi, J. Suero, L. Mahon, P. Longmire, and P. Roffers. 2002. *Monitoring land cover changes in California, a USFS and CDF cooperative program, South Coast Project Area*. State of California, Resources Agency, Department of Forestry and Fire Protection, Sacramento, CA.

Rogan, J., J. Miller, D. Stow, J. Franklin, L. Levien, and C. Fischer. 2002. Land cover change monitoring using multitemporal landsat TM and ancillary data. In *Proceedings of the Ninth Biennial Forest Service Remote Sensing Conference, RS2002*. San Diego, CA, 8-12 April.

Rogan, J., J. Franklin, D. Stow, L. Levien, and C. Fischer. 2001. Toward operational monitoring of forest cover change in California using multitemporal remote sensing data. In *Proceedings of the International Geoscience and Remote Sensing Symposium (IGARRS 01)*, Sydney, Australia, 9-13 July.

Fischer, C.S. and L.M. Levien. 2001. Monitoring California's hardwood rangelands using remotely sensed data. In *Proceedings of the Oaks in California's Changing Landscape Conference*. San Diego, CA, October 22-25.

Levien, L., P. Roffers, B. Maurizi, J. Suero, C. Fischer, and X. Huang. 1999. A machine-learning approach to change detection using multi-scale imagery. In *Proceedings of the American Society of Photogrammetry & Remote Sensing 1999 Annual Conference*, Portland, OR.

Levien, L., C. Fischer, and B. Maurizi, J. 1999. *Monitoring land cover changes in California, a USFS and CDF cooperative program, Southern Sierra California Project Area*. State of California, Resources Agency, Department of Forestry and Fire Protection, Sacramento, CA.

Levien, L., C. Fischer, P. Roffers, and B. Maurizi. 1998. Statewide change detection using multitemporal remote sensing data. In *Proceedings of the First International Conference on Geospatial Information in Agriculture & Forestry*, Lake Buena Vista, FL.

Levien, L., C. Fischer, P. Roffers, and B. Maurizi. 1998. Statewide change detection using multitemporal remote sensing data. In *Proceedings of the Seventh Forest Service Remote Sensing Applications Conference*, Nassau Bay, Texas.

White papers and presentations

Fischer, C.S. and T.T. Shih. *Tracking forest management practices using multi-temporal satellite imagery*. Internal USFS, CDF document, 2001.

Levien, L., C. Bell, and B. Maurizi. 1996. *Large area change detection using satellite imagery: Southern Sierra Change Detection Project* (presented at USDA Forest Service and the Society of American Foresters Remote Sensing Group Conference: Remote Sensing, People in Partnership with Technology. Sequoia-Kings Canyon National Park, April 29 - May 3.

Fischer, L. 2001-2006. *California Land Cover Monitoring: A cooperative program*. Presentation given to Geography and Ecology Graduate Groups at the University of California, Davis.

Appendix II - FHP funding by program area

FHP Funding	YEAR							
Category	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	
Land Cover Monitoring related incl: imagery, software, contracts grants	$75,000	$115,500	$125,000	$175,000	$130,000	$115,000	$100,000	
GIS Support incl: risk mapping and analysis, pitch canker, prev/suppression tracking, aerial survey gis support	$74,000	$64,000	$75,000	$105,000	$90,000	$85,000	$97,000	
Hardware/Software		$6,580	$1,000		$3,500			
Flights SOD (non-SOD colored $)		$7,500						
Publications			$10,000	$7,350				
Aerial Surveys	$90,000	$90,000	$90,000	$95,000	$100,000	$100,000	$100,000	
Aerial Survey - Training					$107,000			
Pacific Basin support					$50,000	$50,000	$68,000	
So Cal Surveys						$200,000		
TOTAL	**$239,000**	**$283,580**	**$301,000**	**$382,350**	**$480,500**	**$550,000**	**$365,000**	**$2,362,430**
Total w/out LC Monitoring	**$164,000**	**$160,000**	**$176,000**	**$207,350**	**$350,500**	**$434,500**	**$265,000**	**$1,593,350**

Appendix III - LCMMP survey

LCMMP survey and results

There were 21 total responses to this survey sent out in January and due March 15, 2006. Of the 21 responses one response asked for their survey to be withdrawn. The compilation of results is based on a total of 20 responses. These responses are broken down as follows:

USFS – Forest Health Protection:	4
USFS – Research and Development:	2
USFS – National Forest System:	6
University of California:	4
California Dept. of Forestry and Fire Protection:	1
California Polytechnical University:	1
Natural Resources Conservation Service:	1
US Bureau of Reclamation:	1

Do you consider yourself a user/client of these data?

Yes	14
No	3
Limited use/Occasional Use	3

What types of natural resources information do you use for your work? E.g., digital image data, aerial photography, field collected data, etc.

