Project title: Upland Fuel Reduction Treatments in the Lake Tahoe Basin: Forest Restoration Effectiveness

Science Theme # 2: Forest Management, Fuels Reduction, and Stream and Meadow Restoration

Subtheme: Fire and Fuels

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II. Narrative
a. Justification

There is clear policy direction in the National Fire Plan (USDA and USDI 2001) and the Healthy Forest Restoration Act (HRFA 2003) to restore forest habitats and reduce the risk of wildfire, particularly on the wildland-urban interface (WUI). Addressing the wildfire threat and implementing restoration measures in the Lake Tahoe basin presents unique challenges. First, the white-fir and red-fir dominated forests in the lower montane zone that developed under fire suppression after extensive logging are overly dense and crowded with small trees and extraordinary accumulations of fuels (Barbour et al 2002, Taylor 2004). Second, the proximity of these unusual forests to populated areas and the importance of tourism have limited the use of prescribed burning as a management option because of smoke and water and air quality concerns. Third, much of the fuel load in the basin is in the form of small trees with low commercial value, thus the use of mechanical harvester-forwarding systems with mastication and/or chipping of the slash has been employed on relatively few acres. Although this method is efficient and the goal of managers is to increase its use, it is currently limited by its low profitability, the complex regulatory environment of the Tahoe Basin, and the small number of contractors willing to do the work. As a result, the vast majority of fuel treatments in the lower montane zone that have been implemented or are scheduled for implementation in the near future utilize hand thinning with chain saws, followed by piling of the slash. Under burning is scheduled for piles, but for the reasons above, there is a large backlog of piles awaiting burning on National Forest system lands.

A large body of scientific literature addresses many issues associated with wildland fire and different fuel treatments applied in various vegetation types, but empirical studies of on-the-ground effects of fuels reduction treatments in treated versus untreated stands are few (van Wagtendonk 1996; Stephens 1998; Pollet and Omi 2002; Graham et al. 2004; Agee and Skinner 1995; Stephens and Moghaddas 2005). Consequently, no scientific consensus exists regarding the specifics of how treatments are implemented and the relative effectiveness of different prescriptions across vegetation types (Carey and Schumann 2003; USDA 2004; Stephens and Ruth 2005; Peterson et al. 2006; Fites et al, in progress). In particular, the extent to which mechanical treatments can mimic the ecological role of fire is poorly understood (Weatherspoon 2000). Although recent studies are beginning to address the effects of mastication treatments (Busse et al. 2005; Stephens and Moghaddas 2005; Kane et al. 2006, and Knapp et al. 2006) only one published study on mastication has been conducted in the Lake Tahoe basin (Hatchet et al, 2006).

Heightened environmental concerns in the Tahoe basin, including specific requirements for vegetation and wildlife conditions, demand a better understanding of the impacts of fuels management approaches over both short and longer terms. Several projects in the Sierra region are underway to address some of the knowledge gaps in fuel treatment effects and effectiveness. One study is addressing the effects of both prescribed fire and mechanical treatments on dry mixed conifer forests (see Knapp et. al 2004); however, those forests in the far southern Sierra occur at lower elevations, and experience very different climates and consist of different mixes of forest types compared to those in the LTBMU. The USFS Adaptive Management Services Enterprise Team (AMSET) recently finished collecting data on fuel treatments in all Region 5 National Forests, including the Sierra region; but, only looked at vegetation conditions and too few plots were established in the LTBMU to be statistically valid to address the basin alone.

With respect to wildlife habitat, effects of fuels treatments that are currently being implemented in the specific forest types in the LTBMU are essentially unknown. There is no empirical data on the long term effects of mastication treatments on vegetation succession and wildlife habitat suitability in the basin or elsewhere. In general, treatments that are primarily designed to reduce fuels tend to simplify and homogenize the landscape, particularly mechanical treatments. The removal of overstory and understory trees and the more even spacing of remaining trees will likely result in significant changes in vegetation composition and habitat structure and have the potential to greatly affect habitat conditions for a majority of native animal species for many decades after treatment (George and Zack 2001). Models such as CWHR (Mayer and Laudenslayer 1996) use too coarse a depiction of habitat structure and composition to provide a sensitive measure of changes in habitat suitability (Manley et al. 2007). CWHR is particularly insensitive to changes in understory vegetation, canopy complexity, and amount and condition of dead wood, the very elements being altered through fuels treatments. The most recent synthesis of what is known about wildlife and invertebrate response to fuels reduction treatments in dry conifer forests in the United States concluded that there were tremendous information gaps (Pilliod et al 2006). Extensive fuel treatments are proposed for the remainder of the lower elevations in the basin, particularly the south shore. Critical habitat for many wildlife species will be affected, including special status species of concern associated with old forest condition. Rapid feedback is needed to assess impacts of current prescriptions on habitat suitability and occupancy so they can be revised and refined as needed to reduce impacts and improve accomplishment of forest restoration objectives.

