Point Blue Report

Bird and Bat Inventories in the Moonlight, Storrie, and Chips Fire Areas

2015 Report to the Lassen and Plumas National Forests

August 5, 2016

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Conservation science for a healthy planet

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Cover photos*: A landscape burned in the Storrie and Chips Fire is home to high densities of snag-nesting birds, including Northern Flickers. Left photo: Point Blue. Right photo: Tom Grey.*

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EXECUTIVE SUMMARY

In this report we present our 2015 activities and results from bird and bat inventories in and near post-fire habitats of the Moonlight, Storrie, and Chips fire areas. This report provides an update on work completed with an analyses that focus primarily on guiding forest restoration projects in the fire areas.

We investigated the avifauna of the proposed Moonlight Fire reforestation polygons by comparing bird data collected from within the planned impact areas to representative control locations elsewhere in the Moonlight Fire. Both the impact and control samples contained high abundances of bird species associated with early seral forest understory and post-fire snag forest, with very few species associated with open or dense mature forest. Of the top 25 most abundant bird species among the control and impact samples, only one species was more abundant in the control than impact.

We investigated the avifauna of the Green Island and Ridge project areas on the Lassen National Forest by analyzing bird data collected from several regions in and adjacent to the Chips and Storrie fire areas in 2015. The Ridge project area contained abundances of bird species in the early seral, post-fire snag, and open forest guilds that were as high, or higher, than the rest of the Storrie and Chips Fire footprints and adjacent unburned areas. The Green Island project area currently has relatively high abundances of open forest and early seral forest bird species, and generally low (but patchily moderate and high) abundance of dense forest species and very few post-fire snag species. The introduction of prescribed fire would likely result in an avifauna similar to that currently found in the area proposed for fuels reduction treatment of the Ridge project, but likely with fewer post-fire snag species.

We sampled bats in and adjacent to the Storrie and Chips fire areas on both Lassen and Plumas National Forests. We detected 56,258 passes from 16 bat species in 2015, including all three USFS bat species of conservation concern. For most species, presence was equivalent or higher in areas that burned at moderate and high severity compared areas that burned at low severity and unburned green forest, which adds to the scant evidence that bats are resilient to wildfire and that early successional habitats are an important landscape component for bats, as has been demonstrated for birds.

In addition to the field work and associated results presented herein, we are making significant progress on other deliverables in the form of manuscripts and analyses. We are in the writing phase of a manuscript investigating the effects of time since fire and burn severity on birds in the northern Sierra region. We are also conducting an analysis to predict habitat suitability for cavity-nesting birds in the footprints of future northern Sierra wildfires, using data gathered in the Storrie, Moonlight, Cub and Chips fire areas, including data gathered in 2015. Lastly, we have completed collecting the data required to publish two other papers—one on the effects salvage logging on birds and the other the effects of the Chips Fire on the avian community from before to after the fire—and we are in the process of collecting the data required to publish a paper on the effects of fire severity and salvage logging on bats in the northern Sierra.

2015 Field Activities

- We surveyed birds at 132 point count stations to provide guidance on reforestation activities in the Moonlight Fire on Plumas Nation Forest.
- We surveyed birds at 102 point count stations established this year in the Green Island and Ridge project areas on Lassen National Forest to provide guidance on restoration activities.
- We surveyed birds at existing post-fire study plots established in 2009 in the Storrie fire footprint (75 point count stations on 15 nest searching transects and 14 other point count stations) on Plumas and Lassen National Forest.
- We surveyed birds at 6 post-fire study plots established in 2013 in the Chips fire area outside of the Storrie fire footprint (30 point count stations on 6 nest searching transects) on Lassen National Forest.
- We surveyed birds at most Plumas-Lassen Administrative Study (PLAS) green forest point count stations that burned in the Chips fire (195 point count stations) on Lassen and Plumas National Forests.
- We surveyed birds at point count stations established in 2013 inside and outside salvage units in the Chips fire area (110 point count stations) on Lassen and Plumas National Forests.
- We surveyed bats at 63 randomly selected point count stations Storrie and Chips fire areas and adjacent unburned green forest locations on Lassen and Plumas National Forests.

- We collected vegetation/habitat data at 61 nests, 73 random locations, and 500 PC locations in the Storrie and Chips fire areas on Lassen and Plumas National Forests.

Post-fire Habitat Management Recommendations

Recommendations are a culmination of our results, scientific literature, and expert opinion from 15 years of studying birds in the Sierra Nevada. Some of these are hypotheses that should be tested and further refined to ensure they are achieving the desired outcome of sustaining biological diversity in the Sierra Nevada.

General

- Whenever possible restrict activities that depredate breeding bird nests and young to the non-breeding season (August–March).
- Consider post-fire habitat as an important component of the Sierra Nevada ecosystem because it maintains biological diversity.
- When determining what percentage of the fire area to salvage log, consider the area of a fire that was forested and burned at high severity, as opposed to the area of the entire fire.
- Consider the landscape context (watershed, forest, ecosystem) and availability of different habitat types when planning post-fire management actions.
- Approach post-fire management through a climate-smart lens. Using the past to inform while planning for the future, find solutions that promote resiliency and foster adaptation.
- Use existing climate predictions of vegetation communities to guide reforestation locations and species mixes.
- Be patient, strategic, and constrained in aiding the recovery of a post-fire landscape. Monitor, evaluate, and continually improve management activities.

Snags

- Manage a substantial portion of post-fire areas for large patches (20–300 acres) burned with high severity as wildlife habitat.

- Retain high severity burned habitat in locations with higher densities of medium to larger diameter trees.
- Retain high severity patches in areas where pre-fire snags are abundant as these are the trees most readily used by cavity nesting birds in the first three years after a fire.
- Retain snags in salvaged areas at far greater abundances than green forest standards and retain some in dense clumps.
- Snag retention immediately following a fire should aim to achieve a range of snag conditions from heavily decayed to recently dead in order to ensure a longer lasting source of snags for nesting birds.
- When reducing snags in areas more than five years post fire (e.g. Moonlight and Storrie fire), snag retention should favor large pine and Douglas Fir, but decayed snags with broken tops of all species should be retained in recently burned areas.
- Consider that snags in post-fire habitat are still being used by a diverse and abundant avian community well beyond the 2 – 8 years they are used by Black-backed Woodpeckers.
- Retain snags (especially large pine trees that decay slowly) in areas being replanted, as they can provide the only source of snags in those forest patches for decades to come.
- Retain smaller snags in heavily salvaged areas to increase snag densities because a large range of snag sizes, from as little as 6 inches DBH, are used by a number of species for foraging and nesting. Though, most cavity nests are in snags over 15 inches DBH.

Early Successional Habitat

- Manage post-fire areas for a diverse and abundant understory plant community including shrubs, grasses, and forbs. Understory plant communities provide a unique and important resource for many species in a conifer-dominated ecosystem.

- Most shrub patches should be at least 10 acres and shrub cover should average over 50% across the area in order to support area-sensitive species such as Fox Sparrow.
- Retain natural oak regeneration with multiple stems; these dense clumps create valuable understory bird habitat in post-fire areas 5–15 years after the fire.
- When treating shrub habitats, ensure some dense patches are retained.
- In highly decadent shrub habitat, consider burning or masticating half the area (in patches) in one year and burning the rest in the following years once fuel loads have been reduced.
- Maximize the use of prescribed fire to create and maintain montane chaparral habitat and consider a natural fire regime interval of 20 years as the targeted re-entry rotation for creating disturbance in this habitat.

Shaping Future Forest

- In areas with significant oak regeneration, limit replanting of dense stands of conifers. When replanting these areas, use conifer plantings in clumps to enhance the future habitat mosaic of a healthy mixed conifer hardwood or pine-hardwood stand.
- Consider managing smaller burned areas (<5000 acres) and substantial portions of larger fires exclusively for post-fire resources for wildlife, especially when there have been no other recent fires (within the last 10 years) in the adjoining landscape.
- Retain patches of high burn severity adjacent to intact green forest patches, as the juxtaposition of unlike habitats is positively correlated with a number of avian species, including those declining such as Olive-sided Flycatcher, Western Wood-Pewee, and Chipping Sparrow.
- Incorporate fine-scale heterogeneity in replanting by clumping trees with unplanted areas interspersed to create fine-scale mosaics that will invigorate understory plant communities and natural recruitment of shade intolerant tree species.

- Plant a diversity of tree species where appropriate, as mixed conifer stands generally support greater avian diversity than stands dominated by single species in the Sierra Nevada.
- Consider staggering plantings across decades and leaving areas to naturally regenerate in order to promote uneven-aged habitat mosaics at the landscape scale.
- Consider fuels treatments to ensure the fire resiliency of remnant stands of green forest within and adjacent to the fire perimeter to promote habitat mosaics.
- Avoid planting conifer species in or adjacent to riparian areas to avoid future shading of riparian deciduous vegetation and desiccation.
- Consider replanting riparian tree species (cottonwood, willow, alder, aspen) in riparian conservation areas affected by stand-replacing fire where natural regeneration is lacking.

INTRODUCTION

With the growing recognition of fire as a primary driver of ecosystem form and function in the Sierra Nevada (North et al. 2009; North 2012), and the increasing intensity, extent, and frequency of wildfires in the last few decades despite suppression efforts (Westerling et al. 2006; Miller & Safford 2012; Steel et al. 2015), there is substantial and urgent need to understand the value of habitats created by wildfire and how post-fire habitats are used by the unique wildlife community that occupy them (eg. Fontaine et al. 2009). Current knowledge of wildlife response to fire and post-fire management in the Sierra Nevada is based almost entirely upon studies of a limited number of bird and small mammal species. While birds are excellent indicators of ecological processes that can provide important feedback regarding the health of managed fire-prone ecosystems (Alexander et al. 2007), there is increasing interest in the response of other wildlife taxa, such as bats, to fire.

There is one study on the effects of wildfire on bats in the Sierra Nevada (Buchalski et al. 2013), and very little knowledge to draw from elsewhere in North America (Fisher & Wilkinson 2005; Fontaine et al. 2009). Buchalski et al. (2013) found bat response was categorically neutral to positive one year after wildfire, suggesting bats are resilient to wildfire and that naturally generated early successional habitats are an important landscape component for bats, as has been demonstrated for birds (Smucker et al. 2005; Hutto 2008; Fontaine et al. 2009). Many important knowledge gaps remain about bat response to wildfire, such as the effects of salvage logging, time since fire, and pre-fire forest conditions. Effective management of post-fire areas for bats depends on answers to these questions.

Considerable debate surrounds the management of post-fire habitat in the Sierra Nevada. Ecological restoration objectives can seem disparate and contradictory (e.g. fuels management and wildlife habitat). Ecological monitoring can be used to minimize tradeoffs, find complementary values, and maximize benefits among restoration objectives (Hutto & Belote 2013). Management actions in post-fire habitat can affect the forest composition that will exist there for decades (Lindenmayer & Noss 2006; Swanson et al. 2010). Thus, it is necessary to carefully consider and study the species using post-fire habitat under different management prescriptions soon after fire and well into the post-fire time horizon. In this report we present data and findings from our bird and bat inventories in the Storrie, Moonlight, and Chips fire areas, with specific implications and guidance for restoration projects therein.

METHODS

Study Location

The study area for projects presented in this report includes the footprints of Moonlight, Storrie and Chips Fires on the Mount Hough Ranger District of Plumas National Forest and the Almanor Ranger District of Lassen National Forest in the Sierra Nevada mountains of Northeastern California (Figure 1A,B). The Storrie Fire occurred in the summer of 2000, burning 56,677 acres. The Moonlight Fire occurred in the summer of 2007, burning 64,997 acres. The Chips Fire occurred in the summer of 2012 and burned 76,890 acres; many of those acres are within the Storrie Fire footprint. The elevations of sites we surveyed within these fires ranges from 1287–1941 m.

Bird Sampling Designs

In 2015 we selected 132 sampling locations in the Moonlight fire area on Mount Hough Ranger District to inventory birds and help guide the proposed reforestation treatments (Figure 1A). Site selection of these sampling locations occurred in a GIS framework. Using the reforestation polygon layer provided by the Plumas National Forest, we first overlaid it on polygons delineating completed salvage units. We limited our impact sample to proposed reforestation units that had not received any prior post-fire salvage or reforestation treatments. Within these proposed reforestation units, we manually distributed points ≥250 m apart and >125 m from treatment unit boundaries and >125 m away from any salvaged area (roadside or otherwise), in a way that maximized sampling density. A few reforestation units were not sampled because they were either too narrow to meet the above rule or, in one case, a single polygon that could only fit 3 points was isolated from any other units. This resulted in 73 sampling locations in reforestation units among 9 transects with 5–10 points per transect. We then selected control locations that will not be treated. We anchored these around six of our pre-existing Moonlight Fire transects that were predominately in high severity by adding up to 7 additional points to those transects. We dropped any existing points on these transects <125 m of a salvage unit boundary. All control locations were >125 m outside of any post-fire treatment, past or proposed. This resulted in 59 sampling locations across six transects.

In 2015 we added 78 sampling locations in the Ridge project area. Site selection occurred in a GIS framework. First we masked out areas in the project boundary that were >30 degrees slope and dissolved the treatment unit boundaries by treatment type. We then manually distributed points ≥250 m apart and >100 m from treatment unit boundaries, in a way that maximized sampling coverage of points in the surveyable areas of the polygons, while avoiding the few riparian areas in the project area. All points were positioned within the Storrie-Chips overburn area, >100 m from the Chips Fire boundary—a small area of one polygon that was burned only once in the Storrie Fire was avoided. Points were placed irrespective of habitat type (other than riparian) and fire severity, which was fairly homogenous within treatment areas. Forty-one points were placed within the reforestation treatment area and 37 in the fuel reduction treatment area. The points were split into six transects using topography, access roads, and point proximities, with 12–14 points per transect, and a mix of fuels and reforestation points on most transects.

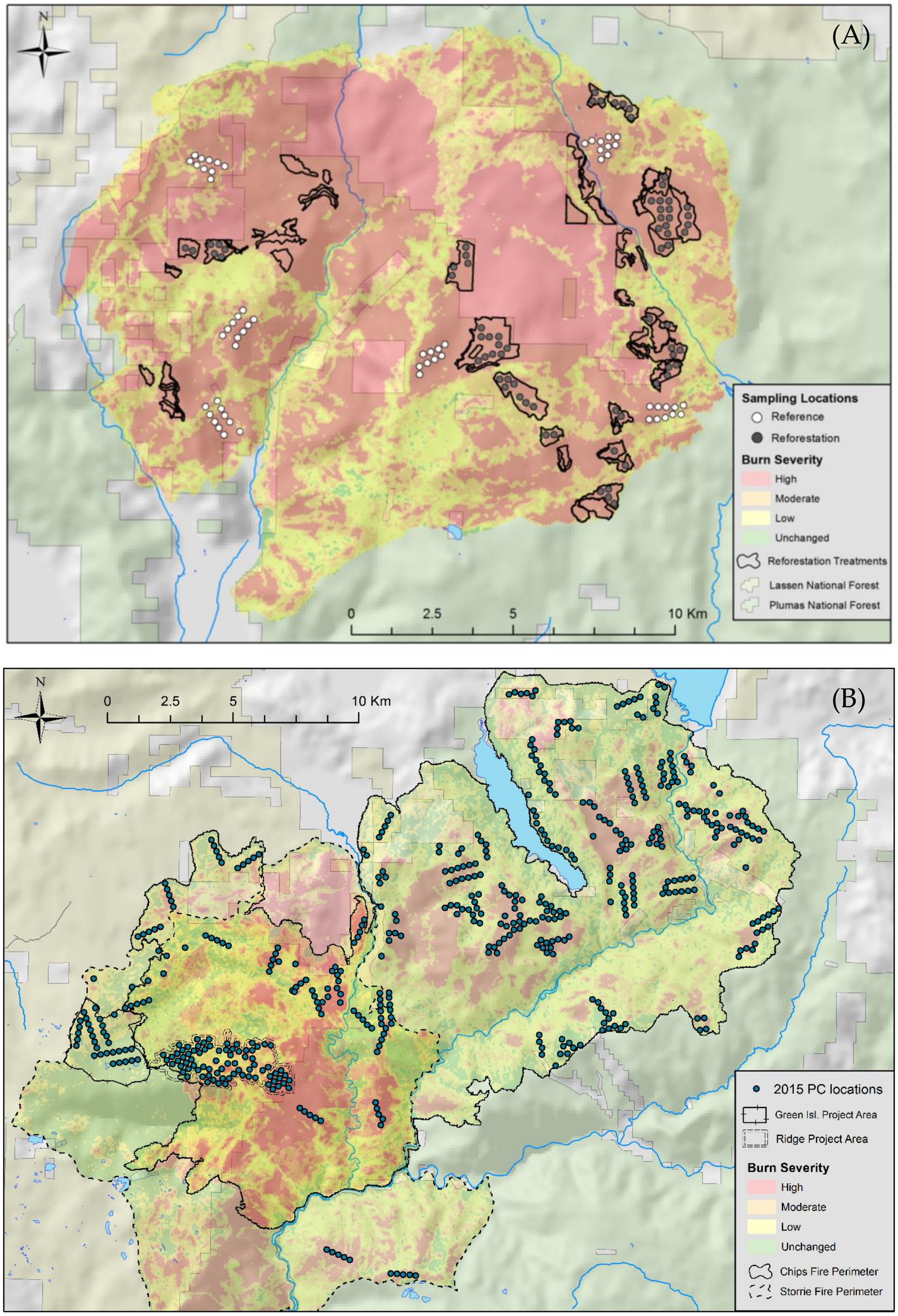
In 2015 we added 24 sampling locations in the Green Island Project area, in addition to the 8 pre-existing sampling locations that fell inside the project boundary. Site selection occurred in a GIS framework. First we masked out areas in the project boundary that were >30 degrees slope. We distributed 24 points on two line-transects >100 m from the project boundary edge. Each transect consisted of 12 points with two transect lines of points spaced 250 m apart. All points fell in white fir, sierra mixed conifer, red fir, and montane chaparral.

