# Chapter IV – Meeks Creek Restoration Project

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# EXECUTIVE SUMMARY

This report summarizes pre-restoration wildlife monitoring data at Meeks Creek and a control site (General Creek) and illustrates project objectives based on pre-restoration monitoring data. Three years of pre-restoration data have been collected at both Meeks Creek and the associated control site (General Creek) for songbirds, small mammals, bats, and owls. However, only two years of pre-restoration data have been collected for butterflies, reptiles, and amphibians.

**Restoration Project Goals**

Restoration goals in the Meeks Creek watershed focus on increasing the amount of wetland habitat, restoring natural fluvial geomorphic processes that sustain healthy ecosystem function, and enhancing riparian vegetation. 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. **Special Habitats**: Maintain and restore the distribution and health of biotic communities in special aquatic habitats (such as springs, seeps, vernal pools, fens, bogs and marshes) to perpetuate their unique functions and biological diversity.
2. **Floodplains and Water Tables:** Maintain and restore the connections of floodplains, channels, and water tables to distribute flood flows and sustain diverse habitats.
3. **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 Meeks Creek restoration project was 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). In particular it is expected to restore more wet meadow conditions to the middle portion of the lower watershed where conifer encroachment has disrupted meadow conditions, and completely revitalize the biological integrity of the degraded lagoonal marsh system below the Hwy 89 bridge crossing. 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.

## Management Recommendations

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. Recommendations have been divided based on the two major components of the restoration project (1) lagoon restoration (east of Hwy 89), and (2) conifer removal (upstream). Based on the expected habitat and associated wildlife responses to restoration actions we also recommend the following post-restoration monitoring objectives and associated metrics and protocols for the Meeks Creek restoration project. These 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>Butterflies</u>

**Recommended restoration actions**

*Conifer removal*

1. Because we detected few butterfly species and individuals within survey areas 1, 3, 5, and 6 restoration actions should seek to improve soil moisture which is expected to improve conditions for flowering plants that butterflies rely on to complete their life-cycles.
2. Survey areas 3 and 5 contained encroaching lodgepole pine; therefore, we recommend that encroaching lodgepole pine be removed from these areas to improve conditions for flowering plant species and butterflies
3. Emphasize the following plant species in seed mixes where opportunities exist for revegetation on floodplain surfaces to provide maximal potential for enhancing butterfly diversity: wandering daisy (*Erigeron peregrines*), yarrow (*Achillea millefolium*), western aster (*Aster occidentalis*), penstemon (*Penstemon* spp), pennyroyal (*Monardella* spp.), pussypaws (*Calyptridium umbellatum*), bistort (*Polygonum bistortoides*), pearly everlasting (*Anaphalis margaritacea*), shooting star (*Dodecatheon* spp.), yellow composite species, violets (Viola spp.), thistle (*Cirsium* spp.), clover (*Trifolium* spp.) Nettles *(Urtica spp*.), and fruiting shrubs. These species represent important host and nectar plant species for desired condition butterflies.

**Recommended restoration objectives**

*Conifer removal*

1. Increase richness and abundance of butterflies and desired condition butterfly species within the meadow.
    - Metric: Richness (number of species detected within survey areas) and abundance (number of individuals detected within survey areas).
    - Methods: Visual encounter sweep net surveys conducted twice a month from June through August.

**Monitoring 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. Collecting more specific data such as this will give us a better understanding of ecological features required by butterfly species that will help the Forest Service make better restoration decisions. Additionally, no surveys have been initiated to determine flowering plant composition within survey areas. Thus, we cannot determine if lack of butterflies is due to the absence of host plants or due to other factors. Although no pre-restoration data exist, we suggest that a pilot study be conducted to help determine key ecological requirements of butterflies. The costs to complete such a survey are unknown.

2. We recommend that an additional year of pre-restoration butterfly surveys take place to allow for effective comparisons of pre- and post-restoration data as well as to better develop desired condition species.

## Reptiles and amphibians

### Recommended restoration actions

*Lagoon restoration*

1. Create ephemeral pools to provide locations and opportunities for amphibians to lay eggs.

*Conifer removal*

1. Removing encroaching conifer should improve soil moisture conditions that should in turn, benefit reptile and amphibian species.

### Recommended restoration objectives

*Lagoon restoration and conifer removal*

1. Increase the distribution of desired condition reptile and amphibian species at Meeks Creek
    - Metric: Richness (number of species detected) and distribution (location of individuals detected within Big Meadow).
    - 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. To obtain distribution data, surveys should be intensified, locations of individuals should be marked with a GPS, and vegetation associations should be recorded where the individual was detected.