- Aerial Survey
- Aerial Photography
- Satellite Imagery
- Field data collection
- GPS data
- Routine GIS data, e.g. roads, fire history, streams
- FIA plot data
- Digital Orthophoto Quarter Quads (DOQQ)
- Digital Elevation Models (DEMs)
- Other digital data such as plant, vertebrate information, classified vegetation, historical reports and records
- Precipitation and Snowpack data

Do you have a need for long-term trend information for the resources you manage?

No	3
Not at this time but interested:	1

Most resource managers aware of changes with/without this product:

Yes:	14

Summary of why this info is needed:

- Long-term monitoring of land use change is essential
- Use these data for long term habitat monitoring and incorporation into our data

- Synthesis of these data and other ancillary data provide opportunities to understand ecological relationships, as well as impacts of management activities over various spatial scales
- More specific trend and change information including where, how and what is causing the changes
- Necessary for monitoring insect populations and associated tree mortality
- Need to know magnitude and type of diseases are in the area
- Assist various agencies to address environmental planning
- Statistical trend and ground change projections
- Trend analysis needed in every project
- Assess appropriateness of current regulations, ordinances, etc.
- Valuable in developing county general plans

Have you used the change detection products in the past 6 months? If so, how?

Yes	10
No	7

No, not in the past 6 months but have plans to use is in the next 6 mos: 3

Summary of how these data have been used:

- Fire regime and condition class mapping
- Examine land conservation activities the TNC has undertaken
- Change data has been incorporated into Reclamation's own data to produce maps and tabulations of change acreage
- Teaching/Educational at the college level
- Assess public safety
- Update vegetation maps
- Countywide planning
- "Big picture" watershed level planning to help focus activities
- Incorporation into wildlife habitat modeling
- Determination of changes in mortality patterns on the ground, infestation and affected stands of trees
- Support many projects including impacts of projected population growth and transportation build out on remaining natural habitats
- Calibrate forest stand changes with historic vegetation data (circa 1930)

Would you consider the change data to be useful in your programs mission? If so, be specific on how these data may help you accomplish your goals and objectives.

Possibly	4
No	3
Yes	13

If Yes, how?:

- Valuable tool for development and/or assessment of local approaches to oak woodland conservation
- Understand how CA landscapes are changing – parameterize models
- Availability of spatial data over large regions permits analysis spanning multiple ownerships
- Useful as a guide for agencies (State) for tree removal projects in established emergency zones, such as Southern California
- Monitor condition class through time
- Characterizing changes in habitat and vegetation cover over time for trends and effects analysis
- Teaching
- Essential because this is the only large area record of gross vegetation change patterns over past couple of decades
- Help develop projects and where to go to reduce pest infestation
- Valuable and critical data source because we don't have the resources to conduct this type of program on our own – we rely on this cooperative work

Would the lack of this data impact your work? If yes, what would the impacts be?

Not sure:	2
No:	5
Yes:	13

Impacts without these data:

- Wouldn't have regional/state change information
- Would have data gaps
- Decreased ability to measure consequences to biodiversity and ecosystem processes
- Couldn't differentiate temporary changes vs. permanent changes
- Couldn't look at analysis over large spatial regions
- Difficulty in monitoring impacts of global warming, management activities, fire severity and pest disturbances
- Greater costs for partners to conduct mapping/monitoring
- Reduce accuracy of analyzing and monitoring prevention/suppression activities
- Would need to contact similar work
- Could lose litigation or appeals – ultimately need it to make decisions about current conditions
- Assumptions would be made and may or may not be correct for land cover assessment
- Reduced capacity to examine key factors of landscape condition
- Reduce ability to forecast increase in fire hazard areas
- Decrease ability to interpret changes associated with management practices
- Decrease effectiveness of educational programs

- Important tool for landowners/managers and decision makers

Currently this data is available every 5 years in any given area of the state, would a yearly cycle be more beneficial?

Maybe:	7
No:	5
Yes:	7

Additional comments:

- Aerial survey works for annual surveys
- More beneficial would be to go back in time as far as possible to capture more historical changes
- Use higher resolution data in rural areas
- Provide more resources on outreach and delivering other related products
- Cost of increase in cycle is a concern
- Useful for annual updates on spread of disease centers
- 3 years would be a better interval
- 1 year only marginally more beneficial or if special circumstances
- Beneficial especially in established pest infested zones

Has the data been distributed to you easily? Do you have suggestions for improved data distribution mechanisms?

No:	7
Yes:	12

Suggestions for improving distribution:

- Provide more support to extend information and deliver other related products useful to potential users
- Send notification when data is available
- Provide CDs or use the Intranet as opposed to Internet
- Provide the data via ftp
- Better marketing of the data
- Poor understanding of uses of the data