Sampling designs for other bird survey locations on Lassen and Plumas National Forest visited in 2015 in the Storrie and Chips fire areas (Figure 1B) have been described in detail in previous reports.

Passive Point Count Surveys

Surveyors conducted standardized five-minute exact-distance point counts (Ralph et al. 1995) at each point count station. With the aid of rangefinders, surveyors estimated the exact distance to each individual bird. The initial detection cue (song, visual, or call) for each individual was also recorded. Counts began around local sunrise, were completed within four hours, and did not occur in inclement weather. Surveyors received three weeks of training to identify birds and estimate distances and passed a double-observer field test. All transects were visited twice during the peak of the breeding season from mid-May to late-June.

Figure 1. (A) Survey locations in the Moonlight fire area. (B) Survey locations in the Storrie and Chips fire areas. The fire severity layers are transparent, such that both fires' severities are visible in the burn overlap area.



Black-backed Woodpecker Playbacks

To select points at which to conduct Black-backed Woodpecker playback surveys in the Green Island and Ridge Projects, we selected a random point on each of the 8 new transects in those project areas. The random point became a playback sampling location. The next closest point ≥500 m was also selected; points within 500 m were dropped from the selectable pool. This last step was repeated until all points in a transect were selected or dropped. Playback sampling locations were located ≥500 m apart to increase independence of detections within 100 m of playback locations.

We conducted a playback survey for Black-backed Woodpeckers following the passive point count survey at each point selected for a playback survey. The playback survey duration was 6 min, with a series of three 25-sec playbacks followed by 95 sec of listening and watching. Playbacks included the scream-rattlesnarl and pik calls and territorial drumming sounds (recording by G. A. Keller, Macaulay Library of Natural Sounds, Cornell Laboratory of Ornithology). Playbacks were broadcast at a standardized volume (90 db) using FOXPRO® ZR2 digital game callers (FOXPRO Inc., Lewistown, Pennsylvania, USA). Playback surveys have been shown to significantly increase detection probability for this species compared to individual passive point count surveys (Saracco et al. 2011). Playback surveys were only conducted >500 m apart to avoid influencing detection probability on subsequent surveys via individuals drawn toward the broadcast from large distances away. Based on our field observations, the approximate range at which human observers can hear the playback calls is 200 m, but highly variable depending on topography and vegetation.

Black-backed Woodpecker Detections

All field personnel were instructed to record the locations of all Black-backed Woodpeckers they detected in the Moonlight, Storrie, and Chips fire areas in 2015, regardless of their activity at the time of the detection. Detections are summarized in Appendices 1-4. It is important to note that the detections are not independent because detections from multiple visits and multiple observers are included, such that each detection should not be considered a separate Black-backed Woodpecker.

Nest Cavity Surveys

A 20-ha area (200 x 1000 m rectangle) surrounding nest cavity point count transects was surveyed for nests of cavity-nesting birds following the protocol outlined in "A field protocol to monitor cavity-nesting birds" by Dudley & Saab (2003). In order to focus our attention on species of greatest management interest, we ignored some of the more common cavity-nesters (e.g. chickadees, wrens). Our focal species included both species of bluebird, all woodpeckers, and all cavity-nesting raptors.

After the point count surveys were completed on all five point count locations, the nest survey was conducted for between two and four hours depending on the habitat, terrain, and time spent waiting to confirm a cavity's status. All nest surveys were completed by noon. The primary search method for finding nests was bird behavior, though, once an individual of the focal species was located, observers often conducted a systematic search of snags in the vicinity. Once a potential nest was found, it was observed from a distance for up to 20 minutes to confirm the cavity was an active nest. We do not present results from the nest monitoring in this report but they are being incorporated into our cavity nest habitat suitability model analysis and manuscript (see Discussion).

Vegetation/Habitat Surveys

Vegetation data was collected at all point count locations in the Storrie and Chips Fires in 2015. We measured vegetation characteristics within a 50-m radius plot centered at each point count station following a modified version of the relevé protocol outlined in Ralph et al. (1993). On these plots we ocularly estimated shrub cover, live tree cover, herbaceous cover, as well as the relative cover of each species in the shrub and tree layers. We also measured basal area of live trees and snags using a 10-factor basal area key at five fixed locations in each plot.

From 2013–2015, at all nests confirmed as active, a variety of characteristics of both the nest tree and the cavity were recorded: diameter at breast height (DBH), tree height, tree species, tree decay class, scorch height on tree, cavity height, orientation of the cavity opening, aspect, and slope. For tree decay, we used a qualitative scale of decay ranging from one to eight, with one being a live, intact tree and eight being a severely decayed stump.

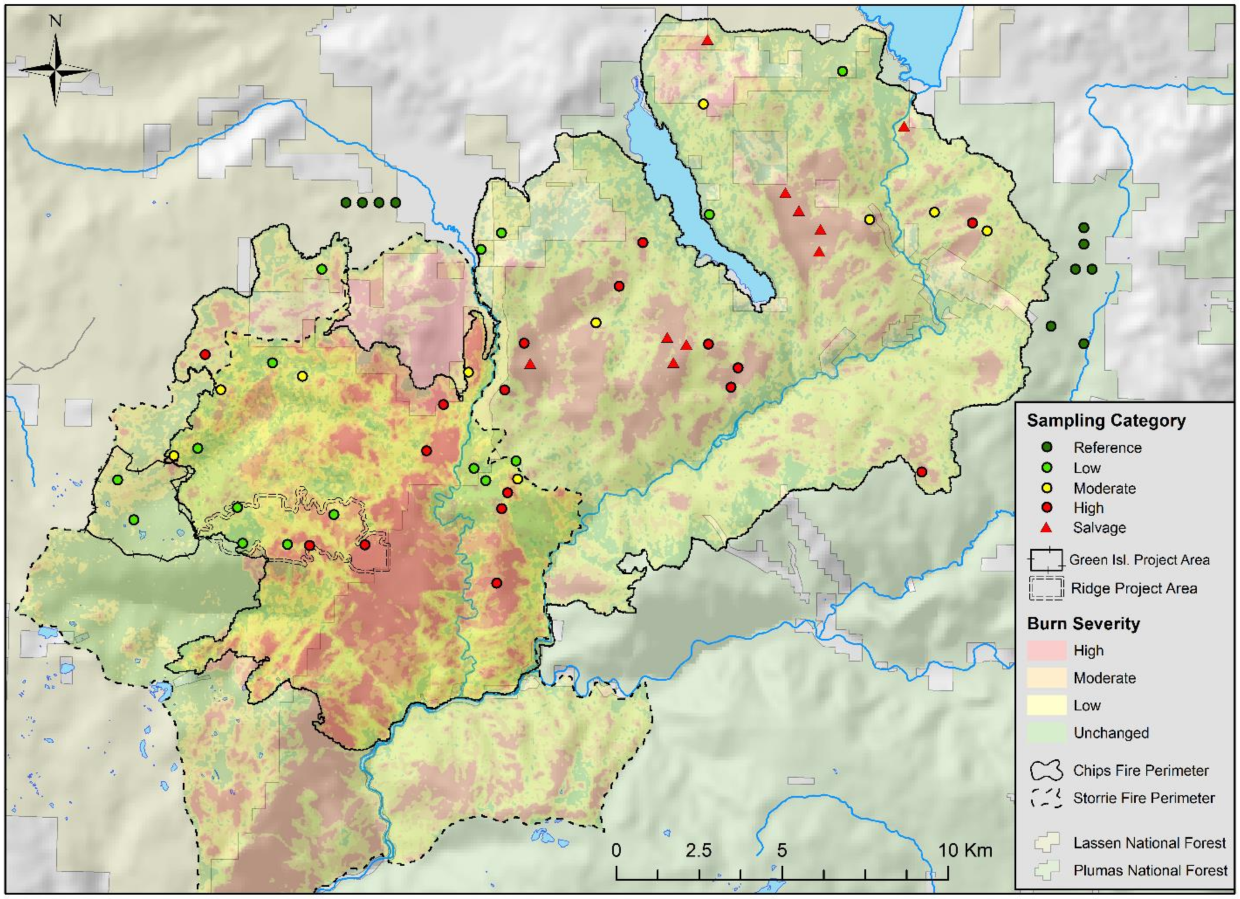
To estimate the density of snags on nest searching plots in 2013–2015, we counted every snag on 11.3-m plots ("snag plots") centered on point count locations, also recording each snag's DBH, species, height, and decay class. We collected these same snag plot data at all active nests and at five random locations distributed throughout the 20 ha nest plot. Once in the field, the observer navigated to within 10 m of a random location and chose the closest tree or snag >12 cm DBH as the snag plot center. The center trees of these random snag plots were used as a sample of random trees to compare to the trees with confirmed active nests. All data collected for trees and snags with active nests were also collected for these random trees.

Bat Sampling

We used 7 automated recorder units (ARUs; SM3BAT, Wildlife Acoustics, Maynard, Maryland, USA) paired with an ultrasonic and acoustic microphone (SMM-A1 & SMM-U1, Wildlife Acoustics, Maynard, Maryland, USA) to sample bats at 63 locations in the Storrie and Chips Fires, including 8 total locations in the Ridge and Green Island project areas. Of the 63 locations, 20 were in the Storrie-Chips overlap area, 2 were in Storrie only, 31 were in Chips only, and 10 were in unburned green forest areas adjacent to the fire perimeters on Lassen and Plumas National Forests (Figure 2). In the Green Island and Ridge project areas, we deployed ARUs at one randomly selected point on each of the 8 newly established avian point count transects, resulting in 6 ARU sampling locations in Ridge and 2 in Green Island. Outside of these project areas, ARU sampling locations were also randomly selected from our existing and actively sampled avian point count locations, but sampling locations were stratified by fire history and treatment rather than by transect. All active point count sampling locations were stratified into the following five categories based on a set of rules:

- Unburned green forest: Management Indicator Species sampling locations within 5 km and elevation range of either fire
- Low severity: burned at low severity in either Chips or Storrie only; low severity in both fires
- Moderate severity: burned at moderate severity in either Chips or Storrie only; low severity in Storrie and moderate severity in Chips; moderate severity in Storrie and low severity in Chips; moderate severity in both Chips and Storrie
- High severity unsalvaged: burned at high severity in both or either Storrie or Chips
- High severity salvaged: within the Chips Fire perimeter only, burned at high severity and >70% of the area within a 100-m radius of the survey point treated by tractor or helicopter according to the R5 Forest Activities spatial data

Figure 2. Locations where automated recorder units were deployed in the Storrie and Chips Fire areas to sample the calls of bats and other nocturnal wildlife.



Burn severity was classified according to the composite burn index in USFS spatial data layers. Points in the non-salvage categories had to have less than 1% of the area within 100 m treated to be eligible for selection. We ranked all points within each of these categories with a random prioritization number. All ranked points were ≥500 m apart.

Locations were sampled in order of priority within each category. In rare cases where a sampling location could not be reached because of logistics or other constraints, the point was dropped and the next highest priority location was sampled. All ARUs were deployed from 5 May to 3 September. ARUs recorded ultrasonic and acoustic sound wavelengths on alternating nights to sample bat and owl species respectively. Recordings started 30 minutes prior to sunset and ended 30 minutes after sunrise. We targeted a deployment length of 11 nights for each sampling location (the approximate battery life) before being moved to a different sampling location. Because of logistical constraints and hardware failure, deployments (i.e. number of nights with data) ranged from 3-17 nights (mean 10.2 nights) at each point.

Analysis: Bird Abundance in Moonlight Fire Reforestation Areas

We used passive point count data collected inside (impact sample) and outside (control sample) of planned reforestation areas in 2015 to evaluate the abundance of birds in the project areas. We tested whether the abundance of the 20 most prevalent bird species was equal among the control and impact samples.

To evaluate each species' abundance within the samples, we built generalized linear mixed models with Poisson error and logarithmic link function using the package lme4 version 1.1-9 (Bates et al. 2015), in program R x64 version 3.2.2. Our sample unit was a single point count visit and the dependent variable was the count of all individuals. The name of all sampling point locations and transects were used as random intercepts to account for repeated measures on each point and transect within a year. There were 7 fixed effects included in the models: sampling area, burn severity, canopy cover, aspect, precipitation, slope, elevation. The fixed effect for sampling area was of primary interest and included two factor levels: one for the control sample and one for the impact sample. The control sample factor level was used as the reference category for the fixed effect such that coefficient estimates for the factor level of impact sample are interpreted as relative to the control sample. The other fixed effects were included to absorb variation around mean estimates of bird abundance for each sampling area. Twenty-two points in the control sample were outside the range of values of canopy cover, burn severity, and elevation, and were removed from the analysis. The remaining sample sizes were 73 impact points and 37 control points. We expect once the treatment units are finalized some of the units will be dropped, resulting in a more equitable distribution of impact and control points.

We used a likelihood ratio test to compare this model to one without the fixed effect of area. We interpreted a significant P-value < 0.05 as a rejection of the null hypothesis that the species was equally abundant among the two sampling areas.

Analysis: Bird Abundance in the Green Island and Ridge Project Areas

We used passive point count data collected inside and outside of the Green Island and Ridge project areas in 2015 to evaluate the abundance of 33 bird species in four habitat guilds in relation to the project areas. Based on our local knowledge and published information about the habitat associations of these species, these species are closely aligned with four broad forest conditions in the Sierra Nevada: post-fire snags, early seral understory, mid- to late-seral open canopy forest, and mid- to late-seral dense forest. The guilds represent four structural forest conditions that are created by fire or lack of fire: (1) snags created by a very recent fire, (2) early successional conditions created by regenerating vegetation following stand-replacing or frequent fire, (3) open and mature conditions created by frequent low to moderate severity fire, and (4) dense and mature conditions created by primarily long-term fire absence. There are 7 species in the post-fire snags guild, 9 species in the early seral understory guild, 9 species in the open forest guild, and 9 species in the dense forest guild. These species include year-round residents, short-distance migrants, and Neotropical migrants.

The mature dense forest (MDF) guild is comprised of: Pileated Woodpecker (*Dryocopus pileatus*), Cassin's Vireo (*Vireo cassinii*), Golden-crowned Kinglet (*Regulus satrapa*), Pacific Wren (*Troglodytes hiemalis*), Hermit Thrush (Catharus guttatus), Hermit Warbler (*Setophaga occidentalis*), Red-breasted Nuthatch (*Sitta canadensis*), Western Flycatcher (*Empidonax difficilis & occidentalis*), and Hammond's Flycatcher (*Empidonax hammondii*). The open mature forest (OMF) species are those that occur along forest edges and openings and/or utilize shade intolerant resources from the sub-canopy to the forest floor and included: Western Wood-Pewee (*Contopus occidentalis*), Olive-sided Flycatcher (*Contopus cooperi*), Warbling Vireo (*Vireo gilvus*), American Robin (*Turdus migratorius*), Nashville Warbler (*Oreothlypis ruficapilla*), Yellow-rumped Warbler (*Setophaga coronata*), Chipping Sparrow (*Spizella passerina*), Black-headed Grosbeak (*Pheucticus melanocephalus*), and Western Tanager (*Piranga ludoviciana*). The early seral forest (ESF) guild is comprised of species that use herbaceous and shrub habitats and included: Mountain Quail (*Oreortyx pictus*), Dusky Flycatcher (*Empidonax oberholseri*), Spotted Towhee (*Pipilo maculatus*), Green-tailed Towhee (*Pipilo chlorurus*), Fox Sparrow (*Passerella iliaca*), Chipping Sparrow (*Spizella passerina*),Yellow Warbler (*Setophaga petechia*), MacGillivray's Warbler (*Geothlypis tolmiei*), and Lazuli Bunting (*Passerina amoena*). Finally, the post-fire snag (PFS) guild is comprised of species that use fire-killed trees: Lewis' Woodpecker, Hairy Woodpecker (*Picoides villosus*), Black-backed Woodpecker (*Picoides arcticus*), White-headed Woodpecker (*Picoides albolarvatus*), Northern Flicker (*Colaptes auratus*), House Wren (*Troglodytes aedon*), and Mountain Bluebird (*Sialia currucoides*).

We tested whether the abundance of these guilds was equal among six areas: the Green Island project area, the Ridge project area, areas of the Storrie fire that did not reburn in the Chips Fire, areas of the Storrie Fire that did reburn in Chips, areas of Chips that were not in the Storrie Fire, and nearby unburned green forest. We restricted the analysis to only points with less than 1% of the area within 100-m of the sampling location experiencing salvage treatments according to the USFS Region 5 Forest Activities geospatial dataset. Black-backed Woodpecker was analyzed as part of a guild and separately because of management concern for this species in burned forest.

