Lake Tahoe Upland Fuels Research Project: Lake Tahoe State Park Sites

Final Report to Nevada Division of State Lands Grant LTLP 08-10 and 09-02

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Background

This report presents the final results of our analysis of the effects of two forest management treatments conducted in the Lake Tahoe State Park, Nevada. These data are also being analyzed as part of a larger data set of sites throughout the Lake Tahoe basin, and a final report summarizing those results will be made available to all the land management agencies the basin. The science team represents collaboration between University of Nevada, Reno (UNR), US Forest Service Pacific Southwest Research Station (PSW), and BMP Ecosciences (a research consultant). The principle investigators in this project are Dennis Murphy (UNR), Patricia Manley (PSW), and Bruce Pavlik (BMP). Matthew Timmer was instrumental in conducting the analysis and writing the final report.

Previous grants from the Southern Nevada Public Lands Management Act (Round 5) funded pre-treatment data collection in 2006 on six pairs of sites on the west shore. Documents summarizing results for 2006 were prepared (Manley 2006, Stanton and Dailey 2007). A grant from Nevada State License Plate Funds (LTLP 07-01) funded a second year of sampling in 2007 on the west-shore sites and established two pairs of sites on the east shore on Nevada State Lands. Two additional grants from Nevada State License Plate Funds (LTLP 08-10 and 09-02) completed sampling and analysis for the two pairs of east-side sites, respectively. This report presents the results of sampling the east shore sites in Nevada, associated with grants LTLP 08-10 and 09-02.

Introduction

Mechanical and prescribed fire treatments are used to reduce fuels and change forest structure and reduce the potential size and intensity of wildfires. The relative effectiveness of treatment combinations in meeting various objectives, such as reducing fire risk or meeting biological resource objectives, is still uncertain. Of particular interest are the individual and combined effects of mechanical and burning treatments. Fuel levels are at unprecedented high levels in the Lake Tahoe Basin (hereafter, "the basin") as a result of timber harvest in the late 1800s resulting in single-aged stands, and fire suppression since the early 1900s. Desired treatment objectives for forests in the basin are: 1) to reduce the risk of catastrophic fire, and 2) to restore the health and ecological integrity of forests. The restoration of the natural fire regime, if possible, is likely to be the most effective approach to achieving desired conditions for forests in the basin. However, many obstacles limit managers' ability to implement a natural fire regime. Instead, managers are exploring options for manipulating vegetation using a variety of tools to move forests toward desired conditions.

Standard fuel reduction prescriptions are designed to reduce surface and ladder fuels in order to modify fire intensity and limit the potential for crown fire spread. The prescriptions utilize hand and mechanical treatments including: chainsaw thinning, cut-to-length forwarder/processor thinning, piling, pile burning, mastication, and chipping. With hand thinning, the slash is piled and the piles are scheduled for burning within 1-3 years. Some prescriptions call for an additional understory burn after the piles are gone. Hand treatments are generally required on units with slopes greater than 30%, but hand treatments are also conducted on slopes less than 30% if there are other limitations on machine access. With mechanical treatment, machine mastication of the slash in place results in residual woody material that is irregularly shaped and generally in excess of 3 inches diameter. Chipping results in more regular pieces of residual woody material that are generally less than 3 inches diameter.

There is little doubt that fuel treatments can modify wildfire behavior, but support is lacking for the widely held belief that simply reducing tree density reduces fire hazard. Substantial evidence supports the effectiveness of prescribed fire, but there is no scientific consensus on the specifics of how treatments are implemented and the relative effectiveness of different prescriptions. Research that addresses effects on biodiversity, wildlife populations, and ecosystem function are virtually nonexistent. The notion that mechanical thinning, or a combination of mechanical thinning and prescribed fire, reduces the incidence of catastrophic fire should be regarded as a working hypothesis. Therefore, fuel treatment programs should include a robust experimental design that provides a scientific basis for the design, implementation, and evaluation of fuel treatments. As the amount of money spent on fuels treatment programs increases every year, a comparable investment should be made in scientific and applied research in order to optimize a higher return on future investments.

Fuel treatments are likely to affect wildlife populations and habitat, particularly species that have narrow habitat tolerances in association with features such as canopy cover, understory structure, herbaceous plants (e.g., seed eaters and understory foraging species), fungi, and standing and downed woody debris (Manley 2009). Fuel treatments are typically designed to achieve short-term (1-2 years) change in forest structure, and to a lesser extent a change in composition. Any substantial manipulation of vegetation will result in a myriad of short and long-term effects on the composition and structure of plants and animal communities and populations (Bigelow and Manley 2009, Manley 2009).

Existing studies in urban-wildland interface zones in the basin are finding that species responses to changes in forest conditions vary within and among taxonomic groups (Manley et al. 2006, Schlesinger et al. 2008, Sanford et al. 2009). Some species appear to be sensitive to site disturbance (e.g., presence of people and equipment), whereas others are highly sensitive to vegetation structure, and still others are well adapted to a wide variety of environmental conditions. Short-term effects on animals are difficult to predict because the response of species to the disruption will vary depending on the timing and intensity of activities and the sensitivity of each species. Longer-term changes in animal communities and populations resulting from treatments are more predictable once a successional trajectory is modeled because then habitat correlates can be used to make inferences about animal responses.

Objectives

The objective of this project was to evaluate the effects of fuels reduction treatments conducted in Lake Tahoe State Park in the North Canyon watershed. The study evaluated the effects of fuels reduction treatments conducted at two sites on vegetation composition and structure, fuel loading, wildlife species, and wildlife habitat. In particular, we focused on the response of small mammals and birds within treatment areas. This report will present a summary of results for the two Nevada sites, with more detailed analyses to be conducted on the full data set (12 additional study sites on the west shore, for which sampling will be completed in 2011).

Study Area and Sampling Design

The study was conducted on the east side of the Lake Tahoe basin on Nevada State Lands in the North Canyon watershed (Figure 1). The east shore montane zone consists of canopy dominants Jeffrey pine (*Pinus jeffreyi*), red fir (*Abies magnifica var. magnifica*), and white fir (*Abies concolor*). Understory vegetation is varied, ranging from grass to shrub dominated with various amounts of herbaceous cover. Site elevations were all near 7500 ft and slopes ranged from 14 to over 40% (Table 1). We chose control sites that were close in proximity to the treatment sites and thereby similar in elevation, forest type and structure.

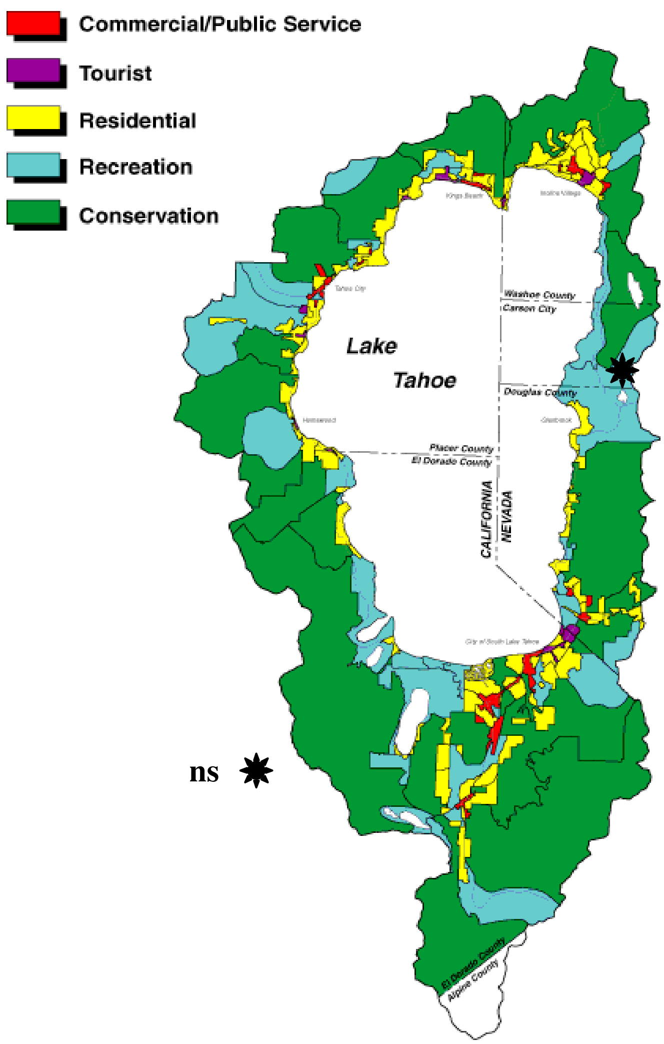

Figure 1. The study area and sample site locations in the Lake Tahoe Basin.

Table 1. Location and characteristics of the RED and WLD treatment (T) and control (C) sample units.

Unit	Forest type	HUC7 watershed	Slope (%)	Elevation (ft)	Aspect
RED C	Fir/Jeffrey pine	North Canyon	42	7,644	W
RED T	Fir/Jeffrey pine	North Canyon	35	7,759	W
WLD C	Jeffrey pine/fir	North Canyon	14	7,585	W
WLD T	Jeffrey pine/fir	North Canyon	21	7,635	S

The Nevada Division of Forestry utilized project-specific prescriptions that utilized a combination of treatments. In the North Canyon RED unit, the diameter limit of hand thinning was 14 inch DBH because the steep slopes make it inaccessible for machinery. The prescription in North Canyon WLD unit specified a combination of hand thinning and machine removal of trees up to 24 inch DBH, although select trees up to 30 inch DBH may be removed on an individual basis (Table 2). The fuels reduction treatments were enacted in 2007 in the RED T unit and in 2008 in the WLD T unit.

Methods

Field Data Collection

An integrated sampling design was used to collect data on vegetation structure and fuel loads, small mammals and birds. 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 small mammal trapping stations, 4 bird survey points, and 7-8 randomly selected vegetation plots (Figure 2). We sampled vegetation one year each pre-treatment and post-treatment and wildlife one year pre-treatment and two years post-treatment to examine the impact of the thinning treatments on wildlife at these sites (Table 2).