The Lake Tahoe basin is ecologically unique in many respects, resulting in the need for basin-specific information on forest conditions and responses to treatments. Its uniqueness lies in the nexus of a highly interspersed urban-wildland interface, high recreation use, high property values, diverse and vulnerable wildlife populations, high-stakes consequences associated with forest management (re: clarity of Lake Tahoe), and extreme forest health problems resulting from extensive clearcutting followed by fire suppression. This unique constellation of factors creates a very different temporal and spatial disturbance dynamic across the landscape, making it unlikely that responses (vegetation or otherwise) observed outside the basin will be applicable to basin circumstances.

b. Problem Statement and Background

An adaptive management framework acknowledges that uncertainty exists about management choices and the impacts of management actions, and provides the formal linkage between management needs and science to ensure that research (and monitoring) is designed to address information gaps, reduce uncertainty, and directly inform management decisions. A major problem facing resource managers in the Lake Tahoe basin is that they simply have little or no data that informs how different fuel reduction treatments being carried out on their forests affect vegetation composition, forest structure, fuel loads, or wildlife response. Without these data, basin managers have no way to evaluate whether their fuels reduction program is successfully reducing fire risk, or if other desired conditions for forest health are being met. Managers are left with limited information on the progress of acres having been treated and dollars having been spent.

The proposed interdisciplinary collaboration here represents the first comprehensive study to address those information gaps. The team first received SNPLMA funds under EIP#10123 to implement the Upland Fuels Reduction Monitoring Program during the summer of 2006. Our research team collaborated directly with the Lake Tahoe Basin Management Unit (LTBMU) to design and implement the project, using a Before-After-Control-Impact (BACI) design with six paired treatment/control sites located in mixed conifer on the west shore (Figure 1). The sample units represent typical conditions being treated on the west shore of Lake Tahoe in terms of forest condition and location in the urban-wildland interface. Allocated funding covered collection of pre-treatment data on vegetation conditions, fuel loads, and vertebrate and invertebrate responses. In 2007, PSW obtained additional funds from the Nevada State License Plate program to collect post-treatment on the two unit pairs on the west shore that were treated in fall 2006 and to install two additional paired treatment/control sites on state lands on the east shore (Figure 1). The LTBMU funded the analysis and reporting of the vegetation and fuels data, along with similar data from another projects (Stanton and Dailey 2007). As of 2007, this project represents an investment of federal and state funds of approximately $225,000, with in-kind contributions of $50,000. The combined database includes parameters for vegetation composition and structure, fuel loading, songbirds and woodpeckers, small mammals, butterflies, and ground-dwelling invertebrates (emphasizing ants). Pre-treatment results for the six paired sites on the west-shore have been presented in two reports (Manley 2007, Stanton and Dailey 2007).

This proposal requests funding to complete the sampling regime on seven of the eight pairs of sample sites. Treatment implementation on one of the eight pairs of sites is uncertain, so it is not included in this proposal. Completion of data collection entails two years of post-treatment sampling on the five paired sites treated in 2007 and 2008, and the second year of post treatment sampling on the two paired sites treated in 2006. Preliminary results of pre-treatment conditions confirm that existing conditions of forest structure and composition are severely departed from historic and desired conditions. Forests are overly dense with small white fir (75% of all trees > 1 in dbh were white fir) and had high densities of snags present, likely due to widespread insect damage that weakened trees (Table 1). This forest structure has resulted in crown bulk density values that exceed the threshold for active crown fire for every site (Figure 2). Mean surface fuel loads were high in each fuel type and across all sites (>30 tons/ac on all sites; Figure 3). Combined with low canopy base heights, the pre-treatment data confirm that the lower montane mixed conifer forests on the west shore have a very high crown fire risk potential.