To evaluate guild and Black-backed Woodpecker abundance among the five areas, we built generalized linear mixed models with Poisson error and logarithmic link function using the package lme4 version 1.1-9 (Bates et al. 2015), in program R x64 version 3.2.2. Our sample unit was a single point count visit and the dependent variable was the count of all individuals of each species in a guild, or in the case of Black-backed Woodpeckers, simply the count of all individuals. The name of all sampling locations was included as a factor and used as a random effect to account for repeated measures on each point within a year. There was one categorical fixed effect that included a factor level for each of the six areas of interest. Unburned green forest was used as the reference category for the fixed effect of area. All coefficient estimates are relative to this reference area.

We used a likelihood ratio test to compare this model to one without the fixed effect of area; we interpreted a significant *P* value as a rejection of the null hypothesis that the species were equally abundant among the seven areas. If area was significant, using the glht function in the package multcomp version 1.4-1 (Hothorn et al. 2008), we ran Tukey multiple comparisons to test for differences in the mean estimates of bird abundance among the seven areas.

Analysis: Bats

Each bat pass (i.e. detection) from the ultrasonic data was automatically classified using SonoBat software version 3.2.1 Western US edition. The software classifies recordings to species when possible. Low quality or ambiguous recordings are classified as unknown species or to a broader taxonomic grouping (e.g., high frequency species). Classifications are made by comparing call characteristics of recorded bat passes against a library of known bat calls from all western bat species. We then used SonoBat to calculate an estimated likelihood of presence for each survey-night at each sampling location (herein referred to as survey-nights) for each of the 17 species known to the SonoBat classifier (Table 1). This SonoBat likelihood estimate is based on the number of classified species and their known overlap and ambiguity of classification. The likelihood estimate is a probabilistic estimate and does not convey certainty. Trained observers manually vetted the detection/non-detection of each USFS bat species of special concern—*Antrozous pallidus, Corynorhinus townsendii, Myotis thysanodes*—as well as *Lasiurus blossevillii*, for all survey-nights with an estimated likelihood of presence > 0.

We investigated the accuracy of SonoBat's estimated likelihoods of presence for each bat species by comparing them against manually classifications of detection/non-detection at 7 survey locations (46 survey-nights) in our Storrie-Chips study area and a subset of 33 survey locations (186 survey-nights) from in a second project area in post-fire habitat at lower latitudes in the Sierra. Samples from this second survey area included sampling locations in the Power and Rim fires and adjacent unburned green forest on El Dorado and Stanislaus National Forests. These data originate from a Point Blue study using an identical study design, protocol, and equipment to our Storrie-Chips bat study, so the data are directly comparable. Trained observers manually vetted the presence/absence of all species with an estimated likelihood of presence > 0 for each of these survey nights.

Using the 'roc' function package 'pROC' (Robin et al. 2011) in program R x64 version 3.2.2 (R Core Team 2015), we made receiver operating characteristic (ROC) curves for each bat species. ROC curves plot the sensitivity of a classifier against its specificity. Sensitivity is the true positive classification rate. Specificity is the true negative classification rate, whereas 1 minus specificity is the false positive classification rate. The area under the ROC curve (AUC) is a commonly used statistic that estimates the accuracy of a classifier. An AUC estimate can be interpreted as the probability that the SonoBat classifier will assign a higher likelihood of presence to a randomly chosen positive detection than to a randomly chosen negative detection. A value of AUC = 0.5 is equivalent to a classifier that has no discrimination power and is equal to random chance. A value of AUC = 1.0 is equivalent to a classifier that has 100% accuracy, representing 100% sensitivity (i.e. no false negative detections [species was present during a survey night but sample classified as absent]) and 100% specificity (no false positives [species was absent during a survey night but sample classified as present]). The purpose of manually vetting the bat detection data was to eliminate false positive classifications. False negative detection rates can be estimated using occupancy models that take into account species detectability (MacKenzie et al. 2003). Thus, manual vetting can be considered an additional conservative check on the presence/absence classifications generated through SonoBat. An assumption of the analysis producing ROC curves and AUC scores is that manually vetted classifications represent the true detections for a given survey-night and species.

Table 1. Bat species known to the classifier in SonoBat version 3.2.1 Western US edition.

Species Name	Common Name	Code
*Antrozous pallidus**	pallid bat	ANPA
*Corynorhinus townsendii**	Townsend's big-eared bat	COTO
Eptesicus fuscus	big brown bat	EPFU
Euderma maculatum	spotted bat	EUMA
Eumops perotis	western mastiff bat	EUPE
Lasiurus blossevillii	western red bat	LABL
Lasiurus cinereus	hoary bat	LACI
Lasionycteris noctivagans	silver-haired bat	LANO
Myotis californicus	California myotis	MYCA
Myotis ciliolabrum	western small-footed myotis	MYCI
Myotis evotis	long-eared myotis	MYEV
Myotis lucifugus	little brown bat	MYLU
*Myotis thysanodes**	fringed myotis	MYTH
Myotis volans	long-legged myotis	MYVO
Myotis yumanensis	Yuma myotis	MYYU
Parastrellus hesperus	western pipistrelle	PAHE
Tadarida brasiliensis	Mexican free-tailed bat	TABR

*USFS Region 5 species of special concern

We used the ‘coords’ function in the ‘pROC’ package to determine the optimal cutoff value (threshold) for SonoBat’s estimated likelihood that maximizes both sensitivity and specificity. The optimal threshold was calculated as the value of the estimated likelihood that maximizes sensitivity plus specificity, and assumes that false negatives and false positives are equally undesirable by weighting sensitivity and specificity equally in the calculation. We used the optimal thresholds for each bat species to predict presence and absence for each ultrasonic sampling night at each survey location for all ARU sampling locations in our Storrie-Chips study area.

Data Management and Access: Sierra Nevada Avian Monitoring Information Network

All avian data from this project is stored in the California Avian Data Center and can be accessed through the Sierra Nevada Avian Monitoring Information Network web portal (http://data.prbo.org/apps/snamin). At this website, species lists, interactive maps of study locations, as well as calculations of richness, density, and occupancy can be generated as selected by the user. Study site locations can be downloaded in various formats for use in GPS, GIS, or online mapping applications as well. Non-avian data (e.g., bats, vegetation) are stored on Point Blue's server.

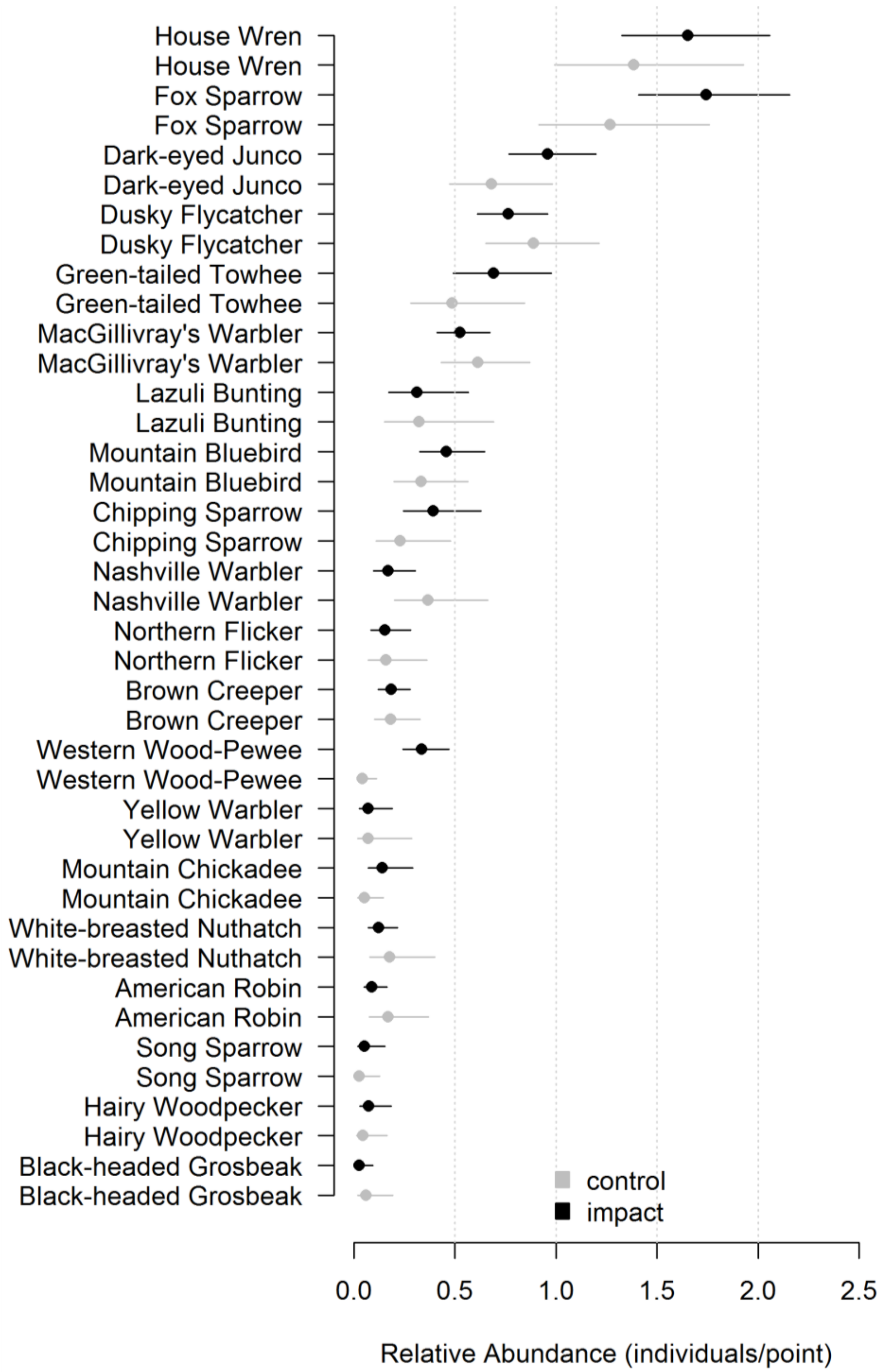
RESULTS

Bird Abundance Inside and Outside of Moonlight Reforestation Project Areas

Abundances of the most prevalent bird species were very similar in the control and impact samples (Figure 3). After controlling for aspect, slope, elevation, precipitation, canopy cover, and burn severity as covariates in the models, only one species—Western Wood-Pewee—differed in abundance between the control and impact samples. This suggests that our refined control sample will provide a good foundation for comparison to the impact sample in a before-after control-impact analysis once the treatments have been implemented.

As expected, species associated with early seral forest understory were the most abundant in the both treatment areas, followed by species associated with post-fire snag forest, and open mature forest. Species associated with dense mature forest were nearly absent. Black-backed Woodpeckers were detected both inside and outside the proposed reforestation polygons (Appendix 1).

Figure 3. Predicted abundances of the 20 most prevalent bird species inside (impact) and outside (control) of proposed reforestation treatment polygons in the Moonlight fire area. Points are mean estimates with 95% confidence intervals (horizontal bars). Western Wood-Pewee was the only species with a statistically significant difference (P < 0.05) between the control and impact samples.

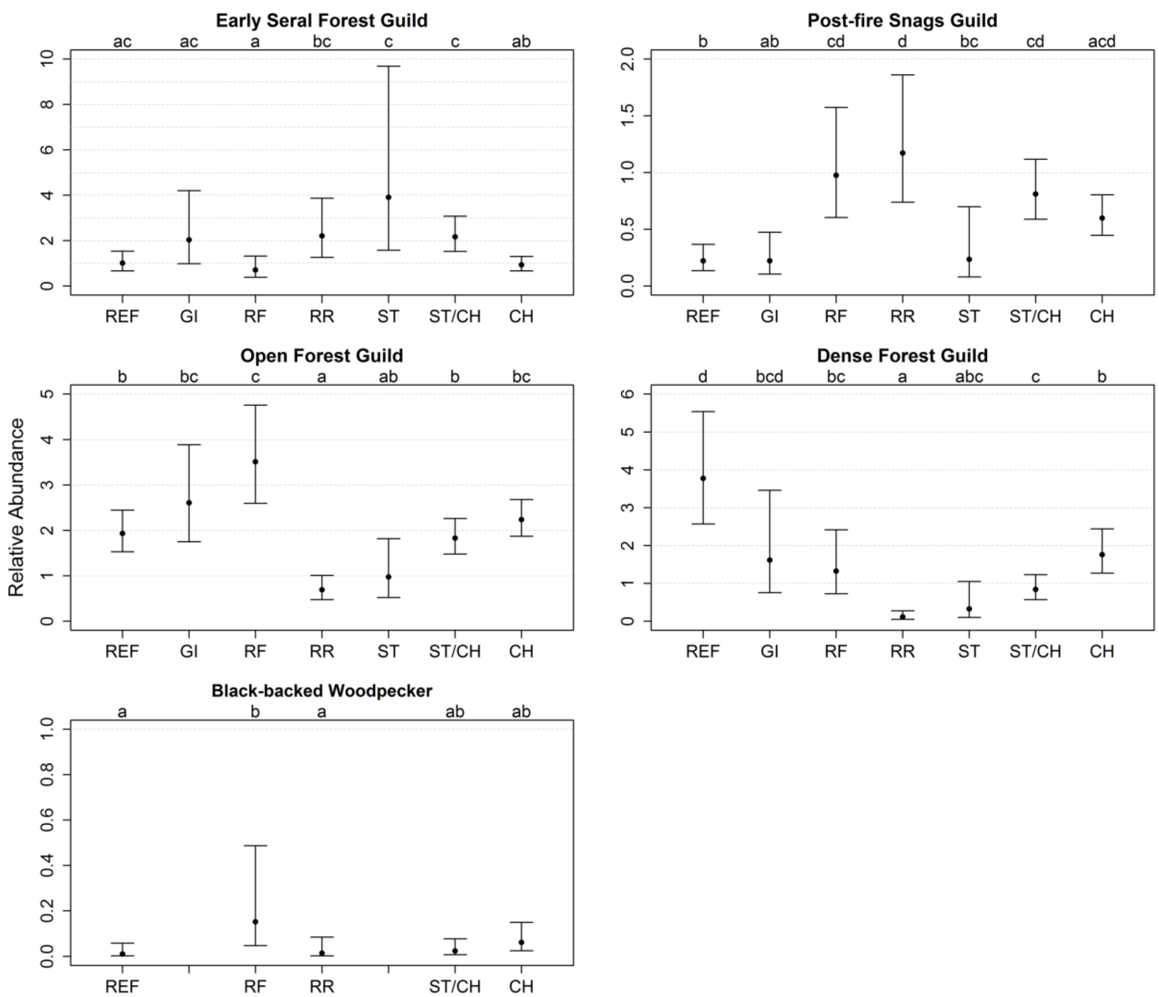


Bird Abundance in the Green Island and Ridge Project Areas

The abundance of the guilds and Black-backed Woodpecker varied among the seven areas of the Storrie and Chips we analyzed ($P < 0.001$, Figure 4). Relative to other areas inside and adjacent to the Storrie and Chips fire footprint, the Green Island project area had a moderate abundance of early seral forest species, low abundance of post-fire snag species, moderately high abundance of open forest, and a moderate abundance of dense forest species. No Black-backed Woodpeckers were detected on passive point counts in the Green Island project area, hence they are not represented in the Green Island project area in this analysis. The fuels reduction treatment area within the Ridge project was characterized by a very low abundance of early seral species, a moderate abundance of dense forest species, and a high abundance of open forest and snag species, including the highest abundance of Black-backed Woodpeckers in the study area. The reforestation treatment areas within the Ridge project was characterized by high abundances of early seral and post-fire snag species, but very low abundances of open and dense forest species, and few Black-backed Woodpeckers despite having a high abundance of post-fire snag species.

It is important to note that this analysis compares areas of differing scales. For example, there are localized areas of the Chips Fire that support higher densities of Black-backed Woodpeckers than their predicted abundance in the proposed fuels reduction area of the Ridge Project.

Figure 4. Relative bird abundance (individuals/point) in seven regions of the Storrie and Chips Fire area. Points are mean estimates with 95% confidence intervals (vertical bars). Letters above each area indicate groupings based on Tukey pairwise comparisons. REF = unburned reference; GI = Green Island; RF = Ridge fuels reduction treatment areas; RR = Ridge reforestation treatment areas; ST = Storrie Fire area burned once only; ST/CH = Storrie Fire area reburned in Chips Fire; CH = Chips Fire area burned once only. See text for guild definitions.



Black-backed Woodpecker Presence in Ridge and Green Island Project Areas

Black-backed Woodpeckers were detected in most areas of the Ridge Project that we sampled, except for areas that were classified as unchanged in both the Storrie and Chips Fires, and areas that burned at high severity in both fires. We had 21 detections of Black-backed Woodpecker in the Ridge project and 2 detections in Green Island (Appendix 2). In the Ridge project, 5 of the detections occurred during playback surveys only, 4 were during passive point count and subsequent playback survey, 9 were during the passive point count or in transit between point counts, and 1 was incidental. Both detections in Green Island were during playback surveys.