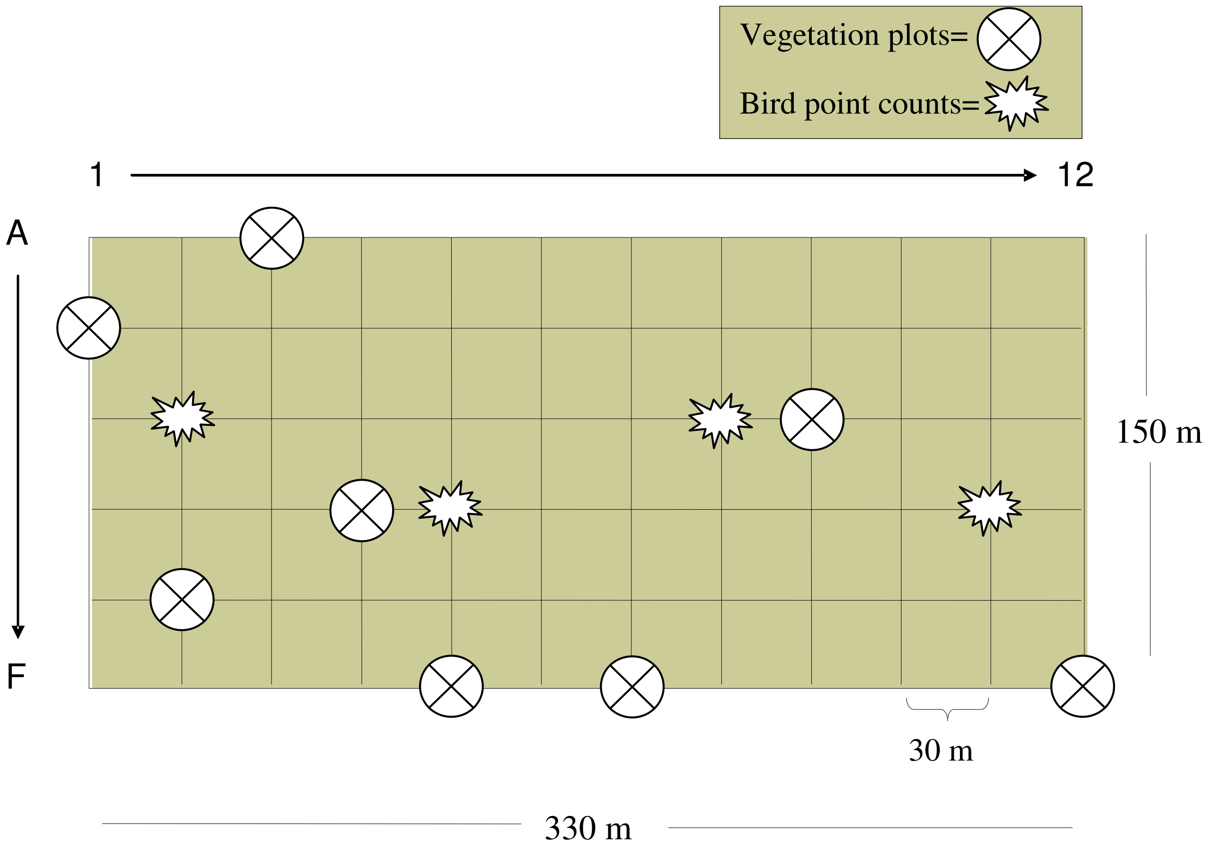

Figure 2. Sampling macroplot in the WLD control unit. Each macroplot occupied 5 ha and consisted of 72 small mammal trapping points (every intersection on the grid), 4 bird survey points, and 7-8 vegetation plots (location of vegetation plots varied by unit).

Table 2. Treatment prescriptions and wildlife sampling schedule for the two paired study sites in the Lake Tahoe Basin. Fuels reduction treatments were conducted in 2007 (RED T) and in 2008 (WLD T).

Unit	Type	Treatment Rx	Harvest Unit	Pre-treatment	Post-treatment year 1	Post-treatment year 2
RED C	Control	none	North Canyon 2	2007	2008	2009
RED T	Treatment	Hand treatment < 14"	North Canyon 2	2007	2008	2009
WLD C	Control	none	North Canyon 1	2007	2009	2010
WLD T	Treatment	Mechanical treatment <30"	North Canyon 1	2007	2009	2010

Vegetation and Fuels

Vegetation sampling focused on forest structure, understory composition, and fuel loads. Vegetation plot lay-out and sampling protocols were developed in collaboration with the USFS Adaptive Management Services Enterprise Team (AMSET, located on the Tahoe National Forest) and the LTBMU and were based primarily on FIREMON, the Fire Effects Monitoring and Inventory System (Lutes et al. 2006). FIREMON is an Access database software tool that is specifically designed to facilitate analysis of changes in plant communities and fuel loadings in response to management activities over time. The resulting sampling protocols have been used by AMSET to monitor other fuels treatment sites elsewhere in the basin. Thus, the protocols used in this project are accepted by management agencies in the basin and will become the primary system to be used for fuels treatment monitoring and associated data management across multiple agencies in the basin (see www.fire.org).

In each unit, we measured vegetation at 7-8 randomly selected plots in 2007 before any fuels reduction treatments were implemented and again in 2009 after treatments were enacted. Plots were fixed-radius circular areas with a 17.84 m (58-ft) radius encompassing 0.1 ha (0.25 ac.). Every tree and snag ≥ 6 inch (15 cm) DBH was tagged with a unique number and the following information recorded: species, DBH, total height, decay class (snags), and live crown ratio. Seedlings and saplings (trees < 6 inch DBH) were recorded in a smaller sub-plot of 0.01 ha (0.025 ac.). Canopy cover was measured using a GRS site-tube densitometer. Surface and ground fuels were sampled on four, 20-m transects in each inventory plot using the line-intercept method (Brown 1974). Herb and shrub percent cover, height, and nested frequency were measured in five 0.25-m^2 quadrats along each transect. Detailed data collection parameters for vegetation and fuels can be found in Appendix A.

Wildlife

Birds and small mammals were the primary focus of vertebrate sampling because 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 (*Strix occidentalis occidentalis*), Northern Goshawk (*Accipiter gentilis*), and American marten (*Martes americana*). Small mammals are closely tied to local conditions as they are highly dependent upon overstory and understory vegetation and they are primarily 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.

Bird point count stations were located near the center of the sample plot (Figure 2). In addition, observers recorded incidental birds as they walked between stations in a zig-zag manner. We conducted three point counts at each sample plot from late May to early July. We used a 10 minute survey period and recorded the distance to all birds using 20-m increments. Paired sites were sampled within two days of one another, and multiple observers were rotated among visits across sites. Surveys began at least 15 min after sunrise and were completed before 0930 hours. We avoided conducting surveys during windy or rainy conditions. Variation between years can also be a function of observer bias and the timing of surveys. For bird point counts, we attempted to minimize this bias by using the same sample periods and limiting variation in observers (two observers in each year, one consistent between years).

We trapped small mammals to determine species presence and abundance. We sampled small mammals by placing one Tomahawk live trap (12.5 x 12.5 x 40 cm) and one extra large Sherman live trap (10 x 11.5 x 38 cm) at each of 72 trap stations (6 x 12 stations, 30 m apart = 150 x 330 m grid = 5 ha area) (Figure 2). We attached Tomahawk traps to the trunk of trees > 20 inch (50 cm) DBH 1.5-2.0 m above ground that were not marked for removal. We selected trees that were as close to the trap station as possible, ideally within 5 m. We covered the traps with a tarp around the outside and placed a nest box (10 x 10 x 6 cm cardboard) at the back of the trap with some polystyrene for warmth. We placed Sherman traps at the base of trees or along larger logs or under shrubs. Traps were securely placed such that they did not rock or move when an animal enters. We covered each Sherman trap with natural materials (or chloroplast if none are available) to insulate traps from the sun and rain, and placed polystyrene in the back of the trap for warmth.

We used a bait mixture of oats, bird seed and raisins. We attempted to include peanut butter and molasses, following the general formula used by Carey et al. (1991), but bear damage was so great that we were forced to eliminate these ingredients from the bait. A small amount of bait was placed at the entrance of the trap and a larger amount at the back of the trap. Traps were set, baited, and locked open for a minimum of three nights before trapping began, then opened for five nights, starting with traps being set in the late afternoon/early evening prior to the first trap evening (just before dusk). We checked traps twice per day, with afternoon checks occurring in the late afternoon/early evening. All traps were removed the morning after the fourth night.

We identified all individuals captured to species and marked each animal using uniquely numbered ear tags and recorded data on sex, age (juvenile or adult), weight, and reproductive status (males: testes enlarged; females: vagina perforate, nipples swollen, enlarged, reddened, lactating, pregnant). Ear, leg, or tail measurements were taken on individuals whose identification was in question.

Data Analysis

Vegetation and Fuels

We characterized forest conditions before and after treatment by generating values for the following variables: quadratic mean tree diameter (hereafter QMD), percent canopy closure, tree density, tree basal area, snag density, shrub height, and the amount of logs or coarse woody debris (hereafter CWD). We calculated tree density by species and diameter class to assess species composition and vegetation structure. The composition and cover of herbaceous and shrub species were also characterized and included in estimates of fuels. Understory vegetation is a critical component of wildlife habitat and it can strongly influence fire behavior. Herb and shrub species richness were calculated as the mean number of species present in each plot across a unit.

Measured surface fuel loads were calculated in tons per acre for three different components: litter and duff, fine woody debris (1, 10, and 100 hr fuels), and CWD (1000 hr fuels). Biomass is calculated based on equations in the Handbook for Inventorying Downed Woody Material (Brown 1974). Non-slash, composite values are used to calculate QMD, non-horizontal correction, and specific gravity of fine woody debris. Decay classes 1-3 are sound with a specific gravity of 0.40. Decay classes 4-5 are rotten and assigned a specific gravity of 0.30. Loading of litter and duff is calculated using bulk densities of 2.75 lbs/ft^3 and 5.5 lbs/ft^3, respectively.

