Chapter III – High Meadow restoration project

Written in conjunction with the USDA Forest Service Lake Tahoe Basin Management Unit and

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EXECUTIVE SUMMARY

This report summarizes two years of pre-restoration wildlife monitoring data at High Meadow and a control site (Fountain Place) and illustrates project objectives based on pre-restoration monitoring data.

Meadow Restoration Project Goals: Restore natural geomorphic and hydrologic function in the meadow by reconstructing the creek channel morphology with improved vegetation capable of withstanding large flow events, increase and enhance meadow and aspen habitats through removal of encroaching conifer, and treat adjacent lodgepole die-off to reduce fuel loads and further insect infestation while enhancing habitat. These goals are supported by the Sierra Nevada Forest Plan Amendment Aquatic Management Strategy (AMS). The AMS defines desired conditions for aquatic, riparian, and meadow ecosystems. Two AMS goals relevant to this project are:

1. **Floodplains and Water Tables:** Maintain and restore the connections of floodplains, channels, and water tables to distribute flood flows and sustain diverse habitats.
2. **Stream Banks and Shorelines:** Maintain and restore the physical structure and conditions of stream banks and shorelines to minimize erosion and sustain desired habitat diversity.

Riparian conservation objectives relevant to the above stated AMS goals include RCO#2, #5 and #6 (SNFPA 2004).

Associated Wildlife Project Goals: In achieving the above stated process oriented restoration project goals and objectives, the High Meadows restoration project is also expected to increase diversity and complexity of riparian and meadow communities and enhance wildlife species that rely on these communities (associated with AMS goals for Species Viability, Plant and Animal Community Diversity, and Special Habitats). From these broad wildlife restoration goals specific management actions (i.e., restoration opportunities), associated prescriptions, and monitoring objectives were identified based on existing conditions compared to desired conditions.

Recommended prescriptions

Two years of pre-restoration data have been collected at both High Meadow and the associated control site (Fountain Place). Methods for and results of data are presented herein. Data collected thus far provide a baseline of existing conditions for comparing pre- and post-restoration conditions. In addition, these pre-restoration data provide information to guide restoration actions through an analysis of existing conditions compared to desired conditions. The following management recommendations and prescriptions are based on this analysis.

1. Increase soil moisture especially in the lower and middle meadow because butterfly species richness in these areas was low and many desired condition butterfly species may benefit from increased plant diversity associated with wet as opposed to dry meadow areas. Increasing soil moisture in these areas is also expected to increase the distribution of pacific treefrogs and western toads in High Meadow.

2. Create dense willow patches along the stream channel and throughout the meadow where microhabitats are suitable and increase the extent and duration of wetness in High Meadow to benefit songbirds and desired small mammal species. Most songbirds and several small mammal species, associated with well developed and healthy riparian habitat, are missing from High Meadow. Additionally, several undesirable upland small mammals (e.g., chipmunks) that are known songbird nest predators are currently present in the meadow. Increasing meadow wetness is expected to limit meadow access by the undesirable upland small mammals.
3. Increase in total willow cover at High Meadow to approximately 60% of the meadow area (Bombay et al. 2003). This recommendation is based on surveys of meadows with willow flycatchers (Bombay et al. 2003). Although willow flycatchers will likely not colonize High Meadow due to the elevation these recommendations should also prove beneficial for yellow warblers, Wilson's warblers, MacGillivray's warblers, warbling vireos, Lincoln's sparrows, and other songbird species that utilize meadows.
4. Increase willow cover $\geq$ 2 m in height within meadow to occupy at least 465 m^2 (0.046 ha) within one hectare of areas suitable for willow establishment (Based on average willow cover in occupied willow flycatcher territories; Bombay-Loffland, Unpublished data).
    - Beneficial for yellow warblers, Wilson's warblers, MacGillivray's warblers, Lincoln's sparrows, warbling vireos, and other songbird species.
5. If possible, plug and pond the "old" stream channel and re-vegetate perimeter with willow to create additional ephemeral aquatic habitat
    - Beneficial for amphibian breeding and additional willow clumps for riparian associated birds.
6. If possible, the eastern-most channel in the lower meadow should be constructed without a distinct channel to allow flooding within the meadow during spring run-off to create a marsh like habitat.
    - Beneficial for marsh associated species such as western toads and yellow warblers.
7. Establish clear pools with fast moving water to provide foraging locations for American dipper and common merganser (Hamas 1994, Kingery 1996, Mallory and Metz 1999).
8. For American dippers, streams should have adequate shading (at least 58% of the stream should be shaded) from streamside vegetation and provide adequate nesting locations such as, logs > 13 cm in diameter and ledges (Loegering and Anthony 2006). Construction of artificial nesting structures may also provide suitable nest sites (Loegering and Anthony 2006).
9. Restoration should focus on improving stream clarity and creating pools < 4 m deep with inorganic sediments to provide foraging opportunities for common mergansers (Mallory and Metz 1999). Additional attention should be paid to the forested areas surrounding lakes and pools to ensure that these areas provide suitable nesting cavities. Construction of nesting cavities also may prove beneficial. (Mallory and Metz 1999).
10. Establish creek-side gravel banks/bars and areas with sandy and firm substrates for foraging and nesting spotted sandpiper (Oring et al. 1997). Create areas with patches of dense vegetation within 100 m of the stream bank for nesting (Oring et al. 1997).
11. Increase aspen regeneration for red-breasted sapsucker, Williamson's sapsucker, white-headed woodpecker, blue grouse, calliope hummingbird, house wren, and Swainson's

thrush (Evans and Young 2000, Walters et al. 2002) by removing conifers (Shepperd et al. 2006).

12. Increase or maintain snag density to approximately 112 snags per 100 ha for red-breasted sapsucker, Williamson's sapsucker, white-headed woodpecker, blue grouse, calliope hummingbird, house wren, and Swainson's thrush (Walters et al. 2002). Exact spatial distribution of snags within 100 ha that may benefit the above species is unknown.
13. Ensure development of multiple patches of mature forest stages (e.g., >10 ha patches) surrounding the meadows to provide nesting areas for northern goshawk; surrounding forest should be a matrix of multiple seral stages.
14. Ensure attainment and maintenance of USFS guidelines for downed wood and snags:
    - Downed wood: minimum of three logs of >30 cm diameter at midpoint per 0.4 ha.
    - Snags: three snags per 0.4 ha >38 cm dbh in decay class 2-5; retain all snags >61 cm dbh in decay class 6-9. Evaluation is on an averaged 4 ha basis.
15. Following prescribed burning and using adaptive management approaches, assess the effects of lodgepole treatments, along with other hydrologic restoration measures, and consider the need for additional measures. If additional fire or non-fire treatments are needed, implement them as necessary.
16. Depending on the response of aspen recovery in restoration and treatment areas, consider planting of small aspen to assist its recovery in desired locations based on site-specific analysis and other available information.
17. Once the fuels of dense lodgepole pines are removed, controlled burning of meadows and undergrowth in conifer forests could replicate the natural processes and disturbance regime of the pre-Comstock era.
18. Within the area at High Meadow affected by die-off, maintain a variety of snags in different size classes to provide foraging and nesting opportunities for species such as black-backed woodpeckers.

Recommended objectives and metrics

Based on the expected habitat and associated wildlife responses to restoration actions, as indicated above, we recommend the following post-restoration monitoring objectives, associated metrics, and protocols for the High Meadow restoration project. The monitoring objectives are intended to evaluate project effectiveness relative to the above project actions and also to contribute to the validation of wildlife and habitat response to ecosystem restoration projects in the Tahoe Basin.

<u>Recommended vegetation objectives</u>

1. Increase meadow wetness in the lower and middle meadow.
    - Metric: Percent of meadow with standing water and saturated soil throughout summer
    - Methods: Meadow wetness transects
2. Increase in total willow cover at High Meadow to approximately 60% of the meadow area (Bombay et al. 2003).
    - Metric: Spatial location of willow clumps pre- and post-restoration
    - Methods: Record location, size, and height of willows using a global positioning system (GPS).

3. Increase willow cover $\geq$ 2 m in height within meadow to occupy at least 465 m^2 (0.046 ha) within one hectare of areas suitable for willow establishment (based on average willow cover in occupied willow flycatcher territories; Bombay-Loffland, Unpublished data).
    - Metric: Spatial location of willow clumps pre- and post-restoration
    - Methods: Record location, size, and height of willows using a global positioning system (GPS).
4. Increase spatial clumping of willow within meadow (willow patches with an approximate mean size of 375 m^2) (Bombay-Loffland, Unpublished data).
    - Metric: Spatial location of willow clumps pre- and post-restoration
    - Methods: Record location, size, and height of willows using a global positioning system (GPS).

<u>Recommended wildlife objectives</u>

1. Increase richness and abundance of butterflies and desired condition butterfly species at High Meadow
    - Metric: Richness and abundance
    - Methods: Visual encounter sweep net surveys conducted twice a month from June through August.
2. Increase distribution of desired condition reptile and amphibian species at High Meadow
    - Metric: Richness, abundance, and distribution
    - Methods: Because reptiles and amphibians can be difficult to locate due, in part, to their cryptic behavior and nocturnal habits, we suggest that survey methods and restoration objectives be re-evaluated. A complete survey of the herpetofauna requires pit fall traps, funnel traps, cover board layouts, night acoustic surveys, and visual encounter surveys (Heyer et al. 1994). However, the cost required to complete such a survey is prohibitive. We suggest intensifying surveys for one or two specific species, such as western toads and Pacific treefrogs, to obtain more accurate data or focusing on specific areas within a project site to obtain more accurate estimates of amphibian and reptile abundance.
3. Increase richness and abundance of songbirds and desired condition songbird species at High Meadow
    - Metric: Richness and abundance
    - Methods: Point-count surveys three times a month during June
4. Maintain or increase productivity of focal songbird species. Expect productivity to increase within meadows due to increased meadow wetness which will reduce the ability of mammalian predators to access nests
    - Metric: Nesting success (e.g., daily nest survival) and percent parasitism by brown-headed cowbirds
    - Methods: Search for and monitor nests of focal songbird species beginning in late May through early August.
5. Increase species richness of desired condition bat species at High Meadow
    - Metric: Richness and relative frequency of use
    - Methods: Three surveys throughout the summer using ultrasonic bat detectors.
6. Increase species richness and abundance of desired condition small mammal species at High Meadow

    - Metric: Richness and relative abundance
    - Methods: Trap and mark small mammals.
7. Decrease abundance of chipmunk species within the meadow as a result of increased meadow wetness
    - Metric: Relative abundance
    - Methods: Trap and mark small mammals.
8. Increase abundance of voles, shrews, weasels, and jumping mice within meadows
    - Metric: Relative abundance
    - Methods: Trap and mark small mammals.

CHAPTER III – HIGH MEADOW RESTORATION PROJECT

INTRODUCTION

High Meadow covers approximately 150 ha at 2440 m in elevation, located between Heavenly Valley ski area to the north and Freel Peak to the south (Appendix 3.1). Tributaries to Cold Creek converge in High Meadow. This historically wet meadow is now dry due to an incised stream channel that is disconnected from its floodplain. High Meadow has been impacted by logging, grazing, fire suppression, and water diversions. These practices led to changes in the riparian shrub vegetation, changes in meadow hydrology, and encroachment of lodgepole pine. Portions of High Meadow are still irrigated by ditches that have remained active, resulting in wet meadows covered by annual and perennial grasses and forbs and a few scattered willows. The surrounding forest is compromised primarily of lodgepole pine (*Pinus contorta*) and red fir (*Abies magnifica*). The forested areas along the southeastern side contain dense stands of lodgepole pine. Starting in 2006 the lodgepole pine stands were affected by pine bark beetle causing a widespread die-off.

Restoration efforts aim at reestablishing environmental conditions that closely resemble those which existed in the pre-Comstock Era (prior to the mid-1800s). Objectives are to (1) restore floodplain processes by reconstructing the creek channel morphology, (2) remove lodgepole encroachment into the meadow, (3) enhance portions of willow (*Salix* spp.), mountain alder (*Alnus incana* t*enuifolia*), and quaking aspen (*Populus tremuloides*) areas, and (4) control future lodgepole pine encroachment by means of fire and mechanical thinning. This area was also part of the ancestral grounds for the Washoe Tribe and was managed by the tribe for certain plant species. An added goal of restoration is to reestablish Washoe cultural practices by managing for plant species that can be used for food, medicine, and basket weaving.

MONITORING AND ADAPTIVE MANAGEMENT

The restoration approaches and measures of this plan are based principally on SNFPA (2004) and other USFS guidance and policy directives. To continue to meet these restoration goals at High Meadow in the future, monitoring and site-specific evaluations and management protocols must be outlined and followed. The use of site-specific monitoring, data evaluation, and information-based decision making to manage these resources constitutes the adaptive management approach for High Meadow.

Compliance with the SNFPA 2004 AMS goals is a principle objective of adaptive management at High Meadow. The AMS goals of SNFPA 2004 are specifically intended to restore the physical and biological processes to riparian and meadow ecosystems as a means to create self-sustaining riparian-dependent plant and wildlife populations. Floodplain and wetland functions are essential for a stable channel and natural growth and sustenance of desired riparian and meadow vegetation. Natural erosion and sediment deposition processes are essential to maintain stable banks, healthy substrate, quality aquatic habitat and cover, and positive and functional hydraulic circulation. These attributes should be tracked during and following restoration implementation to assess the effectiveness of these measures and to assist modification of treatment methodologies where warranted.

The success of restoration at High Meadow will be assessed in part by the biological integrity of its ecosystem. Measures to assess this integrity may include documenting and assessing wildlife diversity and viability through wildlife surveying, monitoring, and tracking of wildlife assemblages and desired condition wildlife species.

LTBMU and partnering agencies shall coordinate in the development and integration of adaptive management monitoring and assessment plans and analyses to support ecosystem restoration measures at High Meadow.

PROJECT GOALS

The overall goal of the High Meadow restoration project is to restore natural geomorphic and hydrologic function in the meadow by constructing a stable fluvial channel with improved vegetation capable of withstanding large flow events. The goal is supported by the Sierra Nevada Forest Plan Amendment Aquatic Management Strategy (AMS). The AMS defines desired conditions for aquatic, riparian, and meadow ecosystems. Two AMS goals relevant to this project are:

1. Floodplains and Water Tables: Maintain and restore the connections of floodplains, channels, and water tables to distribute flood flows and sustain diverse habitats.
2. Stream Banks and Shorelines: Maintain and restore the physical structure and conditions of stream banks and shorelines to minimize erosion and sustain desired habitat diversity.

Riparian Conservation Strategies

The following Riparian Conservation Strategies outlined in the AMS are particularly relevant to the High Meadow restoration project:

- Riparian Conservation Objective #2**:** Maintain or restore: (1) the geomorphic and biological characteristics of special aquatic features, including lakes, meadows, bogs, fens, wetlands, vernal pools, springs; (2) streams, including in stream flows; and (3) hydrologic connectivity both within and between watersheds to provide for the habitat needs of aquatic-dependent species. (RCO #2 is linked to the following AMS Goals: #2: Species Viability; #3: Plant and Animal Community Diversity; #4: Special Habitats; #5: Watershed Connectivity; #6: Floodplains and Water Tables; #8: Streamflow Patterns and Sediment Regimes; #9: Streambanks and Shorelines).
- Riparian Conservation Objective #5: Preserve, restore, or enhance special aquatic features, such as meadows, lakes, ponds, bogs, fens, and wetlands, to provide the ecological conditions and processes needed to recover or enhance the viability of species that rely on these areas. (RCO #5 is linked to the following AMS goals: #1: Water Quality, #2 Species Viability, #3 Plant and Animal Community Diversity, #4 Special Habitats; #7: Watershed Condition; #9: Stream Banks and Shorelines).
- Riparian Conservation Objective #6: Identify and implement restoration actions to maintain, restore or enhance water quality and maintain, restore, or enhance habitat for riparian and aquatic species. (RCO # 6 is linked to all AMS goals).

Specific hydrological project goals and objectives

The complete channel re-alignment is designed to move High Meadow towards the desired conditions stated in the goals below. It is expected that restoration of a stable, fluvial environment to restore meadow geomorphic processes will enhance other meadow functions as described in the more specific project goals listed below:

1. Restore floodplain processes by reconstructing the creek channel morphology
    a. Restore existing abandoned terrace/meadow surface to active floodplain
    b. Increase duration and extent of overbank flooding on small inset of floodplain and terrace/meadow surface
2. Raise the seasonal groundwater table elevation and reduce seasonal variation in the level of groundwater
    c. Increase water retention in soil for groundwater recharge
3. Reestablish natural sedimentation patterns and restore historic surface sedimentary characteristics and nutrient uptake capability
    d. Reduce flushing of suspended sediment through project area by storing sediment on-site in channel bars
    e. Reduce flushing of suspended sediment by storing sediment on terrace/meadow floodplain surface
4. Remove lodgepole encroachment into meadow
5. Control future lodgepole pine encroachment by means of fire and mechanical thinning
6. Reduce runoff of nutrient concentrations to improve the quality of water leaving High Meadow
7. Restore natural soil moisture conditions in the meadow
    f. Increase water retention in soil for groundwater recharge
    g. Reduce groundwater "draining" from meadow to channel by improving vertical channel stability
8. Maintain or increase wet meadow environment
    h. Increase water retention in soil for groundwater recharge
    i. Increase duration and extent of wet meadow
9. Maintain or increase woody shrub stand area
    j. Increase woody shrub (e.g., willow) along channel
10. Enhance quaking aspen stands
11. Reestablish Washoe cultural practices by managing for plant species that can be used for food, medicine, and basket weaving

PLANNED RESTORATION ACTIONS

1. Construct two new channels with increased length and sinuosity in lower meadow (northern most meadow section) with inset floodplains. The channels are to follow outer edges of meadow and will merge near the northern section.
    a. Easternmost channel may be constructed to flow out into a flooded surface and no distinct channel until flow is "recaptured" where it connects back with the westernmost channel.

2. Re-construct a new channel for a section of the main channel in the middle meadow; move channel from the drainage ditch along the east edge of the middle meadow to the center of the middle meadow.
3. Remove nearly all dead standing lodgepole encroaching along western edge of the lower, middle and upper meadow and intermixed amongst the aspen stands.
4. Remove a large portion of standing dead forest encroaching along the east edge of the lower meadow.

DEVELOPMENT OF DESIRED SPECIES CONDITIONS

The desired condition for High Meadow was based on two fundamental analyses (existing conditions and historical conditions) that are presented below. This analysis was conducted for songbirds, reptiles, amphibians, bats, and small mammals. Desired condition butterfly species were selected based on species that rely on montane meadows and riparian areas and those species that have specific host-plant requirements. Species identified through these analyses comprise the *desired species* for High Meadow. Species identified through this analysis are species that should be present pending successful restoration. However, presence of additional species that are relatively common on other meadow sites throughout the Basin (e.g., Wilson's warbler [*Wilsonia pusilla*]) but not at High Meadow will also be used to gauge the progress of restoration. Final designation of desired condition species is contingent on Forest Service decisions. Selection of desired species should be based on the below analysis as well as site potential.