Fifteen of the 21 detections in Ridge were found in the fuels reduction treatment areas. All of these detections were in, or within 30 m of, areas of low or moderate severity burn in the Chips Fire. We also found a nest just outside the Ridge project perimeter, in an area that burned at moderate severity in the Chips Fire. Six of the 21 detections in Ridge were in the reforestation treatment areas. Only one of these detections occurred in a pixel classified as high severity burn in both the Storrie and Chips, but the point was surrounded mostly by pixels classified as moderate severity in the Storrie Fire.

The Black-backed Woodpecker detections in the Green Island project area were approximately 2.2 km from the Chips Fire perimeter and 2.6 km from the nearest other Black-backed Woodpecker detection in the Storrie-Chips overlap area. Based on the proximity of the detections to each other, the detections may represent a single territory.

Bat Presence

We detected 56,258 passes from 16 bat species within the Storrie, Chips, and adjacent reference areas, including all three bat species of conservation concern to the USFS (Figure 5; Appendices 5-7). Fourteen of the 16 species were present in all 5 sample categories (high severity unsalvaged, high severity salvaged, moderate severity, low severity, and unburned green forest). The proportions of sample locations with predicted presences varied among categories within species. Three of the 16 species—*Antrozous pallidus*, *Myotis californicus*, and *Parastrellus Hesperus*—were more prevalent with increasing severity, whereas *Corynorhinus townsendii* prevalence decreased with increasing severity. The other 12 species's prevalence showed no apparent trend with severity. Samples in the high severity salvage category had the highest proportion of points with presences averaged across the 16 species (0.71), followed by high severity unsalvaged (0.59), and unburned green forest, low severity, and moderate severity (0.49 – 0.52; Table 2. In other words, species richness was 20-40% higher in areas that burned at high severity versus other sampling areas. We have not yet determined whether this pattern is a result of increased detectability of bats or increased use by bats in high severity burns and salvaged logged areas, relative to other habitat types.

Figure 5. Bat species richness at all bat sampling locations in the Storrie Fire and Chips Fire areas in 2015.

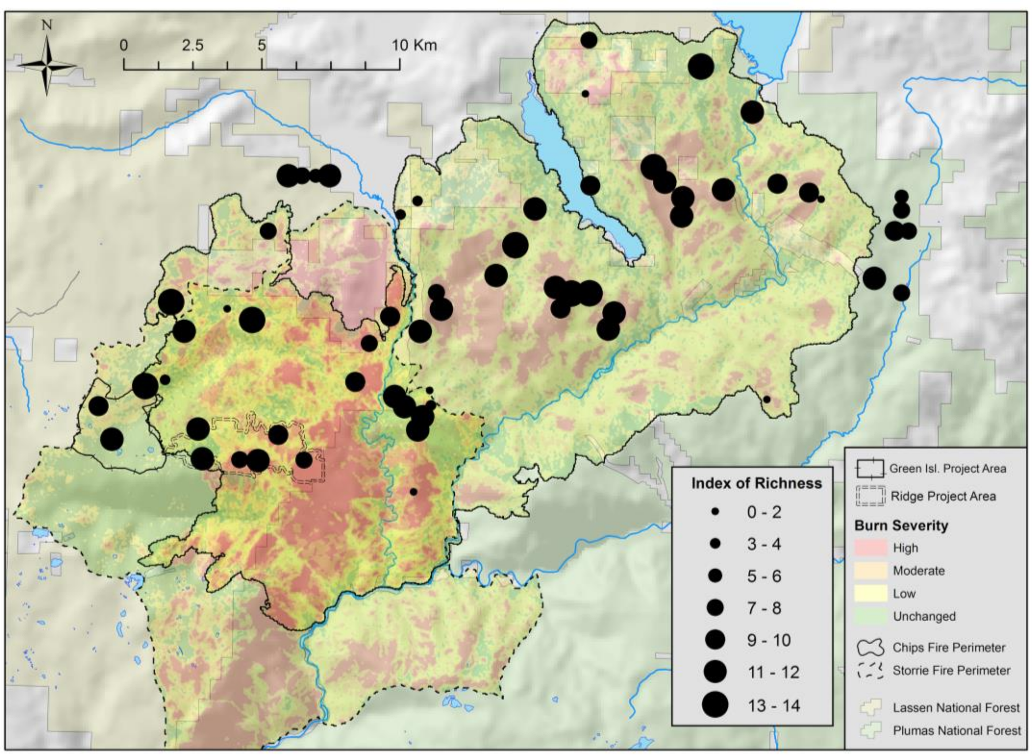


Table 2. The proportion of sampling locations with detections in each of the five sampling categories, for all bat species detected in the Storrie and Chips fire areas in 2015.

	Proportion of Locations with Predicted Species Presence				
Species	Unburned Green Forest (n=10)	Low Severity (n=16)	Moderate Severity (n=10)	High Severity Unsalvaged (n=17)	High Severity Salvaged (n=10)
Antrozous pallidus	0.10	0.12	0.50	0.47	0.70
Corynorhinus townsendii	0.20	0.12	0.00	0.06	0.00
Eptesicus fuscus	0.60	0.75	0.80	0.76	0.90
Eumops perotis	0.00	0.00	0.00	0.06	0.10
Lasiurus blossevillii	0.60	0.31	0.60	0.59	0.90
Lasiurus cinereus	0.60	0.69	0.80	0.88	1.00
Lasionycteris noctivagans	0.80	0.75	0.70	0.88	1.00
Myotis californicus	0.80	0.88	0.70	0.82	1.00
Myotis ciliolabrum	0.30	0.31	0.60	0.59	0.70
Myotis evotis	0.80	0.88	0.70	0.82	0.90
Myotis lucifugus	1.00	0.75	0.70	0.88	1.00
Myotis thysanodes	0.40	0.25	0.30	0.24	0.60
Myotis volans	0.30	0.38	0.20	0.41	0.40
Myotis yumanensis	0.70	0.62	0.60	0.65	0.80
Parastrellus hesperus	0.10	0.25	0.30	0.41	0.50
Tadarida brasiliensis	1.00	0.75	0.80	0.88	1.00

SonoBat's classifier performed well for all 16 species. AUC values >0.75 were observed for all species and >0.90 for 11 species (Table 3, Figures 6 & 7, Appendix 8). AUC confidence intervals included 0.75 for *Eumops perotis* and *Myotis ciliolabrum* only. For *M. ciliolabrum*, the lower confidence interval was 0.742, just below 0.75. The optimal thresholds for SonoBat estimated likelihoods varied between 0.048 and 0.518, but for only two were species were optimal thresholds greater than 0.1 (Table 3, Figure 7). This suggests that for 14 of 16 species, even very low estimated likelihoods of presence (<0.1) from SonoBat are very good indicators of a species' true presence on a survey-night.

Table 3. Summary statistics from receiver operator curve analyses that assessed the classification accuracy of the SonoBat estimate likelihood of nightly presence compared to manually vetted classification of presence. The analyses included data for a subset (231 nights) of ultrasonic data collected in the Storrie, Chips, Power, and Rim Fires in 2014 and 2015.

					Number of Sampling Nights	
Species	AUC (95% CI)	Optimal Threshold	Sensitivity	Specificity	Manually Classified as Present	Manually Classified as Absent
Antrozous pallidus	90.13 (83.42,96.83)	0.048	83.9	96.5	31	200
Corynorhinus townsendii	91.67 (75.33,100.0)	0.121	83.3	100.0	6	225
Eptesicus fuscus	88.18 (83.77,92.59)	0.022	82.3	94.8	96	135
Eumops perotis	77.78 (60.56,94.99)	0.495	55.6	100.0	9	222
Lasiurus blossevillii	93.62 (85.63,100.0)	0.068	88.2	98.1	17	214
Lasiurus cinereus	94.19 (91.54,96.84)	0.080	98.1	80.6	107	124
Lasionycteris noctivagans	92.07 (88.71,95.43)	0.038	88.0	91.2	117	114
Myotis californicus	97.97 (96.49,99.45)	0.092	97.1	92.9	175	56
Myotis ciliolabrum	83.59 (74.22,92.96)	0.097	68.0	99.0	25	206
Myotis evotis	95.98 (93.33,98.62)	0.097	92.2	99.2	102	129
Myotis lucifugus	91.54 (86.83,96.26)	0.096	85.7	91.7	63	168
Myotis thysanodes	96.80 (93.50,100.0)	0.097	94.1	99.4	51	180
Myotis volans	92.77 (81.87,100.0)	0.080	88.9	97.3	9	222
Myotis yumanensis	85.49 (79.34,91.64)	0.055	78.4	90.0	51	180
Parastrellus hesperus	83.61 (75.58,91.65)	0.097	70.6	94.9	34	197
Tadarida brasiliensis	93.51 (90.64,96.39)	0.518	85.2	82.0	142	89

Figure 6. Graphs displaying receiver operator characteristic curves for all 16 species of bats detected in the Storrie and Chips Fire areas. The blue shaded areas represent 95% confidence intervals.

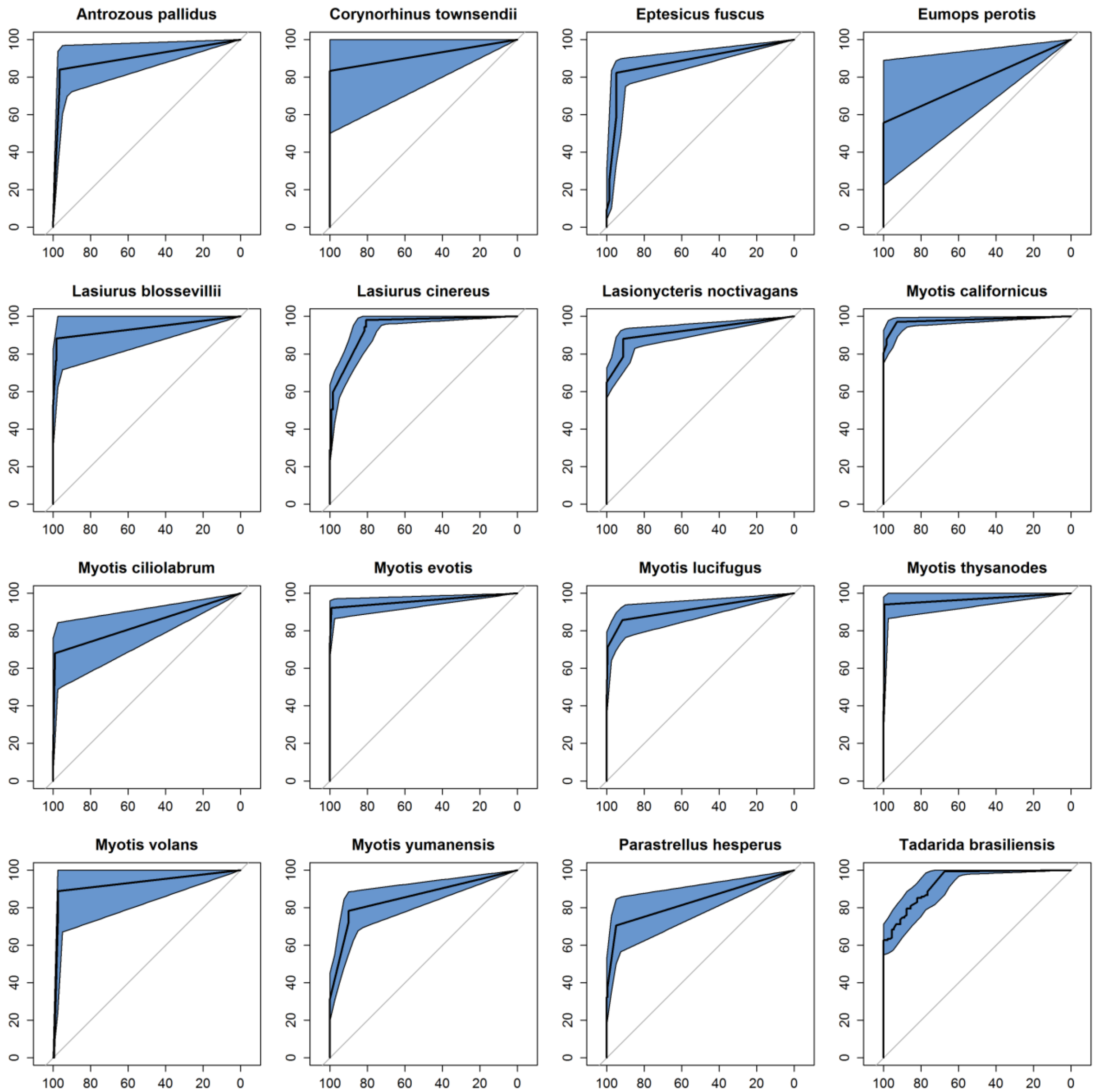
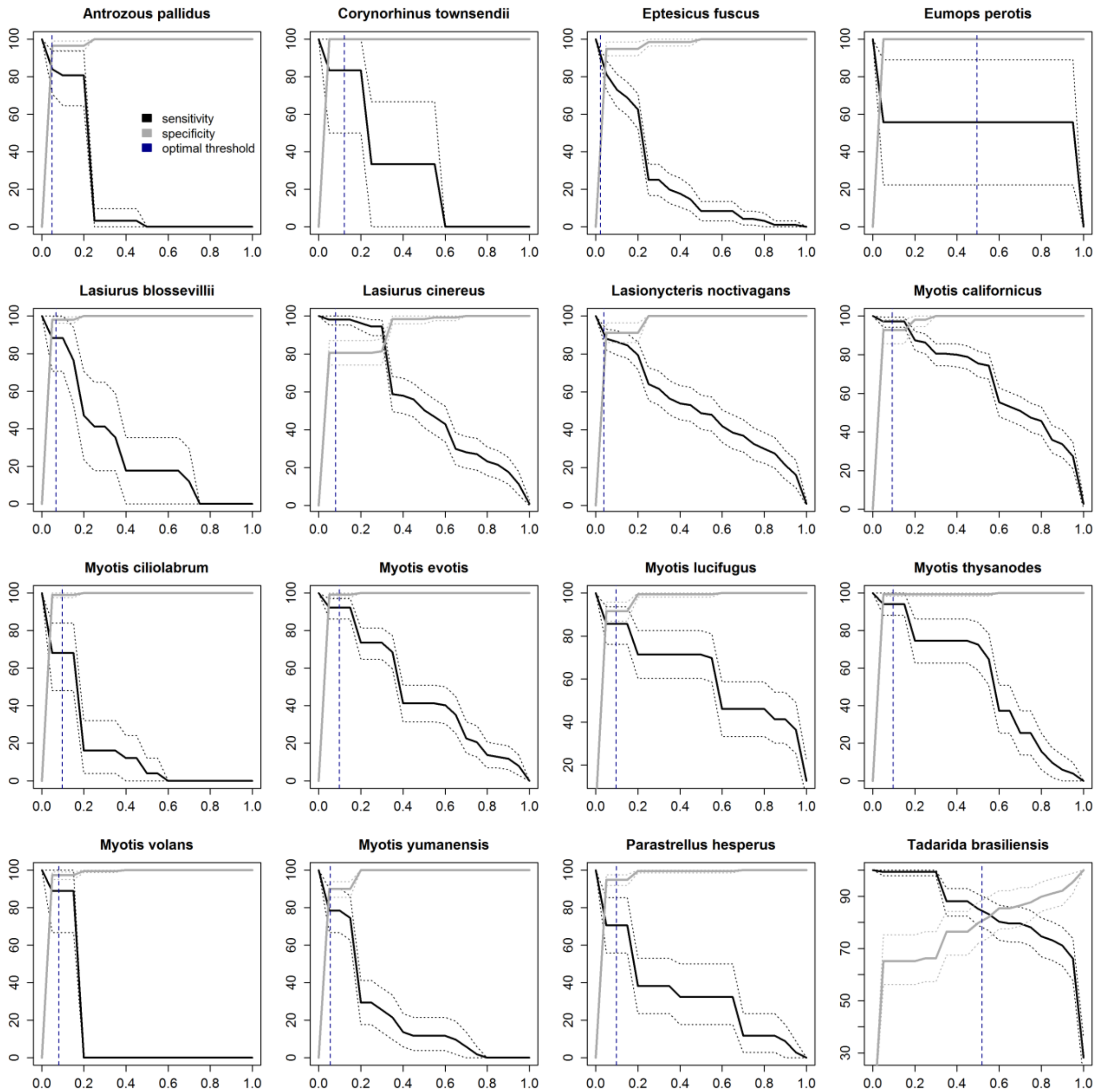


Figure 7. Graphs displaying the relationship between sensitivity and specificity (y-axis) for all values (between 0 and 1) of the SonoBat estimated likelihood of survey-night presence (x-axis). The optimal threshold, calculated as the value that maximizes the sum of sensitivity and specificity, is plotted as a vertical dashed blue line.