Wildlife

We described species abundance, richness, and composition for all small mammal and bird species detected. For small mammal trapping, trap effort was corrected for traps rendered unavailable for some (0.5) or all (1.0) of a trap day as a result of disturbed, sprung, destroyed, or missing traps. Small mammal abundance was calculated using the number of unique individuals tagged per 100 trap days. We calculated species richness by tallying all the unique species captured on at a site over the course of the trapping period. We calculated relative species abundance for each site by dividing the number of captures of a given species by the total number of captures of all species.

Bird species richness and abundance metrics were calculated for each site. Bird species richness was based on all species encountered over the course of all three visits to a site during a year. We calculated bird abundance as the mean number of individuals detected across all four count stations and three visits (12 counts total) for each site and year. Relative species abundance was calculated for each site by dividing the number of detections of a given species by the total number of detections of all species.

Results

Vegetation and Fuels

Forest Structure and Composition

The forest at the four study sites consisted mainly of Jeffrey pine and red and white fir. In terms of density (stems/acre), white fir was most dominant in the RED C control unit while red fir was dominant in the RED T treatment unit. Jeffrey pine was dominant in both WLD units (Figure 3). Based on the change in composition at treated sites, it appeared that most of the trees removed at the treatment sites were firs, but the density of Jeffrey pines also appeared to be slightly lower after the treatments, indicating that they were either cut, died from disease, or that windfall had occurred.

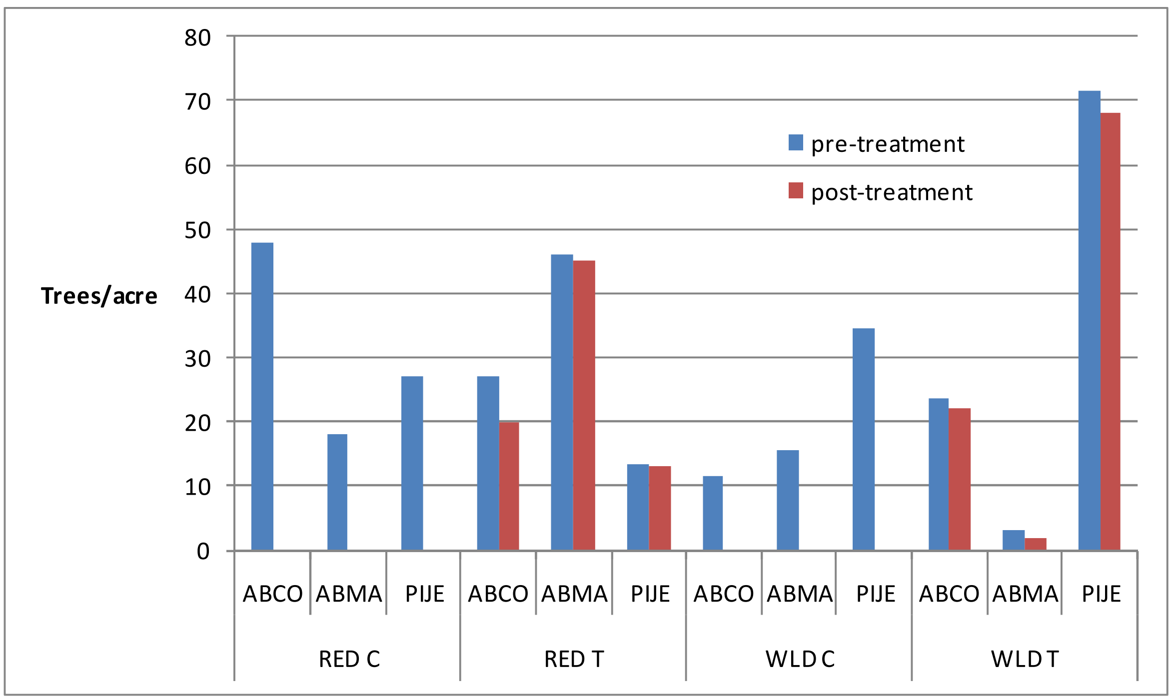

Figure 3. Pre and post-treatment mean tree density for each of three conifer species: ABCO (white fir), ABMA (red fir), and PIJE (Jeffrey pine) at the RED and WLD paired study units on the east shore of Lake Tahoe.

In RED T, the hand thinning was limited to trees up to 14 inch, so almost all trees that were removed were pole size (6-12 inch). Consequently, the size class distribution of residual trees shifted from being dominated by pole size trees to a more even mix of pole and small (12-24 inch) trees (Figure 4). In WLD T, the mechanical thinning operation was capable of removing trees up to 24 inch, so there was a greater decline in small tree (12-24 inch) density than of pole trees. At both sites, the small fluctuations in medium (24-36 inch) sized trees was likely the result of observer variability (slight measurement differences that result in a change of diameter classes) or natural mortality. Only one large (>36 inch) tree was recorded at the four sites (in WLD T).

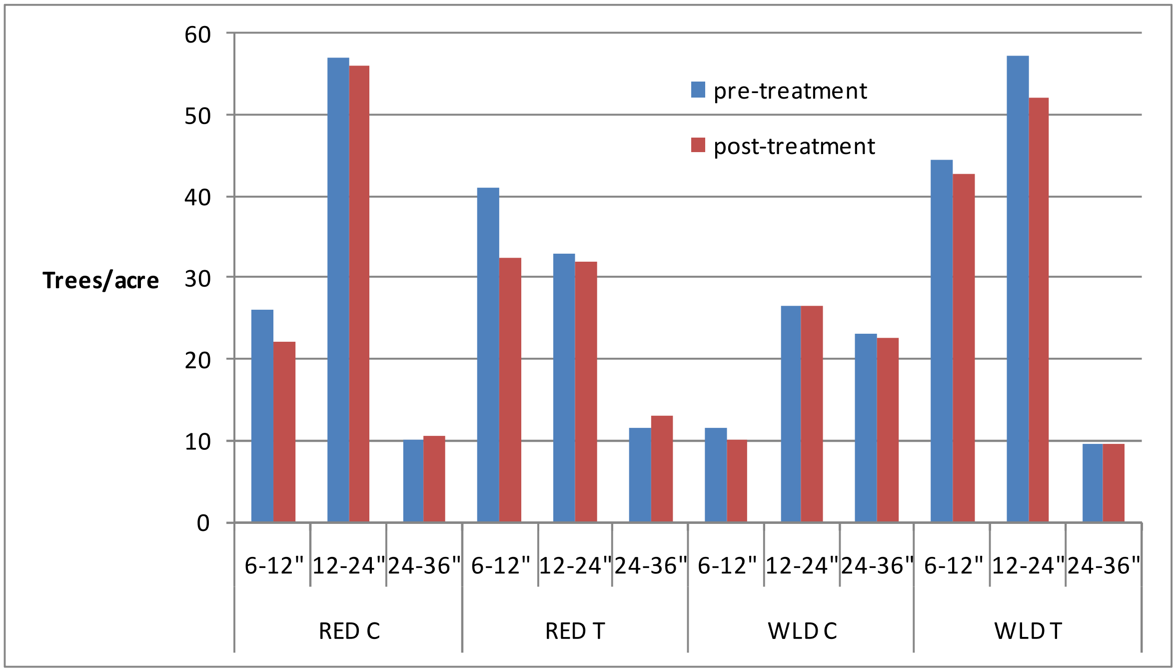

Figure 4. Pre- and post-treatment mean tree density of three diameter classes at the RED and WLD paired study units on the east shore of Lake Tahoe.

Snags provide valuable wildlife habitat; however, their high pre-treatment density may have reflected decadent stand conditions resulting from high insect and pathogen mortality, drought, or lack of fire. The treatments at RED T and WLD T reduced total snag density by 23% and 17%, respectively, with the greatest reduction occurring in the smallest diameter class (Figure 5). However, most of the larger diameter (>24 inch) snags, which provide the highest quality habitat for wildlife (Marcot et al. 2002), were retained.

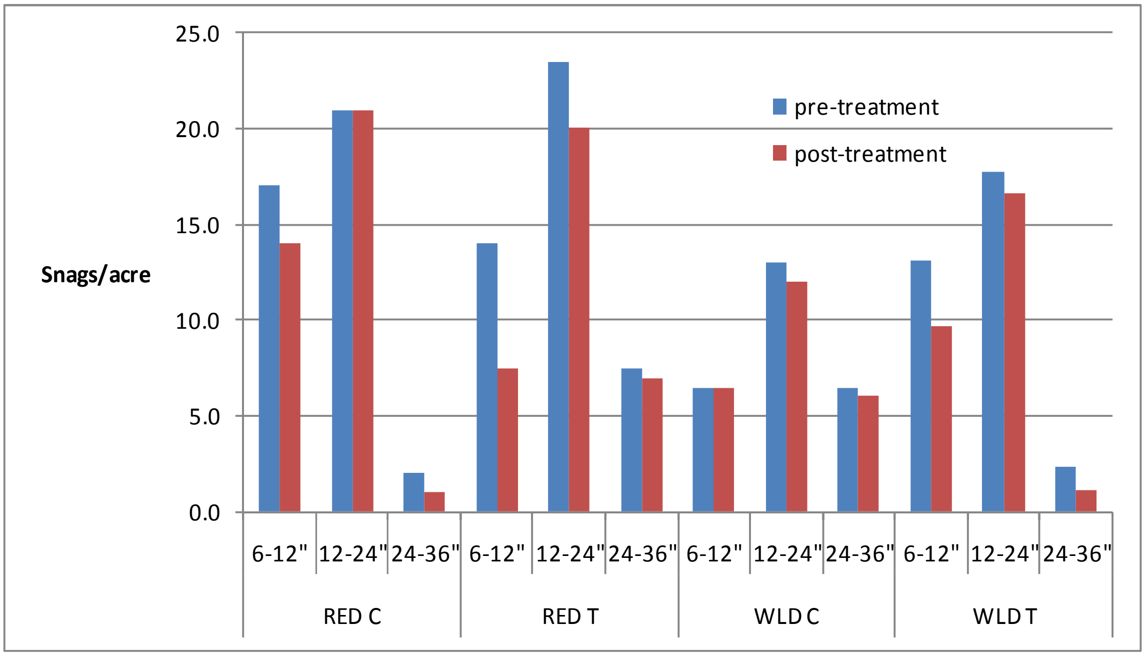

Figure 5. Pre- and post-treatment mean density of three diameter classes of snags in the RED and WLD units on the east shore of Lake Tahoe.