Table 1. Average values for forest structure attributes and habitat conditions pre-treatment and post-treatment (where applicable) for the west-shore sites. (CWHR = CA Wildlife Habitat Relationship class; QD75= Quadratic Mean Diameter, 75th percentile for tree size).

Unit	Treat or Control	CWHR type	Trees/Acre (>1"dbh)	Canopy Closure (%)	QD75 (inches)	Basal Area (ft^2/acre)	Snags/Acre
BLK 1-4	**C**	4M	151	48	23	190	25
	Tpre	4D	208	68	23	309	45
	Tpost	4M	79	44	26	190	19
MCK 13-1	**C**	4D	199	57	21	221	34
	Tpre	4M	140	57	19	147	24
	Tpost	4M	73	40	21	73	10
MCK 13-3	**C**	4M	212	72	23	263	114
	T	4M	205	58	18	305	80
TWC 3	**C**	5D	207	62	26	305	36
	T	4M	172	48	23	191	39
WRD 20-16	**C**	4D	240	71	20	264	26
	T	4M	164	54	22	219	31
WRD 20-9	**C**	4D	195	64	20	227	27
	T	4M	186	49	20	217	34

c. Goals, Objectives, Hypotheses

The goal of this study is to provide forest managers with rapid feedback on the effectiveness and biotic response of hand and mechanical fuel reduction treatments currently being implemented in the specific forest types found in the lower montane zone in the Lake Tahoe basin. The specific objectives of this study are complete sampling on seven paired sites, all of which have either been treated or are scheduled for treatment in 2008 (Scott Parsons, pers. comm.). The study will complete the evaluation of the effects of different fuel reduction treatments on vegetation composition and structure, fuel loading, modeled fire behavior, and animal species and communities (vertebrate and invertebrate). Helping managers in understanding how these elements respond to treatments is essential before they can address three regional key management questions (as identified in the Sierra Nevada Forest Plan Amendment Record of Decision [SNFPA ROD 2004]):

1) Is management direction being implemented as described?
2) Are desired conditions being met?
3) Are management actions resulting in expected outcomes?

Project-level issues that will be addressed include determining if the project: 1) met vegetation performance criteria as identified in project plans; 2) reduced fire risk and improved forest health to the levels specified in project plans; and 3) improved wildlife habitat conditions in PACs and HRCAs, and corresponding maintenance of occupancy and prey populations. In the long term, this project will provide critical project-level data that managers can use to plan future treatments and schedule re-treatments. The reporting out of this effort will evaluate and streamline protocols, and develop indicators that managers can use in fuel treatment reduction prescriptions, in project implementation, and in performance assessment.

Specific hypotheses to be tested include:

1) Reduction of understory and overstory tree density by any method improves fire behavior in upland conifer forest types.
2) Deep mulches of chipped material suppress understory plants, overstory seedling production, and the composition and abundance of fossorial mammals.

3) Reduction of understory and overstory tree density negatively affects the composition and abundance of mature-forest associated bird, small mammal, and invertebrate species, particularly understory associates, and habitat suitability for upper trophic level predators.
4) Reduction in cover of seed-producing shrubs and herbs will reduce granivore and pollinator species richness and abundance.
5) Removal of nitrogen-fixing shrubs (e.g., *Ceanothus velutinus*) will reduce the rate of understory recovery.

d. Approaches, Methods, and Locations

Existing study sites are located in the lower montane zone in four watersheds on the west shore (Twin Crags, Ward Creek, Blackwood Creek, and McKinney Creek) and one watershed on the east shore (North Canyon; Figure 1). West shore units are in mixed conifer forests of red and white fir, Jeffrey pine, incense cedar, and sugar pine. East shore units are in mixed Jeffrey pine and red fir. Understory vegetation is varied, ranging from grass- to shrub-dominated, with various amounts of herbaceous cover. Permission to access all treatment and control sites has been obtained.