DISCUSSION

The response of many species to fire and the role of fire in providing habitat is poorly studied (Fontaine et al. 2009). As average fire severity, fire size, and overall annual burned area increases in the Sierra Nevada (Westerling et al. 2006; Miller & Safford 2012), post-fire habitat management activities will also likely affect an increasing amount of land in the region. Those management activities will in turn influence the abundance and distribution of wildlife, in ways that are often not studied or known, adding another layer to the complexity of managing wildlife populations in post-fire habitat. This reports documents findings from our 2015 inventory and monitoring activities in the Moonlight, Storrie, and Chips fire areas. Here we use these findings and knowledge from previous years of post-fire monitoring to provide recommendations to improve proposed restoration activities in these fire areas.

Management Implications for Moonlight Reforestation Project Area

The reforestation treatments in the Moonlight fire area are intended to establish conifer forest that is resilient to future climate conditions in areas where natural regeneration is unlikely to promote the development of forest, thereby increasing landscape heterogeneity. Treatments would accelerate long-term establishment of native conifer cover by minimizing competition from brush and other vegetation through three consecutive treatments—grapple pile and burn, mastication, and prescribed fire—in founder stands.

Depending on the extent of the footprints of the founder stands, the reforestation projects could have low to moderate impact on the current avifauna. Mastication has negative consequences for wildlife associated with early seral forest understory shrubs (Seavy et al. 2008; Burnett et al. 2009; Campos & Burnett 2014). However, despite the relatively high densities of bird species using the early seral forest understory habitat in the reforestation polygons, if the footprint of the treatment was small (e.g. 10-20% of the area of the reforestation polygons) we would expect only low to moderate impacts to those species. Species associated with post-fire snags are resilient to mastication (Campos & Burnett 2014), but site preparation methods that remove snags, such as grapple pile and burn, would likely have negative effects if they removed a substantial portion of the standing dead trees. To reduce impacts to snag-associated wildlife, to the extent feasible we recommend that founder stands be placed in areas that have the fewest snags. Based on point count data collected during Management Indicator Species monitoring on Plumas National Forest, the relative abundance of snag-associated species on Plumas National Forest ranges from 85-91% lower than species associated with early seral understory shrubs, mature dense forest, and mature open forest, so caution should be used when deciding to remove snag habitat in the Moonlight fire area. While shrubs may regrow quickly and forest may regenerate in 30–50 years, the creation of snags on this landscape (absent another fire) could be 50–100 years away. Retaining as many snags for as long as possible in these burns landscapes affords a number of species potential habitat.

Management Implications for the Ridge Project Area

The Ridge Project area contained abundances of bird species in the early seral, post-fire snag, and open forest guilds that were as high, or higher, than the rest of the Storrie and Chips Fire footprints and adjacent unburned areas. However, there were important differences in the abundance of these species between the fuel reduction and reforestation treatments that both reflected and conflicted with the purpose and need for action for each treatment area.

The fuel reduction treatments in the Ridge Project is intended to reduce hazardous surface and ladder fuels to improve the health and resilience of remnant forest stands and protect them from future high severity fire effects. Most of the area proposed for fuel reduction treatment burned at low to moderate severity in the Chips Fire after burning at low to moderate severity 12 years prior in the Storrie. The draft proposed treatment calls for concentrations of snags and down wood to be removed within the zone designated around the remnant conifer stands.

The proposed fuel reduction treatments overlap some of the highest abundances of Black-backed Woodpeckers in the Storrie and Chips Fire areas. Black-backed Woodpeckers are often thought to be mostly associated with high severity fire areas (Hanson & North 2008; Hutto 2008), which is scarce in the proposed fuel reduction treatment areas. Whereas other evidence that Black-backed Woodpeckers in the Sierra Nevada may require, or at least be more tolerant of, more heterogeneous landscapes than has been suggested for other regions (Saracco et al. 2011). The elevation range and red fir dominated forest of this project area are selected by Black-backed Woodpeckers (Saracco et al. 2011; Fogg et al. 2014), which also likely contributes to the high abundance. Because the project proposal has not yet specified treatment prescriptions, it is difficult to gauge how much material is being proposed for removal and how much

Black-backed Woodpecker habitat would be affected. Black-backed Woodpecker have been shown to be sensitive to silvicultural treatments that retain high snag density (Saab et al. 2007). As stated in the purpose and need for action, most of the fuel that is targeted for removal is in the form of recently killed standing dead timber, so the potential for this project to negatively impact Black-backed Woodpecker habitat suitability could be substantial if implemented within 8-10 years of the Chips fire.

Species in the open mature forest guild also reached their highest abundance in these proposed fuel reduction treatment areas, relative to other areas of the Storrie and Chips fire footprint and adjacent unburned forest. This suggests that the area being proposed for fuel treatment is providing suitable open forest habitat structure, as might be expected after repeated low- to moderate-severity burning under the natural fire regime.

A potential approach to reduce the negative impacts to post-fire associated birds would be to limit the fuel reduction treatments to the portions of the proposed treatment area that were classified as unchanged in both the Chips and Storrie Fires, and the small segment outside of the Chips Fire perimeter. These areas likely require the most fuel management and also pose the lowest potential for negative impacts on the Black-backed Woodpecker population if treated.

The reforestation treatments in the Ridge are intended to reestablish native conifer cover by minimizing competition from brush and other vegetation, and accelerate long-term establishment of conifer stands. According to the draft purpose and need for action, site preparation would take place in a 1- to 2-acre area at locations selected for founder stands and include: (a) for safety, the felling of snags in adjacent to the planting unit felled for safety, except those identified as wildlife habitat, and (b) pile and burn downed woody material and live brush within planting units.

As proposed, the reforestation treatments should have a low impact on the avifauna, but there is room for improvement in placement of founder stands. Despite the relatively high densities of early seral forest bird species in the reforestation treatment area, because of the small proposed extent of the founder stands (≤10% of the treatment area), we expect few impacts to those species. The abundance of post-fire snag species was also high throughout the proposed treatment area, whereas Black-backed Woodpeckers were primarily restricted to areas that did not burn at high severity in

Storrie Fire. To reduce impacts to Black-backed Woodpeckers and other species in the post-fire snag guild, we recommend that founder stands be placed primarily in areas that burned in high severity in the Storrie Fire, as these areas have the fewest snags. To avoid the need to fell large numbers of snags adjacent to the founder stands for safety, founder stands can be placed and sized in a manner such that the edge of the stand planting area is ≥30 m away from areas that burned at moderate severity or lower in the Storrie Fire and high severity in the Chips Fire.

Management Implications for the Green Island Project Area

Our understanding is that the Green Island project involves a prescribed burn of the project area to reduce fuel loading and increase resiliency of the forest when faced with future wildfire. Based on the expectation of a low severity prescribed burn with a few moderate or high severity patches, we can make some conclusions using this year's bird data about the potential effects of the project if implemented using the Ridge Project area as template.

Much like the fuels reduction treatment area of the Ridge Project, after Storrie Fire the Green Island project area was classified as an unchanged and low severity burn with small amount of moderate severity. The Green Island project area currently has relatively high abundances of open forest and early seral forest bird species, and generally low abundance (but patches of moderately high abundance) of dense forest species and very few post-fire snag species. The introduction of prescribed fire would likely result in a modestly more open forest condition with a few more snags, but a significant reduction in surface fuels. Post-fire snag species would likely respond positively – especially Black-backed Woodpeckers given the relatively high elevation of the project area – as would open forest species (Russell et al. 2009; but see Rota et al. 2014).

The presence of Black-backed Woodpeckers in the Green Island project area this year was unexpected, but not unprecedented. Black-backed Woodpecker occupancy is extremely low by 10 years post-fire in the Sierra Nevada (Saracco et al. 2011). In 2015, the Storrie Fire area was in its 15^{th} year post-fire, so the likelihood of Black-backed Woodpecker use of the Green Island project areas was very low. However, Black-backed Woodpeckers nesting in the perimeters of recent fires (e.g. the Chips Fire) do occasionally incorporate large amounts of unburned forest in their home range, and have been tracked as far as 5.4 km from the fire perimeter (Tingley et al. 2014). Black-backed Woodpeckers also occupy territories and nest in unburned green forest in the Sierra Nevada and southern Cascades, well away from recent fires (Fogg et al. 2014), so the Green Island Black-backed Woodpecker detections may be independent of the Chips Fire.

Bats

The results from our bat monitoring represent a significant contribution to the knowledge of bat distribution relative to fire in the Sierra Nevada. Only one other study on bats in a post wildfire landscape exists from the Sierra Nevada region. In that study, Buchalski et al. (2013) found that bat activity in burned areas was either equivalent or higher than in unburned stands for all bat groups that they measured. Except for one species, the pattern found by Buchalski et al. (2013) reflects our findings from this year. These findings from post-fire landscapes in mixed-conifer forests of the Sierra's suggest that bats are resilient to mixed severity fire at the landscape-scale and that some species are preferentially selecting burned areas, including those that burn at the highest severity.

Burned areas may offer increased foraging habitat in the form of forests with reduced obstructions, increased post-fire availability of prey, and more roosts. For some species, fires and other disturbances potentially increase foraging habitat quality by reducing the amount of vegetation in the forest canopy and understory, which can obstruct flyways and interfere with echolocation. Previous studies have found several species of bats avoid foraging in denser forests with more so called "clutter" (Brigham et al. 1997a; Erickson & West 2003). Fire can also increase the abundance of terrestrial and aquatic insect prey (Swengel 2001; Lacki et al. 2009; Malison & Baxter 2010), which likely increases foraging opportunities; however, the structural characteristics of a forest after a fire may be more important than prey density (Armitage & Ober 2012). Lastly, burned areas may be attractive because they provide increased numbers of roosting opportunities (Boyles & Aubrey 2006), such as under flaking bark and tree crevices (Brigham et al. 1997b; Kalcounis & Brigham 1998; Betts 1998; Crampton & Barclay 1998). Species that preferentially roost in trees would likely be more susceptible to salvage and harvest operations. The data presented here does not indicate the reasons for bat presence in the fires (e.g. roosting habitat vs. foraging habitat), which likely varies among species.

The choice of a probability threshold for categorizing probabilities of presence and absence into predicted presence and absence should be carefully evaluated at the discretion of the manager. We calculated an optimal threshold of the estimated SonoBat likelihood as the value that maximizes both sensitivity and specificity. This method assumes that false negative detections and false positive detections are equally undesirable by equally weighting sensitivity and specificity in the calculation. Depending on the question or application of the data, the optimal threshold may vary because a false negative may outweigh false positive and vice versa. Lowering the threshold increases the number of locations classified as occupied, increasing the number of false positives and decreasing the number of false negatives, which could be prudent if the cost of false negatives is high, such as with sensitive, threatened, and endangered species. For rare and sensitive species false negative and false positive detections pose a management problem. Manually vetting the data when the estimated likelihood of presence is >0 reduces false positives. For more common species with plenty of detections, increasing the threshold may be more desirable because false negatives can be addressed by repeated sampling and occupancy modeling, whereas false positives violate the assumptions of many modeling techniques.

Manuscript Progress

We are working on two manuscripts using data collected for post-fire monitoring efforts on Lassen and Plumas National Forest since 2009.

The Relationship of Bird Abundance with Fire Severity and Time Since Fire

We are on track to submit our manuscript, "Burn severity and time since fire create dynamic avian communities in post-fire forests" in 2016. We have completed all analyses and are refining a draft manuscript now. We are targeting Biological Conservation for this publication. The manuscript uses 4 years of point count data from 196 sampling stations in the Moonlight, Storrie, and Cub fires to evaluate the influence of fire severity, time since fire, their interaction, and pre-fire forest condition on the 39 most prevalent species across the three fire areas.

Habitat Suitability Models for Cavity Nesting Birds

The other manuscript will synthesize 8 years of data from cavity nests of birds at over 70 20-ha sampling plots in the Storrie, Moonlight, Chips, and Cub Fires on the Plumas and Lassen National Forests (Table 4). The goal is to develop a predictive model of habitat suitability that can be used to help guide management in future post-fire areas in the Northern Sierra, and hopefully tested elsewhere in the Sierra Nevada range. The habitat suitability models will use variables measured remotely and on-the-ground, at multiple spatial scales, from the nest locations of Black-backed Woodpecker, Hairy Woodpecker, White-headed Woodpecker, Northern Flicker, Mountain Bluebird and Western Bluebird. The data from nest locations will be compared to data from available nest locations using a resource selection function. The predictive capacity of these models will be reliant on remotely sensed data only, however, habitat measurements taken on the ground will help us identify variables of interest that may be derived via LiDAR data.

Table 4. Summary of sample sizes for nest data by species and year.

	Year							
Species	2009	2010	2011	2012	2013	2014	2015	*Totals*
BBWO	4	17	16	14	10	8	10	79
HAWO	12	40	20	33	13	13	9	140
NOFL	13	29	20	29	7	5	11	114
RBSA	7	12	19	11	4	2	1	56
WEBL	4	5	7	13	2	4	7	42
WHWO	10	33	16	31	25	23	14	152
MOBL	10	32	26	44	0	3	7	122
LEWO	3	9	2	10	0	0	0	24
Totals	63	177	126	185	61	58	59	729

We have compiled a dataset of the following remotely sensed variables for all four fires at 100, 250, 500, 1000, and 2000-m radius scales:

- average relative differenced Normalized Burn Ratio
- standard deviation of the relative differenced Normalized Burn Ratio
- length of edge between fire severity classes
- pre-fire three-year average and standard deviation of LANDSAT band 4 values from the growing season (Jun-Jul or Jul-Aug [depending on snow cover])
- proportion of area in each pre-fire CWHR type
- proportion of area in each pre-fire CWHR stand size/density class

In addition to these variables, we will incorporate the following variables measured at a 30-m pixel scale:

- elevation
- slope
- aspect
- pre-fire CWHR type
- pre-fire CWHR stand size classification
- pre-fire CWHR stand density classification
- distance to high severity patch edge
- distance to low severity patch edge
- distance to fire perimeter

Incorporating LiDAR data into the models will likely be an analysis used in a separate manuscript that compares models using on-the-ground habitat measurements and non-LiDAR remotely sensed variables to models that incorporate live tree and snag measurements derived from LiDAR data. LiDAR data is increasingly available for postfire areas in the Sierras and we suspect LiDAR-derived layers such as canopy cover, snag density, and snag volume will be very useful for explaining variance when included in a habitat suitability model for cavity nesting birds. We are working in collaboration with Brian Wing on the LiDAR-specific elements of this research. And we are working with a student seeking an advanced degree in GIS to assist in compiling the remotely sensed layers for analysis.