Other measures of forest structure showed little change as a result of the treatments (Table 4). Total basal area (all stems; live and dead) declined slightly in all plots: RED C, RED T, and WLD C were each reduced ~5 ft^2/acre. WLD T showed the largest reduction in total basal area (13.1 ft^2/acre). Live tree basal area stayed the same or increased slightly in the RED units and declined marginally in the WLD units. The QMD of trees stayed the same in the WLD T unit and increased from 11.8 in to 12.6 in the RED T unit as a result of the treatments. Percent live crown did not change outside the margin of error. As expected, canopy cover was reduced in the RED and WLD treatment units by 7.5% and 12%, respectively.

Table 4. Forest structure at two paired treatment and control sites on the east shore of Lake Tahoe before and after fuels reduction treatments were implemented.

Unit	Year	Stem Density (trees>6"/ac)	Total Basal Area (ft^2/ac)	Live Basal Area (ft^2/ac)	Live Tree QMD (in)	Mean Canopy Cover (%, SE)	Mean Live Crown (%, SE)
RED C	2007	187	204.4	154.9	12.3	43.0 ±2.23	51.6 ±7.00
	2009	178	199.5	155.2	12.6	47.5 ±2.32	58.8 ±7.34
RED T	2007	173	213.2	130.6	11.8	50.0 ±3.78	47.2 ±6.58
	2009	156	208.0	134.5	12.6	42.5 ±4.59	46.9 ±7.56
WLD C	2007	123	213.5	156.5	15.3	41.5 ±5.50	44.1 ±6.92
	2009	119	208.1	154.7	15.4	38.0 ±5.35	46.6 ±7.34
WLD T	2007	196	215.0	167.3	12.5	49.0 ±4.64	43.9 ±6.94
	2009	184	201.9	159.4	12.6	37.0 ±4.52	49.5 ±6.90

Understory

We detected a total of 52 plant species in the understory, including 32 forb/herbs, 7 grasses, 2 sub-shrub, and 11 shrubs (Appendix B). The most common shrubs were bush chinquapin (*Chrysolepis sempervirens*) and tobacco bush or snowbrush (*Ceanothus velutinus*). Pinemat manzanita (*Arctostaphylos nevadensis*) was a common subshrub in the sampling units. Slender penstemon (*Penstemon gracilentus*), Brewer's aster (*Aster breweri*), mountain monardella (*Monardella odoratissima*), and spreading groundsmoke (*Gayophytum diffusum*) were the most common forb/herbs. Interestingly, spreading groundsmoke was the only understory plant that occurred in all four of the units. Squirreltail (*Elymus elymoides*) and needlegrass (*Achnatherum sp.*) were the most frequently detected grasses.

Both the mechanical and hand thinning treatments reduced canopy cover and overstory tree density. The resulting increase in light reaching the forest floor would be expected to eventually lead to an increase in early seral species in the understory. The RED and WLD treatment units both increased in species richness following the treatment (Figure 6). RED C had a substantial decline in species richness: 19 species in 2007 down to 12 species in 2009. Overall, WLD C had much lower species richness than the other three units.

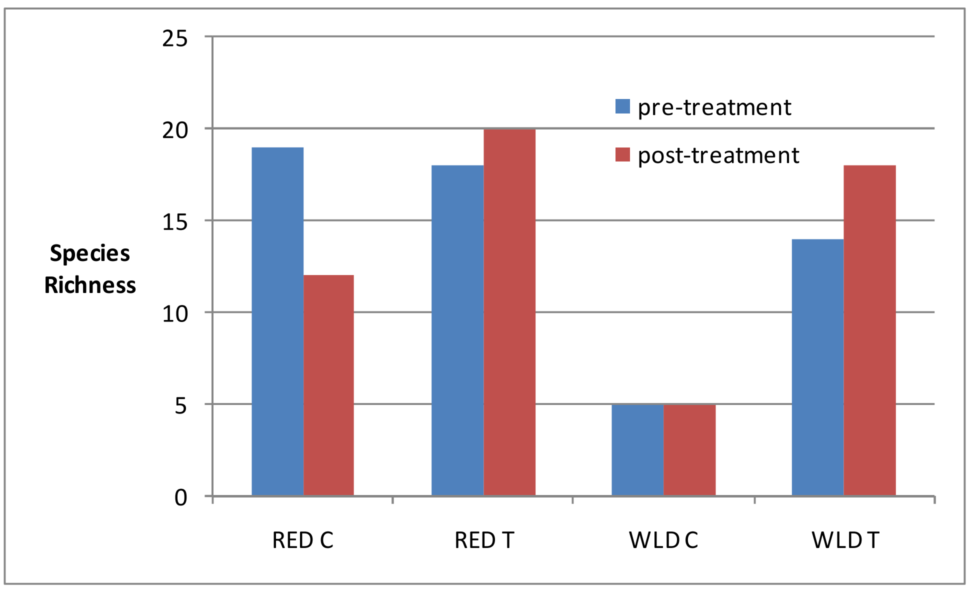

Figure 6. Pre- and post-treatment understory plant species richness at the RED and WLD paired units on the east shore of Lake Tahoe.

Species richness (per plot) ranged from 2.5 to 6.7 with little change between years (Table 5). Shrub height remained consistent between years, even in the units that were treated. Plant cover changed very little outside the margin of error for the control units, but cover was reduced by nearly half in the RED T (10.4% to 5.8%) and over half in the WLD T (5.9% to 2.6%) units. While the WLD C unit had very low species richness, the plant cover was nearly twice as much as its paired unit WLD T. The units in WLD did not appear to be well matched in the characteristics of the understory. The control unit lacked any measurable herb or grass component, while the treatment unit was dominated by herbs and grasses.

Table 5. Understory vegetation structure at two paired treatment and control sites on the east shore of Lake Tahoe before and after fuels reduction treatments were implemented. Mean values are reported with ±SE.

Unit	Year	# plots	Logs/acre (>3" small end)	Mean Shrub Height (m)	Mean Species Richness	Mean Plant Cover (%)
RED C	2007	8	8.0	0.47 ±0.045	5.6 ±1.15	9.7 ±1.80
	2009	8	9.0	0.44 ±0.053	4.1 ±0.72	11.3 ±2.16
RED T	2007	8	22.0	0.42 ±0.049	6.7 ±0.91	10.4 ±2.00
	2009	8	17.5	0.38 ±0.024	5.5 ±1.28	5.8 ±1.36
WLD C	2007	8	9.5	0.28 ±0.023	2.5 ±0.54	11.3 ±1.89
	2009	8	15.0	0.31 ±0.040	3.8 ±0.27	9.2 ±1.75
WLD T	2007	7	29.7	0.25 ±0.023	5.0 ±1.20	5.9 ±2.15
	2009	7	21.7	0.24 ±0.016	5.0 ±1.15	2.6 ±0.69

Downed logs contribute structural diversity to the forest floor and provide habitat and forage for wildlife. The density of down logs declined greatly in the treatment units, with a reduction of 4.5 logs/acre in RED T and 8.0 logs/acre in WLD T (Table 5). This loss of logs translated into an overall decline in the volume of CWD in the treatment units (Figure 7). The control units showed little change in log volume.

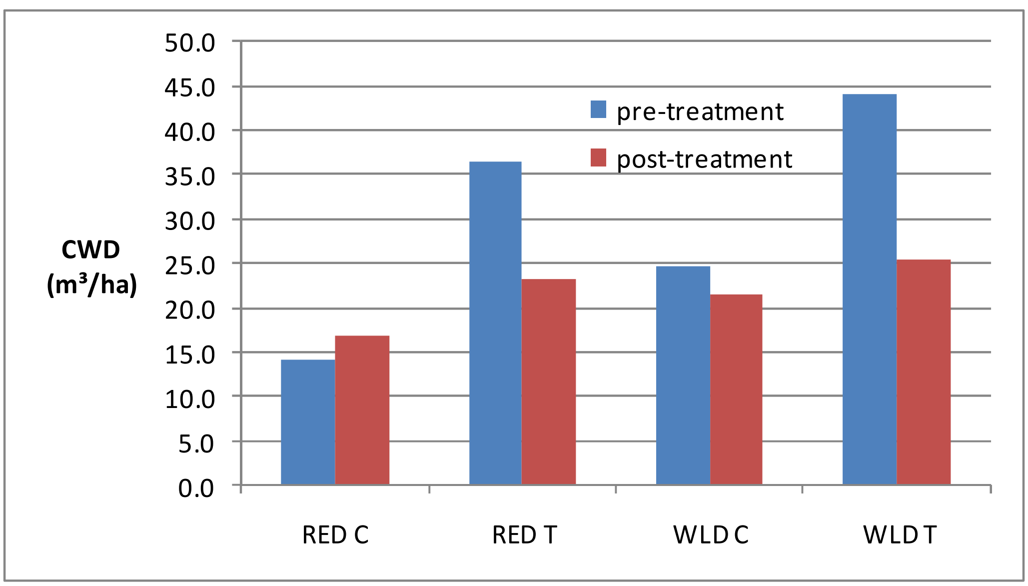

Figure 7. Volume of course woody debris (CWD) at the RED and WLD paired treatment and control units on the east shore of Lake Tahoe before and after fuels reduction treatments.

Fuel Loading

Measured surface fuel loads were quantified as three different components: litter and duff, fine woody debris (1-100 hr fuels), and CWD (1000 hr fuels). Total fuel loads changed very little in the RED T unit, where the prescription was for hand thinning trees up to 14 in. diameter (Figure 8). Interestingly, an increase in duff and litter and fine fuels (1-100hr) was accompanied by a decline in CWD (1000hr fuels), resulting in no net difference. In contrast, in the WLD T unit, where the prescription allowed removal of trees up to 24 in. diameter, the fuel load was reduced 39% from 146 to 90 tons/ha. Most of the reduction came from declines in CWD and duff.