<u>Methods</u>

An integrated sampling design was used to collect data on vegetation structure and fuel loads, small mammals, birds, and invertebrates. A macroplot of 150 x 330 m was established in a relatively homogeneous and representative portion of each unit. The macroplot provided the grid for 72 wildlife trapping stations, point bird counts, and 10 randomly selected vegetation plots. A paired BACI sample design is critical for separating treatment effects from the myriad of environmental factors that can influence plant and animal community composition and structure over time. Two-year post-treatment sampling is required to establish inter-annual variation of the sampling variables, especially the understory vegetation and animal species responses. Together these data will set a baseline for the longer monitoring period (minimum of 5 years) that is required to address longer-term conditions resulting from treatments and whether they are meeting desired conditions for forest health, wildlife habitat, and the maintenance of acceptable predicted fire behavior.

Vegetation plot lay-out and data collections parameters were based primarily on FIREMON, the Fire Effects Monitoring and Inventory System (Lutes et al. 2006). FIREMON is a comprehensive system, designed to satisfy fire management agencies' monitoring and inventory requirements, that consists of standardized sampling methods and manuals, field forms, database, and analysis program (detailed protocols and field forms can be found on the FIREMON website at http//: www.fire.org.). FIREMON has a flexible structure that allows the modification of sampling methods to incorporate locally important evaluation criteria. For mature tree sampling, a breakpoint diameter of >15cm at DBH was used within a fixed 17.58 meter radius (0.25 ac) plot. Plots were installed at 10 randomly selected trapping stations within each macroplot, for a total sampling area of 1 ha (2.5 ac). We followed basic protocols, with some adjustments for the following field forms: Plot Description, Fuel Load, Trees, Cover/Frequency. The sampling protocols for the vegetation and fuels portion of this project were developed in collaboration with the USFS Adaptive Management Services Enterprise Team (AMSET), the LTBMU, and Dr. Scott Stephens (University of California, Berkeley), Thus, the protocols are accepted by management agencies in the basin and promise to become the primary system to be used for fuels treatment monitoring and associated data management across multiple agencies in the basin. Detailed data collection parameters for vegetation and fuels may be found in Stanton and Dailey (2007).

Fuel treatments prescription levels are set based on predicted fire behavior derived from software programs such as FlamMap and Behave. These programs use fuels models which are a best estimate of the real world conditions to generate modeled predictions of fire behavior. Standardized fuels models are frequently used to provide a general definition of the fuels conditions. The capability to use measured fuels values to define custom fuels models for ground fuels is currently not possible, but is being developed (Larry Wilson. pers. comm.). Until a process is developed for converting measured ground fuel characteristics to a fuel model is available, the most reasonable way to determine a the best fuel model for a site is to use plot level photos of the site to apply one of 40 standardized models. For crown fuels, measured values of height to live crown, total tree height, DBH, crown class, and species, are entered into a program called GAMMA for determination of what are considered to be the most accurate values for crown bulk density and height to live crown currently available. These values can be entered into software programs such as Fire Family Plus and Fuels Management Analyst (FMA) to more accurately model predicted crown fire behavior, and crown fire initiation. Improved accuracy in determining the potential for crown fire activity, and particularly crown fire initiation, are critical for determining the design and effectiveness of fuels treatments.

Birds and small mammals are the primary focus of vertebrate sampling – they are directly affected by treatments and have complementary sensitivities to the effects of fuels treatments. They also serve as the primary prey for upper trophic level species of special status in the basin, namely the California spotted owl, Northern goshawk, and American marten. Small mammals are closely tied to the local conditions, they are highly dependent upon overstory and understory vegetation, and they primarily are year-round residents. Birds are more mobile, but most species have relatively narrow environmental conditions in which they can successfully breed, and they are also dependent upon both overstory and understory conditions.

Sampling for birds and small mammals follows standard methods. Bird point count stations are located at each corner of the macroplot grid for a total of 4 count stations with intervening transects. Sites are sampled three times during the spring, with a 10 minute count conducted at each station, recording all individuals seen and heard within 50 m distance intervals (Ralph et al. 1993). New species encountered along transects are also recorded. Live-trap sampling methods target small mammal species presence and abundance, with an emphasis on tree squirrels. All required permits have already been obtained. A total of 72 live trap stations are placed on a 6x12 grid at 30 meter intervals. This spacing represents a balance between encountering a sufficient number of squirrel home ranges and obtaining a high enough recapture rate for chipmunks and mice to obtain reliable estimates of density (e.g., Jones et al. 1996, Converse et al. 2004). One Tomahawk mounted in a tree and one extra-large Sherman trap are placed at each trap station (n = 144 traps total) and baited with a mixture of oats, bird seed, and raisins. All animals are individually marked with ear tags (one in each ear), enabling calculations of population size and turnover rates over time. Traps are open for 5 days and nights, and checked twice per day.