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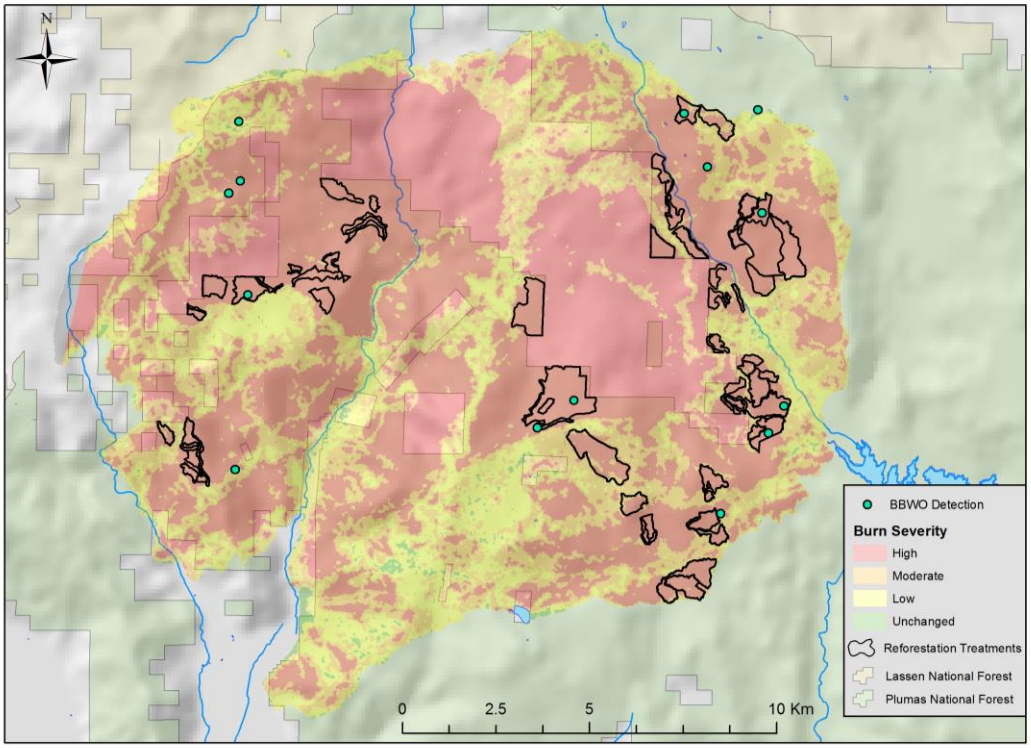
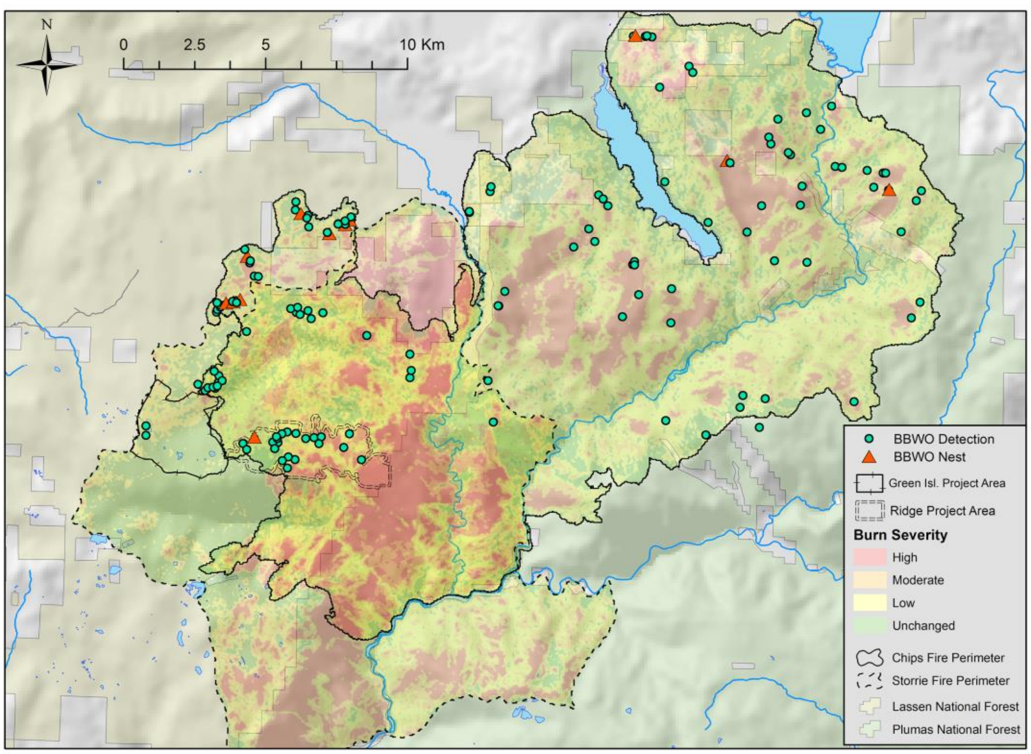
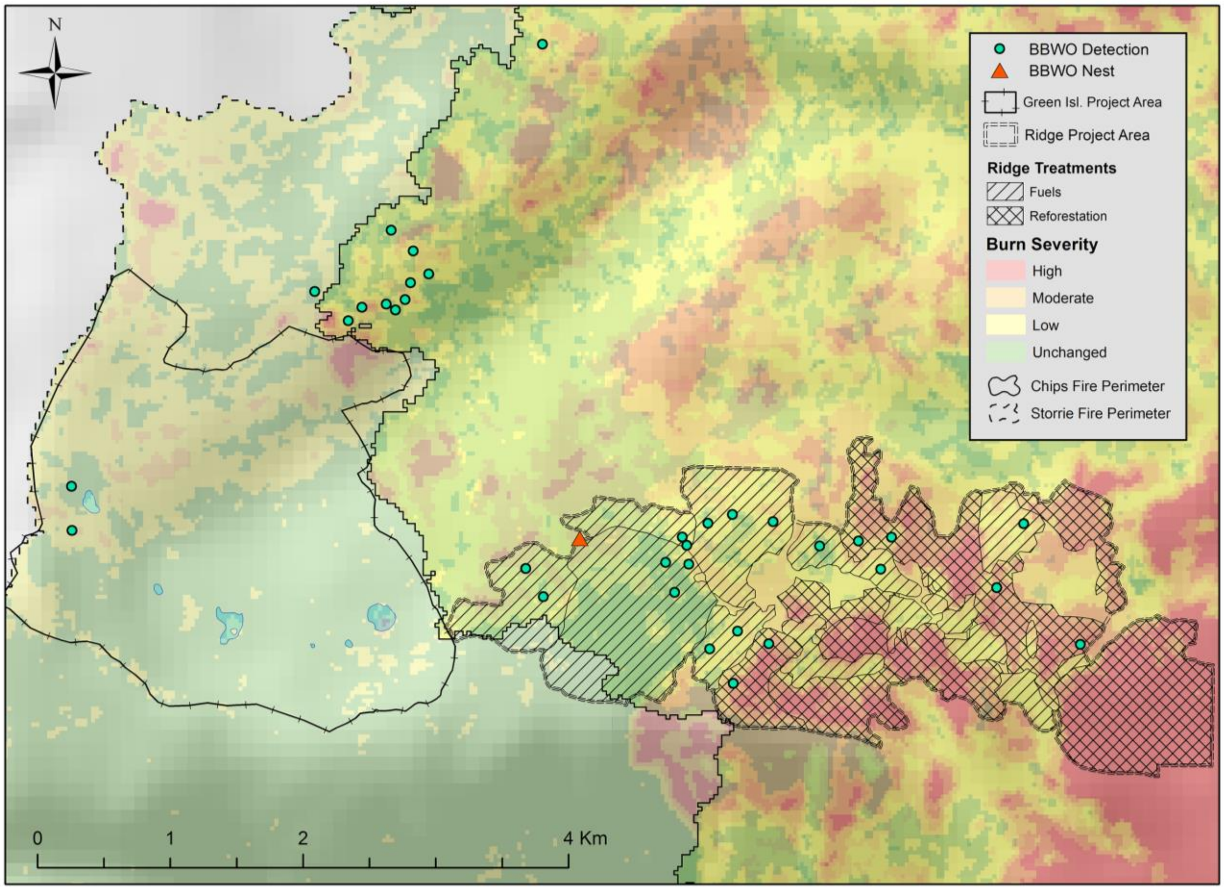
APPENDICES

Appendix 1. Maps of Black-backed Woodpecker locations detected during field work in and near the Moonlight, Storrie, and Chips fire areas.





Appendix 2. Map of Black-backed Woodpecker locations detected during field work in the Ridge and Green Island project areas.



Appendix 3. Detections of Black-backed Woodpecker on Plumas National Forest during field work in and near the Moonlight, Storrie, and Chips fire areas.

Observer	Date	Near Transect	Near Site	Qty Adults	Easting	Northing	Nest	Observer Activity
LMO	8/12/2015	213	2	1	664342	4444724	N	Veg survey
CLS	6/15/2015	213	2	2	664357	4444751	Y	Point count survey
DJL	5/16/2015	213	6	1	665324	4444383	N	Point count survey
DJL	5/16/2015	213	7	1	665493	4444738	N	Point count survey
WCW	6/8/2015	214	2	1	650451	4437552	N	Point count survey
WMH	7/10/2015	222	11	1	665580	4440818	N	Veg survey
DJL	7/24/2015	223	1	1	661357	4447353	N	Veg survey
DJL	7/21/2015	223	8	1	661872	4446784	N	Veg survey
JML	6/8/2015	223	8	1	661872	4446784	N	Point count survey
JML	6/5/2015	224	9	1	660399	4442101	N	Point count survey
WMH	6/1/2015	314	6	2	663371	4437238	N	Point count survey
DJL	5/13/2015	BVR1	1	1	658015	4443374	N	Point count survey
DJL	7/17/2015	BVR1	9	1	656444	4444761	N	ARU deployment
LMO	8/14/2015	BVR2	12	2	656809	4441001	N	Veg survey
DJL	6/1/2015	BVR3	1	1	656158	4448081	N	Point count survey
DJL	6/3/2015	BVR3	1	1	656158	4448081	N	Point count survey
DJL	6/9/2015	CAR1	10	1	655111	4439954	N	Point count survey
LMO	7/28/2015	CAR2	6	1	659356	4436903	N	Veg survey
WMH	6/1/2015	CAR2	9	1	659446	4437326	N	Point count survey
CLS	7/27/2015	CAR3	2	1	658188	4435892	N	Veg survey
LMO	7/27/2015	CAR3	12	1	656754	4436356	N	Veg survey
EEI	5/17/2015	CS03	1	1	662232	4447611	N	Point count survey
WMH	6/15/2015	CS03	1	1	662232	4447611	N	Point count survey
DJL	7/15/2015	CS03	7	1	664125	4445319	N	Veg survey
WMH	6/15/2015	CS03	7	1	664217	4445319	N	Point count survey
WMH	6/15/2015	CS03	9	1	663556	4445392	N	Point count survey
EEI	5/17/2015	CS03	12	1	664829	4443268	N	Point count survey
DJL	6/6/2015	CS04	4	1	661283	4444767	N	Point count survey
DJL	6/6/2015	CS04	8	2	661247	4444089	N	Point count survey
EEI	5/13/2015	CS05	2	1	658618	4445589	Y	Point count survey
DJL	7/7/2015	CS05	3	1	658720	4445498	N	Veg survey
CLS	5/13/2015	CS06	7	1	659403	4443080	N	Point count survey
JML	7/15/2015	CS07	3	1	656822	4439799	N	Veg survey
JML	6/9/2015	CS08	3	1	655478	4441797	N	Point count survey
JML	6/9/2015	CS08	3	1	655412	4441805	N	Point count survey
JML	6/9/2015	CS08	3	3	655460	4441872	N	Point count survey
JML	6/9/2015	CS08	3	1	655474	4441916	N	Point count survey
WMH	7/13/2015	CS08	9	1	655657	4440753	N	Veg survey

Observer	Date	Near Transect	Near Site	Qty Adults	Easting	Northing	Nest	Observer Activity
JML	7/13/2015	CS09	9	1	650937	4440711	N	Veg survey
JEM	5/14/2015	CS09	10	1	650744	4440196	N	Point count survey
DJL	6/4/2015	CS09	10	1	650715	4440197	N	Point count survey
WMH	6/9/2015	CS10	5	3	654127	4444215	N	Veg survey
LMO	7/9/2015	CS10	6	2	654294	4444078	N	Point count survey
WMH	6/9/2015	CS10	7	1	654466	4443848	N	Point count survey
WMH	6/9/2015	CS10	8	1	655474	4441916	N	Point count survey
WMH	6/9/2015	CS10	9	1	655478	4441797	N	Point count survey
DJL	7/14/2015	CS12	1	1	665292	4440253	N	Veg survey
EEI	5/21/2015	CS12	2	1	665292	4440253	N	Point count survey
CLS	6/12/2015	LA44B	C	1	686278	4460205	N	Point count survey
CLS	5/28/2015	ML01	2	1	698166	4460811	N	Point count survey
CLS	6/10/2015	ML01	11	1	686480	4450905	N	Point count survey
CLS	6/11/2015	ML03	4	1	686062	4458291	N	Point count survey
CLS	6/11/2015	ML03	9	1	686371	4458624	N	Point count survey
JML	5/28/2015	ML12	11	1	698840	4459410	N	Point count survey
JEM	5/21/2015	MLT08	6	1	686673	4455586	N	Point count survey
JML	5/29/2015	MLT2	2	1	700336	4458234	N	Point count survey
CLS	6/13/2015	MLT4	4	1	701095	4453096	N	Point count survey
CLS	6/13/2015	MLT4	4	1	701095	4453096	N	Point count survey
CLS	6/13/2015	MLT4	8	1	700698	4452364	N	Point count survey
CLS	6/13/2015	MLT4	8	1	700698	4452364	N	Point count survey
CLS	6/19/2015	MLT5	3	1	699499	4450164	N	Point count survey
JML	6/19/2015	MLT7	5	1	695472	4453059	N	Point count survey
JML	6/18/2015	MLT7	10	1	694520	4452301	N	Incidental
BJL	5/13/2015	MSQ2	2	1	653824	4443013	N	Point count survey
DJL	7/20/2015	MSQ2	8	1	653312	4442358	N	Veg survey
DJL	7/20/2015	MSQ2	11	1	654049	4442577	N	Veg survey
EEI	5/16/2015	OHC1	3	1	660137	4446212	N	Point count survey
EEI	5/16/2015	OHC1	4	1	660054	4446452	N	Point count survey
EEI	5/16/2015	OHC1	7	2	660357	4447093	N	Point count survey
WMH	5/16/2015	OHC1	12	1	660836	4445855	N	Incidental
CLS	6/8/2015	OHC1	12	1	660844	4445857	N	Point count survey
EEI	5/16/2015	OHC1	12	1	660759	4445924	N	Point count survey
EEI	6/15/2015	OHC2	2	1	662430	4445496	N	Point count survey
CLS	5/15/2015	OHC2	3	2	662667	4445468	N	Point count survey
EEI	6/15/2015	OHC2	10	1	663812	4444810	N	Point count survey
CLS	5/18/2015	PL22A	C	1	660058	4436222	N	Playback
EEI	6/1/2015	PL22B	E	1	660237	4437239	N	Point count survey
EEI	8/6/2015	SEN1	1	1	661550	4442089	N	Veg survey
EEI	5/13/2015	SENW	4	2	659882	4444025	N	Point count survey

Observer	Date	Near Transect	Near Site	Qty Adults	Easting	Northing	Nest	Observer Activity
DJL	8/5/2015	ST02	R4	1	650684	4436098	N	Veg survey

Observers: BJL = Brent J. Leyerle, CLS = Carine L. Squibb, DJL = Daniel J. Lipp, EEI = Eric-Evan Irvin, JEM = Jeffrey E. Moker, JML = Joseph M. Leibrecht, LMO = Lauren Morgan-Outhisack, WCW = Wendy C. Willis, WMH = Wyatt M. Hersey

Appendix 4. Detections of Black-backed Woodpecker on Lassen National Forest during field work in and near the Moonlight, Storrie, and Chips fire areas.

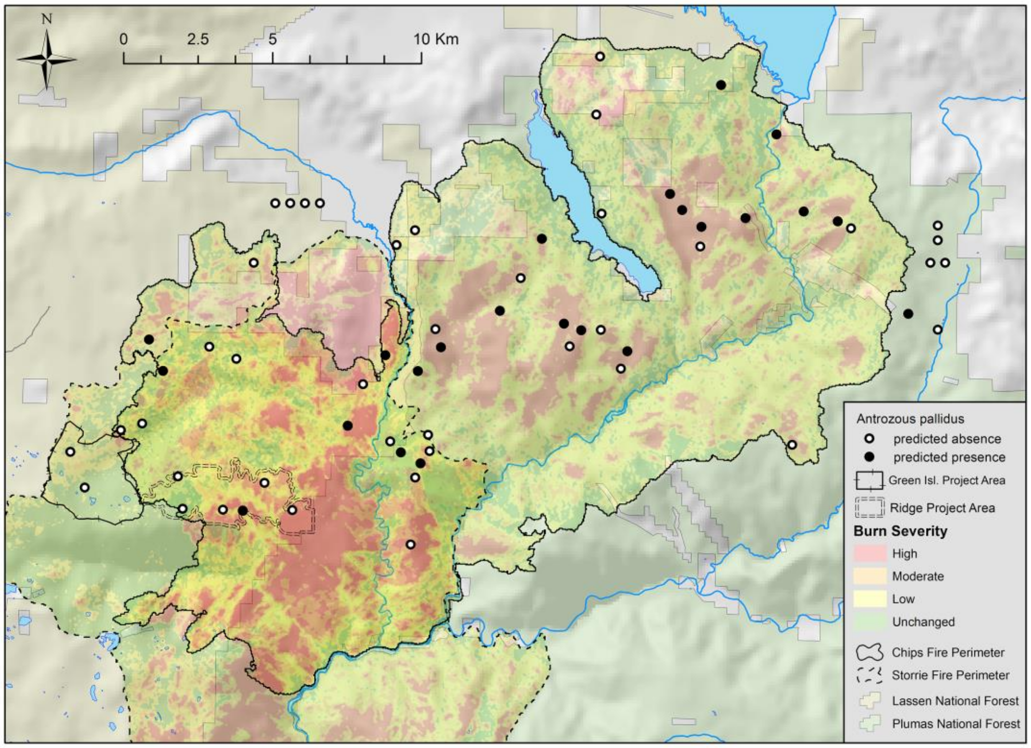
Observer	Date	Near Transect	Near Site	Qty Adults	Easting	Northing	Nest	Observer Activity
JML	7/16/2015	CH01	1	1	640803	4439656	N	Veg survey
WMH	5/19/2015	CH01	1	1	640839	4439740	N	Nest survey
EEI	6/9/2015	CH01	2	1	640940	4439832	N	Point count survey
JML	7/16/2015	CH01	2	1	640938	4439837	N	Veg survey
JML	7/16/2015	CH01	2	1	640913	4439910	N	Veg survey
JML	7/16/2015	CH01	3	2	641124	4439928	N	Veg survey
EEI	6/9/2015	CH01	3	1	641161	4439936	N	Nest survey
WMH	5/19/2015	CH01	3	2	641133	4439989	Y	Nest survey
WMH	5/19/2015	CH01	4	2	641472	4440073	N	Nest survey
EEI	6/9/2015	CH01	4	1	641385	4440041	Y	Nest survey
JML	7/16/2015	CH01	4	1	641357	4440048	N	Veg survey
WMH	5/19/2015	CH01	5	2	641623	4440131	Y	Nest survey
JML	7/30/2015	CH01	R1	1	641500	4440012	N	Veg survey
JML	7/30/2015	CH01	R2	1	640817	4439983	N	Veg survey
EEI	5/19/2015	CH02	1	2	642099	4440962	N	Point count survey
JEM	6/15/2015	CH02	1	2	642099	4440962	N	Nest survey
EEI	5/19/2015	CH02	3	1	641920	4441421	N	Point count survey
EEI	5/19/2015	CH02	4	2	641829	4441656	Y	Nest survey
JEM	6/15/2015	CH02	4	1	641829	4441656	Y	Point count survey
EEI	5/19/2015	CH02	5	1	641736	4441888	N	Point count survey
JML	7/30/2015	CH02	R3	2	641941	4441498	N	Veg survey
JEM	6/8/2015	CH03	1	2	643478	4443625	N	Point count survey
JML	7/28/2015	CH03	2	1	643464	4443341	N	Veg survey
LMO	5/20/2015	CH03	3	1	643919	4443162	N	Nest survey
LMO	5/20/2015	CH03	3	1	643665	4443223	Y	Nest survey
LMO	5/20/2015	CH03	4	1	643879	4443067	N	Nest survey
LMO	5/20/2015	CH03	5	1	643960	4442755	N	Point count survey
JEM	5/20/2015	CH04	1	2	645392	4443053	Y	Nest survey
DJL	6/30/2015	CH04	1	1	645431	4443156	N	Veg survey
JEM	5/20/2015	CH04	2	2	645242	4442892	Y	Nest survey
LMO	7/1/2015	CH04	2	1	645242	4442892	N	Veg survey
LMO	7/15/2015	CH04	2	1	645232	4443008	N	Veg survey
JEM	5/20/2015	CH04	3	1	644992	4442903	N	Incidental
LMO	6/8/2015	CH04	4	1	644985	4442891	N	Point count survey
JEM	5/20/2015	CH04	5	2	644692	4442551	Y	Nest survey
LMO	6/8/2015	CH04	5	2	644614	4442586	N	Point count survey
WMH	6/13/2015	CH06	4	1	650305	4444211	N	Nest survey
JML	7/27/2015	CH06	R3	1	650333	4444386	N	Veg survey