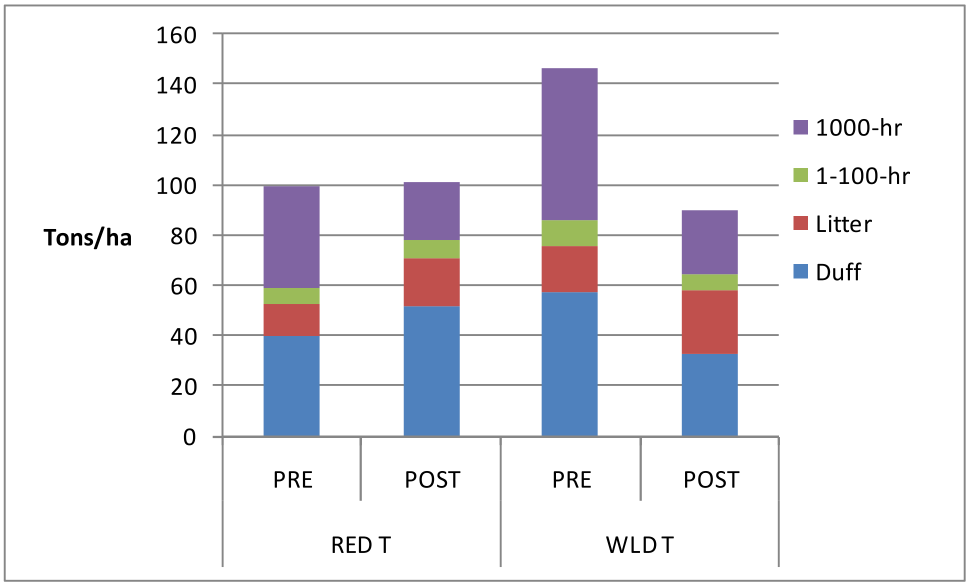

Figure 8. Fuel loadings of litter, duff, fine woody debris (1-100 hr fuels), and coarse woody debris (1000 hr fuels) in the RED and WLD treatment units pre and post fuels reduction treatments.

Small Mammals

A total of 14 species of small mammals were captured across the 4 sample sites (Table 6). The most common species were Lodgepole chipmunk (*Neotamias speciosus*), Yellow-pine chipmunk (*Tamias amoenus*), and Golden-mantled ground squirrel (*Spermophilus lateralis*). The eight most frequently captured species were found at all four sites. Douglas squirrel was only captured at 3 sites, but detected during avian point counts at all 4 sites.

Table 6. Small mammal species detected during live trap sampling at 4 sites on the east side of the Lake Tahoe basin 2007-2010.

Scientific Name	Common Name	Code	# Individuals Marked	Site Frequency (n=4)
Neotamias speciosus	Lodgepole chipmunk	TASP	1155	4
Tamias amoenus	Yellow-pine chipmunk	TAAM	740	4
Spermophilus lateralis	Golden-mantled ground squirrel	SPLA	696	4
Neotamias quadrimaculatus	Long-eared chipmunk	TAQU	574	4
Peromyscus maniculatus	Deer mouse	PEMA	246	4
Neotamias senex	Shadow chipmunk	TASE	104	4
Glaucomys sabrinus	Northern flying squirrel	GLSA	44	4
Tamias minimus	Least chipmunk	TAMI	32	4
Neotamias sp.	chipmunk species	TAXX	7	2
Tamiasciurus douglasii	Douglas squirrel	TADO	7	3
Peromyscus sp.	mouse species	PEXX	5	2
Peromyscus truei	Pinon mouse	PETR	4	2
Sorex sp.	shrew species	SOXX	4	3
Spermophilus beecheyi	California ground squirrel	SPBE	4	1
Microtus longicaudus	Long-tailed vole	MILO	1	1
Neotama cinerea	Bushy-tailed woodrat	NECI	1	1

Species richness ranged from 6 to 9 species across sites and years (Table 7). Overall species richness was the same or higher than pre-treatment numbers at all four sites after the second year of post-treatment sampling. Trap effort was noticeably lower in 2008 in both RED units as result of disturbance by bears, possibly explaining the large dip in richness in the first year following treatments. Mean abundance (all species) ranged widely from 2.10 to 7.21 animals per 100 trap nights (Table 7). Between-year changes in abundance also varied widely from -4.32 (-67%) to +4.22 (201%) per 100 trap nights. One treated site (WLD T) showing little fluctuation from pre-treatment levels in the first post-treatment year (+0.71) and second post-treatment year (-0.16), while the other treated site (RED T) showed an initial decline in abundance in the first treatment year (-0.87) before recovering to a net gain in the second year post-treatment (+2.03). It should be noted that mean abundance also declined markedly in 2008 in the RED control unit, indicating that the reduced abundance in RED T was likely a year effect and not a result of the treatment.

Table 7. Small mammal trapping effort, species richness and mean overall abundance at 4 sites on the east side of the Lake Tahoe basin, 2007-2010. Mean values are reported ±SE.

	Trap Effort (trap nights)				**Species Richness**			**Mean Abundance** (100 trap nights)		
	Pre-Treatment	**Post-treatment**								
	2007	2008	2009	2010	Pre	Post 1	Post 2	Pre	Post 1	Post 2
Treated Units:										
RED T	639.6	497.9	650.8		9	6	9	4.48±1.18	3.62±0.69	6.51±1.19
WLD T	649.1		662.0	646.5	8	8	9	6.50±1.14	7.21±0.86	6.34±1.02
Untreated Units:										
RED C	648.8	516.8	642.3		9	6	9	6.42±1.17	2.10±0.37	6.31±0.80
WLD C	656.7		658.2	651.5	7	9	9	5.83±1.21	6.31±0.78	6.58±1.23

Looking at the response of individual species responses to the treatments revealed few patterns (Figure 9). Deer mice appeared to respond favorably to the treatments in the RED T unit, but a closer look reveals that 2009 was one of extraordinary abundance for this species across all four sites. Long-eared chipmunks also increased in relative abundance at WLD T after the treatments; however, this species also increased significantly in both control units during the same time frame. The only other notable shifts in small mammal community structure were declines in relative abundance of Lodgepole chipmunks in the RED C unit and Golden-mantled ground squirrels in the WLD C unit.

Grouping like species (squirrels, mice, ground squirrels, and chipmunks) also did not reveal any variation that can be attributed to the fuels reduction treatments. Ground squirrels increased in abundance across time in both the RED units and decreased across time in the WLD units (Figure 10). Mice and chipmunk abundance also tracked similarly between the paired treatment and control units.

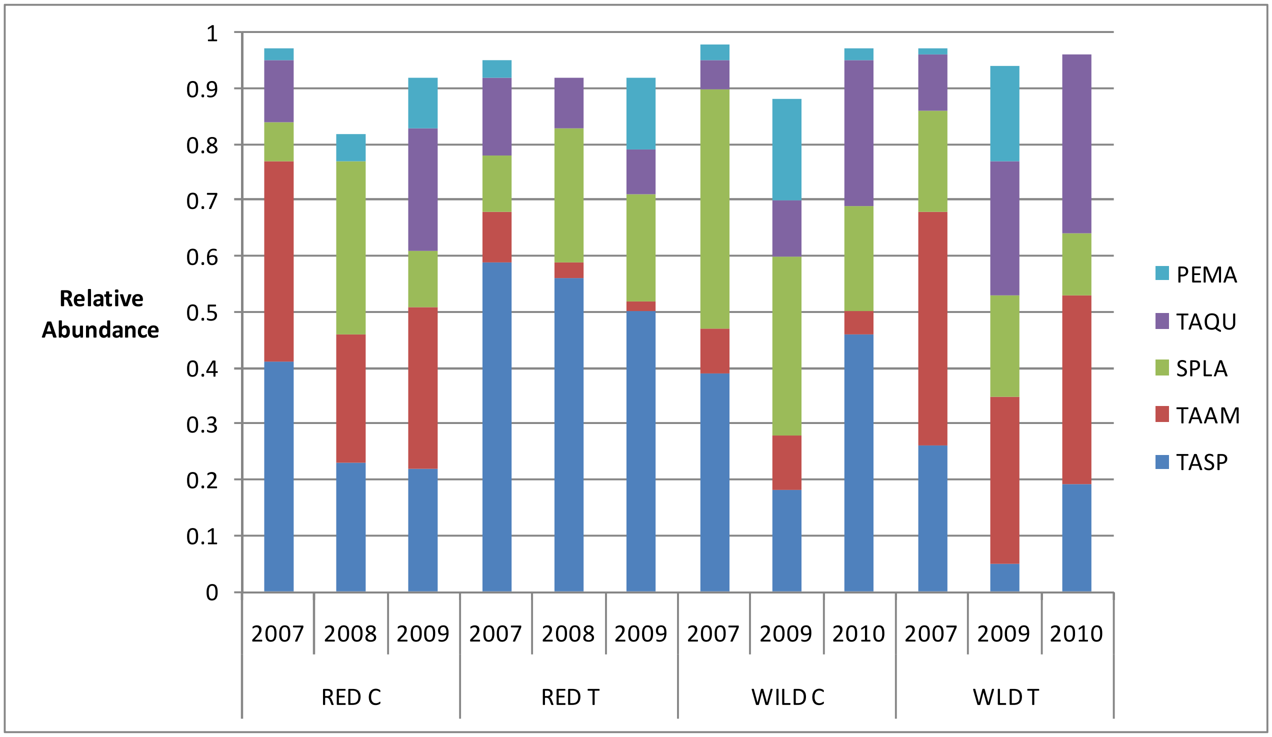

Figure 9. Annual relative species abundance for the five most abundant small mammal species trapped at four sites on the east side of the Lake Tahoe basin before (2007) and after (2008-2010) fuels reduction treatments. PEMA=Deer mouse; TAQU= Long-eared chipmunk; SPLA=Golden-mantled ground squirrel; TAAM=Yellow-pine chipmunk; TASP=Lodgepole chipmunk.