Existing conditions: We used pre-restoration data collected in 2006 and 2007 to assess the existing conditions of wildlife species at High Meadow. We also used knowledge of general species distributions in the Basin based on other data sets, to develop the preliminary analysis presented below.

Based on existing data, we developed a list of all species that occurred on meadows throughout the Basin on our other restoration and reference sites (e.g., Big Meadow, Fountain Place, etc). This overall list of species was then ranked by abundance and overall percent community composition and was compared with the data for High Meadow. We then identified species from this list that (a) *should* occur at High Meadow based on location or expected habitat conditions following restoration, but are currently absent; (b) *could* occur at High Meadow, but were unlikely to do so (e.g., large home range requirements); and (c) were unlikely to occur at High Meadow due to poor site potential. Species that should occur at High Meadow will be the focus of monitoring for wildlife responses to restoration. Thus, this subset of species comprises the desired condition species (Appendix 3.2–3.5).

Historic conditions: The current distribution and abundance of species is largely a reflection of past changes in environmental conditions as well as changes in population health. Because of past and ongoing management activities (e.g., timber harvest, fire suppression, and grazing), and recreation, the patterns of distribution and habitat use of most species would be expected to differ substantially from that which occurred historically. As such, interpretation of current patterns of habitat use and distribution would be expected to be confounded to an unknown degree.

We compared historic records (Orr 1949, Orr and Moffitt 1971) to recent records (e.g., Watershed Assessment, MSIM, and wildlife restoration and monitoring data) to identify species that have apparently declined in abundance within the Basin. We termed these as *desired species* in this document because they are a focus of restoration efforts. Desired species might occur on a

restoration site such as High Meadow, occur on one or more of our other sampling sites, or not occur at all on any sampled site in the Basin. Desired species that should occur at High Meadow were identified and could require special management efforts (e.g., cowbird control) to ensure their occurrence and productivity. These species are not considered indicators of the presence of other more common species, and the presence of common species is not required for restoration to be considered successful. This is because relatively common species are widely distributed throughout the Basin and are not considered at risk of substantial declines at this time. As such, an overall increase in species diversity will not mean that restoration is successful per se.

Summary: In summary, desired species fall into a number of categories. These categories and the resulting species list also relate closely to the Pathway 2007 program that is currently under development in the Basin. Pathway 2007 will develop future desired conditions for all resources within the Basin. Desired species (also known as Special Status Species under Pathway 2007) fall into the following categories:

- Invasive species; native and non-native (e.g., bullfrog [*Rana catesbeiana*], cowbird [*Molothrus ater*]), with the aim of reducing their abundance.
- Public interest species (e.g., bear [*Ursus americanus*], deer [*Odocoileus hemionus*], coyote[*Canis latrans*], osprey [*Pandion haliaetus*])
- Species listed by USFWS under the Endangered Species Act (e.g., bald eagle [*Haliaeetus leucocephalus*], Lahontan cutthroat [*Oncorhynchus clarki henshawi*])
- Species listed as Sensitive by R5 (northern goshawk, spotted owl)
- USFS Management Indicator Species (MIS)
- Species formerly present at higher abundance, based on comparison of current data with historic data (described above)
- Rare species

These categories are not mutually exclusive and a species may fall within several categories. For example, a species could be of high public interest, have specific legal status, and be rare (e.g., bald eagle). These species are not considered indicators of the presence of other more common species (e.g., desired species are not indicator species). Inability to detect a desired conditions species following restoration does not necessarily indicate restoration failure.

CONTROL SITE DESCRIPTION

Control sites were selected in association with the High Meadow restoration project to evaluate the effectiveness of restoration actions. Effectiveness monitoring was designed with pre and post comparisons in a Before-After-Control-Impact (BACI) design. The BACI design is ideal and provides the most accurate assessment of the effects of restoration (Morrison 2002). The BACI design requires that monitoring occur at impact sites (i.e., treated or restored sites) and control sites (i.e., not treated) both before and after impact (i.e., treatment or restoration actions). Control sites are used to help determine if changes observed on restoration sites are due to management actions. That is, if there is a difference in the trend of species occurrence, abundance, or other monitoring metric between control sites and a restoration site before and after restoration then we have support for a conclusion that management actions were responsible for the trend or change observed.

Control sites should be similar to the restoration site in terms of gross vegetation features and be located near the restoration site but far enough away to be considered an independent unit (Block et al. 2001). We selected one control site per restoration project site that meets the above criteria. If additional funds are made available, multiple control sites that consist of similar features could also be compared to the restoration project site to improve the ability to detect an effect of restoration.

Fountain Place is the control site for High Meadow. Fountain Place is 5 km south of High Meadow, at the same elevation, and approximately 120 ha in size (Appendix 3.6). The area is bisected by Trout Creek and consists of both wet and dry meadows, willow thickets, and is surrounded by mixed-conifer forest. A large tract of private property borders the north side of the site. Fountain Place contains scattered patches of willows bordered by aspen stands along the north and east portions of the meadow.

EFFECTIVENESS MONITORING METHODS

Project effectiveness monitoring will be used to measure the effectiveness in meeting the project objectives. Metrics used to assess effectiveness include (1) richness, (2) abundance, (3) distribution, and (4) productivity. Although the distribution metric will not be used to address any specific objectives, information on the distribution of desired condition species will be used to assist in developing restoration plans. We will monitor changes in species richness and abundance of the following species groups: butterflies, reptiles and amphibians, songbirds, and small mammals (including bats) to determine whether meadow associated communities are being enhanced by restoration actions and whether specific desired species are present or are increasing in abundance. We will also monitor productivity for focal bird species to determine whether wildlife productivity is being maintained. Pre-restoration monitoring occurred in 2006 and 2007.

Butterflies

Objective 1: Determine butterfly species richness and abundance at High Meadow pre-restoration.

Objective 2: Determine where butterflies are most abundant at High Meadow pre-restoration.

Metric: Richness and abundance

Methods.—We conducted visual encounter and sweep-net butterfly surveys at High Meadow and associated control site, Fountain Place, to determine species richness and relative abundance. Observers worked in teams of two-to-three and walked slowly in a zigzag pattern through the entire meadow scanning for butterflies. Observers also searched for butterflies within 50 m of the forest-meadow edge. The meadow area was divided into six survey areas to allow us to assess species distribution (Appendix 3.1 and 3.6). Observers recorded the species and the number of individuals detected. We also visually assessed vegetation within 5 m of each butterfly detection based on the dominant shrub species and dominant ground cover. We categorized ground cover as either a mixture of grasses and forbs with no soil moisture (grass/forb dry) or as a mixture of grasses and forbs in wet or moist soils (grass/forb wet). Additional ground cover categories were bare soil containing no vegetation or areas covered by rocks. Shrub cover was categorized by the dominant plant species in the mid-story. Categories included alder, willow, flowering shrub, non-flowering shrub, or absence of shrub layer. Only willows and alders were identified in the shrub layer because these species are important nectar sources for many butterflies. If a butterfly species was detected feeding on a flowering plant, we recorded the plant species the individual butterfly was using. Butterflies that we could not identify from a distance we captured with a sweep net and released after identification. We conducted butterfly surveys twice a month from June to August 2006 and 2007.

Data analysis.—We calculated richness as the number of species detected across all surveys. We calculated abundance as the total number of individuals observed across all surveys. We chose to report total abundance instead of taking an average across all survey periods because butterflies are short lived and tend to move frequently throughout the landscape.

Reptiles and amphibians

Objective 3: Determine richness and distribution of reptiles and amphibians at High Meadow pre-restoration.

Metric: Richness and Distribution

Methods.—We conducted visual encounter surveys for amphibians and reptiles at High Meadow, and Fountain Place to determine species richness. Observers worked in teams of two-to-three and walked slowly in a zigzag pattern, searching water bodies, and opportunistically turning over rocks and debris in search of reptiles and amphibians. The riparian area was broken into six survey areas that we searched for 30 minutes per person (Appendix 3.1 and 3.6). We conducted visual encounter surveys between mid-to-late morning. We surveyed each site once during June in 2006. No surveys were conducted in any other year. The amount of time spent searching each site varied by the size of the site, but all meadow areas within each site was thoroughly scanned for reptiles and amphibians.

Songbirds

Objective 4: Determine richness and abundance of songbird species at High Meadow pre-restoration.

Metric: Richness and abundance

Methods.—We established avian point-count stations at High Meadow and Fountain Place to assess bird species richness and abundance (Appendix 3.1 and 3.6). We established point-count stations 250 m apart at both sites. The number of point-count stations established at each site varied by the size of the meadow (Appendix 3.1 and 3.6). We conducted avian point-counts in June 2006 and 2007. Each site was surveyed three times separated by one week. Point counts began 15 minutes before sunrise and finished no later than four hours after sunrise. Observers recorded all birds seen or heard within 50 m at each point for 10 minutes. Observers also recorded Douglas squirrels (*Tamiasciurus douglasii*) during point counts. Observers did not conduct point counts during inclement weather (e.g., precipitation or wind >9 km/hr).

Data analysis.—We calculated species richness as the total number of species detected across all surveys. To calculate abundance we averaged the of individuals detected within 50 m of point-count stations across the three surveys and divided by the number of points sampled to correct for differences in the number of points surveyed at each site.

Objective 5: Determine productivity of focal songbird species at High Meadow pre-restoration.

Metric: Productivity

Methods.—We searched for and monitored nests of six focal species: willow flycatcher, dusky flycatcher (*Empidonax oberholseri*), warbling vireo (*Vireo gilvus*), yellow warbler (*Dendroica petechia*), MacGillivray's warbler (*Oporornis tolmiei*), and Wilson's warbler (*Wilsonia pusilla*) to quantify productivity or reproductive success and brown-headed cowbird (*Molothrus ater*) parasitism. We chose to monitor nests of these species because (1) their nests are low in height (nests typically <5 m tall), (2) they are a species of concern (e.g., willow flycatcher), or (3) they are associated with riparian vegetation. At each site, observers searched for nests within 200 m of the main creek or meadow area. Nests were monitored every three to five days until nest outcome could be determined.

Data analysis.—We estimated nesting success by calculating Mayfield estimates of daily nest survival (Mayfield 1961). Mayfield estimates account for the fact that successful nests are more likely to be found by observers than nests that fail early in the season and hence provide less-biased estimates of nesting success (Mayfield 1961). Daily nest survival is one minus daily mortality, which is the total number of nests that fail per species divided by the total number of days all nests of that species were exposed or were active. Nests were considered successful if at least one fledgling was observed. Failed nests were those at which the eggs or nestlings were destroyed or when parental activity ceased prior to the expected fledging date. When calculating Mayfield estimates, we considered parasitized nests that fledged *only* cowbirds as nest failures; we considered nests that were parasitized but fledged at least one host young as successful. Nests at which we could not determine fate with certainty were excluded from analysis. Nests that never received eggs were considered abandoned and were also removed from analysis.

We also calculated the percentage of nests that were parasitized by brown-headed cowbirds. Parasitized nests include all nests in which a brown-headed cowbird egg or nestling was detected, regardless of final nest outcome. Unparasitized nests include nests in which we did not detect the presence of a brown-headed cowbird egg or nestling. At several nests we were

unable to determine if a nest was parasitized because we were unable to check nest contents. Nests in which cowbird parasitism could not be accurately determined were removed from analyses.

Owls

Objective 6: Assess richness of owl species at High Meadow pre-restoration.
Metric: Richness

Methods.—We conducted nocturnal broadcast surveys for six owl species to determine species presence. Each call point was 500 m apart to minimize the chance of detecting the same owl at more than one call point (Morrison et al. 2001, Johnsgard 2002); the number of call points depended on site size (Appendix 3.1 and 3.6). With each survey separated by at least one week, we conducted three surveys from May to July 2006, and March to June 2007. Given that most owl species begin courtship and nesting in late winter or early spring (Johnsgard 2002), we believed that starting owl surveys in March would increase the probability of detecting individuals. (Based on data collected at LTBMU restoration and control sites, the probability of detecting a northern saw-whet owl with six surveys (May–July) in 2006 was 0.04 but increased to 0.16 with six surveys (March–June) in 2007). Surveys commenced 15-30 minutes after sunset and continued until all points at the site were surveyed. Initiating the evening surveys soon after sunset potentially increased the chances of detecting the diurnal northern pygmy-owl (*Glaucidium californicum*). Surveys occasionally occurred before dawn if weather prevented the nocturnal survey from being completed. The order of the call points changed with each visit to the site to decrease the chances of temporal bias (Morrison et al. 2001). At each call point, observers listened for five minutes and recorded all species seen or heard. After the initial five-minute listening period, six species of owls were broadcast using a portable CD player and Foxpro Wildlife Caller ® (an amplified speaker). Standard owl calls were used, taken from Peterson Field Guide Audio Series® and Stokes Field Guide to Bird Songs®. Species were broadcast from the smallest to the largest owl species (i.e., flammulated owl [*Otus flammeolus*], northern pygmy-owl, northern saw-whet owl [*Aegolius acadicus*], western screech-owl [*O. kennicottii*], long-eared owl [*Asio otus*], and great horned owls [*Bubo virginianus*]). Each species was broadcast for 30 seconds followed by 30 seconds of silence and repeated twice in succession. At the end of the broadcast series observers listened for five minutes and searched the area for silent owls with a half-million candle-watt spotlight (Nite Tracker 2287) for the first two minutes. Observers recorded the species, interval of the call series during which the owl responded, and the direction and distance of the owl's response. Detections of common nighthawk (*Chordeiles minor*) and common poorwill (*Phalaenoptilus nuttallii*) were also recorded. Surveys did not take place in heavy rain or winds >20 km/hr.

Data analysis.—We report the presence of owl species detected both during surveys and incidentally. The number of individual owls per site is also noted. If an owl of the same species was detected at the same call point on subsequent visits, it was counted as one individual.

Bats

Objective 7: Determine richness and relative frequency of use of desired condition bat species.
Metric: Richness and relative frequency of use

Methods.—We conducted acoustic surveys for bats using Pettersson ultrasonic detectors (model D240X) at High Meadow and Fountain Place to assess bat species richness. We placed Pettersson recorders in suitable openings, near habitat transition zones, or in likely movement

corridors (Appendix 3.1, 3.6–3.7). Bats were recorded on three different nights separated by at least one week from June to August 2006 and 2007. We placed detectors in different locations upon subsequent visits; each location was at least 100 m apart. Detectors were not set up on rainy nights.

Data analysis.—Bat sonograms were analyzed with SonoBat version 2.2 (DNDesign 2004), which facilitates our comparison of sonograms recorded in the field to known species standards. For each visit, we divided the number of recordings of each species by the total number of recordings as an approximation of relative occurrence.

Small mammals

Objective 8. Determine richness and abundance of small mammal species at High Meadow pre-restoration.

Metric: Richness and abundance

Methods.—We conducted small mammal surveys at High Meadow and Fountain Place using Sherman Live Traps in July 2006 and from June to July 2007 to quantify species richness and abundance. We placed Sherman Live Traps along transects throughout the meadow at each site (Appendix 3.1 and 3.6). Trapping transects also extended into the upland habitat surrounding the meadows to sample the small mammal community in upland-forest communities and to determine if chipmunk species (*Tamias* spp.) are avoiding the meadow due to increased wetness associated with restoration activities. Transect length and number of traps varied between sites based on meadow size. We placed large Sherman Live Traps every 25 m along each transect. At alternating 25 m, we placed both large and extra-large Sherman Live Traps. At each location, we placed Sherman traps in the nearest appropriate location ensuring that the trap was sufficiently protected from the elements (e.g., sun). We baited traps with a mixture of rolled oats and peanut butter. We checked traps twice daily (morning and dusk) for three consecutive days. We identified captured animals to species, sexed, and aged if possible. Additionally, we tagged chipmunks and squirrels (*Spermophilus* spp.) with numbered aluminum ear tags to allow for individual identification. In 2006, we marked deer mice (*Peromyscus maniculatus*) and vole (*Microtus* spp.) species by clipping a small amount of fur from their rump. In 2007, we continued to mark vole species by clipping their fur, whereas deer mice were tagged with ear tags.

Data analysis.—We calculated the number of unique individuals captured by subtracting the number of recaptures and unknown captures from the total number of captures per species. We could not directly compare abundance of unique individuals between years and sites because the number of traps varied among years and sites (due to size of and conditions within the meadows). Thus, we calculated relative abundance of each species; that is, the number of unique individuals captured per 100 trap nights. We divided the total number of unique individuals per species by the total number of traps available throughout the entire trapping session, multiplied by 100. The number of traps placed varied between years due to conditions within the meadow. If the meadow area was excessively wet we could not place traps in that area, thus affecting the number of traps placed each year. Our analysis adjusts for these differences to allow adequate comparisons.

Throughout the two years of surveys, traps were located in both meadow and upland areas at High Meadow, and Fountain Place. There is the potential for a different suite of species to occur in each of those areas; thus, we conducted the above analysis not only for all traps total at each site, but also for meadow and upland traps separately.

RESULTS AND DISCUSSION

Butterflies

Objective 1. Determine richness and abundance of butterfly species at High Meadow pre-restoration.

Species richness at High Meadow was similar to the control site (Fountain Place) in both years (Fig. 3.1 and Appendix 3.8–3.9). Richness declined in 2007 at both sites, suggesting that changes in species richness may be due to Basin wide conditions (e.g., below normal snow-pack in the previous year). Richness of preliminary desired condition butterfly species (Appendix 3.2) was similar across sites and years (Fig. 3.2).

The abundance of preliminary desired condition butterfly species, however, differed across sites and years (Fig. 3.3). In 2006, abundance of desired condition butterfly species detected at High Meadow was 75% lower relative to Fountain Place (control site). In 2007, numbers of individual desired condition butterfly species declined by 48% at Fountain Place, while abundance of butterflies did not change between 2006 and 2007 at High Meadow (Fig. 3.3).

Objective 2: Determine where butterflies are most abundant at High Meadow pre-restoration.

Survey areas 2 (n = 22) located within the eastern portion of the lower meadow and survey area 3 (n = 25) (Appendix 3.1) located within the upper and middle meadow supported the most butterfly species within High Meadow. Ninety percent of our detections were within 5 m of areas containing dry patches of grasses and forbs. Only 8% of the detections were within 5 m of wet or moist meadow patches containing grasses and forbs. Lack of detection in wet meadow areas indicates that there is little wet meadow community within High Meadow. Because the percentage of detections in wet meadow areas was low and many desired condition butterfly species may benefit from wet meadow areas (Appendix 3.2), we suggest that restoration efforts increase soil moisture especially in survey areas 2 and 3 (Eastern portion of the lower meadow and the middle and upper meadow). Increasing the amount of saturated or moist soil within the meadow should increase butterfly species richness even more by increasing flowering plant diversity.

Survey area 4 in the eastern meadow (Appendix 3.1) contained the largest number of desired condition individuals (n = 63 per ha). Other areas that supported a large number of individuals included areas 1 (n = 51 per ha) and 2 (n = 47 per ha) located in the lower and middle meadow and area 3 (n = 29 per ha) within the upper meadow. Restoration actions should focus on mimicking conditions found in the eastern meadow because a large number of desired butterfly species were detected there.