Invertebrate herbivores sampling focuses on mostly monophagous or narrowly polyphagous species of butterflies that will be variously impacted by proposed treatments; thus, the combined responses of plants, vertebrates, and invertebrates will provide rich information about ecological conditions. The nearly four dozen resident species of ground-dwelling ants in the Tahoe basin will be sampled from pitfall traps established on each macroplot grid, and opened for a 1-week periods during the same sample season. At each 0.04 ha inventory plot, an experienced observer identifies and records all butterflies observed during a 10-minute count period (Fleishman et al. 1999, Mac Nally et al. 2004). Counts are conducted once each month in June, July, and August under conditions highly suitable to insect flight activities (mostly sunny skies, warm temperatures, and light or no wind). Ants taken at pitfall traps at mid-summer maxima of ant activity are differentiated into functional groups defined by the ecosystem services that they provide (including aerator ants that create complex tunnel systems in the ground, thatch nesting species that build extensive above ground nests from available vegetation, and decomposer ants that use dead and downed woody materials). Inference regarding ecosystem services provision, including facilitation of water infiltration, will be inferred from ant functional group diversity and abundances.

<u>Data Analysis</u>

For changes in conditions resulting from treatment, the identity of paired sites will be retained in all analysis. Analysis of variance will be used to compare pre and post treatment conditions and if significant differences are detected, a Tukey-Kramer HSD test will be performed to determine if there were significant differences between treatments. With additional samples (requiring data collection in 2008), more sophisticated data analyses would be possible, such as structural equation modeling. 10 vegetation/fuels plots or less per unit (fixed area 0.1ha plots) were shown to be adequate to determine changes as small as 25% for most of the key characteristics required to evaluate desired conditions and address key management questions with 80% statistical certainty.

For each time step (pre and post), fire behavior will be modeled under three fire weather conditions using Fire Family Plus and Fuels Management Analyst (FMA). Analysis of variance (ANOVA) will be used to determine if significant differences ($p < 0.05$) existed in variables for vegetation, fuel loads, fire behavior (rate of spread, fire line intensity, flame length, torching index, crowning index), and fire effects (predicted tree mortality) for each treatment type and after each treatment stage. If significant differences are detected, a Tukey-Kramer HSD test will be performed to determine if there were significant differences between treatments. Parameters that have the greatest influence on model outputs in the basin will be identified to inform future monitoring investments.

Targeted small mammal parameters will include species composition, richness, abundance, and turnover for all species detected (13 species to date). Bird parameters will include composition, richness, and abundance (50 species detected to date). Invertebrate sampling will result in a description of species composition, species richness (number of species), and abundance (number of individuals) of ground-dwelling and pollinator invertebrates (at least to genus) and lepidoptera (to species). Pre-treatment conditions will be characterized using simple descriptive statistics. Changes in conditions resulting from treatment, the identity of paired sites will be retained in all analysis. Analysis of variance will be used to compare pre and post treatment conditions. As with analysis of fire behavior, if significant differences are detected, a Tukey-Kramer HSD test will be performed to determine if there were significant differences between treatments. A logistic regression will be used to relate all selected microhabitat variables to the occurrence of northern flying squirrels. For each significant parameter in the logistic regression model, we will calculate the odds ratios and their confidence intervals based on Quasi-Newton estimation. In addition, comparisons with predictions based on the California Wildlife Habitat Relationships (CWHR) will be generated and compared to observed to quantify the accuracy and precision of CWHR predictions for fuel treatment effects analysis. We will determine the potential impacts on upper trophic level predators by assessing effects on habitat conditions and their primary prey species. We will also conduct an analysis of the proposed P7 terrestrial indicators to determine their response to fuel treatments.

e. Strategy for engaging with managers

As our team determined in the implementation of this project, scheduled and proposed treatments in the basin are implemented within a complex of regulatory and logistical considerations. Our team has worked in close collaboration with agency staff from the beginning of the project to identify sampling units and incorporate relevant data collection protocols. We have support to continue this cooperation to insure that treatments are implemented on the remaining five units within a reasonable timeframe.