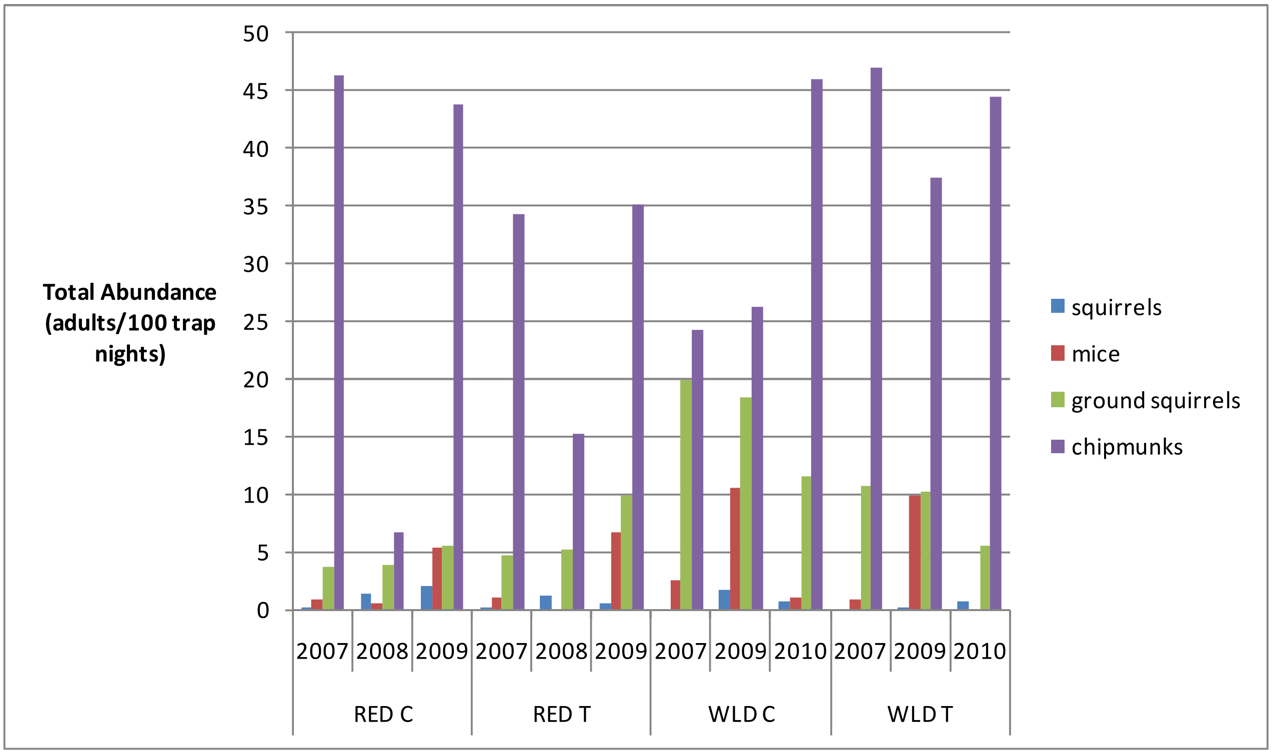

Figure 10. Total abundance of small mammals by group at two paired treatment and control sites on the east shore of Lake Tahoe before (2007) and after (2008-2010) fuels reduction treatments.

Birds

We conducted point counts from late May to early July 2007-2010 and observed 50 bird species within 100 m of count stations (Appendix C). Mountain Chickadee (*Poecile gambeli*), Red-breasted Nuthatch (*Sitta canadensis*), Yellow-rumped Warbler (*Dendroica coronata*), Dark-eyed Junco (*Junco hyemalis*), and Dusky Flycatcher (*Empidonax oberholseri*) were the most frequently detected species at the four sites. These five species represent and use various structural components of the forest. For instance, the Mountain Chickadee and Red-breasted Nuthatch both nest in cavities and rely on the presence of snags, Yellow-rumped Warblers nest in the foliage of the canopy, Dark-eyed Juncos nest on the ground, and Dusky Flycatchers nest in shrubs.

The mean abundance of individuals detected per point count survey varied by unit and year (Figure 11). The greatest decline in abundance was recorded in the RED T unit (-4.9 birds/visit, -29%) between the first (2007) and last (2009) year of surveys. Since abundance fluctuated little in that time span in the RED control, it is conceivable that the variation can be attributed to the treatments. Although there was a small spike in mean bird abundance at the WLD sites in the first post-treatment sample year (2009), there was little net change between first and last sample years.

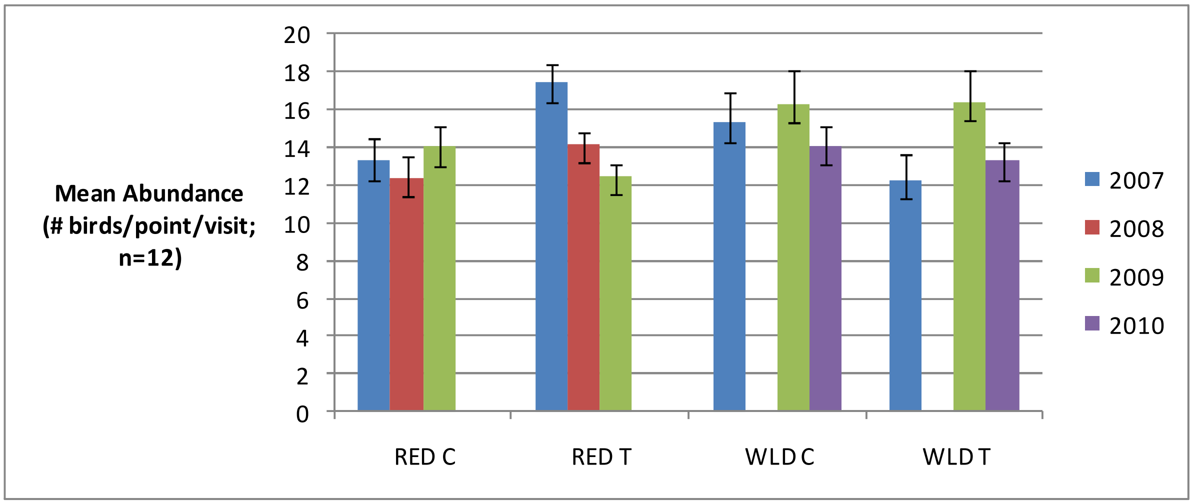

Figure 11. Mean abundance of birds detected using point counts at two paired treatment and control sites on the east shore of Lake Tahoe before (2007) and after (2008-2010) fuels reduction treatments.

Bird species richness declined the first year following the implementation of the treatments in the RED T unit from 32 to 25 species (Figure 12). The RED C unit was more consistent, only fluctuating by two species from year to year. Both WLD units saw similar inter-annual variation: an initial surge in species richness in the first post-treatment year (2009) before relaxing to a level slightly higher level than during the pre-treatment year (2007).

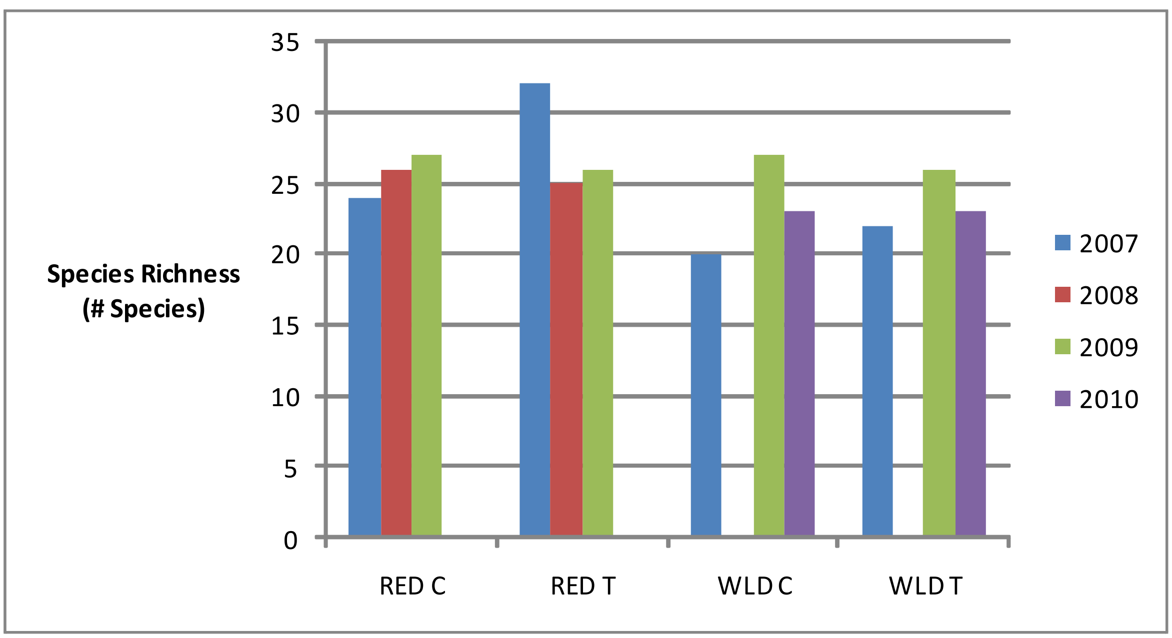

Figure 12. Total species richness of birds detected using point counts at two paired treatment and control sites on the east shore of Lake Tahoe before (2007) and after (2008-2010) fuels reduction treatments.

Calculating relative species abundance takes into account seasonal fluctuations in overall abundance and can show shifts in community composition. While there were shifts in species relative abundance, no patterns arose that would indicate that the changes were a response to the treatments. Mountain Chickadees increased (0.06 to 0.17) in the years after the treatments in the RED T unit while it stayed constant in the control unit (Figure 13). Red-breasted Nuthatches increased in relative abundance in the RED C from 0.04 to 0.11. On the other hand, Yellow-rumped Warblers relative abundance was halved from 0.14 to 0.07 in the WLD T unit between 2007 and 2010. The relative abundance of Dark-eyed Juncos declined at all four sites across the sample years.