We observed butterflies using a variety of plant species during our surveys; 27% of our observations were of butterflies feeding on wandering daisy (*Erigeron peregrines*) and 24% on yarrow (*Achillea millefolium*). Other flowering plants that we observed butterflies using included western aster (*Aster occidentalis*; 10%), penstemon (*Penstemon* spp.; 8%), pennyroyal (*Monardella* spp.; 7%), pussypaws (*Calyptridium umbellatum*; 7%), bistort (*Polygonum bistortoides*; 3%), and pearly everlasting (*Anaphalis margaritacea*; 2%). Because our observations indicate that butterflies were using these plant species we recommend that restoration actions improve conditions for the above flowering plants as well as those listed in Appendix 3.2.

Recommendations

1. Although we recorded gross vegetation features where butterflies were first detected, additional vegetation and soil moisture data should be collected within each survey area to determine if vegetation and hydrological features influence butterfly diversity, abundance, and distribution.
2. Continue monitoring butterflies at High Meadow and the control site.

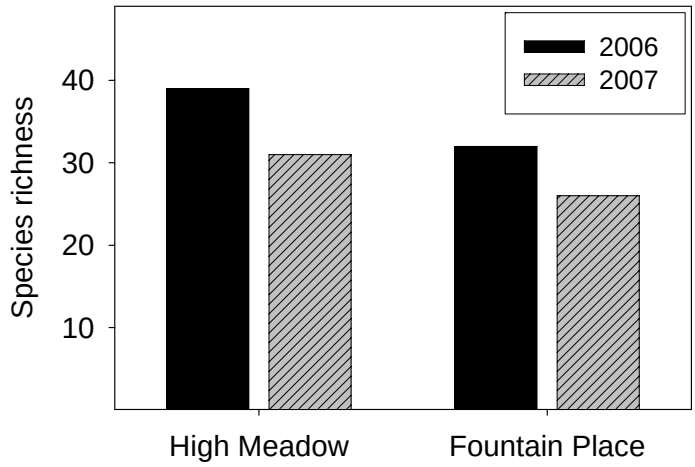

Figure 3.1. Number of butterfly species detected at High Meadow and the control site (Fountain Place) in 2006 and 2007. Numbers of butterflies detected decreased at both sites from 2006 to 2007.

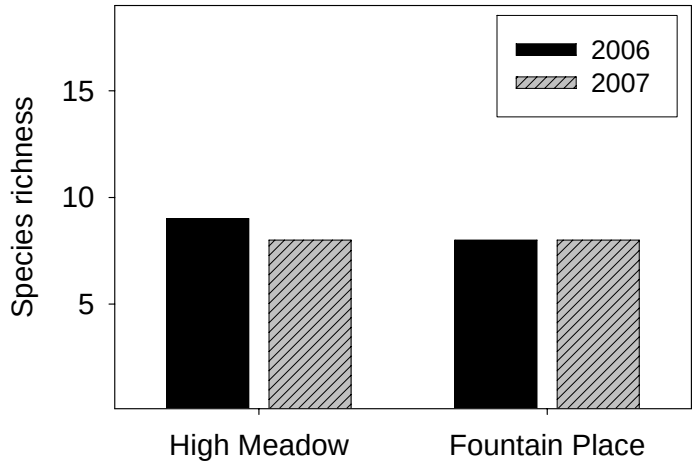

Figure 3.2. Number of desired condition butterfly species detected at High Meadow and the control site (Fountain Place) in 2006 and 2007. Species richness of desired condition species was similar across years and sites.

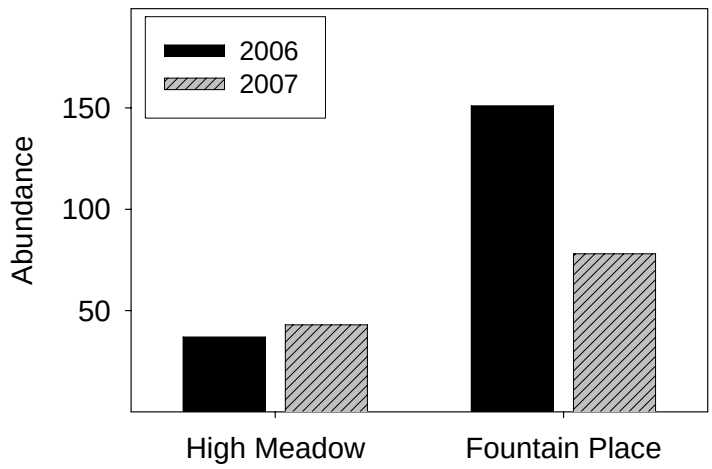

Figure 3.3. Abundance of desired condition butterfly species (adjusted for size of meadow surveyed) at High Meadow (27 ha) and the control site, Fountain Place (12.9 ha).

Reptiles and amphibians

Objective 3. Determine richness and distribution of reptiles and amphibians at High Meadow pre-restoration.

Only two amphibian species were detected at High Meadow in 2006; western toad and pacific treefrog (Appendix 3.3). We detected both adult and juvenile stages for each species. Compared to other meadows (Cookhouse, Grass Lake, Fountain Place, Big Meadow, and Taylor/Tallac) within the Basin species diversity at High Meadows was ranked second to last (n = 2). Pacific treefrogs were found in the lower meadow near an oxbow in the creek channel as well as in portions of the eastern meadow. We detected western toads in the lower meadow and in the east meadow.

Lack of detection of other species at High Meadow does not mean that other reptiles and amphibians do not occur at High Meadow. Rather, it is more likely that the visual encounter surveys we conducted were not sufficient to detect additional species. In addition, High Meadow was searched only once during June 2006 due to funding limitations. We recommend that visual encounter surveys be discontinued due to the low numbers of species detected utilizing this method. Because reptiles and amphibians can be difficult to locate due, in part, to their cryptic behavior and nocturnal habits, we suggest that survey methods and restoration objectives be re-evaluated. A complete survey of the herpetofauna requires pit fall traps, funnel traps, cover board layouts, night acoustic surveys, and visual encounter surveys (Heyer et al. 1994). However, the cost required to complete such a survey is prohibitive. We suggest intensifying surveys for one or two specific species, such as western toads and Pacific treefrogs, to obtain more accurate data or focusing on specific areas within a project site to obtain more accurate estimates of amphibian and reptile abundance.

A total of six amphibian species and eight reptilian species have been reported within the Basin (Schlesinger and Romsos 2000). The northern leopard frog (*Rana pipiens*) is apparently extinct, and the non-native bullfrog has been added to the fauna. Thus, a total of 13 amphibians and reptiles now occur in the Basin. Manley et al. (2002) found all 13 species in the Basin and surrounding national forest, and reported the distribution of these species by elevation. However, five of the species were reported from below 1600 m and thus are unlikely to occur in our study sites: Ensatina (*Ensatina eschscholtzii platensis*), California newt (*Taricha torosa*), southern alligator lizard (*Elgaria multicarinata*), California mountain kingsnake (*Lampropeltis zonata*), and gopher snake (*Pituophis catenifer*). Based on historic data and current survey results (Schlesinger and Romsos 2000), the desired herpetofauna includes western aquatic garter snakes (*Thamnophis couchii*), western terrestrial garter snakes (*Thamnophis elegans*), common garter snakes (*Thamnophis sirtalis*), long-toed salamanders (*Ambystoma macrodactylum*), western toads (*Bufo boreas*), and pacific treefrogs (*Hyla regilla*) (Appendix 3.3).

Although a small population of mountain yellow-legged frogs (*Rana muscosa*) exists within the Hellhole Basin and historically occurred in Tallac Marsh, non-native trout and bullfrogs severely limit the possibility for reintroduction (Knapp and Matthews 2000). However, even if removal of trout and bullfrogs was feasible within the Cold Creek watershed, populations of mountain yellow-legged frogs need to occur nearby to allow for recolonization (Knapp et al. 2001). However, distance to source populations may not affect the success of physical reintroduction other niche factors still need to be present at High Meadow. The source population in Hellhole is greater than 5 km from the Cold Creek Basin and no streams directly connect these two areas, greatly reducing the probability that the Hellhole population could recolonize Cold Creek on its own, even in the absence of fish. In addition, because tadpoles typically overwinter prior to metamorphosis water bodies need to be >2 m deep, although the probability of occurrence increased significantly with water depths >5 m (Knapp 2005). Cold Creek currently does not contain water bodies deep enough to support overwintering tadpoles, thus we recommend that deep pools be created at Cold Creek if reintroduction of mountain yellow-legged frogs is desired. Successful restoration and reintroduction requires (1) removal of non-native trout and bullfrogs, (2) reestablishment within areas containing at least three interconnected fishless water bodies, and (3) water bodies > 2 m deep that do not freeze during the winter months (Knapp 2000, Knapp and Matthews 2000, Knapp et al. 2001, Knapp 2005).

Several human influenced factors can influence herpetofauna within the Lake Tahoe Basin, such as habitat modification and exotic fishes that may negatively affect native frog species (Hayes and Jennings 1986, Adams 1999). For example, non-native fishes (e.g., rainbow trout) are negatively affecting populations of mountain yellow-legged frogs (*Rana muscosa*) in the Sierra Nevada's (Knapp and Matthews 2000). Retention of ephemeral wetland habitat may prove beneficial to native amphibians because non-native fishes are more often associated with permanent open-water bodies (Adams 1999). All of the species listed herein depend on aquatic habitats for part or all of their life stages, which indicate that specific attention should be given to the distribution and condition of egg laying locations and locations suitable for development of sub-adult life stages. These locations usually include relatively slow moving water, riffles, and ponds. Down logs, deep duff/soil, and vegetative cover are also necessary for other life cycle stages. Thus, restoration actions should focus on creating the above conditions to improve richness and abundance of reptiles and amphibians. Because we detected pacific treefrogs and western toads in the lower and eastern meadow areas, restoration actions should focus on either

improving conditions within these areas (e.g., increase amount of standing water in portions of the meadow) or mimic conditions found in these areas in the middle and upper meadow.

Recommendations

1. Re-evaluate restoration objectives for reptiles and amphibians.
2. To evaluate changes in distribution of reptiles and amphibians we recommend that survey intensity be increased to include pitfall traps, drift fences, visual encounter surveys, and assessment of hydrological and vegetation features throughout the summer months.
3. Reptile and amphibian surveys should be conducting during the breeding season (late May and June).

Songbirds

Objective 4. Determine richness and abundance of songbirds and desired condition bird species at High Meadow pre-restoration.

Species richness at High Meadow during the first two years of pre-restoration monitoring was consistent across years and sites for species detected in the meadow and in the upland (Fig. 3.4). Two preliminary desired condition songbird species (Lincoln's sparrow and red-breasted sapsucker) occurred at High Meadows during the 2006 surveys and three (Lincoln's sparrow, red-breasted sapsucker, and white-headed woodpecker) occurred during the 2007 surveys (Fig 3.5, Appendix 3.4 and 3.10). Abundance of desired condition songbird species detected within 50 m of the meadow point-count stations was quite low at High Meadow compared to the control site (Fountain Place; Fig. 3.6). However, abundance of desired condition songbird species in the uplands was similar between sites (Fig 3.6). Other species detected at High Meadows that comprised more than 5% of the avian community within the meadow included dark-eyed junco (22%), dusky flycatcher (12%), American robin (12%), Cassin's finch (9%), pine siskin (9%), mountain chickadee (6%), and brown-headed cowbird (5%) (Appendix 3.10). At point-count stations in the uplands species that comprised >5% of the songbird community included dusky flycatcher (12%), mountain chickadee (12%), American robin (10%), dark-eyed junco (10%), pine siskin (10%), and brown creeper (6%) (Appendix 3.10).

Compared to other high elevation meadow sites in the Basin (Cookhouse (pre-restoration), Big Meadow, Grass Lake, and Fountain Place), only Cookhouse Meadow supported a larger number of brown-headed cowbirds (0.67 per point). Per point (summing meadow and upland detections) we detected 0.78 cowbirds at Fountain Place (Appendix 3.11), 0.44 at Big Meadow, 0.62 at High Meadow, and 0.17 at Grass Lake. Other species commonly detected at other meadow sites but not at High Meadow or were detected in low numbers included MacGillivray's warbler, Wilson's warbler, song sparrow, tree swallow, white-crowned sparrow, brewer's blackbird, and red-winged blackbird. Many of these species are typically found in wet meadows with dense understory cover, which suggests that restoration efforts should focus on improving wet meadow condition and the understory shrub component to improve conditions for these species. Although these species are not listed as desired condition species because they have not declined in abundance across the Basin, we feel that restoration actions should focus on improving conditions such that these more common wet meadow species will occur at High Meadow following restoration. Occurrence of typical meadow songbirds (e.g., song sparrow, Wilson's warbler) of the Basin will indicate positive progression of the restoration project.

Nine desired condition songbird species (yellow warbler, willow flycatcher, calliope hummingbird, Lincoln's sparrow, common merganser, spotted sandpiper, red-breasted sapsucker, pileated woodpecker, and Swainson's thrush) occurred at similar meadow sites (Cookhouse Meadow, Fountain Place, Grass Lake, and Big Meadow) throughout the Basin but did not occur at High Meadow, which suggests that restoration actions should be directed at improving meadow conditions that favor theses species. All of the desired condition songbird species detected across all meadow sites sampled within the Basin were relatively rare; for example, the most abundant desired condition species, the yellow warbler, was the 12th most abundant species overall, but comprised only 2% of the community. Thus, all desired condition species were rare throughout all of the meadows analyzed. Because these desired species were relatively rare throughout the Basin restoration actions directed towards these species should prove extremely beneficial.

Willow flycatcher, although a desired species at other meadow sites, is not a desired species at High Meadow because High Meadow will likely not support willow flycatchers. Willow flycatchers rarely occur at elevations above 2,440 m (Grinnell and Miller 1944) and the average elevation at High Meadow is 2,440 m. Although willow flycatchers are not a desired species for High Meadow, we are using recommendations based on data collected from the willow flycatcher monitoring project (Bombay et al. 2003, Bombay-Loffland, unpublished data, and Morrison, unpublished data) because recommendations developed for willow flycatchers will likely prove beneficial for other species such as yellow warblers and Lincoln's sparrows.

Recommendations

1. Continue current survey methods for songbirds.
2. Restoration actions should focus on increasing willow density throughout the meadow.

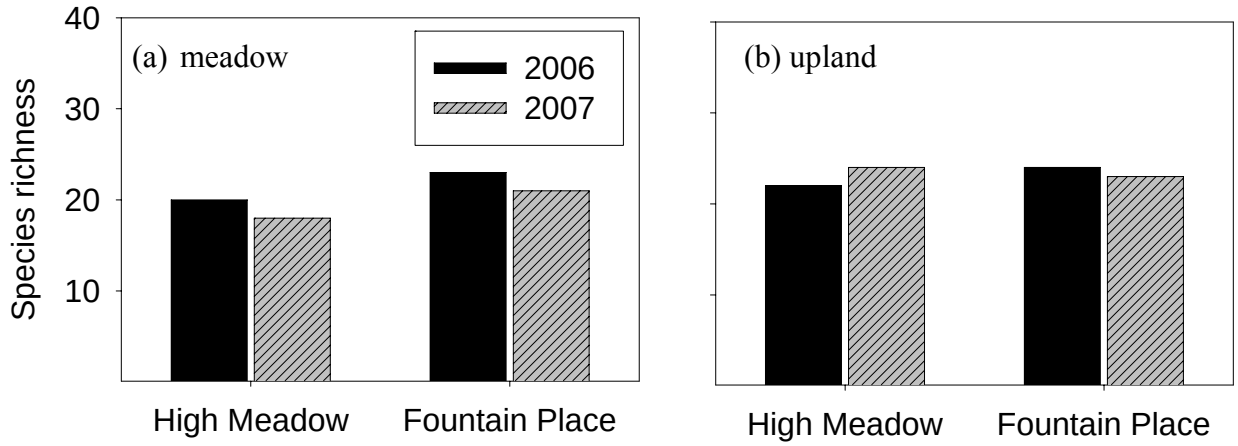

Figure 3.4. Species richness of songbirds detected within 50 m of point-count stations within the meadow (a) and uplands (b) at High Meadow and Fountain Place (Control site) in 2006 and 2007. Songbird species richness was similar across treatment and controls and years for songbirds within the meadow and uplands.

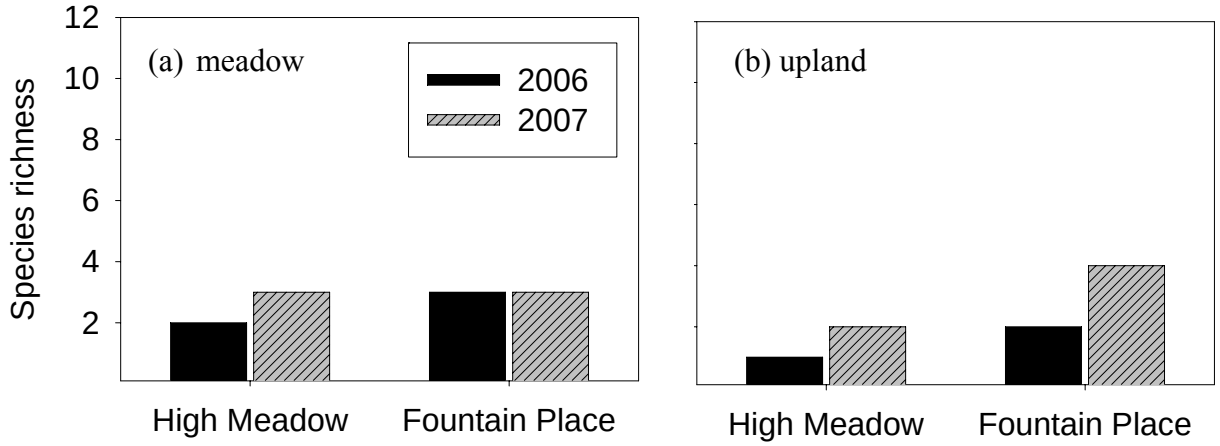

Figure 3.5. Desired condition songbird species richness of songbirds detected within 50 m of point-count stations located in the meadow (a) and in the uplands (b) at High Meadow and Fountain Place (Control site) in 2006 and 2007. Desired condition species richness was similar across sites and years in both the meadow (a) and upland (b) locations.