Within one year, pre-treatment and year-one post treatment data would be available for at least five pairs of sites to share with managers to determine if a project met criteria for vegetation performance, reduced fire risk, maintain habitat for forest associated species, and restore forests to desired conditions. Clearly, fuels treatments are changing forest structure, as evidenced by the reductions in tree density (~ 50%), basal area (~30-50%), and canopy cover (~ 30%) observed in the two treatment sites we sampled (BLK 1-4 and MCK 13-1; Table 1).

Effects of treatments on plant and animal populations and communities require a greater sample size and more in-depth analysis. For example, portions of a Goshawk PAC (Protected Activity Center) and a Spotted Owl PAC occur in the BLK 1-4 unit and the Ward 20-16 unit; our analysis will evaluate the effect of treatments on these units on habitat suitability and primary prey species. In general, fuel objectives have first priority in developing prescriptions, but the prescription for units with PACS are prepared in consultation with wildlife biologists in order to maintain or enhance habitat conditions while meeting the purpose and need of the proposed fuel reduction objectives. The prescription for the treatment of these two units had specific objectives. For example, the BLK 1-4 prescription calls for the following:

- Remove understory trees from 3 to 19.9 inches (8-51 cm) DBH.
- Maintain two canopy layers.
- Retain approximately 140 ft^2/ac (32 m^2 /ha) in residual basal area and 48% average canopy closure in the treated portion of the stand.
- Retain 6-7 snags/ac (3/ha) in the largest diameter size class.
- Chip existing down logs and slash less then 15 inch (38 cm) DBH to leave approximately 4 tons/acre of down woody debris.

These prescription criteria are intended to reduce surface and ladder fuels to reduce fire intensity and the potential for spread of crown fire. The evaluation of a subset of the combined pre and post treatment vegetation variables collected in this study (basal area, tree density and spacing, canopy base height, canopy closure, number of canopy layers, snags, and surface fuel loads) will enable us to assess project implementation and develop indicators that managers can use in fuel treatment reduction prescriptions and in performance assessment.

f. Deliverables

We expect the results of the study to directly inform the design and implementation of fuel treatments to meet multiple restoration and conservation objectives in the Lake Tahoe basin. Deliverables will be in the form of quarterly reports tracking progress in the primary activities that will be made available to all interested managers. During the study period we expect to provide multiple presentations at agency and scientific meetings. The final report in 2011 will evaluate the observed changes in conditions at treated sites, assess their ability to meet desired conditions, and identify candidate indicators for that best detect changes in forest structure and composition. In addition, we expect to produce a minimum of one (and likely several) peer-reviewed publications.

g. Schedule

We will work with the LTBMU and NDF to insure that treatments and sampling are coordinated and completed in a timely manner (Table 2). One unit, McKinney Cr. Unit 13-3 is not included in this proposal because its treatment is likely to fall outside the 3 year window set by SNPLMA for project completion. Products will be delivered according to the schedule in Table 3.

Table 2. Sample units included in this study.

Unit Name and #	Treatment Rx	Treatment year	1 yr post-sample	2 yr post-sample
Ward Ck Unit 20-16	PAC, hand to 10", pile/burn	2007	2008	2009
McKinney Ck Unit 13-1	Hand to 14", pile/burn	2006	2007	2008
Ward Ck Unit 20-9	Mechanical to 24", masticate	2008	2009	2010
Blackwood Ck Unit 1-4	PAC, mechanical to 24", masticate	2006	2007	2008
Twin Crags Unit 3	PAC, mechanical to 24", masticate	2008	2009	2010
North Canyon Unit 1	Hand to 14", pile/burn	2007	2008	2009
North Canyon Unit 2	Hand to 14" pile/burn	2007	2008	2009

Table 3. Schedule for deliverables.