Observer	Date	Near Transect	Near Site	Qty Adults	Easting	Northing	Nest	Observer Activity
LMO	5/13/2015	CS01	13	1	657163	4448853	N	Point count survey
LMO	5/13/2015	CS01	14	1	657305	4448637	N	Incidental
BJL	6/9/2015	CS02	3	1	655823	4449840	N	Incidental
CLS	6/9/2015	CS02	4	1	655588	4449852	N	Incidental
JEM	5/13/2015	CS02	4	1	655650	4449874	N	Incidental
JEM	5/13/2015	CS02	6	1	655174	4449844	N	Point count survey
CLS	6/9/2015	CS02	6	2	655243	4449885	Y	Point count survey
LMO	6/29/2015	CS09	1	1	649599	4443453	N	Point count survey
DJL	6/29/2015	CS09	1	2	649593	4443485	N	Incidental
JML	7/13/2015	CS09	9	1	650937	4440711	N	Veg survey
JML	6/15/2015	GRN1	1	2	638465	4435233	N	Point count survey
BJL	5/25/2015	GRN1	2	1	638451	4435565	N	Playback
LMO	5/19/2015	LA08B	W	1	644556	4439747	N	Point count survey
LMO	5/19/2015	LA08C	E	1	644027	4439804	N	Point count survey
LMO	5/19/2015	LA08C	W	1	643615	4439732	N	Point count survey
WMH	6/3/2015	RDG1	1	1	641891	4435059	N	Point count survey
BJL	6/17/2015	RDG1	1	1	641892	4435059	N	Playback
BJL	6/17/2015	RDG1	2	2	642031	4434853	N	Point count survey
BJL	6/3/2015	RDG1	12	2	642291	4435299	Y	Incidental
BJL	6/3/2015	RDG2	3	1	643118	4435133	N	Incidental
CLS	6/17/2015	RDG2	3	1	642944	4435140	N	Point count survey & playback
JML	6/3/2015	RDG2	4	1	643018	4434917	N	Point count survey
JML	6/3/2015	RDG2	7	1	643742	4435473	N	Playback
CLS	6/17/2015	RDG2	9	1	643435	4435516	N	Point count survey
CLS	6/17/2015	RDG2	11	2	643253	4435444	N	Point count survey & playback
JML	6/3/2015	RDG2	12	1	643099	4435274	N	Point count survey
CLS	6/17/2015	RDG2	12	1	643063	4435335	N	Point count survey
EEI	6/17/2015	RDG3	1	2	643740	4434555	N	Point count survey & playback
EEI	6/17/2015	RDG3	2	3	643503	4434642	N	Point count survey
JML	6/4/2015	RDG3	3	1	643296	4434502	N	Point count survey & playback
JML	6/4/2015	RDG3	4	1	643483	4434248	N	Point count survey
BJL	6/3/2015	RDG4	11	1	645444	4435033	N	Playback
EEI	6/16/2015	RDG5	1	2	644099	4435302	N	Point count survey
EEI	6/16/2015	RDG5	2	1	644391	4435348	N	Playback
BJL	6/4/2015	RDG5	4	1	644638	4435385	N	Playback
EEI	6/16/2015	RDG5	5	1	644565	4435142	N	Point count survey
EEI	6/16/2015	RDG5	10	3	645630	4435519	N	Point count survey
BJL	6/16/2015	RDG6	2	1	646087	4434627	N	Playback
DJL	7/13/2015	ST01	3	1	646129	4439002	N	Veg survey
LMO	6/15/2015	ST06	1	1	643419	4439860	N	Nest survey
LMO	6/15/2015	ST06	2	1	643658	4439911	N	Nest survey

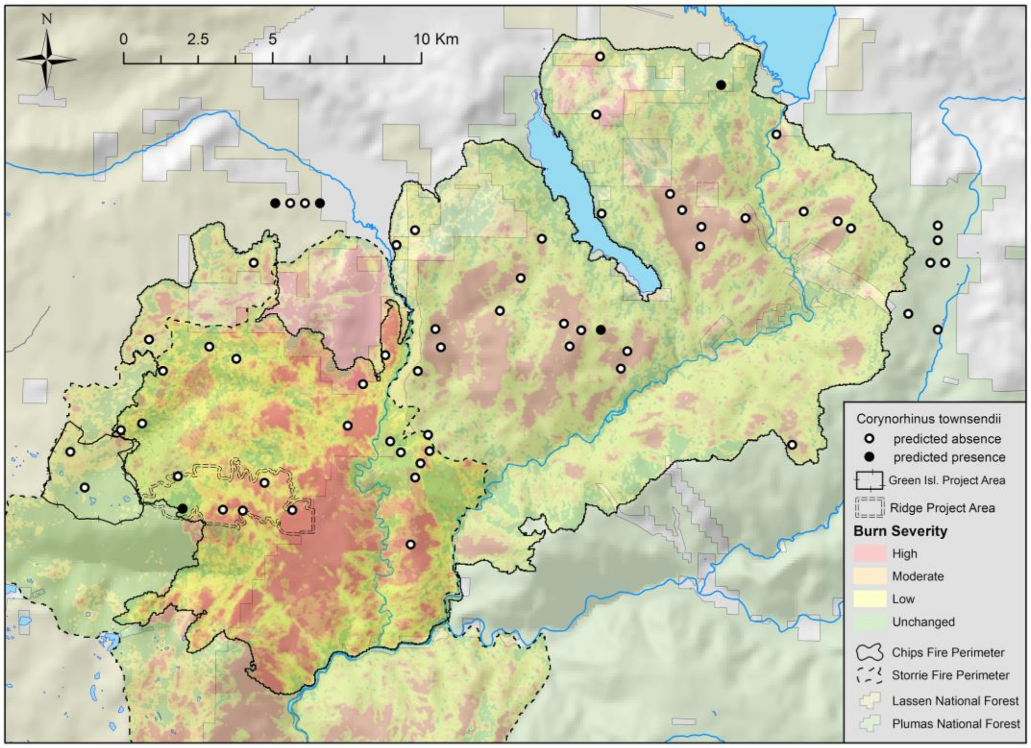
Observer	Date	Near Transect	Near Site	Qty Adults	Easting	Northing	Nest	Observer Activity
LMO	6/15/2015	ST06	3	2	643753	4439663	N	Nest survey
LMO	5/19/2015	ST06	4	1	644153	4439530	N	Incidental
LMO	5/15/2015	ST11	4	1	647697	4437570	N	Nest survey
BJL	5/8/2015	ST11	5	1	647733	4437821	N	Incidental
EEI	6/6/2015	ST13	5	1	647665	4438390	N	Point count survey
JEM	6/16/2015	ST15	2	2	640954	4437178	N	Point count survey
BJL	5/27/2015	ST15	4	1	640494	4436877	N	Nest survey
JML	5/27/2015	ST15	5	1	640234	4437089	N	Incidental
BJL	5/27/2015	ST15	5	2	640966	4437417	N	Point count survey
DJL	7/30/2015	ST15	R1	1	640847	4436969	N	Veg survey
DJL	7/30/2015	ST15	R2	1	640593	4436981	N	Veg survey
DJL	7/30/2015	ST15	R3	1	640775	4437011	N	Veg survey
DJL	7/30/2015	ST15	R4	1	641088	4437248	N	Veg survey
DJL	7/30/2015	ST15	R5	1	640916	4437050	N	Veg survey
DJL	7/16/2015	STMW	3	2	640794	4437567	N	Bat detector deployment
WMH	6/15/2015	STMW	9	1	642235	4440952	N	Point count survey
DJL	7/28/2015	STMW	11	1	641889	4439002	N	Bat detector deployment

Observers: BJL = Brent J. Leyerle, CLS = Carine L. Squibb, DJL = Daniel J. Lipp, EEI = Eric-Evan Irvin, JEM = Jeffrey E. Moker, JML = Joseph M. Leibrecht, LMO = Lauren Morgan-Outhisack, WCW = Wendy C. Willis, WMH = Wyatt M. Hersey

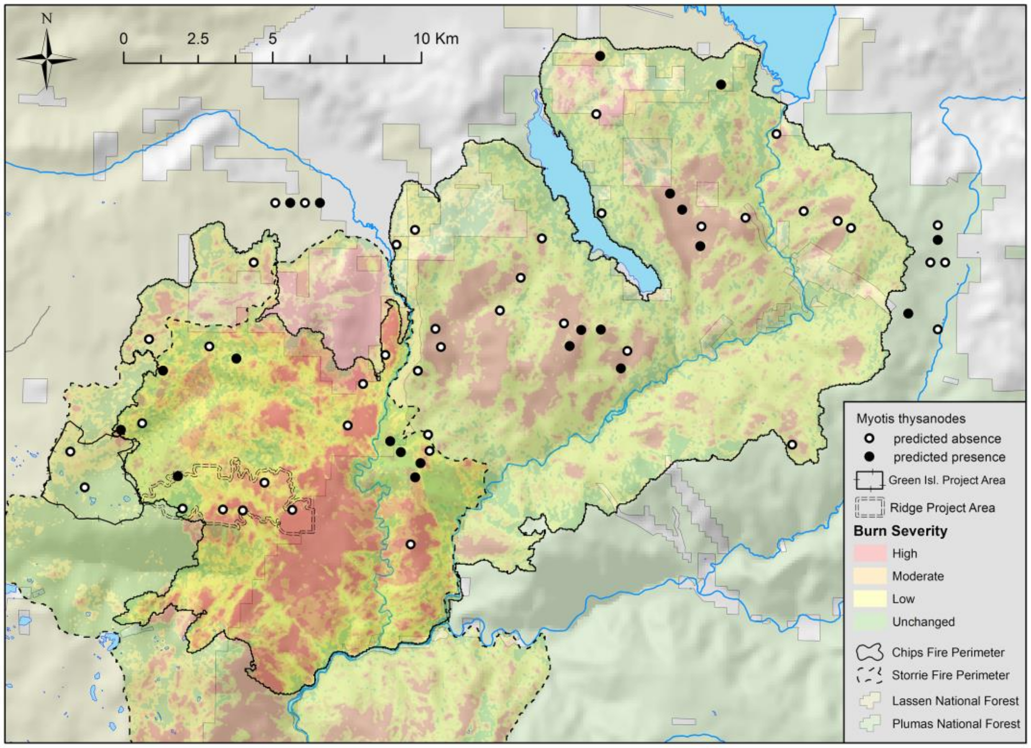
Appendix 5. Predicted presence of *Antrozous pallidus* as calculated by applying an optimal threshold on SonoBat estimated nightly likelihoods.



Appendix6. Predicted presence of *Corynorhinus townsendii* as calculated by applying an optimal threshold on SonoBat estimated nightly likelihoods.



Appendix 7. Predicted presence of *Myotis thysanodes* as calculated by applying an optimal threshold on SonoBat estimated nightly likelihoods.



Appendix 8. Confusion matrices showing the number of correctly and incorrectly classified presences (ones) and absences (zeroes) when applying an optimal threshold (see methods for calculation) on the 231 nights of data used in classification analyses. Each 4-by-4 table includes the number classifications that are true positive (top left), true negative (bottom right), false positive (bottom left), and false negative (top right) for each species for each of the 231 nights.

```
anpa
          Manual
Prediction   0   1
         0 193   6
         1   7  25
```

```
myci
          Manual
Prediction   0   1
         0 204   8
         1   2  17
```

```
labl
          Manual
Prediction   0   1
         0 210   2
         1   4  15
```

```
myvo
          Manual
Prediction   0   1
         0 216   1
         1   6   8
```

```
coto
          Manual
Prediction   0   1
         0 225   1
         1   0   5
```

```
myev
          Manual
Prediction   0   1
         0 128   8
         1   1  94
```

```
laci
          Manual
Prediction   0   1
         0 100   2
         1  24 105
```

```
myyu
          Manual
Prediction   0   1
         0 162  11
         1  18  40
```

```
epfu
          Manual
Prediction   0   1
         0 128  26
         1   7  70
```

```
mylu
          Manual
Prediction   0   1
         0 154   9
         1  14  54
```

```
lano
          Manual
Prediction   0   1
         0 104  16
         1  10 101
```

```
pahe
          Manual
Prediction   0   1
         0 187  10
         1  10  24
```

```
eupe
          Manual
Prediction   0   1
         0 222   4
         1   0   5
```

```
myth
          Manual
Prediction   0   1
         0 179   3
         1   1  48
```

```
myca
          Manual
Prediction   0   1
         0  52   5
         1   4 170
```

```
tabr
          Manual
Prediction   0   1
         0  58   1
         1  31 141
```

Appendix 9. Relative raw average abundance (individuals per point per visit) of all bird species at sampling locations on Plumas National Forest in the Moonlight, Storrie, and Chips fire areas in 2015. This method of abundance calculation differs from the methods presented in the body of the report in that all detections at unlimited distance were used, and the control sample was unrefined (see Methods). This table is provided as a comprehensive list of species detected. ST = Storrie. ML = Moonlight.