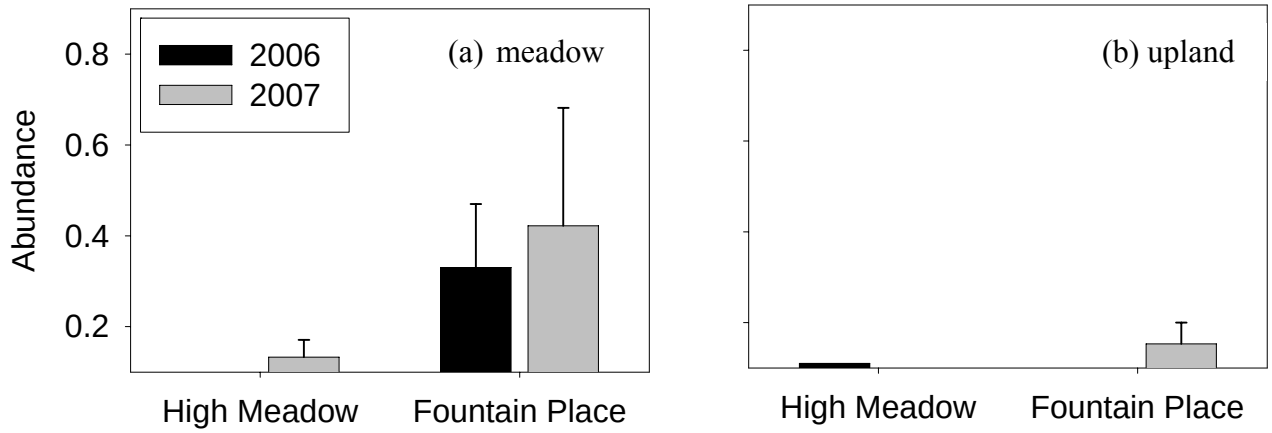

Figure 3.6. Abundance (± SE) of desired condition songbird species detected within 50 m of point-count stations in the meadow (a) and upland (b) at High Meadow and the control site (Fountain Place).

Objective 5. Determine productivity of focal songbird species at High Meadow pre-restoration.

Daily nest survival of dusky flycatchers, Wilson's warblers, and warbling vireos was consistent across years and sites (Fig. 3.7). Although daily nest survival of all three species appears to be relatively high, the percentage of Wilson's warbler nests parasitized by brown-headed cowbirds maybe a cause for concern. The daily nest survival estimates provided below account for parasitism because nests that were parasitized and failed to fledge host young were considered nest failures. No dusky flycatcher or warbling vireo nests were parasitized at High Meadow or Fountain Place in either 2006 or 2007. However, 60% of the Wilson's warbler nests monitored (n = 5) at High Meadow were parasitized by brown-headed cowbirds in 2007 while 19% were parasitized at Fountain Place (*n* = 16). Although the number of Wilson's warbler nests monitored at High Meadow was quite small (*n* = 5), the number of Wilson's warblers breeding at High Meadow was also small. Wilson's warblers were found breeding only in Bear Glad. Because parasitism is >30% (established threshold level, see Chapter 1) for Wilson's warblers, the parasitism levels observed at High Meadow may be a cause of concern and we suggest that monitoring continue to determine if high rates of parasitism persist and if additional actions need to be taken to reduce parasitism.

We suggest that monitoring of avian nesting success continue because avian abundance does not always correlate with habitat quality or reproductive success (Van Horne 1983). Moreover, restoration of vegetation structure will do little to support wildlife species if other niche components are not provided or if excessive predation reduces reproduction (Morrison 2002). For example, restoring dense willow patches for willow flycatchers will do little if excessive predation prevents flycatchers from producing successful broods. Based on historic data (Orr and Moffitt 1971, TRPA, unpublished data), restoration efforts should seek to improve habitat conditions for meadow and riparian associated birds as well as bird species associated with old growth forest conditions. Increasing the density of willows in meadows as well as increasing the proportion and

duration of wet-meadow area will likely improve habitat conditions for these species. Additional research being conducted in conjunction with the restoration project will also help determine if the habitat being created is contributing to successful reproduction of bird species.

Recommendations

1. Continue to monitor productivity and cowbird parasitism to determine if high rates of parasitism persist and if additional actions need to be taken to reduce parasitism.

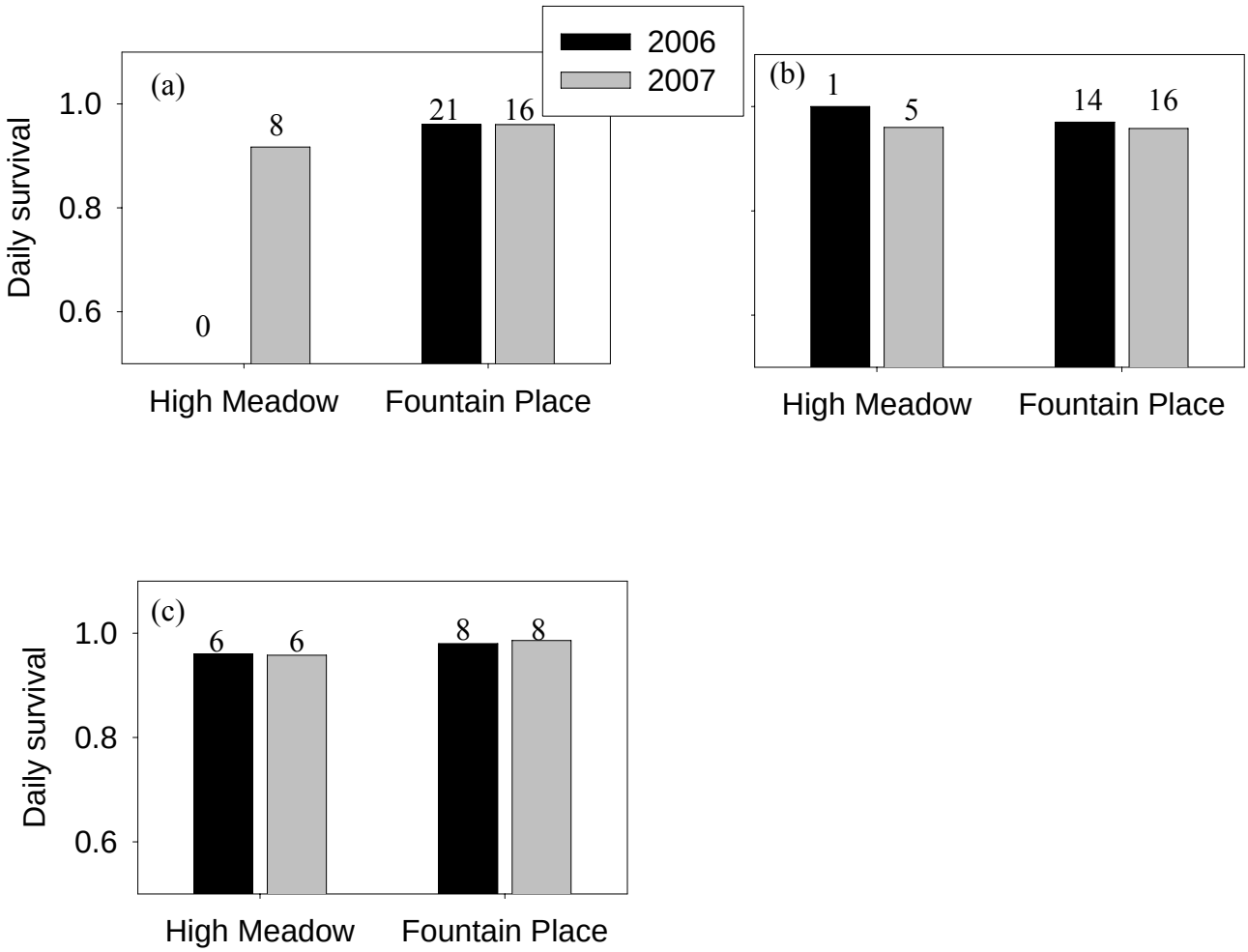

Figure 3.7. Daily nest survival of dusky flycatcher (a), Wilson's warbler (b), and warbling vireo (c) at High Meadow and Fountain Place (Control site) in 2006 and 2007. Number above the bar indicates the number of nests monitored.

Owls

Objective 6: Assess richness of owl species at High Meadow pre-restoration.

Northern saw-whet owls and great horned owls were the only owl species detected at High Meadow and Fountain Place, although the species were not consistently detected across all years (Table 3.1). The detection of owl species does add to the overall avian species richness at High Meadow, yet the continued inclusion of owl surveys may be of limited benefit when attempting to quantify restoration success. The ability to detect the presence owls both pre- and post-restoration is necessary to understand how restoration efforts may affect owls; however, detection of owl species is low due to the relatively large home ranges that owls inhabit and the difficulty of observing nocturnal species. In addition, detections are hampered by the timing of surveys. Starting surveys in March 2007 increased our ability to detect northern saw-whet owls at most sites throughout the Basin. Based on data collected at LTBMU restoration and control sites, the probability of detecting a northern saw-whet owl with six surveys (May–July) in 2006 was 0.04 but increased to 0.16 with six surveys (March–June) in 2007. Maintaining similar detection rates in subsequent years could be difficult because 1) it may be infeasible to begin multi-species owl surveys in the spring (when owls are more responsive), as this time frame has limited overlap with other restoration monitoring surveys, and 2) owls tend to inhabit relatively large home ranges and may be temporarily absent from a specific survey point at any one time, requiring that several surveys be conducted throughout the breeding season. Thus, a relatively large effort would be required to detect the presence of owls.

Recommendations:

1. If continued monitoring of owl richness is deemed important, we suggest beginning surveys in mid-March or early April and completing them no later than mid-June.
2. If determining the response of cavity-nesting owls to the creation and maintenance of snags in High Meadow is deemed important, we recommend focusing on the reproductive success of owls in the area. Determining productivity, however, is time-intensive and would require an increase in manpower.

Table 3.1. Number of individual owls detected during nocturnal broadcast surveys at High Meadow and Fountain Place, 2006–2007. The table includes detections of common nighthawks and common poorwills.

Common Name	Scientific Name	High Meadow		Fountain Place	
		2006	2007	2006	2007
Northern saw-whet owl	*Aegolius acadicus*	3	2		3
Great horned owl	*Bubo virginianus*		1	1	
Unknown owl		1			
Common nighthawk	*Chordeiles minor*	1		4	
Common poorwill	*Phalaenoptilus nuttallii*		2	3	2

Bats

Objective 7. Determine richness and relative frequency of use of desired condition bat species.

A combined total of six bat species were detected at High Meadow in 2006 and 2007. Two of the six detected species are listed as species of special concern by various state and federal

agencies (WBWG 2005, Manley et al. 2000) and included as desired condition species for High Meadow (Appendix 3.5): long-eared myotis (*Myotis evotis*) and fringed myotis (*Myotis thysanodes*). Fringed myotis appears to be relatively rare at both sites whereas long-eared myotis was detected at High Meadow in both years of surveys (Table 3.2).

Fringed myotis need caves or tree cavities in which to roost (O'Farrell and Studier 1980). Given the paucity of caves (and mines) in the Basin, it is likely that this species uses tree cavities. Individuals have been radio tracked to tree hollows, particularly large conifer snags in Oregon and Arizona, and rock crevices in cliff faces in southern California (Bradley et al. 2006). Long-eared myotis, especially pregnant females, tend to roost near or at ground level (e.g., leaf litter, stumps) (Manning and Jones 1989), indicating that human activities could negatively impact this species. Both bat species are insectivorous, often preferring aquatic insects, moths, or beetles, and often forage along or near streams, ponds, and forest edges (Grindal et al. 1999; Bradley et al. 2006).

Much is still unknown about the habitat needs of many bat species in the Lake Tahoe Basin. We recommend that more intensive studies be initiated to locate and quantify roosting and maternity sites, which will require the use of telemetry. What is known of their habitat preferences suggests that it may prove beneficial to focus on improving or preserving riparian habitat corridors, cottonwood, willow, and alder woodlands, areas with open water, and roost sites such as snags, caves, and rock crevices (Bradley et al. 2006). Because snags are a potential source of roost sites, efforts should be made to determine if the number of snags with cavities is sufficient to meet the needs of bats in the Basin.

Recommendations:

1. Continue current survey methods for bats.
2. If bat activity does not increase post-restoration relative to the control site, we recommend that more intensive studies be initiated to locate and quantify roosting and maternity sites, which will require the use of telemetry

Table 3.2. Relative frequency of use by bat species detected with Pettersson ultrasonic detectors at High Meadow and Fountain Place, 2006–2007.

Common name	Scientific name	High Meadow		Fountain Place	
		2006	2007	2006	2007
Big brown bat	*Eptesicus fuscus*		2.0		
Silver-haired bat	*Lasionycteris noctivagans*	72.9	62.5	63.8	57.9
Long-eared myotis[1]	*Myotis evotis*	4.7	19.6		
Little brown bat	*Myotis lucifugus*	19.9	15.1	35.6	37.9
Fringed myotis[1]	*Myotis thysanodes*		0.9		0.7
Free-tailed bat	*Tadarida brasiliensis*	1.9			3.6
Unknown myotis	*Myotis* spp.	0.6			
Unknown bat				0.6	

[1] Desired condition species (Appendix 3.5)

Small mammals

Objective 8. Determine richness and abundance of small mammal species at High Meadow pre-restoration.

In the two years of surveys, we trapped a total of 12 small mammal species at High Meadow and 10 at Fountain Place (Appendix 3.12 and 3.13). Six small mammal species are listed as desired condition species for the Basin (Appendix 3.5) and we detected two of those species at High Meadow (Table 3.3 and 3.4).

Table 3.3. Relative abundance of desired condition small mammal species trapped in meadow areas at High Meadow and associated control site, Fountain Place, 2006–2007.

Common Name	Scientific Name	High Meadow		Fountain Place	
		2006	2007	2006	2007
Belding's ground squirrel	*Spermophilus beldingi*	0.38	1.18		
Vagrant shrew	*Sorex vagrans*			0.85	
Western jumping mouse	*Zapus princeps*			2.99	4.26

Table 3.4. Relative abundance of desired condition small mammal species trapped in upland areas at High Meadow and associated control site, Fountain Place, 2006–2007.

Common Name	Scientific Name	High Meadow		Fountain Place	
		2006	2007	2006	2007
Belding's ground squirrel	*Spermophilus beldingi*	0.39			
Western jumping mouse	*Zapus princeps*	0.39		0.89	

Belding's ground squirrels are usually found close to water, in open areas, and require friable soils for burrowing (Verner and Boss 1980, Jenkins and Eshelman 1984). Vagrant shrews occur primarily in patchy, open areas with wet micro-habitats (e.g., wet meadows, streambanks) (Findley 1999), foraging for insects and other invertebrates under moist leaf litter and duff (Gillihan and Foresman 2004). Western jumping mice are typically found in open areas (i.e., without coniferous canopy cover) along margins of montane riparian areas and are usually associated with intermediate to dense herbaceous cover (Brown 1970, Belk et al. 1988). In the Central Rocky Mountains, this species is most numerous in moist aspen groves, willow-alder thickets, and damp forb-sedge meadows (Brown 1967). Trowbridge's shrews and long-tailed weasels are more associated with open coniferous forests and dry ground (George 1989, Sheffield and Thomas 1997), although weasels appear to prefer meadow areas (Verner and Boss 1980). Weasels typically nest in tree cavities, snags, logs, or burrows created by other small mammals (e.g., chipmunks, ground squirrels) (Verner and Boss 1980). Maintaining open, wet meadows, along with retaining adequate downed woody debris and snags, should encourage the persistence of these desired condition small mammal species at High Meadow.

In addition to the desired condition species, we captured several meadow-associated vole and shrew species, primarily in the meadow areas at both sites (Appendix 3.12 and 3.13). Few species were captured at High Meadow compared to Fountain Place (Fig. 3.8 and 3.9). In general, voles and shrews typically occur in montane riparian and wet meadow habitat (e.g., Findley 1999), although voles can also be found in nearby forests (e.g., Smolen and Keller 1987). We

trapped both species primarily in relatively dry, grass-covered areas of the meadows, with and without nearby conifer canopy cover. Most of the voles and shrews trapped at Fountain Place were in traps located near willow cover; willow cover was not available, however, at any of the trap locations at High Meadow. Increasing willow cover at High meadow, along with increasing open, wet meadow, may be beneficial to these species.

We also captured three species of chipmunks in both the meadow and upland areas of High Meadow (Appendix 3.12 and 3.13). The same species were detected at Fountain Place. The chipmunks have been found in higher abundance in the upland areas of both sites (Figure 3.10). In general, chipmunks are typically found in open canopy forests or in areas with relatively dense shrub cover (e.g., Verner and Boss 1980). Chipmunks are potential predators of several desired condition avian species during the birds' nesting stages; maintaining open, wet meadows may deter chipmunks from predating bird nests that are located in meadow areas (Cain et al. 2003).

Recommendations

1. Continue current survey methods for small mammals.
2. Restoration actions should focus on maintaining open, wet meadows, retaining adequate downed woody debris and snags, and increasing willow cover to encourage the persistence of desired condition small mammal species and other meadow-associated species, and to deter chipmunks from predating bird nests that are located in meadow areas.

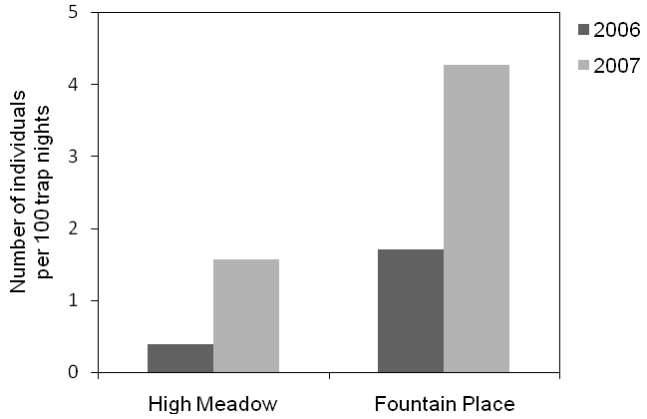

Figure 3.8. Relative abundance of vole species (*Microtus* spp.) trapped in meadow areas at High Meadow and Fountain Place, 2006–2007.

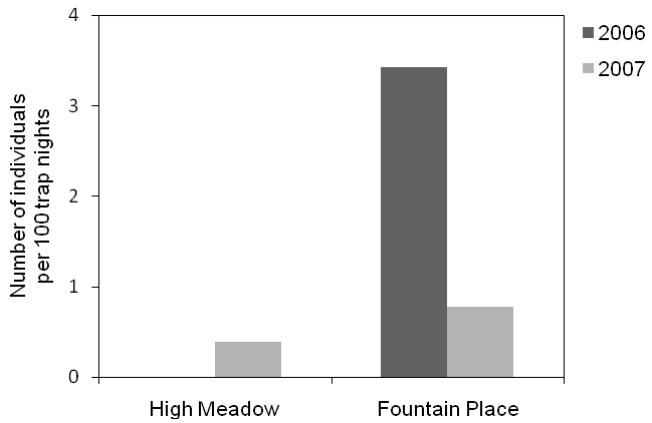

Figure 3.9. Relative abundance of shrew species (*Sorex* spp.) trapped in meadow areas at High Meadow and Fountain Place, 2006–2007.