Task	Completion date
Invoicing will occur on a quarterly basis	
Quarterly report – status for 2008	September 1, 2008
1 yr post treatment sampling of 6 units, 2 yr post treatment sampling of 4 units	September 30, 2008
Quarterly report –field data collection	December 1, 2008
Quarterly report –data entry and analysis	March 1, 2009
Quarterly report – preliminary results for 2008	June 1, 2009
Quarterly report- status for 2009	September 1, 2009
2 yr post treatment sampling of 6 units, 1 yr post sampling of 4 units	September 30, 2009
Quarterly report –field data collection	December 1, 2009
Quarterly report –data entry and analysis	March 1, 2010
Quarterly report – draft report	June 1, 2010
2 yr post treatment sampling of 4 units	September 30, 2010
Quarterly report –field data collection	December 1, 2010
Quarterly report –data entry and analysis	March 1, 20111
Final report	June 30, 2011

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III. Figures

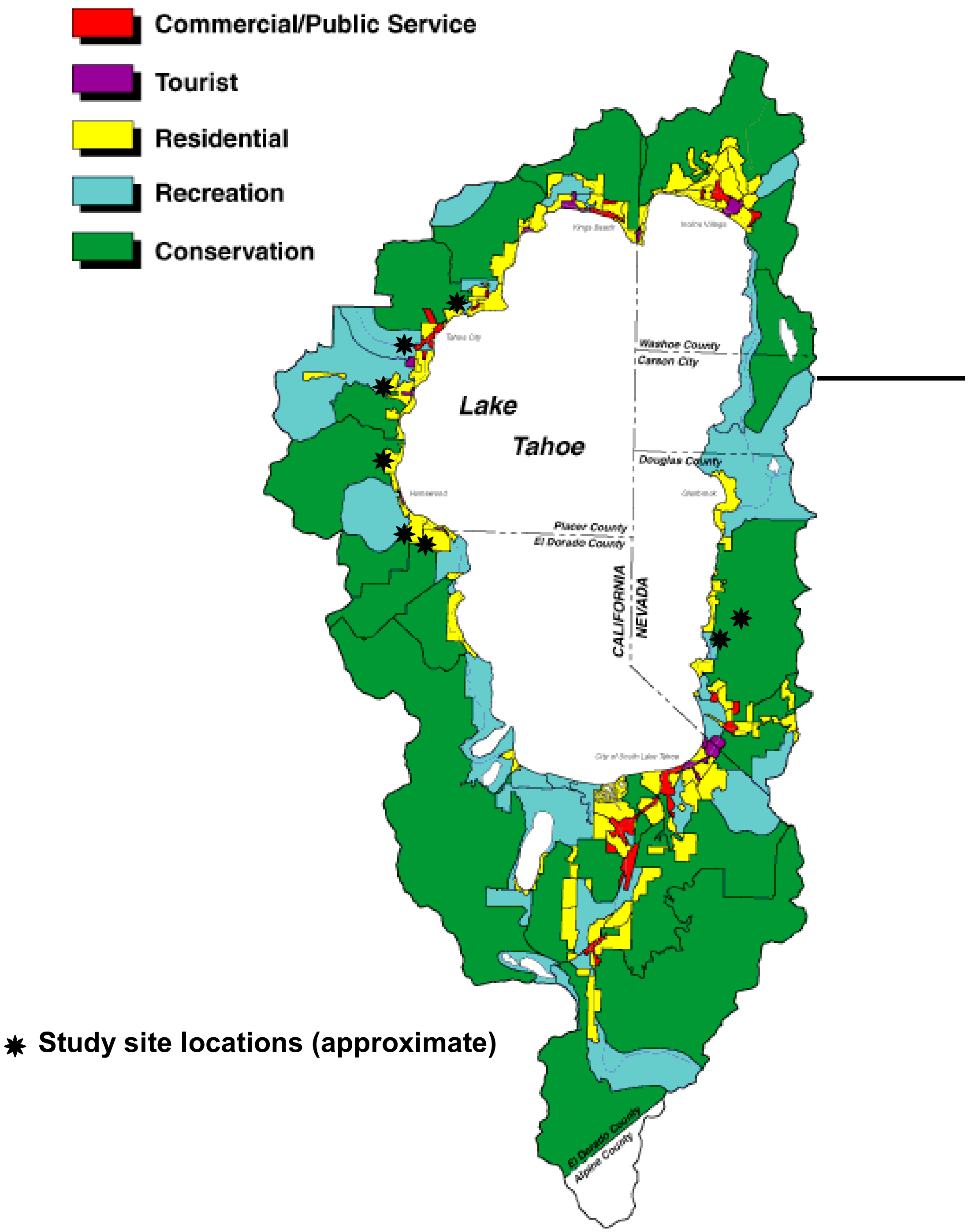

Figure 1. Study site locations.