Common Name	Storrie and Chips	Moonlight Control	Moonlight Impact
Acorn Woodpecker	--	0.008	--
American Goldfinch	0.008	--	--
American Kestrel	0.005	0.025	0.055
American Robin	0.123	0.381	0.267
Anna's Hummingbird	0.021	0.017	--
Ash-throated Flycatcher	0.002	--	--
Band-tailed Pigeon	0.010	0.008	--
Bewick's Wren	0.010	0.076	--
Black-backed Woodpecker	0.053	0.110	0.130
Black-headed Grosbeak	0.154	0.619	0.103
Black-throated Gray Warbler	0.015	--	--
Blue-gray Gnatcatcher	0.002	--	--
Brewer's Sparrow	--	0.051	0.260
Brown Creeper	0.335	0.305	0.226
Brown-headed Cowbird	0.006	0.008	0.027
Bullock's Oriole	0.002	--	--
Bushtit	0.010	0.229	0.014
California Quail	--	0.025	0.007
Calliope Hummingbird	0.026	0.008	0.014
Canyon Wren	--	0.008	--
Cassin's Finch	0.194	0.110	0.178
Cassin's Vireo	0.220	0.085	--
Chipping Sparrow	0.123	0.263	0.664
Clark's Nutcracker	--	0.034	--
Common Nighthawk	0.002	--	0.014
Common Raven	0.010	0.059	0.096
Dark-eyed Junco	0.778	0.873	1.144
Dusky Flycatcher	0.306	0.788	1.041
European Starling	--	--	0.027
Evening Grosbeak	0.006	0.017	0.007
Fox Sparrow	0.282	1.678	2.370
Golden-crowned Kinglet	0.094	--	--
Green-tailed Towhee	0.036	0.441	1.055
Hairy Woodpecker	0.306	0.178	0.226
Hammond's Flycatcher	0.066	--	--
Hermit Thrush	0.047	0.008	0.014

Common Name	Storrie and Chips	Moonlight Control	Moonlight Impact
Hermit Warbler	0.563	--	--
House Wren	0.277	1.432	2.178
Hutton's Vireo	0.002	--	--
Lazuli Bunting	0.675	1.356	0.466
Lesser Goldfinch	0.024	0.025	0.021
Lewis's Woodpecker	0.002	0.025	0.007
Lincoln's Sparrow	0.002	--	0.034
MacGillivray's Warbler	0.121	0.788	0.651
Mountain Bluebird	0.157	0.314	0.637
Mountain Chickadee	0.455	0.203	0.356
Mountain Quail	0.070	0.958	1.110
Mourning Dove	0.034	0.068	0.096
Nashville Warbler	0.372	0.983	0.226
Northern Flicker	0.102	0.610	0.753
Northern Pygmy-Owl	0.006	--	--
Olive-sided Flycatcher	0.097	0.220	0.082
Orange-crowned Warbler	0.037	0.153	0.096
Pacific Wren	0.006	--	--
Pacific-slope Flycatcher	0.008	--	--
Pileated Woodpecker	0.008	0.025	--
Pine Siskin	0.034	0.008	0.103
Purple Finch	0.031	--	--
Pygmy Nuthatch	0.002	0.017	0.014
Red-breasted Nuthatch	0.400	0.034	0.062
Red-breasted Sapsucker	0.034	0.068	0.082
Red Crossbill	0.003	0.008	0.055
Red-tailed Hawk	--	--	0.062
Rock Wren	0.044	0.085	0.021
Rufous Hummingbird	0.003	--	0.014
Sandhill Crane	--	0.008	--
Song Sparrow	0.003	0.195	0.329
Sooty Grouse	0.005	0.034	0.021
Spotted Towhee	0.230	0.534	0.027
Steller's Jay	0.214	0.686	0.452
Townsend's Solitaire	0.223	0.042	0.014
Townsend's Warbler	0.040	--	--
Tree Swallow	0.028	0.008	0.075
Unid. Bird	0.006	0.017	0.021
Unid. Empidonax Flycatcher	0.002	--	--
Unid. Finch	0.002	--	--
Unid. Hummingbird	0.021	0.017	0.014

Common Name	Storrie and Chips	Moonlight Control	Moonlight Impact
Unid. Warbler	0.002	--	--
Unid. Woodpecker	0.065	0.246	0.322
Vaux's Swift	0.002	--	--
Warbling Vireo	0.021	0.102	0.055
Western Bluebird	0.076	0.076	0.062
Western Flycatcher	0.005	0.008	--
Western Scrub-Jay	0.002	--	--
Western Tanager	0.662	0.500	0.226
Western Wood-Pewee	0.065	0.576	0.699
White-breasted Nuthatch	0.008	0.169	0.219
White-crowned Sparrow	--	0.008	0.007
White-headed Woodpecker	0.126	0.051	0.027
Williamson's Sapsucker	--	0.017	0.007
Wilson's Warbler	0.005	0.068	0.048
Wrentit	0.005	--	--
Yellow-breasted Chat	0.003	--	--
Yellow-rumped Warbler	0.445	0.068	0.055
Yellow Warbler	0.015	0.288	0.185

Appendix 10. Coordinates of sampling locations on Plumas National Forest in the Moonlight, Storrie, and Chips fire areas in 2015. Coordinate datum is NAD83 UTM Zone 10N.

Moonlight Reforestation Control Sample Locations

Name	Easting	Northing
ML0101	686809	4451097
ML0102	686933	4450862
ML0103	687048	4450660
ML0104	687212	4450462
ML0106	687535	4450174
ML0107	687046	4450060
ML0108	686880	4450267
ML0109	686746	4450454
ML0110	686586	4450671
ML0111	686446	4450909
ML0302	685716	4458473
ML0303	685931	4458361
ML0304	686154	4458247
ML0305	686400	4458182
ML0306	686372	4457938
ML0307	686794	4458352
ML0308	686565	4458460
ML0309	686306	4458525
ML0310	686067	4458569
ML0311	685859	4458662
ML0401	700162	4450972
ML0402	700408	4450991
ML0403	700657	4451042
ML0404	700884	4451155
ML0405	701145	4451161
ML0406	701206	4451445
ML0407	700946	4451371
ML0408	700679	4451371
ML0409	700430	4451371
ML0410	700172	4451371
ML1202	698109	4459522
ML1203	697891	4459426
ML1206	698379	4459501
ML1207	698379	4459243
ML1208	698411	4458953
ML1209	698611	4459095
ML1210	698610	4459356

Moonlight Reforestation Control Sample Locations

Name	Easting	Northing
ML1211	698840	4459410
ML1212	698880	4459659
ML1213	698623	4459654
ML2002	693778	4453079
ML2003	693581	4452931
ML2004	693347	4452833
ML2005	693111	4452755
ML2006	693013	4452369
ML2007	693026	4452125
ML2008	693250	4452487
ML2009	693474	4452606
ML2010	693691	4452724
ML2301	687504	4453925
ML2302	687356	4453731
ML2303	687203	4453528
ML2304	687053	4453326
ML2305	686901	4453127
ML2306	687314	4452825
ML2307	687365	4453071
ML2308	687534	4453268
ML2309	687679	4453470
ML2310	687849	4453651

Moonlight Reforestation Impact Sample Locations

Name	Easting	Northing
MLT101	698152	4461010
MLT102	698089	4460745
MLT103	698345	4460753
MLT104	698779	4460716
MLT105	699027	4460685
MLT106	699233	4460533
MLT107	699290	4460278
MLT201	700393	4458470
MLT202	700336	4458234
MLT203	701126	4457563
MLT204	701159	4457300

Moonlight Reforestation Impact Sample Locations

Name	Easting	Northing
MLT205	701163	4457021
MLT206	701071	4456790
MLT207	700566	4456369
MLT208	700361	4456266
MLT301	700007	4457724
MLT302	700278	4457733
MLT303	700550	4457737
MLT304	700568	4457485
MLT305	700302	4457467
MLT306	700320	4457210
MLT307	700582	4457214
MLT308	700487	4456973
MLT309	700261	4456879
MLT310	700544	4456728
MLT401	700069	4454080
MLT402	700631	4453906
MLT403	700786	4453198
MLT404	701045	4453146
MLT405	700842	4452991
MLT406	700945	4452680
MLT407	700710	4452604
MLT408	700683	4452353
MLT409	700348	4452091
MLT501	699128	4451215
MLT502	699296	4451042
MLT503	699121	4449962
MLT504	699479	4449531
MLT505	698977	4448775
MLT506	698740	4448696
MLT507	698983	4448525
MLT508	699165	4448337
MLT601	695505	4452058
MLT602	695762	4452064
MLT603	695683	4451821
MLT604	695951	4451926
MLT605	696147	4451532
MLT606	696338	4451359

Moonlight Reforestation Impact Sample Locations		
Name	Easting	Northing
MLT607	696576	4451243
MLT608	696990	4450387
MLT609	697238	4450404
MLT701	694886	4453626
MLT702	694891	4453353
MLT703	695143	4453357
MLT704	695433	4453375
MLT705	695442	4453123
MLT706	695702	4453021
MLT707	695528	4452836
MLT708	695259	4452827
MLT709	695031	4452734
MLT710	694826	4452607
MLT801	685662	4455786
MLT802	685889	4455714
MLT803	686440	4455925
MLT804	686700	4455931
MLT805	686888	4455782
MLT806	686783	4455552
MLT807	686564	4455644
MLT901	694324	4456103
MLT902	694336	4455851
MLT903	694405	4455606
MLT904	693970	4455473
MLT905	693927	4455215

Storrie and Chip Fire Sample Locations		
Name	Easting	Northing
213_1	664158	4444870
213_10	664841	4445065
213_11	664746	4445292
213_12	664638	4445512
213_2	664386	4444764
213_3	664610	4444654
213_4	664836	4444544
213_5	665066	4444434
213_6	665325	4444382
213_7	665494	4444737

Storrie and Chip Fire Sample Locations		
Name	Easting	Northing
213_8	665272	4444832
213_9	665045	4444934
214_1	650428	4437803
214_10	650844	4437358
214_11	650803	4437634
214_12	650796	4437825
214_2	650450	4437552
214_3	650470	4437325
214_4	650488	4437089
214_5	650510	4436808
214_6	650533	4436571
214_7	650931	4436607
214_8	650907	4436852
214_9	650866	4437147
222_1	665178	4441059
222_10	665794	4440950
222_11	665581	4440817
222_12	665354	4440692
222_2	665387	4441145
222_3	665592	4441304
222_4	665797	4441431
222_5	665995	4441570
222_6	666191	4441694
223_1	661359	4447352
223_10	661771	4447214
223_11	661684	4447466
223_12	661681	4447725
223_2	661301	4447142
223_3	661448	4446899
223_4	661441	4446670
223_5	661340	4446417
223_6	661644	4446391
223_7	661775	4446570
223_8	661873	4446783
223_9	661822	4446984
224_1	659892	4442397
224_10	660373	4442337
224_11	660352	4442583
224_12	660325	4442810

Storrie and Chip Fire Sample Locations		
Name	Easting	Northing
224_2	659952	4442116
224_3	660074	4441945
224_4	660035	4441697
224_5	660076	4441460
224_6	660123	4441226
224_7	660434	4441630
224_8	660418	4441882
224_9	660400	4442100
314_5	663102	4437217
314_6	663373	4437237
314_7	663466	4436800
314_8	663215	4436750
BVR1_1	658004	4443373
BVR1_10	656408	4445037
BVR1_11	656303	4445258
BVR1_12	656084	4445878
BVR1_2	657877	4443541
BVR1_3	657662	4443735
BVR1_4	657349	4443816
BVR1_5	657093	4443873
BVR1_6	656898	4444080
BVR1_7	656775	4444314
BVR1_8	656645	4444504
BVR1_9	656445	4444760
BVR2_1	656735	4441851
BVR2_10	657292	4440977
BVR2_11	657050	4440969
BVR2_12	656804	4441027
BVR2_2	656666	4441615
BVR2_3	656909	4441566
BVR2_4	657135	4441483
BVR2_5	656968	4441281
BVR2_6	657241	4441247
BVR2_7	657488	4441292
BVR2_8	657730	4441219
BVR2_9	657522	4441064
BVR3_1	656159	4448080
BVR3_10	656909	4446359
BVR3_11	656930	4446095

Storrie and Chip Fire Sample Locations		
Name	Easting	Northing
BVR3_12	657154	4445921
BVR3_2	656101	4447858
BVR3_3	656265	4447683
BVR3_4	656165	4447437
BVR3_5	656335	4447275
BVR3_6	656526	4447055
BVR3_7	656475	4446802
BVR3_8	656705	4446736
BVR3_9	656697	4446468
CAR1_10	655112	4439953
CAR1_11	654923	4439776
CAR1_12	655043	4439548
CAR1_13	654706	4439558
CAR1_14	654712	4439793
CAR1_3	656550	4440859
CAR1_4	656306	4440875
CAR1_5	656088	4440739
CAR1_6	655917	4440545
CAR1_7	655679	4440495
CAR1_8	655518	4440275
CAR1_9	655296	4440122
CAR2_1	660055	4436723
CAR2_10	659253	4437491
CAR2_11	659134	4437719
CAR2_12	658900	4437830
CAR2_2	660242	4436890
CAR2_3	659822	4436806
CAR2_4	659584	4436691
CAR2_5	659333	4436617
CAR2_6	659388	4436904
CAR2_7	659568	4437082
CAR2_8	659745	4437299
CAR2_9	659448	4437325
CAR3_1	658477	4436002
CAR3_10	656955	4435839
CAR3_11	656846	4436078
CAR3_12	656827	4436344
CAR3_2	658201	4435877
CAR3_3	658034	4436073

Storrie and Chip Fire Sample Locations		
Name	Easting	Northing
CAR3_4	657736	4436211
CAR3_5	657809	4435934
CAR3_6	657690	4435622
CAR3_7	657974	4435644
CAR3_8	657519	4435147
CAR3_9	656962	4435568
CS0104	661048	4449699
CS0105	660936	4449470
CS0106	661118	4449279
CS0301	662232	4447612
CS0302	662330	4447381
CS0303	662538	4447237
CS0304	662508	4446987
CS0305	663434	4446502
CS0306	663686	4446182
CS0307	664125	4445320
CS0308	664467	4445306
CS0309	663558	4445392
CS0310	664514	4444368
CS0311	664332	4444166
CS0312	664830	4443268
CS0401	660962	4444103
CS0402	661056	4444339
CS0403	661120	4444574
CS0404	661283	4444768
CS0405	661362	4444528
CS0406	661400	4444284
CS0407	661468	4444002
CS0408	661248	4444089
CS0501	658259	4445643
CS0502	658528	4445656
CS0503	658721	4445497
CS0504	659146	4444974
CS0505	659360	4444849
CS0506	659613	4444576
CS0507	659813	4444427
CS0508	659796	4443766
CS0509	658935	4445091
CS0510	658716	4444314

Storrie and Chip Fire Sample Locations		
Name	Easting	Northing
CS0607	659424	4443077
CS0608	659439	4442810
CS0609	659424	4442547
CS0610	659492	4441727
CS0701	657269	4439582
CS0702	657025	4439621
CS0703	656856	4439810
CS0704	656631	4439918
CS0705	656767	4440121
CS0706	656988	4440018
CS0707	657168	4439835
CS0708	657221	4440084
CS0709	657460	4440170
CS0710	657707	4440141
CS0711	657894	4440290
CS0801	655143	4442244
CS0802	655249	4442018
CS0803	655460	4441872
CS0804	655715	4441869
CS0805	655970	4441692
CS0806	655686	4441617
CS0807	655686	4441348
CS0808	655912	4441071
CS0809	655890	4440828
CS0810	655658	4440753
CS0811	655386	4440619
CS0812	655151	4440713
CS0813	655306	4441031
CS0903	650390	4442634
CS0904	650510	4442420
CS0908	650938	4440954
CS0909	650992	4440702
CS0910	650716	4440198
CS0911	650964	4440211
CS0912	651195	4440102
CS0913	650731	4439902
CS0914	650449	4439274
CS1001	652600	4443481
CS1002	652607	4443732

Storrie and Chip Fire Sample Locations		
Name	Easting	Northing
CS1003	653503	4443649
CS1004	653370	4443441
CS1005	654127	4444215
CS1006	654257	4443987
CS1007	654466	4443849
CS1008	654470	4443593
CS1009	654521	4443353
CS1201	665293	4440253
CS1202	665206	4440017
CS1203	664959	4440055
CS1204	664727	4439964
CS1205	664667	4439720
MSQ1_1	652907	4441275
MSQ1_10	654080	4441545
MSQ1_11	653961	4441783
MSQ1_12	654227	4441855
MSQ1_2	653137	4441389
MSQ1_3	653389	4441390
MSQ1_4	653396	4441043
MSQ1_5	653601	4441237
MSQ1_6	653854	4441233
MSQ1_7	654033	4441037
MSQ1_8	654083	4440780
MSQ1_9	654173	4441303
MSQ2_1	654062	4443073
MSQ2_10	653799	4442507
MSQ2_11	654050	4442576
MSQ2_12	654283	4442639
MSQ2_2	653826	4443012
MSQ2_3	653584	4442946
MSQ2_4	653361	4442871
MSQ2_5	653125	4442786
MSQ2_6	652872	4442726
MSQ2_7	653065	4442266
MSQ2_8	653313	4442357
MSQ2_9	653549	4442454
OHC1_1	660321	4445693
OHC1_10	660605	4446387
OHC1_11	660676	4446154

Storrie and Chip Fire Sample Locations		
Name	Easting	Northing
OHC1_12	660761	4445923
OHC1_2	660233	4445934
OHC1_3	660139	4446211
OHC1_4	660056	4446451
OHC1_5	659980	4446694
OHC1_6	659901	4446935
OHC1_7	660359	4447092
OHC1_8	660440	4446858
OHC1_9	660527	4446620
OHC2_1	662346	4445677
OHC2_10	663813	4444809
OHC2_11	663636	4444665
OHC2_12	663577	4444427
OHC2_13	662085	4445711
OHC2_14	662432	4445226
OHC2_2	662431	4445495
OHC2_3	662681	4445462
OHC2_4	662914	4445442
OHC2_5	663201	4445449
OHC2_6	663100	4445217
OHC2_7	663230	4445054
OHC2_8	663424	4444916
OHC2_9	663628	4444985
SEN1_1	661557	4442124
SEN1_10	662004	4442658
SEN1_11	661753	4442611
SEN1_12	661662	4442368
SEN1_2	661807	4442165
SEN1_3	662057	4442201
SEN1_4	662307	4442233
SEN1_5	662562	4442270
SEN1_6	662812	4442316
SEN1_7	662729	4442792
SEN1_8	662482	4442758
SEN1_9	662248	4442712
SENW_1	660021	4444207
SENW_2	660233	4444035
SENW_3	660044	4443838
SENW_4	659883	4444024

Storrie and Chip Fire Sample Locations		
Name	Easting	Northing
ST0201	650714	4436416
ST0202	650641	4436183
ST0203	650560	4435948
ST0204	650479	4435701
ST0205	650403	4435467
ST0301	650640	4432561
ST0302	650715	4432797
ST0303	650545	4432976
ST0304	650462	4433209
ST0305	650401	4433449
ST0501	651227	4426675
ST0502	651477	4426667
ST0503	651722	4426645
ST0504	651986	4426643
ST0505	652226	4426621
ST0701	648652	4427539
ST0702	648880	4427445
ST0703	649115	4427352
ST0704	649348	4427253
ST0705	649581	4427157
ST0901	650154	4436396
ST0902	649969	4436530
ST0903	649785	4436724
ST1201	648239	4432645
ST1202	647391	4433128
ST1203	647587	4432995
ST1204	647803	4432869
ST1205	648026	4432759