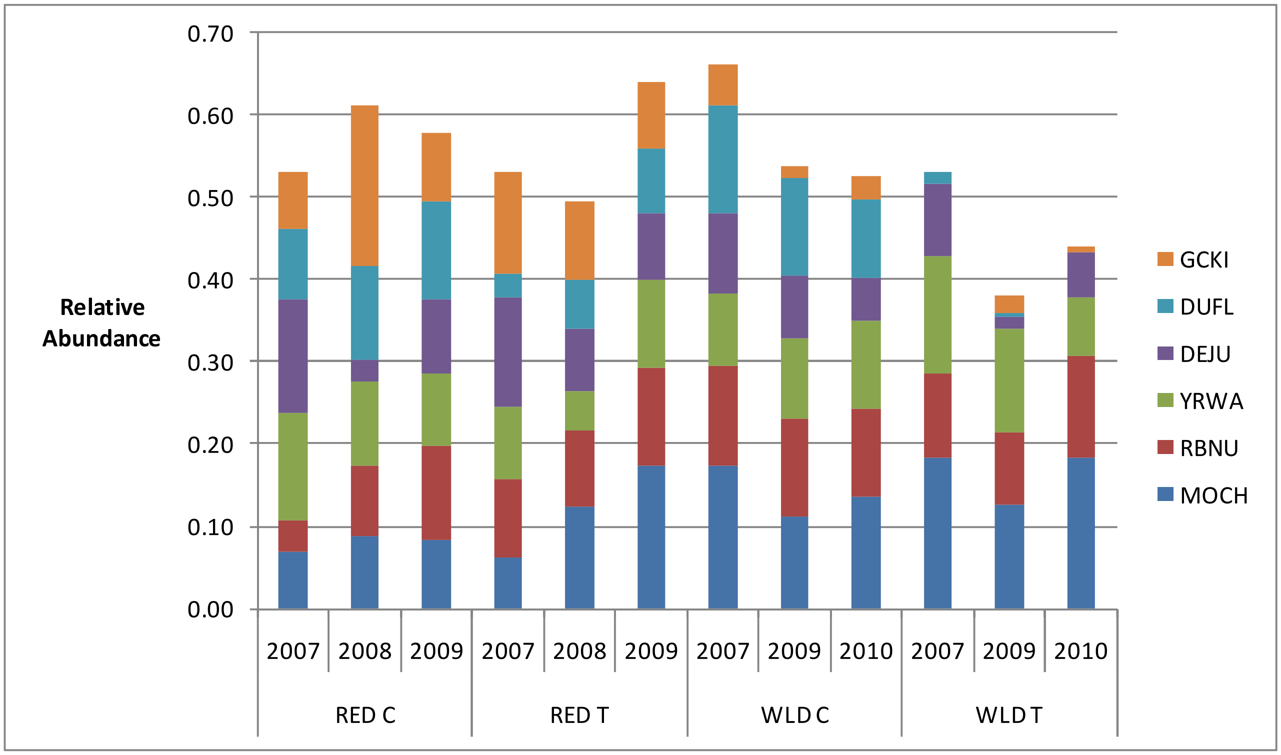

Figure 13. Annual relative species abundance for the six most abundant bird species detected at four sites on the east side of the Lake Tahoe basin before (2007) and after (2008-2010) fuels reduction treatments. GCKI=Golden-crowned Kinglet; DUFL=Dusky Flycatcher; DEJU=Dark-eyed Junco; YRWA=Yellow-rumped Warbler; RBNU=Red-breasted Nuthatch; MOCH=Mountain Chickadee.

Discussion

Overall, we observed moderate change in live vegetation as a result of the treatments. The largest changes to live vegetation were reductions of both canopy cover and understory plant cover. While understory plant cover was initially reduced, we expect that it will increase in the future with more sunlight reaching the forest floor. We found that the fuels reduction treatments had a greater impact on the non-living components of the vegetation. For example, snag and log density and volume declined greatly in the treatment units. As expected, the mechanical thin of trees <30 inch in the WLD unit was more effective in reducing the fuel load than the hand-thin <14 inch in the RED unit. Consequently, the fuel load was reduced in the WLD treatment unit by 39%. There was no net change in fuel loading in the RED T unit. It is possible that our vegetation sampling technique did not adequately capture the changes that occurred as a result of the treatments. By sampling vegetation at only 7 or 8 plots in a grid, we may by chance have missed capturing the structural change if the thinning was clumped instead of uniform throughout the sampling macroplot.

Wildlife exhibited no clear patterns of response to the treatments. Small mammal species richness and abundance were very consistent across all four sites by the second year of post-treatment sampling, indicating that if there were any initial treatment effects, they were alleviated after 2-3 years when the small mammal abundance and diversity were back to pre-treatment levels. We measured large amounts of inter-annual variation in avian diversity and abundance, but the treatment units tracked with the control units, ruling out any treatment effect.

If the treatments in fact met the forest management objectives to reduce the risk of wildland fire, it is encouraging that the wildlife did not appear to respond negatively in the short term. However, with the limited scope of this project, we do not want to infer that fuels reductions treatments have no net effect on wildlife. Fortunately, the data for these paired sites will be analyzed with six other paired sites in the Lake Tahoe Basin that have received similar thinning treatments to produce a clearer picture of how wildlife responds to fuels reduction.

Acknowledgements

The Nevada Division of State Lands provided funding for data collection in 2007 and made the continuation of this project in 2007 possible. Elizabeth Harrison (NDSL) worked closely with the science team to coordinate funding and negotiate complex logistics associated with access to Lake Tahoe State Park. Roland Shaw of Nevada Division of Forestry designed and implemented the treatments on the east shore sites. The addition of these sites to the study greatly enhanced the ability of the research to address the array of forest conditions on both sides of the lake, and in particular contribute more to the management of forested ecosystems on the east side of the basin. Multiple agency staff provided valuable assistance in the location and coordination of treatments in units, including Ray Machado (LTMBU), Scott Parsons (LTBMU), Judy Clot (CTC), and Juan Carlos (CTC). Previous years funding was received from the Southern Nevada Public Lands Management Act. Field team leaders and members did a fantastic job of implementing the study, with particular thanks to Kris McIntyre, Marchel Munnecke, Dan Moses, Matty Holdgate, Scott Appleby, Katie Heckendorn, and Haruka Furuya.

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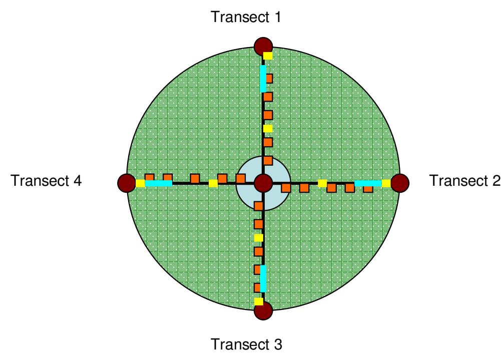
Appendix A. Vegetation data collection protocol.

Vegetation was measured within a fixed 17.58 meter (58 ft) radius plot of 0.1 ha (0.25 ac). A random azimuth was selected for the first transect and then three additional transects were established at subsequent 90° angles with the 0 meter marks at the plot center. The four transects were the basis for sampling down woody debris (DWD), herbaceous and shrub cover and frequency, and duff and litter depths (Figure A-1). Plots were monumented with five 2 foot pieces of rebar capped with yellow plastic caps imprinted with "USFS UPFU"; one at the plot center and one at the distal end of each transect.

Vegetation Plot Layout



Tree Macroplot 17.58 m (57.68') radius

Sapling and Seedling Subplot 3.57 m (11.77') radius- tree saplings and seedlings less than 1 cm dbh.

DWD 17.58 m transects, 0 is at plot center. 1 and 10hr fuels counted from 15-17m, 100 hr from 12-17 m, and 1,000 hr for the entire length.

Litter and duff measurement and vegetation cylinder conducted at 8 m and 16 m.

Cover and Frequency - .5 m^2 quadrats on all transects at the 3, 6, 9, 12, and 15 m marks placed on the right side of transect (from center of plot).

Permanent rebar stake locations- photo points are from outer 4 rebar stakes looking in to plot.

Figure A1. Uplands Fuels research project vegetation plot lay-out.

Plot Description

Descriptive data collected in each plot included: UTM coordinate in NAD 27, slope, aspect, general landform, horizontal and vertical slope shape. The two most dominant species with greater than 10% canopy cover were recorded for three stratums; upper (> 3 m tall), mid (3 to 10 m tall), and low (< 1 m tall). A photo point was established at the distal end of each transect looking down the meter tape toward the plot center.

Tree Data

A breakpoint of 15 cm (6 in) diameter at breast height (DBH) was selected for sampling mature trees. The following data was recorded for all mature trees within the entire plot: species, DBH, total height, height to live crown base, live crown ratio, crown position, and observed damage. Snags were also sampled within the entire plot. Snag data included: species, DBH, total height, and decay class. Within a 3.57 m (11.7 ft) fixed radius subplot of 0.01 ac (0.004ha) nested at the plot center, the species, DBH, total height, and live crown ratio was recorded for all saplings greater than 1.37 m (4.5 feet) tall with a DBH less than the breakpoint. Saplings were categorized by 4 size classes based on DBH: 0-2.5, 2.5-5, 5-10, 10-15 cm. The number of all seedlings less than of 1.37 meters tall was recorded for each species. Seedlings were categorized by 5 height classes: 1-15, 15-30, 30-60, 60-100, and 100-140 cm. The midpoint values of size and height classes were used in calculations. Each mature tree and snag was permanently marked with an aluminum tree tag and nail. Canopy cover was measured at 25 points using a 5 m by 5 m grid using a GRS site-tube densitometer.

Fuels Data

Surface and ground fuels were sampled on all four transects in each inventory plot using the line-intercept method (Brown, 1974). One-hour (0-0.64 cm) and ten-hour (0.64-2.54 cm) fuels were tallied from 15-17 meters, 100-hour (2.54-7.62 cm) fuels from 12-17 meters, and 1000-hour (>7.62 cm) fuels were sampled along the entire length (17.84 meters) of each transect. The larger fuels (1000-hour) represent coarse woody debris (CWD) that has high value for many wildlife species, so the following information was collected for each CWD: species, diameter at the tape, diameter at each end, length, and decay class. Duff and litter depth (cm) was measured at the 8 and 16 meter marks. At the same locations, the surveyors estimated the following within an imaginary 2m by 2m cylinder: live and dead tree/shrub cover, average tree/shrub height, live and dead herb cover, and average herb height. Measurements were conducted towards the distal ends of the transects to avoid the disturbance that was generally concentrated in the plot center.