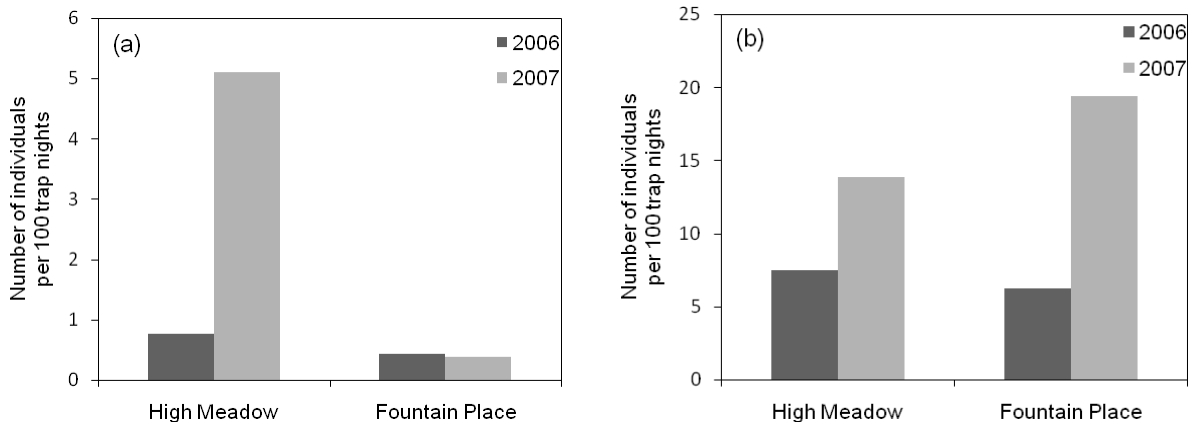

Figure 3.10. Relative abundance of chipmunk species (*Tamias* spp.) trapped at (a) meadow and (b) upland areas in High Meadow and Fountain Place, 2006–2007.

RECOMMENDED PRESCRIPTIONS FOR WILDLIFE RESTORATION

The following basic treatments should be conducted to prepare the site for occupancy by desired condition wildlife species. For species-specific detail, see Appendices 3.2–3.5.

Meadow

1. Increase meadow wetness in the lower and middle meadow. Increasing meadow wetness should prove beneficial for butterflies, songbirds, bats, Belding's ground squirrels, western jumping mice, shrews, and weasels.
2. Increase in total willow cover at High Meadow to approximately 60% of the meadow area (Bombay et al. 2003). This recommendation is based on surveys of meadows with willow flycatchers (Bombay et al. 2003). Although willow flycatchers will likely not

colonize High Meadow due to the elevation these recommendations should also prove beneficial for yellow warblers, Wilson's warblers, MacGillivray's warblers, warbling vireos, Lincoln's sparrows, and other songbird species that utilize meadows.

3. Increase willow cover ≥ 2 m in height within meadow to occupy at least 465 m^2 within one hectare (0.046 ha) of areas suitable for willow establishment (Based on average willow cover in occupied willow flycatcher territories; Bombay-Loffland, unpublished data). Action should prove beneficial for yellow warblers, Wilson's warblers, MacGillivray's warblers, Lincoln's sparrows, and warbling vireos, western jumping mice, shrews, and voles.
4. If possible, plug and pond the "old" stream channel and re-vegetate perimeter with willow to create additional ephemeral aquatic habitat for breeding amphibians and riparian associated songbirds.
5. If possible, the eastern most channel in the lower meadow should be constructed without a distinct channel to allow flooding within the meadow during spring run-off to create a marsh like habitat for marsh-associated species such as western toads, yellow warblers, and foraging areas for bats.

Riparian

6. Establish clear pools with fast moving water to provide foraging locations for American dipper, common merganser (Hamas 1994, Kingery 1996, Mallory and Metz 1999).
7. For American dippers streams should have adequate shading (at least 58% of the stream should be shaded) from streamside vegetation and provided adequate nesting locations such as, logs > 13 cm in diameter and ledges (Loegering and Anthony 2006). Construction of artificial nesting structures may also provide suitable nesting structures (Loegering and Anthony 2006).
8. Restoration should focus on improving stream clarity and creating pools < 4 m deep with inorganic sediments to provide foraging opportunities for common mergansers (Mallory and Metz 1999). Additional attention should be paid to the forested areas surrounding lakes and pools to ensure that these areas provide suitable nesting cavities. Construction of nesting cavities also may prove beneficial. (Mallory and Metz 1999).
9. Establish creek-side gravel banks/bars and areas with sandy and firm substrates for foraging and nesting spotted sandpiper (Oring et al. 1997). Create areas with patches of dense vegetation within 100 m of the stream bank for nesting (Oring et al. 1997).

Aspen

10. Increase aspen regeneration for red-breasted sapsucker, Williamson's sapsucker, white-headed woodpecker, blue grouse, calliope hummingbird, house wren, and Swainson's thrush (Evans and Young 2000, Walters et al. 2002) by removing conifers (Shepperd et al. 2006).
11. Increase or maintain snag density to approximately 112 snags per 100 ha for red-breasted sapsucker, Williamson's sapsucker, white-headed woodpecker, blue grouse, calliope hummingbird, house wren, and Swainson's thrush (Walters et al. 2002). Exact spatial distribution of snags within 100 ha that may benefit the above species is unknown.

Forest

12. Ensure development of multiple patches of mature forest stages (e.g., >10 ha patches) surrounding the meadows to provide nesting areas for northern goshawk; surrounding forest should be a matrix of multiple seral stages.
13. Ensure attainment and maintenance of USFS guidelines for downed wood and snags:
    a. Downed wood: minimum of three logs of >30 cm diameter at midpoint per 0.4 ha.
    b. Snags: three snags per 0.4 ha >38 cm dbh in decay class 2-5; retain all snags >61 cm dbh in decay class 6-9. Evaluation is on an averaged 4 ha basis.

The above forest prescriptions should prove beneficial for northern goshawks, white-headed woodpeckers, pygmy nuthatch, mountain bluebird, hermit warbler, and pileated woodpeckers. In addition to the above prescriptions, previous work on northern goshawks suggests that pairs typically utilize 15–20 ha surrounding their nest site and have an average home range of 2698 ha for males (sd = 1043) and 2016 ha for females (sd = 1690) (Keane et al. 2006). Thus restoration should focus on improving conditions within an area large enough to support adult breeding home ranges.

Although absolute differences in structural characteristics may differ between vegetation types and geographical regions, relative habitat use patterns of northern goshawks are consistent. Numerous habitat studies and modeling efforts have found nest sites to be associated with proximity to water or meadow habitat; forest openings; level terrain or 'benches' of gentle slope; northerly aspects; patches of larger, denser trees; low shrub/sapling cover; and low numbers of small diameter trees. In the Lake Tahoe region, Keane et al. (2006) found that northern goshawk nest sites had significantly greater numbers of live trees >100 cm dbh (mean = 39.0/ha, sd = 5.54), >60–100 cm dbh (54.7/ha, sd = 8.02) and canopy cover (mean = 70.4%, sd = 3.14), and significantly lower shrub/sapling cover (mean = 9.9%, sd = 2.04) and number of live trees >5-30 cm dbh (mean = 299.8/ha, sd = 30.49) than random plots based on 36 m diameter plots centered on nest trees and random points. High canopy cover is the most consistent structural feature across studies of northern goshawk nesting habitat (Siders and Kennedy 1996). Hargis et al. (1994) reported average canopy covers of only approximately 30% at northern goshawk nest sites in eastside pine vegetation in the eastern Sierra Nevada. However, canopy cover was still significantly greater than at randomly sampled sites.

Lodgepole Pine

Long-term restoration management, planning, and implementation will be needed for lodgepole encroachment to ensure that the restored montane meadow conditions retain desired conditions and ecosystem function. General monitoring and management considerations are summarized below:

14. Following prescribed burning and using adaptive management approaches, assess the effects of lodgepole treatments, along with other hydrologic restoration measures, and consider the need for additional measures. If additional fire or non-fire treatments are needed, implement them as necessary.
15. Depending on the response of aspen recovery in restoration and treatment areas, consider planting of small aspen to assist its recovery in desired locations based on site-specific analysis and other available information.

16. Once the fuels of dense lodgepole pines are removed, controlled burning of meadows and undergrowth in conifer forests could replicate the natural processes and disturbance regime of the pre-Comstock era.
17. Within the area at High Meadow affected by die-off, maintain a variety of snags in different size classes to provide foraging and nesting opportunities for species such as black-backed woodpeckers and secondary cavity nesters (e.g., small owls).

Implementation of these lodgepole management measures will help restore the vegetation cover at High Meadow Complex to pre-1850 conditions. These measures, along with the creek and other restoration actions described in this plan, are designed to achieve desired vegetation cover conditions of late-seral stage old growth forest and riparian meadow wetland communities as targeted in the 2004 SNFPA AMS goals. The desired restoration and management practices envisioned for High Meadow are some of those recommended in the Washoe WCP (Washoe Tribe 2002), and these may involve Washoe participation in the long-term management of meadow and forest areas for growing culturally important plants.

RECOMMENDED VEGETATION OBJECTIVES

1. Increase meadow wetness in the lower and middle meadow.
2. Increase in total willow cover at High Meadow to approximately 60% of the meadow area (Bombay et al. 2003).
3. Increase willow cover $\geq$ 2 m in height within meadow to occupy at least 465 m^2 (0.046 ha) within one hectare of areas suitable for willow establishment (based on average willow cover in occupied willow flycatcher territories; Bombay-Loffland, unpublished data).
4. Increase spatial clumping of willow within meadow (willow patches with an approximate mean size of 375 m^2) (Bombay-Loffland, unpublished data).

RECOMMENDED WILDLIFE OBJECTIVES

1. Increase richness and abundance of butterflies and desired condition butterfly species at High Meadow.
2. Increase distribution of desired condition reptile and amphibian species at High Meadow.
3. Increase richness and abundance of songbirds and desired condition songbird species at High Meadow.
4. Maintain or increase productivity of focal songbird species. Expect productivity to increase within meadows due to increased meadow wetness which will reduce the ability of mammalian predators to access nests. Proper restoration of the meadow environment should provide conditions that prevent excessive nest predation; that is, prevent easy access by mammalian predators (e.g., weasels, chipmunks, mice) to nests. Relatively high nest predation would warrant re-evaluation of the success of meadow restoration.
5. Increase species richness of desired condition bat species High Meadow.
6. Increase species richness and abundance of desired condition small mammal species at High Meadow.
7. Decrease abundance of chipmunk species within the meadow as a result of increased meadow wetness.

8. Increase abundance of voles, shrews, weasels, and jumping mice within meadows.

MONITORING RECOMMENDATIONS

1. Evaluate meadow wetness and vegetation features (e.g., willows) at High Meadow in 2008.
2. Due to the response of songbird species seen at Cookhouse, we recommend that pre- and post-restoration songbird surveys continue at High Meadow and the control site to more accurately determine the effects of restoration.
3. We recommend that surveys for songbirds, bats, butterflies, and small mammals continue to more accurately detect the effect of restoration. Conducting three years of pre-restoration data allows us to assess the natural variability within the system when comparing pre- and post-restoration data.
4. Although we recorded gross vegetation features where butterflies were first detected, additional vegetation and soil moisture data should be collected within each survey area to determine if vegetation and hydrological features influence butterfly diversity and abundance.
5. We recommend that visual encounter surveys for reptiles and amphibians be discontinued and that objectives and methods be re-evaluated.
6. Proposed songbird monitoring activities will include quantification of nest parasitism by brown-headed cowbirds and overall nesting success or productivity. High frequency of nest parasitism (i.e., >30%) would warrant consideration of implementation of cowbird control in and around High Meadow.
7. If continued monitoring of owl richness is deemed important, we suggest beginning surveys in mid-March or early April and completing them no later than mid-June. In addition, if determining the response of cavity-nesting owls to the creation and maintenance of snags in High Meadow is deemed important, we recommend focusing on the reproductive success of owls in the area. Determining owl productivity, however, is extremely time-intensive and would require an increase in manpower.
8. We suggest continued monitoring of bat species at High Meadow and Fountain Place, to determine if activity increases post-restoration. If activity does not increase post-restoration, we recommend that more intensive studies be initiated to locate and quantify roosting and maternity sites, which will require the use of telemetry.

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LITERATURE CITED

Adams, M. J. 1999. Correlated factors in amphibian decline: exotic species and habitat change in western Washington. Journal of Wildlife Management 63:1162–1171.

Belk, M.C., Smith, H.D., and J. Lawson. 1988. Use and partitioning of montane habitat by small mammals. Journal of Mammalogy 69: 688–695.

Block, W. M., A. B. Franklin, J. P. Ward, Jr., J. L. Ganey, and G. C. White. 2001. Design and implementation of monitoring studies to evaluate the success of ecological restoration on wildlife. Restoration Ecology 9:293-303.

Bombay, H. L., M. L. Morrison., and L. S. Hal. 2003. Scale perspectives in habitat selection and animal performance for willow flycatchers (*Empidonax traillii*) in the central Sierra Nevada, California. Studies in Avian Biology 26:60-72.

Bradley, P. V., M. J. O'Farrell, J. A. Williams, and J. E. Newmark. Editors. 2006. The revised Nevada bat conservation plan. Nevada Bat Working Group. Reno, Nevada.

Brown, L. N. 1967. Seasonal activity patterns and breeding of the western jumping mouse (*Zapus princeps*) in Wyoming. American Midland Naturalist 78: 460–470.

Brown, L. N. 1970. Population dynamics of the western jumping mouse (*Zapus princeps*) during a four-year study. Journal of Mammalogy 51: 651–658.

Cain, J. W. III, M. L. Morrison, and H. L. Bombay. 2003. Predator activity and nest success of willow flycatchers and yellow warblers. Journal of Wildlife Management 67: 600–610.

Evans Mack, D., and W. Yong. 2000. Swainson's Thrush (*Catharus ustulatus*). *In* The Birds of North America, No. 540 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Findley, J.S. 1999. Vagrant shrew: *Sorex vagrans*. Pages 46–47 *in* Wilson, D. E. and S. Ruff, editors. The Smithsonian book of North American mammals. Smithsonian Institute Press, Washington and London.

George, S. B. 1989. *Sorex trowbridgii*. Mammalian Species 337: 1–5.

Gillihan, S. W. and K. R. Foresman. 2004. *Sorex vagrans*. Mammalian Species 744: 1–5.

Grindal, S. D., J. L. Morissette, and R. M. Brigham. 1999. Concentration of bat activity in riparian habitats over an elevational gradient. Canadian Journal of Zoology 77: 972–977.

Grinnell, J. and A. H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna. 27:1-608.

Hamas, M. J. 1994. Belted Kingfisher (*Ceryle alcyon*). *In* The Birds of North America, No. 84 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Hargis, C.D., C. McCarthy, and R.D. Perloff. 1994. Home ranges and habitats of northern goshawks in eastern California. Studies in Avian Biology 16: 66–74.

Hayes, M. P., M. R. Jennings. 1986. Decline of ranid frog species in western North America: are bullfrogs (*Rana catesbeiana*) responsible? Journal of Herpetology 20: 490–509.

Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster, editors. 1994. Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington D.C.

Jenkins, S. H., and B. D. Eshelman. 1984. *Spermophilus beldingi*. Mammalian Species 221: 1–8.

Johnsgard, P. L. 2002. North American owls: biology and natural history. Second edition. Smithsonian Institution Press, Washington, D.C., USA.

Keane, J.J., M.L. Morrison, and D.M. Fry. 2006. Prey and weather factors associated with temporal variation in northern goshawk reproduction in the Sierra Nevada, California. Studies in Avian Biology 31: 85–99.

Kingery, H. E. 1996. American Dipper (*Cinclus mexicanus*). *In* The Birds of North America, No. 229 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Knapp, R. A. 2000. Mountain yellow-legged frog. www.mylfrog.info.

Knapp, R. A., and K. R. Matthews. 2000. Non-native fish introductions and the decline of the mountain yellow-legged frog from within protected areas. Conservation Biology 14:428-438.

Knapp, R.A., K.R. Matthews, and O. Sarnelle. 2001. Resistance and resilience of alpine lake fauna to fish introductions. Ecological Monographs, Ecological Monographs 71:401-421.

Knapp, R. A. 2005. Effects of nonnative fish and habitat characteristics on lentic herpetofauna in Yosemite National Park, USA. Biological Conservation 121:265-279.

Loegering, J. P., and R. G. Anthony. 2006. Nest-site selection and productivity of American dippers in the Oregon coast range. The Wilson Journal of Ornithology 118: 281–428.

Mallory, M., and K. Metz. 1999. Common Merganser (*Mergus merganser*). *In* The Birds of North America, No. 442 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Manley, P. N., J. A. Fites-Kaufman, M. G. Barbour, M. D. Schlesinger, D. M. Rizzo. 2000. Biological integrity. Pages 403-598 *in* D. D. Murphy and C. M. Knopp, editors. Lake Tahoe watershed assessment: Volume II. U.S. Forest Service General Technical Report PSW-175.

Manley, P. N., J. Roth, M. McKenzie, and M. Schlesinger. 2002. Multiple-Species Inventory and Monitoring, 2002 Monitoring Report. Lake Tahoe Basin Management Unit (rev. Nov 13, 2002).

Manning, R. W., and J. K. Jones, Jr. 1989. *Myotis evotis*. Mammalian Species 329: 1–5.

Mayfield, H. 1961. Nesting success calculated from exposure. The Wilson Bulletin 73: 255–261.

Morrison, M. L., W. M. Block, M. D. Strickland, and W. L. Kendall. 2001. Wildlife study design. Springer-Verlag, New York, New York, USA.

Morrison, M. L. 2002. Wildlife Restoration: techniques for habitat analysis and animal monitoring. Island Press, Washington D.C.

O'Farrell, M. J., and E. H. Studier. 1980. *Myotis thysanodes*. Mammalian Species 137: 1–5.

Oring, L. W., E. M. Gray, and J. M. Reed. 1997. Spotted Sandpiper (*Actitis macularia*). *In* The Birds of North America, No. 289 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Orr, R. T. 1949. Mammals of Lake Tahoe. California Academy of Sciences, San Francisco, California.

Orr, R. T., and J. Moffitt. 1971. Birds of the Lake Tahoe region. California Academy of Sciences, San Francisco, California.

Schlesinger, M. D., and J. S. Romsos. 2000. Vertebrate species of the Lake Tahoe Basin. Pages G1–G15 *in* D. D. Murphy and C. M. Knopp, editors. Lake Tahoe Watershed Assessment: Volume II. Appendixes. USDA Forest Service General Technical Report PSW-GTR-176.

Sheffield, S. R., and H. H. Thomas. 1997. *Mustela frenata*. Mammalian Species 570: 1–9.

Shepperd, W. D., P. C. Rogers., D. Burton, and D. L. Bartos. 2006. Ecology, biodiversity, management, and restoration of aspen in the Sierra Nevada. USDA Forest Service Rocky Mountain Research Station General Technical Report RMRS-GTR-178.

Siders, M.S., and P.L. Kenndey. 1994. Nesting habitat of *Accipiter* hawks: is body size a consistent predictor of nest habitat characteristics? Studies in Avian Biology 16: 92–96.