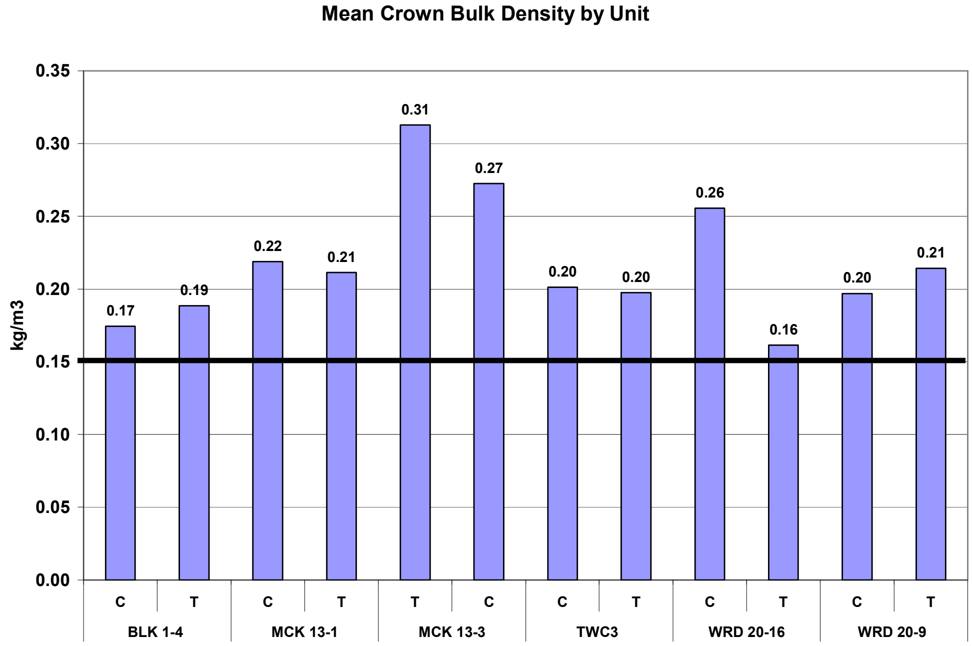

Figure 2. Mean crown bulk density (CBD) of trees >1"dbh by unit. Active crown fire potential is considered high when CBD exceeds 0.15.

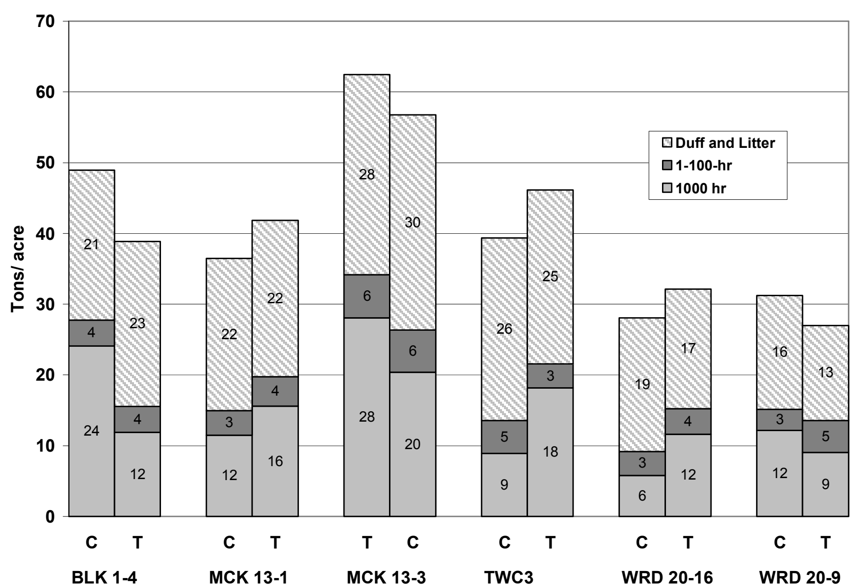

Figure 3. Mean fuel loading (tons/acre) of duff and litter, fine woody debris (1-100 hr), and coarse woody debris (1000 hr) by unit. The mean pre-treatment surface fuel loading across all units of 41 tons/acre is considered high.