Herbaceous and Shrub Cover/Frequency

Herb and shrub percent cover, height, and nested frequency were measured in five 0.25m^2 quadrats located at 3 meter intervals (3,6,9,12,15) along all four transects, for a total sample area of 1.25 m^2. Frequency describes the abundance and distribution of species and is very useful for comparing significant differences between two plant communities or detecting significant change in a single community over time. A reasonable sensitivity to change results from capturing frequencies between 20 and 80 percent, and therefore, a nested quadrat system was used to avoid problems resulting from using a single quadrat size. Nested quadrat sizes (5x5, 25x25, 25x50, 50x50 cm) corresponded to a nested rooted frequency ratio of 1:25:50:100.

Plant cover was measured as the vertical projection of foliage within a percentage of the quadrat and the percent value indicates the relative influence of each species on the community. A system of 12 cover classes, (0-1, 1-5, 5-15, 15-25, 25-35, 35-45, 45-55, 55-65, 65-75, 75-85, 85-95, 95-100) was used to reduce human error and increase the consistency of estimates. Midpoint values were used for computation.

Height gives detailed information about the vertical distribution of plant species cover with in the plot. It allows calculations of 1) plant species volume (cover x height) and 2) biomass (height x cover x bulk density). FIREMON uses 0.8 kg/ m^3 for herbaceous BD and 1.8 kg/m^3 for shrubs.

Appendix B. Understory plant species recorded during vegetation surveys across 4 sites on Nevada Division of State Land property on the east shore of Lake Tahoe, 2007-2009.

Scientific Name	Common Name	Code	Growth Habit	Total Frequency	Site Frequency (n=4)
Chrysolepis sempervirens	bush chinquapin	CHSE11	shrub	59	3
Ceanothus velutinus	snowbrush ceanothus	CEVE	shrub	47	3
Elymus elymoides	squirreltail	ELEL5	graminoid	32	3
Arctostaphylos nevadensis	pinemat manzanita	ARNE	shrub	26	3
Penstemon gracilentus	slender penstemon	PEGR4	forb/herb	21	2
Aster breweri	Brewer's aster	ASBR12	forb/herb	19	2
Monardella odoratissima	mountain monardella	MOOD	forb/herb	17	2
Gayophytum diffusum	spreading groundsmoke	GADI2	forb/herb	14	4
Wyethia mollis	woolly mule-ears	WYMO	forb/herb	13	1
Hieracium albiflorum	white hawkweed	HIAL2	forb/herb	8	1
Achnatherum	needlegrass	ACHNA	graminoid	7	3
Allium campanulatum	dusky onion	ALCA2	forb/herb	6	2
Alnus incana ssp. tenuifolia	thinleaf alder	ALINT	shrub	5	2
Lupinus sp.	lupine	LUPIN	forb/herb	5	2
Ribes viscosissimum	sticky currant	RIVI3	shrub	5	3
Agrostis variabilis	mountain bentgrass	AGVA	graminoid	4	1
Allophyllum gilioides	dense false gilyflower	ALGI	forb/herb	4	1
Arabis platysperma	pioneer rockcress	ARPL	forb/herb	4	2
Carex rossii	Ross' sedge	CARO5	graminoid	4	2
Chimaphila menziesii	little prince's pine	CHME	subshrub	4	2
Pteridium aquilinum var. pubescens	hairy brackenfern	PTAQP2	forb/herb	4	2
Artemisia tridentata	big sagebrush	ARTR2	shrub	3	1
Gilia leptalea	Bridges' gilia	GILE	forb/herb	3	1
Lathyrus nevadensis	Sierra pea	LANE3	forb/herb	3	1
Purshia tridentata	antelope bitterbrush	PUTR2	shrub	3	1
Pyrola picta	whiteveined wintergreen	PYPI2	forb/herb	3	1
Ribes cereum	wax currant	RICE	shrub	3	1
Apocynum androsaemifolium	spreading dogbane	APAN2	forb/herb	2	1
Arabis holboellii	Holboell's rockcress	ARHO2	forb/herb	2	2
Arctostaphylos patula	greenleaf manzanita	ARPA6	shrub	2	1
Balsamorhiza sagittata	arrowleaf balsamroot	BASA3	forb/herb	2	1
Ceanothus cordulatus	whitethorn ceanothus	CECO	shrub	2	1
Cirsium andersonii	rose thistle	CIAN	forb/herb	2	1
Cryptantha	cryptantha	CRYPT	forb/herb	2	1
Thalictrum fendleri	Fendler's meadow-rue	THFE3	forb/herb	2	1
Achnatherum occidentale	western needlegrass	ACOC3	graminoid	1	1

Achnatherum speciosum	desert needlegrass	ACSP12	graminoid	1	1
Agoseris glauca	pale agoseris	AGGL	forb/herb	1	1
Arabis sp.	rockcress	ARABI2	forb/herb	1	1
Aster occidentalis	western mountain aster	ASOC	forb/herb	1	1
Cryptantha affinis	quill cryptantha	CRAF	forb/herb	1	1
Elymus glaucus	blue wildrye	ELGL	graminoid	1	1
Erigeron breweri	Brewer's fleabane	ERBR4	forb/herb	1	1
Eriodictyon californicum	California yerba santa	ERCA6	shrub	1	1
Eriogonum nudum	naked buckwheat	ERNU3	forb/herb	1	1
Linanthus nuttallii	Nuttall's linanthus	LINU3	forb/herb	1	1
Lupinus argenteus	silvery lupine	LUAR3	forb/herb	1	1
Pedicularis semibarbata	pinewoods lousewort	PESE2	forb/herb	1	1
Penstemon rydbergii	Rydberg's penstemon	PERY	forb/herb	1	1
Phlox diffusa	spreading phlox	PHDI3	forb/herb	1	1
Populus tremuloides	quaking aspen	POTR5	tree	1	1
Ribes sp.	currant	RIBES	shrub	1	1
Ribes nevadense	Sierra currant	RINE	shrub	1	1
Senecio integerrimus	lambstongue ragwort	SEIN2	forb/herb	1	1

Appendix C. Bird species detected during point counts conducted late May through early July across 4 sites on Nevada Division of State Land property on the east shore of Lake Tahoe, 2007-2010.

Scientific Name	Common Name	AOU code	Total Detections	Site Frequency (n=4)
Poecile gambeli	Mountain Chickadee	MOCH	256	4
Sitta canadensis	Red-breasted Nuthatch	RBNU	207	4
Dendroica coronata	Yellow-rumped Warbler	YRWA	203	4
Junco hyemalis	Dark-eyed Junco	DEJU	161	4
Empidonax oberholseri	Dusky Flycatcher	DUFL	145	4
Regulus satrapa	Golden-crowned Kinglet	GCKI	130	4
Passerell iliaca	Fox Sparrow	FOSP	101	4
Piranga ludoviciana	Western Tanager	WETA	83	4
Cyanocitta stelleri	Steller's Jay	STJA	68	4
Myadestes townsendi	Townsend's Solitaire	TOSO	62	4
Carduelis pinus	Pine Siskin	PISI	56	4
Certhia americana	Brown Creeper	BRCR	54	4
Carpodacus cassinii	Cassin's Finch	CAFI	49	4
Nucifraga columbiana	Clark’s Nutcracker	CLNU	41	4
Sitta carolinensis	White-breasted Nuthatch	WBNU	40	4
Contopus sordidulus	Western Wood Pewee	WEWP	38	4
Loxia curvirostra	Red Crossbill	RECR	38	3
Turdus migratorius	American Robin	AMRO	37	4
Picoides albolarvatus	White-headed Woodpecker	WHWO	33	4
Catharus guttatus	Hermit Thrush	HETH	31	4
Picoides villosus	Hairy Woodpecker	HAWO	28	4
Vireo gilvus	Warbling Vireo	WAVI	22	2
Regulus calendula	Ruby-crowned Kinglet	RCKI	21	2
Coccothraustes vespertinus	Evening Grosbeak	EVGR	16	4
Oporornis tolmiei	MacGillivray's Warbler	MGWA	14	4
	unknown woodpecker	XXWO	13	3
Oreothlypis ruficapilla	Nashville Warbler	NAWA	8	3
Colaptes auratus	Northern Flicker	NOFL	8	3
Columba fasciata	Band-tailed Pigeon	BTPI	8	2
Wilsonia pusilla	Wilson's Warbler	WIWA	8	2
Molothrus ater	Brown-headed Cowbird	BHCO	8	1
Sphyrapicus thyroideus	Williamson's Sapsucker	WISA	7	2
Contopus cooperi	Olive-sided Flycatcher	OSFL	6	3
Dendragapus obscurus	Sooty Grouse	SOGR	6	3
Pipilo chlorurus	Green-tailed Towhee	GTTO	6	2
Troglodytes aedon	House Wren	HOWR	6	2
Sphyrapicus ruber	Red-breasted Sapsucker	RBSA	5	3

Vireo cassinii	Cassin's Vireo	CAVI	5	2
Spizella passerina	Chipping Sparrow	CHSP	4	3
Stellula calliope	Calliope Hummingbird	CAHU	4	2
Sitta pygmaea	Pygmy Nuthatch	PYNU	4	2
Zenaida macroura	Mourning Dove	MODO	4	1
Picoides arcticus	Black-backed Woodpecker	BBWO	2	1
Corvus corax	Common Raven	CORA	2	1
Buteo jamaicensis	Red-tailed Hawk	RTHA	2	1
Thryomanes bewickii	Bewick's Wren	BEWR	1	1
Accipiter cooperii	Cooper’s hawk	COHA	1	1
Dendroica occidentalis	Hermit Warbler	HEWA	1	1
Oreortyx pictus	Mountain Quail	MOQU	1	1
Selasphorus rufus	Rufous Hummingbird	RUHU	1	1
Melospiza melodia	Song Sparrow	SOSP	1	1