Sierra Nevada Forest Plan Amendment, Record of Decision. 2004. Appendix A, Management Goals and Strategies, Aquatic Management Strategy. http://www.fs.fed.us/r5/snfpa/final-seis/rod/appendix-a/goals-strategies/ecosystems.html

Smolen, M. J., and B. L. Keller. 1987. *Microtus longicaudus*. Mammalian Species 271: 1–7.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47: 893–901.

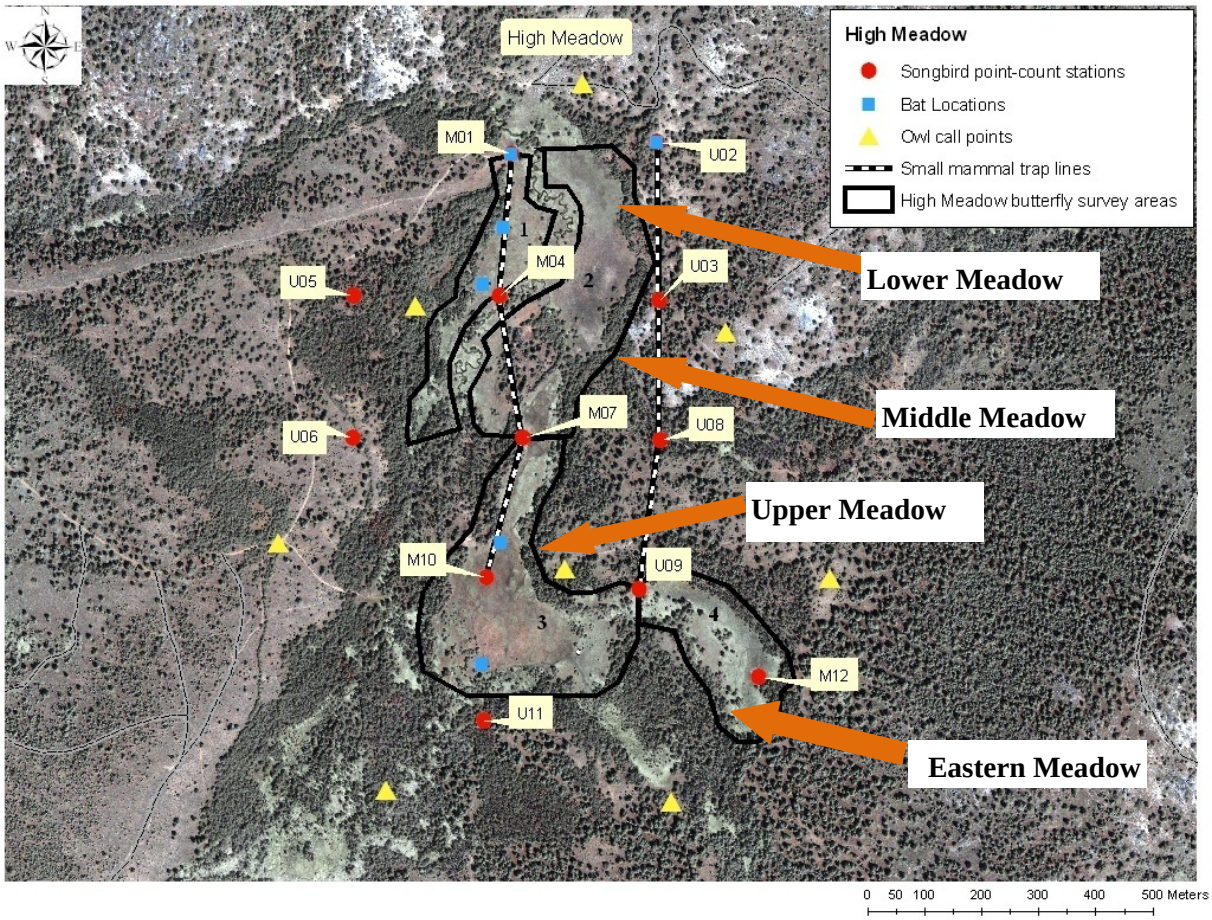
Verner, J., and A. S. Boss. 1980. California wildlife and their habitats: western Sierra Nevada. U.S. Forest Service General Technical Report PSW-37.

Walters, E. L., E. H. Miller, and P. E. Lowther. 2002. Red-breasted Sapsucker (*Sphyrapicus ruber*) and Red-naped Sapsucker (*Sphyrapicus nuchalis*). *In* The Birds of North America, No. 663 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Washoe Tribe. 2002. Meeks Creek (Ma' yala wata) and Taylor Creek (Dagachu wata) Wetland Conservation Plan, Washoe Tribe of Nevada and California, April 1, 2002.

Western Bat Working Group [WBWG]. 2005. WBWG home page. <http://www.wbwg.org/>.

Appendix 3.1. Survey locations at High Meadow. Bat detector locations as indicated are for 2007 only.



Appendix 3.2. Desired condition butterfly species detected at High Meadow in 2006 and 2007. Potentially beneficial restoration activities are based on habitat preferences; up arrows suggest that restoration could focus on increasing the abundance of host plants. Species were selected based those that have specific host-plant preferences and are generally restricted to wet meadow and riparian communities.

Species	**Detected in 2006**	**Detected in 2007**	**Community[1]**	**Potentially beneficial restoration activities[2]**
Northern Blue (*Lycaeides idas*)			Meadow	↑*Astragalus* spp., *Lotus* spp., *Lupinus* spp., yarrow (*Achillea millefolium*), flowers in fabaceae family ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies
Greenish Blue (*Plebejus saepiolus*)	Y	Y	Meadow Riparian	↑ in *Trifolium* spp., clover spp. ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies
Sierra Nevada Blue (*Agriades podarce*)	Y	Y	Meadow	↑ in *Dodecatheon* spp., yellow composite spp., bistort (*Polygonum bistortoides*) ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies
Great Spangled Fritillary (*Speyeria cybele*)			Meadow Riparian	↑ in *Viola* spp., thistle spp. (*Cirsium* spp.), clover spp. ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies
Pacific Fritillary (*Boloria epithore*)	Y	Y	Meadow	↑ in *Viola* spp. ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies
Sonoran Skipper (*Polites sonora*)	Y	Y	Meadow	↑ in *Festuca* spp., white-flowered thistle spp. (*Cirsium* spp.) ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies
Western tiger swallowtail (*Papilio rutulus*)	Y	Y	Riparian	↑ in *Populus* spp., *Salix* spp. ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies
Purplish copper (*Lycaena helloides*)			Riparian	↑ in *Polygonum* spp., *Rumex* spp., species in the buckwheat family (Polygonaceae), cinquefoil (*Potentilla* spp.) ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies
Lilac-bordered copper (*Lycaena nivalis*)	Y		Riparian	↑ in *Polygonum* spp., *Rumex* spp., species in the buckwheat family (Polygonaceae) ↑ open forest patches
Satyr comma (*Polygonia satyrus*)	Y	Y	Riparian	↑ in *Urtica* spp., fruiting shrubs ↑ open forest patches and ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies
Mourning cloak (*Nymphalis antiopa*)	Y	Y	Riparian	↑ in *Populus* spp (cottonwood and aspen)., *Salix* spp. ↑ openings along riparian areas
Lorquin's admiral (*Limenitis lorquini*)	Y	Y	Riparian	↑ in *Prunus* spp., *Populus* spp., *Salix* spp ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies

[1]Community types: Meadow – includes within-meadow streams; Forest – mixed-conifer forest; Riparian – aspen and cottonwood forests along riparian corridors; Marsh – wetland and open-water areas.
[2]Source: http://www.butterfliesandmoths.org/

Appendix 3.3. Reptile and amphibian representative of desired conditions detected in 2005 at High Meadow and the potentially beneficial restoration activities based on habitat preferences. Up arrows suggest that restoration could focus on increasing or creating specified condition and down arrows suggest that restoration could focus on decreasing specified condition.

Species	Desired condition species[1]	MIS[2]	Detected in 2006	Community	Potentially beneficial restoration activities[3]	Notes
Long-toed salamander (*Ambystoma macrodactylum*)	X			Forest Riparian Meadow	↓ non-native trout, ↑ habitat near breeding ponds, ↓ bullfrogs, ↑ number of temporary pools of water for breeding sites, ↑ downed woody debris	Potentially vulnerable terrestrial vertebrate (Manley et al. 2000)
Western toad (*Bufo boreas*)	X		Y	Riparian Meadow	↑ number of temporary pools, ↑ vegetative cover around pools to decrease UV radiation, ↓ non-native trout	Species with known population declines (Manley et al. 2000). Potentially vulnerable terrestrial vertebrate (Manley et al. 2000).
Pacific treefrog (*Hyla regilla*)	X		Y	Forest Riparian Meadow	↓ non-native trout, ↓ bullfrogs, ↑ shallow-water pools	Species with known population declines (Manley et al. 2000). Potentially vulnerable terrestrial vertebrate (Manley et al. 2000).
W. terrestrial garter snake (*Thamnophis elegans*)	X	X		Forest Riparian Meadow	↓ non-native trout, ↑ downed-woody debris, ↑ marsh/wetland vegetation	Species with known population declines (Manley et al. 2000)
W. aquatic garter snake (*Thamnophis couchii*)	X	X		Meadow	↑ number of shallow pools and wetland vegetation	Potentially vulnerable terrestrial vertebrate (Manley et al. 2000)
Common garter snake (*Thamnophis sirtalis*)	X			Forest Riparian Meadow	↑ number of shallow pools and wetland vegetation	

[1]Desired condition species are species that should be present following restoration data based on historic and current data.
[2]USDA Forest Service Management Indicator Species (MIS) identified in the Sierra Nevada Forest Plan Amendment – Final Supplemental Environmental Impact Statement.
[3]Sources: Stebbins, R. C. 1985. A field guide to western reptiles and amphibians. Houghton Mifflin Company, Boston.

Appendix 3.4. Potentially beneficial management and restoration activities for desired condition bird species, Partners in Flight (PIF), riparian habitat joint venture focal bird species (RHJV), USDA Forest Service Management Indicator Species (MIS), and USDA Forest Service Species At Risk (SAR), that were detected within 50 m of point-count stations in 2006 and 2007 at High Meadow. Up arrows suggest that restoration could focus on increasing or creating specified condition and down arrows suggest that restoration could focus on decreasing specified condition.

Species	Desired condition species[1]	PIF[2]	RHJV[3]	MIS[4]	SAR[5]	Detected in 2006	Detected in 2007	Community[6]	Potentially beneficial restoration activities[7]
Common Merganser (*Mergus merganser*)	X							Meadow Marsh	Provide nest boxes, ↑ snags near lakes and rivers bordered by forest
Northern Goshawk (*Accipter gentilis*)	X							Forest	↑ mature forest trees, ↓ disturbance during the breeding season
Blue Grouse (*Dendragapus obscurus*)	X			X				Forest	↑ proportion of early successional vegetation, ↑ aspen regeneration, ↓ OHV use in areas with Blue Grouse
Mountain Quail (*Oreortyx pictus*)				X				Forest	↑ shrubby vegetation
Spotted Sandpiper (*Actitis macularia*)	X		X					Meadow	↓ stream incision, ↑ gravel bars and sinuosity
Wilson's Snipe (*Gallinago gallinago*)	X							Marsh Meadow	↑ wet willow/alder thickets, ↑ duration of wet conditions, ↓ activities that compact soil
Calliope Hummingbird (*Stellula calliope*)	X			X			Y	Meadow	↑ early successional vegetation, ↑aspen regeneration along streams
Belted Kingfisher (*Ceryle alcyon*)	X	X						Meadow	↑ stream clarity, create streams with riffles, ↓ turbidity, provide areas with earthen banks for nesting cavities
Red-breasted Sapsucker (*Sphyrapicus ruber*)	X			X		Y	Y	Riparian	↑ snags (112 snags/100 ha)
Williamson's Sapsucker (*Sphyrapicus thyroideus*)	X			X				Riparian	↑ aspen regeneration, ↑ snags in groups
Hairy Woodpecker (*Picoides villosus*)				X		Y	Y	Forest	↑ snags
Downy Woodpecker (*Picoides pubescens*)				X				Forest	↑ snags
Black-backed Woodpecker (*Picoides arcticus*)				X				Forest	↑ snags

Appendix 3.4 (Cont.)

Species	Desired condition species[1]	PIF[2]	RHJV[3]	MIS[4]	SAR[5]	Detected in 2006	Detected in 2007	Community[6]	Potentially beneficial restoration activities[7]
White-headed Woodpecker (*Picoides albolarvatus*)	X	X		X			Y	Forest	↑ snags, ↑ areas with 50-50% open canopy with sparse understory in coniferous forests
Northern Flicker (*Colaptes auratus*)		X		X				Forest	↑ snags (93 snags/100 ha), ↑ aspen regeneration, ↑ cottonwood density along creeks
Pileated Woodpecker (*Dryocopus pileatus*)				X				Forest	↑ snags, ↑ old-growth conditions, ↑ canopy closure >60%
Olive-sided Flycatcher (*Contopus cooperi*)		X						Forest	↑ proportion of late successional forests with <50% canopy cover, ↑ snags, ↑ use of prescribed fire
Western Wood-Pewee (*Contopus sordidulus*)		X				Y	Y	Forest	↓ densely vegetated understories, ↑ standing dead trees, ↑ habitat type transition zones
Hammond's Flycatcher (*Empidonax hammondii*)				X				Forest	↑old-growth conditions, dense fir and aspen
Warbling Vireo (*Vireo gilvus*)			X			Y	Y	Meadow Riparian	↓ parasitism risk, ↑ deciduous component
Violet-green Swallow (*Tachycineta thalassina*)		X	X	X				Meadow Riparian	↓ tree density, ↑ snags
Bank Swallow (*Riparia riparia*)			X					Meadow Riparian	↑ streams with low gradient meanders and eroding banks for nesting substrate
Mountain Chickadee (*Poecile gambeli*)		X				Y	Y	Forest	↑ aspen, ↑ snags, maintain incense cedar for wintering forage, ↑ conifer diversity
White-breasted Nuthatch (*Sitta carolinensis*)				X				Forest	↑ snags 30-38 cm dbh, ↑ mature forest with diverse conifer species
Red-breasted Nuthatch (*Sitta canadensis*)		X		X		Y	Y	Forest	↑ snags with existing cavities, ↑ mature deciduous forest
Pygmy Nuthatch (*Sitta pygmaea*)	X							Forest	↓ stand density in Jeffery pine forests, ↑ snags, ↓ forest disturbances, ↑ heterogeneous mix of well-spaced pines of various ages
Brown Creeper (*Certhia americana*)		X		X		Y	Y	Forest	↑ proportion of old-growth forest conditions, ↑ snags (>40 cm dbh), preserve large trees (>100 cm dbh),

Appendix 3.4 (Cont.)

Species	Desired condition species[1]	PIF[2]	RHJV[3]	MIS[4]	SAR[5]	Detected in 2006	Detected in 2007	Community[6]	Potentially beneficial restoration activities[7]
House Wren (*Troglodytes aedon*)	X			X				Forest Riparian	Provide nest boxes, ↑ deciduous component along streams
Golden-crowned Kinglet (*Regulus strapa*)		X		X		Y	Y	Forest	↓ logging, ↑ old-growth forest conditions
American Dipper (*Cinclus mexicanus*)	X							Meadow Riparian	Create streams with rocky bottoms, ↑ water clarity, create riffles in streams, ↓ pollution
Swainson's Thrush (*Catharus ustulatus*)	X		X		X			Meadow Riparian	↑ ground and shrub cover along streams, ↑ meadow wetness, ↑ aspen regeneration, ↑ forest tree density and canopy closure
Mountain Bluebird (*Sialia currucoides*)	X			X				Meadow Riparian	↑ snags >38 cm dbh
Orange-crowned Warbler (*Vermivora celata*)		X						Meadow	↑ ground and shrub cover along streamsides
Yellow Warbler (*Dendroica petechia*)	X	X	X	X				Meadow	↑ willow, ↓ parasitism risk, ↑ meadow wetness
Hermit Warbler (*Dendroica occidentalis*)	X	X						Forest	↑ old-growth conditions with high canopy volume
Wilson's Warbler (*Wilsonia pusilla*)		X	X	X				Meadow Riparian	↑ ground and shrub cover
Western Tanager (*Piranga ludoviciana*)		X				Y	Y	Forest	↑ aspen regeneration, ↑ deciduous component along streams, create habitat type transition zones
Chipping Sparrow (*Spizella passerina*)		X				Y	Y	Forest	Provide open grassy areas in conifer forests, ↑ early succession community
Song Sparrow (*Melospiza melodia*)			X	X				Meadow Riparian	↑ meadow wetness and duration, ↑ willow and shrub component
White-crowned Sparrow (*Zonotrichia leucophrys*)				X	X			Meadow	↑ patches of open grassy meadow, ↑ density of shrubs
Lincoln's Sparrow (*Melospiza lincolnii*)	X			X		Y	Y	Meadow Riparian	↑ meadow wetness and duration, ↑ density of willow and shrub component,

Appendix 3.4 (Cont.)

Species	Desired condition species[1]	PIF[2]	RHJV[3]	MIS[4]	SAR[5]	Detected in 2006	Detected in 2007	Community[6]	Potentially beneficial restoration activities[7]
Fox Sparrow (*Passerella iliaca*)				X				Forest	Prefers shrubby component
Black-headed Grosbeak (*Pheucticus melanocephalus*)		X	X					Meadow	↑ willow, ↑ cottonwood along creeks, ↑ aspen regeneration, create habitat type transition zones
Brewer's Blackbird (*Euphagus cyanocephalus*)		X						Meadow Marsh	↑ open areas with suitable perches
Cassin's Finch (*Carpodacus cassinii*)		X		X		Y	Y	Forest	↓ tree density in coniferous forests
Evening Grosbeak (*Coccothraustes vespertinus*)		X					Y	Forest	↓ mixed conifer density to provide more open canopy

[1]Desired condition species are species that should be present following restoration data based on historic and current data.
[2]Based on Partners in Flight assessment scores (PIF 2005). Species selected as priority species if they met any of the following criteria, (1) in need of management attention to reduce long-term population declines, (2) severe deterioration in the future of breeding conditions is expected due to vulnerability to human activities, habitat fragmentation or loss, or high levels of nest depredation or parasitism, (3) population trend exhibits a >15% decline, (4) regional stewardship is required to maintain or improve population, or (5) percent of the breeding population is >10% in the Sierras.
[3] Focal riparian area species selection based on (1) the use of riparian vegetation during the breeding season, (2) species status (e. g., threatened), the reduction in historical breeding range, (3) abundance of the species to allow for adequate sample sizes, and (4) species that represent all successional stages within riparian areas (Riparian Habitat Joint Venture 2004).
[4]USDA Forest Service Management Indicator Species (MIS) identified in the Sierra Nevada Forest Plan Amendment – Final Supplemental Environmental Impact Statement.
[5]USDA Forest Service Species At Risk (SAR) identified in the Sierra Nevada Forest Plan Amendment FEIS Appendix E.
[6]Sites: Big Meadow (BM), Blackwood (BW), Cookhouse (CH), High Meadow (HM), Meeks (MC), Sunset Reach (SR), Tallac Marsh (TLM), Taylor Marsh (TYM), and Ward Creek (WC).
[7]Community types: Meadow – includes within-meadow streams; Forest – mixed-conifer forest; Riparian – aspen and cottonwood forests along riparian corridors; Marsh – wetland and open-water areas.
[8]Sources:
Altman, B., and R. Sallabanks. 2000. Olive-sided Flycatcher (*Contopus cooperi*). *In* The Birds of North America, No. 502 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Ammon, E. M. 1995. Lincoln's Sparrow (*Melospiza lincolnii*). *In* The Birds of North America, No. 191 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.
Ammon, E. M., and W. M. Gilbert. 1999. Wilson's Warbler (*Wilsonia pusilla*). *In* The Birds of North America, No. 478 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Arcese, P., M. K. Sogge, A. B. Marr, and M. A. Patten. 2002. Song Sparrow (*Melospiza melodia*). *In* The Birds of North America, No. 704 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Austin, J. E., and M. R. Miller. 1995. Northern Pintail (*Anas acuta*). *In* The Birds of North America, No. 163 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.
Bemis, C., and J. D. Rising. 1999. Western Wood-Pewee (*Contopus sordidulus*). *In* The Birds of North America, No. 451 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Brown, C. R., Knott, A. M., and E. J. Damrose. 1992. Violet-green Swallow. *In* The Birds of North America, No. 14 (A. Poole, P. Stettenheim, and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union.
Buehler, D. A. 2000. Bald Eagle (*Haliaeetus leucocephalus*). *In* The Birds of North America, No. 506 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Bull, Evelyn L., and Jerome A. Jackson. 1995. Pileated Woodpecker (Dryocopus pileatus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/148
Butler, R. W. 1992. Great Blue Heron. *In* The Birds of North America, No. 25 (A. Poole, P. Stettenheim, and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union.
Calder, W. A., and L. L. Calder. 1994. Calliope Hummingbird (*Stellula calliope*). *In* The Birds of North America, No. 135 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.
Chilton, G., M. C. Baker, C. D. Barrentine, and M. A. Cunningham. 1995. White-crowned Sparrow (Zonotrichia leucophrys), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/183
Cullen, S. A., J. R. Jehl Jr., and G. L. Nuechterlein. 1999. Eared Grebe (*Podiceps nigricollis*). *In* The Birds of North America, No. 433 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Davis, W. E., Jr. 1993. Black-crowned Night-Heron (*Nycticorax nycticorax*). *In* The Birds of North America, No. 74 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.
Dobbs, R. C., T. E. Martin, and C. J. Conway. 1997. Williamson's Sapsucker (*Sphyrapicus thyroideus*). *In* The Birds of North America, No. 285 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
Evans Mack, D., and W. Yong. 2000. Swainson's Thrush (*Catharus ustulatus*). *In* The Birds of North America, No. 540 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Gardali, T., and G. Ballard. 2000. Warbling Vireo (*Vireo gilvus*). *In* The Birds of North America, No. 551 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Garrett, K. L., M. G. Raphael, and R. D. Dixon. 1996. White-headed Woodpecker (*Picoides albolarvatus*). *In* The Birds of North America, No. 252 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
Garrison, B. A. 1999. Bank Swallow (*Riparia riparia*). *In* The Birds of North America, No. 414 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Ghalambor, C. K., and T. E. Martin. 1999. Red-breasted Nuthatch (*Sitta canadensis*). *In* The Birds of North America, No. 459 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Gibbs, J. P. , S. Melvin, and F. A. Reid. 1992. American Bittern. *In* The Birds of North America, No. 18 (A. Poole, P. Stettenheim, and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union.
Gillihan, S. W., and B. Byers. 2001. Evening Grosbeak (*Coccothraustes verspertinus*). *In* The Birds of North America, No. 599 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Greene, E., W. Davison, and V. R. Muehter. 1998. Steller's Jay (*Cyanocitta stelleri*). *In* The Birds of North America, No. 343 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Gutiérrez, R. J., A. B. Franklin, and W. S. Lahaye. 1995. Spotted Owl (*Strix occidentalis*). *In* The Birds of North America, No. 179 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.

Gutiérrez, R. J., and D. J. Delehanty. 1999. Mountain Quail (*Oreortyx pictus*). *In* The Birds of North America, No. 457 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Hahn, T. P. 1996. Cassin's Finch (*Carpodacus cassinii*). *In* The Birds of North America, No. 240 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
Hamas, M. J. 1994. Belted Kingfisher (*Ceryle alcyon*). *In* The Birds of North America, No. 84 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.
Hejl, S. J., K. R. Newlon, M. E. McFadzen, J. S. Young, and C. K. Ghalambor. 2002. Brown Creeper (*Certhia americana*). *In* The Birds of North America, No. 669 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Hill, G. E. 1995. Black-headed Grosbeak (*Pheucticus melanocephalus*). *In* The Birds of North America, No. 143 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.
Hudon, J. 1999. Western Tanager (*Piranga ludoviciana*). *In* The Birds of North America, No. 432 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Ingold, J. L., and G. E. Wallace. 1994. Ruby-crowned Kinglet (*Regulus calendula*). *In* The Birds of North America, No. 119 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.
Ingold, J. L., and R. Galati. 1997. Golden-crowned Kinglet (*Regulus satrapa*). *In* The Birds of North America, No. 301 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
Johnson, K. 1995. Green-winged Teal (*Anas crecca*). *In* The Birds of North America, No. 193 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.
Johnson, L. S. 1998. House Wren (*Troglodytes aedon*). *In* The Birds of North America, No. 380 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Keppie, D. M., and C. E. Braun. 2000. Band-tailed Pigeon (*Columba fasciata*). *In* The Birds of North America, No. 530 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Kingery, H. E. 1996. American Dipper (*Cinclus mexicanus*). *In* The Birds of North America, No. 229 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
Kingery, H. E., and C. K. Ghalambor. 2001. Pygmy Nuthatch (*Sitta pygmaea*). *In* The Birds of North America, No. 567 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
LeSchack, C. R., S. K. McKnight, and G. R. Hepp. 1997. Gadwall (*Anas strepera*). *In* The Birds of North America, No. 283 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
Lowther, P. E., C. Celada, N. K. Klein, C. C. Rimmer, and D. A. Spector. (1999). Yellow Warbler (*Dendroica petechia*). The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Laboratory of Ornithology; Retrieved from The Birds of North American Online database: http://bna.birds.cornell.edu/BNA/account/Yellow_Warbler/.
Mallory, M., and K. Metz. 1999. Common Merganser (*Mergus merganser*). *In* The Birds of North America, No. 442 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Martin, S. G. 2002. Brewer's Blackbird (*Euphagus cyanocephalus*). *In* The Birds of North America, No. 616 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
McCallum, D. A., R. Grundel, and D. L. Dahlsten. 1999. Mountain Chickadee (*Poecile gambeli*). *In* The Birds of North America, No. 453 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
McNicholl, M. K., P. E. Lowther, and J. A. Hall. 2001. Forster's Tern (*Sterna forsteri*). *In* The Birds of North America, No. 595 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Melvin, S. M., and J. P. Gibbs. 1996. Sora (*Porzana carolina*). *In* The Birds of North America, No. 250 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
Middleton, A. L. 1998. Chipping Sparrow (*Spizella passerina*). *In* The Birds of North America, No. 334 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Moore, W. S. 1995. Northern Flicker (*Colaptes auratus*). *In* The Birds of North America, No. 166 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.
Mueller, H. (2005). Wilson's Snipe (*Gallinago delicata*). The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Laboratory of Ornithology; Retrieved from The Birds of North American Online database: http://bna.birds.cornell.edu/BNA/account/Wilsons_Snipe/.
Muller, M. J., and R. W. Storer. 1999. Pied-billed Grebe (*Podilymbus podiceps*). *In* The Birds of North America, No. 410 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Oring, L. W., E. M. Gray, and J. M. Reed. 1997. Spotted Sandpiper (*Actitis macularia*). *In* The Birds of North America, No. 289 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
Pearson, S. F. 1997. Hermit Warbler (*Dendroica occidentalis*). *In* The Birds of North America, No. 303 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
Poole, A. F., R. O. Bierregaard, and M. S. Martell. 2002. Osprey (*Pandion haliaetus*). *In* The Birds of North America, No. 683 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Poulin, R. G., S. D. Grindal, and R. M. Brigham. 1996. Common Nighthawk (*Chordeiles minor*). *In* The Birds of North America, No. 213 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.
Power, H. W., and M. P. Lombardo. 1996. Mountain Bluebird (*Sialia currucoides*). *In* The Birds of North America, No. 222 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
Pravosudov, V. V., and T. C. Grubb, Jr. 1993. White-breasted Nuthatch (Sitta carolinensis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/054doi:bna.054
Sedgwick, J. A. 2000. Willow Flycatcher (*Empidonax traillii*). *In* The Birds of North America, No. 533 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
James A., Sedgwick., J. A. 1994. Hammond's Flycatcher (Empidonax hammondii), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/109doi: bna.109
Sogge, M. K., W. M. Gilbert, and C. v. Riper III. 1994. Orange-crowned Warbler (*Vermivora celata*). *In* The Birds of North America, No. 101 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.
Twedt, D. J., and R. D. Crawford. 1995. Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*). *In* The Birds of North America, No. 192 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.
Walters, E. L., E. H. Miller, and P. E. Lowther. 2002. Red-breasted Sapsucker (*Sphyrapicus ruber*) and Red-naped Sapsucker (*Sphyrapicus nuchalis*). *In* The Birds of North America, No. 663 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Williams, J. M. 1996. Nashville Warbler (*Vermivora ruficapilla*). *In* The Birds of North America, No. 205 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.
Woodin, M. C., and T. C. Michot. 2002. Redhead (*Aythya americana*). *In* The Birds of North America, No. 695 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
Zwickel, F. C. (2005). Blue Grouse (*Dendragapus obscurus*). The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Laboratory of Ornithology; Retrieved from The Birds of North American Online database: http://bna.birds.cornell.edu/BNA/account/Blue_Grouse/.

Appendix 3.5. Mammal species representative of desired ecological conditions and USDA Forest Service Management Indicator Species (MIS) and potentially beneficial restoration activities based on habitat preferences. A "Y" indicates that this species was detected during surveys. Up arrows suggest that restoration could focus on increasing or creating specified condition and down arrows suggest that restoration could focus on decreasing specified condition.

Species	Desired condition species[1]	MIS[2]	Detected in 2006	Detected in 2007	Community	Potentially beneficial restoration activities[4]	Notes
Bats							
Spotted bat (*Euderma maculatum*)	X				Forest Riparian Meadow	↓ human disturbance near roost sites, ↑ duration of meadow wetness	Federal species of special concern (Bradley et al. 2006)
Townsend's big-eared bat (*Corynorhinus townsendii*)	X				Forest Riparian Meadow	↓ human disturbance near roost sites, ↑ duration of meadow wetness	Federal species of special concern (Bradley et al. 2006)
Long-eared myotis (*Myotis evotis*)			Y	Y	Forest Riparian Meadow	↑ duration of meadow wetness, ↑ willows along streams, ↑ tree cavities for roost sites	Federal species of special concern (Manley et al. 2000)
Fringed myotis (*Myotis thysanodes*)				Y	Forest Riparian Meadow	↓ human disturbance near roost sites, ↑ duration of meadow wetness	Federal species of special concern (Manley et al. 2000)
Yuma myotis (*Myotis yumanensis*)					Forest Riparian Meadow	↑ number of tree cavities near streams, ↑ tree cavities for roost sites	Federal and state species of special concern (Manley et al. 2000)
Small Mammals							
Trowbridge's shrew (*Sorex trowbridgii*)	X				Riparian Meadow	↑ old-growth conditions, ↑ ground litter and ground cover	Potentially vulnerable terrestrial vertebrate (Manley et al. 2000)
Vagrant shrew (*Sorex vagrans*)	X	X			Riparian Meadow	↑ old-growth conditions, ↑ ground litter and ground cover	
Broad-footed mole (*Scapanus latimanus*)	X				Forest Riparian Meadow	↑ moisture level in soils, ↑ duration of moist soil conditions	Potentially vulnerable terrestrial vertebrate (Manley et al. 2000)
Long-tailed weasel (*Mustela frenata*)	X				Forest Riparian Meadow	↑ areas with standing water, ↑ understory shrub density	
Belding's ground squirrel (*Spermophilus beldingi*)	X		Y		Meadow	↑ proportion of succulent vegetation, ↑ areas with standing water, create meadow-like openings	Potentially vulnerable terrestrial vertebrate (Manley et al. 2000)

Appendix 3.5 (Cont.)

Species	Desired condition species[1]	MIS[2]	Detected in 2006	Detected in 2007	Community	Potentially beneficial restoration activities[4]	Notes
Northern flying squirrel (*Glaucomys sabrinus*)	X	X			Forest	↑ proportion of old-growth conditions	
Western jumping mouse (*Zapus princeps*)	X	X	Y		Forest Riparian Meadow	↑ and maintain meadow wetness, ↑ herbaceous cover near water	Potentially vulnerable terrestrial vertebrate (Manley et al. 2000)
Medium/Large Mammals							
American marten (*Martes americana*)	X	X			Forest Riparian	↑ proportion of mature coniferous forest with 30-50% crown density, ↑ downed-woody debris and dense understory shrub and forb component	Potentially vulnerable terrestrial vertebrate (Manley et al. 2000)
Mountain beaver (*Aplontia rufa*)	X	X			Meadow	↑ early successional vegetation along streams, ↓ soil compaction	Federal and state species of special concern (Manley et al. 2000)
Porcupine (*Erethizon dorsatum*)	X				Forest Riparian Meadow	↑ pine, ↓ coyotes	
Coyote (*Canis latrans*)	X			Y	Forest Riparian Meadow	↑ early successional vegetation	
Mule deer (*Odocoileus hemionus*)	X	X			Forest Riparian Meadow	↑ availability of succulent forage, ↑ early successional vegetation	

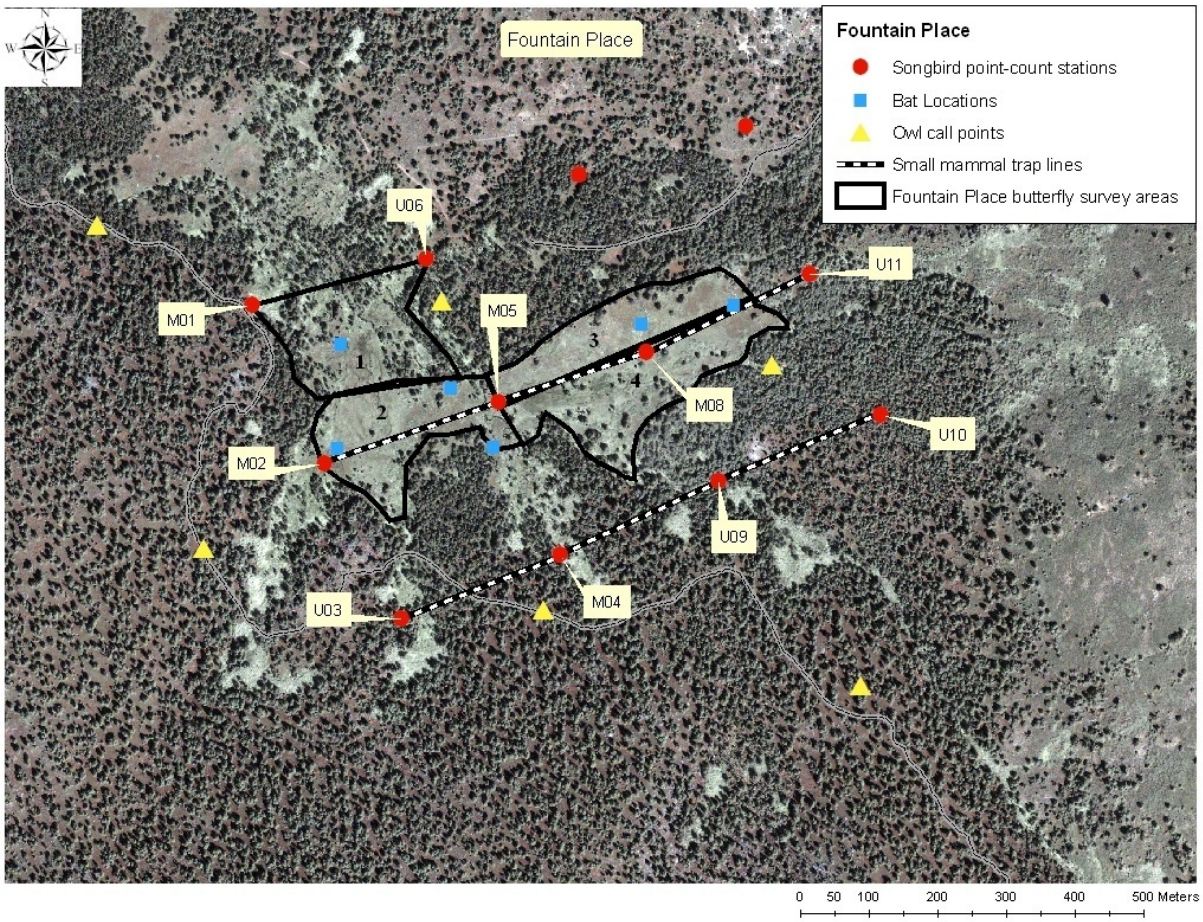
[1]Desired condition species are species that should be present following restoration data based on historic and current data.
[2]USDA Forest Service Management Indicator Species (MIS) identified in the Sierra Nevada Forest Plan Amendment – Final Supplemental Environmental Impact Statement.
[3]Sites: Big Meadow (BM), Blackwood (BW), Cookhouse (CH), High Meadow (HM), Meeks (MC), Sunset Reach (SR), Tallac Marsh (TLM), Taylor Marsh (TYM), and Ward Creek (WC).
[4]Sources:

Anderson, A. E., and O. C. Wallmo. 1984. *Odocoileus hemionus*. Mammalian Species 219:1-9.
Bekoff, M. 1977. *Canis latrans*. Mammalian Species 79:1-9.
Bradley, P. V., M. J. O'Farrell, J. A. Williams, and J. E. Newmark. Editors. 2006. The revised Nevada bat conservation plan. Nevada Bat Working Group. Reno, Nevada.
Carraway, L. N., and B. J. Verts. 1993. *Aplodontia rufa*. Mammalian Species 431:1-10.
Clark, T. W., E. Anderson, C. Douglas, and M. Strickland. 1987. *Martes americana*. Mammalian Species 289:1-8.
George, S. B. 1989. *Sorex trowbridgii*. Mammalian Species 337:1-5.
Jenkins, S. H., and P. E. Busher. 1979. *Castor Canadensis*. Mammalian Species 120:1-8.
Jenkins, S. H., and B. D. Eshelman. 1984. *Spermophilus beldingi*. Mammalian Species 221:1-8.

Appendix 3.5 (Cont.)

Manley, P. N., J. A. Fites-Kaufman, M. G. Barbour, M. D. Schlesinger, D. M. Rizzo. 2000. Biological integrity. Pages 403-598 *in* D. D. Murphy and C. M. Knopp, editors. Lake Tahoe watershed assessment: Volume II. U.S. Forest Service General Technical Report PSW-175.
Manning, R. W., and J. K. Jones, Jr. 1989. *Myotis evotis*. Mammalian Species 329:1-5.
O'Farrell, M. J., and E. H. Studier. 1980. *Myotis thysanodes*. Mammalian Species 137:1-5.
Sheffield, S. R., and H. H. Thomas. 1997. *Mustela frenata*. Mammalian Species 570:1-9.
Shump, K. A., Jr., and A. U. Shump. 1982. *Lasiurus borealis*. Mammalian Species 183:1-6.
Smith, F. A. 1997. *Neotoma cinerea*. Mammalian Species 564:1-8.
Vert, B. J., and L. N. Carraway. 2001. *Scapanus latimanus*. Mammalian Species 666:1-7.
Watkins, L. C. 1977. *Euderma maculatum*. Mammalian Species 77:1-4.

Appendix 3.6. Survey locations at Fountain Place (Control site). Bat detector locations as indicated are for 2007 only.



Appendix 3.7. UTM locations of bat detectors used to record sonograms of passing bats in 2007.

Site	Year	Visit	Zone	Easting	Northing
Fountain Place	2007	1	11	245457	4303973
Fountain Place	2007	1	11	245442	4303822
Fountain Place	2007	2	11	245897	4303973
Fountain Place	2007	2	11	246035	4303993
Fountain Place	2007	3	11	245670	4303808
Fountain Place	2007	3	11	245614	4303898
High Meadow	2007	1	11	248191	4309617
High Meadow	2007	1	11	248446	4309620
High Meadow	2007	2	11	248169	4309489
High Meadow	2007	2	11	248127	4309393
High Meadow	2007	3	11	248129	4308939
High Meadow	2007	3	11	248080	4308728

Appendix 3.8. Total number of individual butterflies detected at High Meadow during visual encounter and sweep-net surveys in 2007. Number of individuals detected is also corrected for the amount of area surveyed at High Meadow (Number/27 ha).

Common name	Scientific name	Total number of individuals detected	Number of individuals detected corrected for area surveyed (27 ha)
Anise swallowtail	*Papilio zelicaon*	3	0.11
Western tiger swallowtail	*Papilio rutulus*	7	0.26
Pale swallowtail	*Papilio eurymedon*	9	0.33
Checkered white	*Pontia protodice*	2	0.07
Western white	*Pontia occidentalis*	1	0.04
Cabbage white	*Pieris rapae*	2	0.07
Unknown white	*Subfamily Pierinae*	1	0.04
Stella orangetip	*Anthocharis stella*	14	0.52
Orange sulphur	*Colias eurytheme*	90	3.33
Unknown sulphur	*Colias spp.*	14	0.52
Edith's copper	*Lycaena editha*	19	0.70
Western pine elfin	*Callophrys eryphon*	2	0.07
Spring azure	*Celastrina ladon*	9	0.33
Unknown dotted-blue	*Euphilotes spp*	3	0.11
Silvery blue	*Glaucopsyche lygdamus*	1	0.04
Greenish blue	*Plebejus saepiolus*	419	15.52
Boisduval's blue	*Icaricia icarioides*	138	5.11
Sierra Nevada blue	*Agriades podarce*	408	15.11
Unknown blue	*Subfamily Polyommatinae*	49	1.81
Plebejus spp	*Plebejus spp*	1	0.04
Unknown Speyeria spp.	*Speyeria spp.*	3191	118.19
Pacific fritillary	*Boloria epithore*	96	3.56
Northern checkerspot	*Chlosyne palla*	11	0.41
Field crescent	*Phyciodes pratensis*	535	19.81
Unknown crescent	*Phyciodes spp.*	67	2.48
Satyr comma	*Polygonia satyrus*	60	2.22
Hoary comma	*Polygonia gracilis zephyrus*	20	0.74
Unknown comma	*Polygonia spp.*	3	0.11
California tortoiseshell	*Nymphalis californica*	3	0.11
Mourning cloak	*Nymphalis antiopa*	2	0.07
Milbert's tortoiseshell	*Nymphalis milberti*	3	0.11
American lady	*Vanessa virginiensis*	4	0.15
Lorquin's admiral	*Limenitis lorquini*	14	0.52
Monarch	*Danaus plexippus*	2	0.07
Mexican cloudywing	*Thorybes mexicanus*	1	0.04
Unknown cloudywing	*Thorybes spp*	20	0.74
Unknown duskywing	*Erynnis spp.*	47	1.74

Appendix 3.8. (Cont.)

Common name	Scientific name	Total number of individuals detected	Number of individuals detected corrected for area surveyed (27 ha)
Common checkered skipper	*Pyrgus communis*	1	0.04
Juba skipper	*Hesperia juba*	4	0.15
Sandhill skipper	*Polites sabuleti*	4	0.15
Sonoran skipper	*Polites sonora*	164	6.07
Unknown skipper	*Subfamily Hesperioidea*	45	1.67

Appendix 3.9. Total number of individual butterflies detected at Fountain Place during visual encounter and sweep-net surveys in 2007. Number of individuals detected is also corrected for the amount of area surveyed at Fountain Place (Number/12.9 ha).

Common name	Scientific name	Total number of individuals detected	Number of individuals detected corrected for area surveyed (12.9 ha)
Anise swallowtail	*Papilio zelicaon*	2	0.16
Western tiger swallowtail	*Papilio rutulus*	13	1.01
Pale swallowtail	*Papilio eurymedon*	12	0.93
Cabbage white	*Pieris rapae*	5	0.39
Unknown white	*Subfamily Pierinae*	7	0.54
Stella orangetip	*Anthocharis stella*	17	1.32
Orange sulphur	*Colias eurytheme*	74	5.74
Unknown sulphur	*Colias spp.*	18	1.40
Edith's copper	*Lycaena editha*	51	3.95
Lilac-bordered copper	*Lycaena nivalis*	8	0.62
Unknown copper	*Lycaena spp.*	1	0.08
Spring azure	*Celastrina ladon*	5	0.39
Unknown dotted-blue	*Euphilotes spp*	2	0.16
Silvery blue	*Glaucopsyche lygdamus*	2	0.16
Greenish blue	*Plebejus saepiolus*	598	46.36
Boisduval's blue	*Icaricia icarioides*	18	1.40
Sierra Nevada blue	*Agriades podarce*	310	24.03
Unknown blue	*Subfamily Polyommatinae*	47	3.64
Unknown Speyeria spp.	*Speyeria spp.*	729	56.51
Pacific fritillary	*Boloria epithore*	5	0.39
Unknown fritillary	*Genus Speyeria*	2	0.16
Northern checkerspot	*Chlosyne palla*	12	0.93
Unknown checkerspot	*Chlosyne spp.*	1	0.08
Field crescent	*Phyciodes pratensis*	132	10.23
Unknown crescent	*Phyciodes spp.*	35	2.71
Hoary comma	*Polygonia gracilis zephyrus*	10	0.78
Unknown comma	*Polygonia spp.*	3	0.23
California tortoiseshell	*Nymphalis californica*	1	0.08
Mourning cloak	*Nymphalis antiopa*	30	2.33
Unknown lady	*Vanessa spp.*	1	0.08
Common buckeye	*Junonia coenia*	1	0.08
Lorquin's admiral	*Limenitis lorquini*	18	1.40
California sister	*Adelpha bredowii*	1	0.08
Monarch	*Danaus plexippus*	1	0.08
Unknown cloudywing	*Thorybes spp*	5	0.39
Propertius duskywing	*Erynnis propertius*	6	0.47
Unknown duskywing	*Erynnis spp.*	22	1.71

Appendix 3.9. (Cont.)

Common name	Scientific name	Total number of individuals detected	Number of individuals detected corrected for area surveyed (12.9 ha)
Juba skipper	*Hesperia juba*	3	0.23
Sonoran skipper	*Polites sonora*	19	1.47
Unknown skipper	*Subfamily Hesperioidea*	6	0.47

Appendix 3.10. Average number of birds detected per point within 50 m of point-count stations (± SE) at High Meadow and the percentage of the avian community each species comprises. Data from 2007.

Community Type	Common name	Scientific name	Average number detected per point	SE	Percent composition
Meadow	Calliope Hummingbird	*Stellula calliope*	0.07	0.07	1
Meadow	Red-breasted Sapsucker	*Sphyrapicus ruber*	0.13	0.13	2
Meadow	Hairy Woodpecker	*Picoides villosus*	0.07	0.07	1
Meadow	Western Wood-Pewee	*Contopus sordidulus*	0.20	0.12	3
Meadow	Dusky Flycatcher	*Empidonax oberholseri*	0.80	0.12	12
Meadow	Warbling Vireo	*Vireo gilvus*	0.20	0.00	3
Meadow	Steller's Jay	*Cyanocitta stelleri*	0.07	0.07	1
Meadow	Mountain Chickadee	*Poecile gambeli*	0.40	0.00	6
Meadow	Brown Creeper	*Certhia americana*	0.27	0.07	4
Meadow	American Robin	*Turdus migratorius*	0.80	0.20	12
Meadow	Yellow-rumped Warbler	*Dendroica coronata*	0.20	0.20	3
Meadow	Western Tanager	*Piranga ludoviciana*	0.07	0.07	1
Meadow	Lincoln's Sparrow	*Melospiza lincolnii*	0.20	0.12	3
Meadow	Dark-eyed Junco	*Junco hyemalis*	1.53	0.33	22
Meadow	Black-headed Grosbeak	*Pheucticus melanocephalus*	0.13	0.07	2
Meadow	Brown-headed Cowbird	*Molothrus ater*	0.33	0.18	5
Meadow	Cassin's Finch	*Carpodacus cassinii*	0.60	0.23	9
Meadow	Pine Siskin	*Carduelis pinus*	0.60	0.35	9
Upland	Red-tailed Hawk	*Buteo jamaicensis*	0.05	0.05	1
Upland	Hairy Woodpecker	*Picoides villosus*	0.05	0.05	1
Upland	White-headed Woodpecker	*Picoides albolarvatus*	0.10	0.10	1
Upland	Western Wood-Pewee	*Contopus sordidulus*	0.33	0.17	5
Upland	Dusky Flycatcher	*Empidonax oberholseri*	0.86	0.14	12
Upland	Warbling Vireo	*Vireo gilvus*	0.19	0.05	3
Upland	Steller's Jay	*Cyanocitta stelleri*	0.10	0.05	1
Upland	Mountain Chickadee	*Poecile gambeli*	0.81	0.21	12
Upland	Red-breasted Nuthatch	*Sitta canadensis*	0.10	0.05	1
Upland	Brown Creeper	*Certhia americana*	0.43	0.16	6
Upland	Golden-crowned Kinglet	*Regulus satrapa*	0.05	0.05	1
Upland	Hermit Thrush	*Catharus guttatus*	0.05	0.05	1
Upland	American Robin	*Turdus migratorius*	0.71	0.22	10
Upland	Yellow-rumped Warbler	*Dendroica coronata*	0.57	0.00	8
Upland	Western Tanager	*Piranga ludoviciana*	0.19	0.05	3
Upland	Chipping Sparrow	*Spizella passerina*	0.14	0.14	2
Upland	Lincoln's Sparrow	*Melospiza lincolnii*	0.05	0.05	1
Upland	Dark-eyed Junco	*Junco hyemalis*	0.71	0.00	10
Upland	Black-headed Grosbeak	*Pheucticus melanocephalus*	0.05	0.05	1

Appendix 3.10. (Cont.)

Community Type	Common name	Scientific name	Average number detected per point	SE	Percent composition
Upland	Brown-headed Cowbird	*Molothrus ater*	0.29	0.08	4
Upland	Pine Grosbeak	*Pinicola enucleator*	0.14	0.14	2
Upland	Cassin's Finch	*Carpodacus cassinii*	0.24	0.05	3
Upland	Pine Siskin	*Carduelis pinus*	0.71	0.30	10
Upland	Evening Grosbeak	*Coccothraustes vespertinus*	0.05	0.05	1

Appendix 3.11. Average number of birds detected per point within 50 m of point-count stations (± SE) at Fountain Place and the percentage of the avian community each species comprises. Data from 2007.

Community type	Common name	Scientific name	Average number detected per point	SE	Percent composition
Meadow	Calliope Hummingbird	*Stellula calliope*	0.27	0.18	4
Meadow	Red-breasted Sapsucker	*Sphyrapicus ruber*	0.07	0.07	1
Meadow	Western Wood-Pewee	*Contopus sordidulus*	0.13	0.07	2
Meadow	Dusky Flycatcher	*Empidonax oberholseri*	1.20	0.53	19
Meadow	Warbling Vireo	*Vireo gilvus*	0.33	0.33	5
Meadow	Steller's Jay	*Cyanocitta stelleri*	0.13	0.13	2
Meadow	Mountain Chickadee	*Poecile gambeli*	0.40	0.12	6
Meadow	Brown Creeper	*Certhia americana*	0.27	0.13	4
Meadow	Golden-crowned Kinglet	*Regulus satrapa*	0.27	0.13	4
Meadow	American Robin	*Turdus migratorius*	0.47	0.07	7
Meadow	Yellow-rumped Warbler	*Dendroica coronata*	0.47	0.24	7
Meadow	MacGillivray's Warbler	*Oporornis tolmiei*	0.13	0.07	2
Meadow	Wilson's Warbler	*Wilsonia pusilla*	1.33	0.13	21
Meadow	Western Tanager	*Piranga ludoviciana*	0.07	0.07	1
Meadow	Song Sparrow	*Melospiza melodia*	0.33	0.24	5
Meadow	Lincoln's Sparrow	*Melospiza lincolnii*	0.93	0.13	15
Meadow	White-crowned Sparrow	*Zonotrichia leucophrys*	0.47	0.07	7
Meadow	Dark-eyed Junco	*Junco hyemalis*	1.07	0.29	17
Meadow	Brown-headed Cowbird	*Molothrus ater*	0.67	0.07	11
Meadow	Cassin's Finch	*Carpodacus cassinii*	0.33	0.24	5
Meadow	Pine Siskin	*Carduelis pinus*	1.13	0.18	18
Upland	Calliope Hummingbird	*Stellula calliope*	0.06	0.06	1
Upland	Red-breasted Sapsucker	*Sphyrapicus ruber*	0.17	0.10	3
Upland	Hairy Woodpecker	*Picoides villosus*	0.17	0.10	3
Upland	White-headed Woodpecker	*Picoides albolarvatus*	0.11	0.11	2
Upland	Western Wood-Pewee	*Contopus sordidulus*	0.28	0.15	4
Upland	Dusky Flycatcher	*Empidonax oberholseri*	0.50	0.10	8
Upland	Warbling Vireo	*Vireo gilvus*	0.33	0.19	5
Upland	Steller's Jay	*Cyanocitta stelleri*	0.17	0.10	3
Upland	Mountain Chickadee	*Poecile gambeli*	0.44	0.15	7
Upland	Red-breasted Nuthatch	*Sitta canadensis*	0.11	0.06	2
Upland	Brown Creeper	*Certhia americana*	0.28	0.11	4
Upland	Golden-crowned Kinglet	*Regulus satrapa*	0.39	0.11	6
Upland	American Robin	*Turdus migratorius*	0.39	0.20	6
Upland	Nashville Warbler	*Vermivora ruficapilla*	0.06	0.06	1
Upland	Yellow-rumped Warbler	*Dendroica coronata*	0.39	0.20	6
Upland	MacGillivray's Warbler	*Oporornis tolmiei*	0.11	0.06	2

Appendix 3.11. (Cont.)

Community type	Common name	Scientific name	Average number detected per point	SE	Percent composition
Upland	Wilson's Warbler	*Wilsonia pusilla*	0.33	0.19	5
Upland	Western Tanager	*Piranga ludoviciana*	0.06	0.06	1
Upland	Lincoln's Sparrow	*Melospiza lincolnii*	0.28	0.06	4
Upland	Dark-eyed Junco	*Junco hyemalis*	1.06	0.40	17
Upland	Brown-headed Cowbird	*Molothrus ater*	0.11	0.06	2
Upland	Pine Grosbeak	*Pinicola enucleator*	0.06	0.06	1
Upland	Pine Siskin	*Carduelis pinus*	0.50	0.00	8

Appendix 3.12. Relative abundance of small mammals captured in meadow areas of High Meadow and associated control site, Fountain Place, during summers of 2006 and 2007. An asterisk indicates a desired condition species.

Common Name	Scientific Name	High Meadow		Fountain Place	
		2006	2007	2006	2007
Long-tailed vole	*Microtus longicaudus*		0.78		2.33
Montane vole	*Microtus montanus*	0.38	0.78	1.71	1.94
Deer mouse	*Peromyscus maniculatus*	4.62	3.14	8.12	4.26
Belding's ground squirrel*	*Spermophilus beldingi*	0.38	1.18		
Vagrant shrew*	*Sorex vagrans*			0.85	
Unknown shrew	*Sorex spp.*		0.39	2.56	0.78
California ground squirrel	*Spermophilus beecheyi*	0.38			
Golden-mantled ground squirrel	*Spermophilus lateralis*	0.38	0.39		
Yellow-pine chipmunk	*Tamias amoenus*		2.35		0.39
Shadow chipmunk	*Tamias senex*	0.38			
Lodgepole chipmunk	*Tamias speciosus*		1.18	0.43	
Unknown chipmunk	*Tamias spp.*	0.38	1.57		
Douglas squirrel	*Tamiasciurus douglasii*	0.77			
Mountain pocket gopher	*Thomomys monticola*	0.38			
Western jumping mouse*	*Zapus princeps*			2.99	4.26

Appendix 3.13. Relative abundance of small mammals captured in upland areas of High Meadow and associated control site, Fountain Place, during summers of 2006 and 2007. An asterisk indicates a desired condition species.

Common Name	Scientific Name	High Meadow		Fountain Place	
		2006	2007	2006	2007
Northern flying squirrel*	*Glaucomys sabrinus*			0.89	
Long-tailed vole	*Microtus longicaudus*	0.39	0.41	0.89	0.97
Deer mouse	*Peromyscus maniculatus*	7.84	4.07	8.89	15.53
Belding's ground squirrel*	*Spermophilus beldingi*	0.39			
Unknown shrew	*Sorex spp.*			0.44	
California ground squirrel	*Spermophilus beecheyi*	0.39			
Golden-mantled ground squirrel	*Spermophilus lateralis*	4.71	2.03	0.89	0.97
Yellow-pine chipmunk	*Tamias amoenus*	2.35	8.17	0.44	9.71
Shadow chipmunk	*Tamias senex*	2.75		0.44	
Lodgepole chipmunk	*Tamias speciosus*	0.78	3.25	4.89	5.83
Unknown chipmunk	*Tamias spp.*	1.57	2.44	0.44	3.88
Western jumping mouse*	*Zapus princeps*	0.39		0.89	