### Monitoring recommendations

1. Re-evaluate restoration objectives for reptiles and amphibians.
2. Restoration objectives should also consider that natural colonization of reptiles and amphibians following restoration may be dependent on distance of Meeks Creek from a source population and ability of reptiles and amphibians to move across the landscape.
3. To evaluate changes in distribution of reptiles and amphibians we recommend that survey intensity be increased or that surveys focus on a limited number of species. Locations of detected individuals should be marked with a GPS.

4. Reptile and amphibian surveys should be conducting during the breeding season (late May and June).

## Songbirds

### Recommended restoration actions

*Lagoon restoration and conifer removal*

1. Based on low detections of desired condition songbirds associated with riparian areas, restoration efforts should focus on improving the willow component and structural diversity of the understory plant community to enhance nesting and foraging opportunities for yellow warblers, calliope hummingbirds, Lincoln's sparrows, willow flycatchers, and red-breasted sapsuckers.

*Conifer removal*

1. We recommend utilizing prescribed fire within the meadow as planned, as burning the meadow is expected to increase forb regeneration which may increase vegetation cover at nest sites for songbirds, which may subsequently reduce predation risk and enhance productivity in the long run. Control burns should take place outside the breeding season (May- August), however, to minimize disturbance that could negatively affect nesting success in the short term.
2. Maintain snags in areas slated for conifer removal to provide nesting and foraging opportunities for olive-sided flycatcher, white-headed woodpecker, red-breasted sapsucker, white-breasted nuthatch, and Williamson's sapsucker.
3. Maintaining snags with cavities during thinning and burning operations, and/or installing nest boxes which should be beneficial for mountain bluebirds, house wrens, white-breasted nuthatch and other secondary cavity nesters which are often limited by insufficient cavities for nesting.
4. Increase willow density in areas slated for conifer removal. Increase total willow cover within treated areas to approximately 60% of the area (Bombay et al. 2003). Recommendation is based on average willow cover in occupied willow flycatcher territories within the Sierras (Bombay et al. 2003, Bombay-Loffland, unpublished data).
5. Willows planted within the treated area should be planted in patches with a mean size of 375 $m^2$ (Bombay-Loffland, unpublished data). Recommendation is based on average spatial arrangement of willows within willow flycatcher territories (Bombay-Loffland, unpublished data).

### Recommended restoration objectives

*Lagoon restoration and conifer removal*

1. Increase richness and abundance of songbirds and desired condition songbird species that inhabit the meadow/riparian community at Meeks Creek
    - Metric: Richness (number of species detected across all survey points per year) and abundance (total number of individuals detected across all survey points per year).
    - Methods: Point-count surveys three times a month during June

### Monitoring recommendations

1. Continue current survey protocols post-restoration as part of effectiveness monitoring.

## Songbird productivity

### Recommended restoration actions

*Lagoon restoration and conifer removal*

1. Because we detected few breeding pairs of the focal species restoration actions may want to focus on improving the willow component and structural diversity of the understory plant community to enhance nesting and foraging opportunities for yellow warblers, Lincoln's sparrows, willow flycatchers, MacGillivray's warblers, and Wilson's warblers.

*Conifer removal*

1. We recommend utilizing prescribed fire within the meadow as planned, as burning the meadow is expected to increase forb regeneration which may increase vegetation cover at nest sites for songbirds, which may subsequently reduce predation risk and enhance productivity in the long run. Control burns should take place outside the breeding season (May- August), however, to minimize disturbance that could negatively affect nesting success in the short term.
2. Maintain snags in areas slated for conifer removal to provide nesting and foraging opportunities for olive-sided flycatcher, white-headed woodpecker, red-breasted sapsucker, white-breasted nuthatch, and Williamson's sapsucker.
3. Maintaining snags with cavities during thinning and burning operations, and/or installing nest boxes which should be beneficial for mountain bluebirds, house wrens, white-breasted nuthatch and other secondary cavity nesters which are often limited by insufficient cavities for nesting.
4. Increase willow density in areas slated for conifer removal. Increase total willow cover within treated areas to approximately 60% of the area (Bombay et al. 2003). Recommendation is based on average willow cover in occupied willow flycatcher territories within the Sierras (Bombay et al. 2003, Bombay-Loffland, unpublished data).
5. Willows planted within the treated area should be planted in patches with a mean size of 375 $m^2$ (Bombay-Loffland, unpublished data). Recommendation is based on average spatial arrangement of willows within willow flycatcher territories (Bombay-Loffland, unpublished data).

### Recommended restoration objectives

*Lagoon restoration and conifer removal*

1. Maintain or increase productivity of focal songbird species.
    - Metrics: Daily nest survival (Mayfield 1961) and brown-headed cowbird parasitism rate (% of nests parasitized per species)
    - Methods: Search for (daily) and monitor nests of focal songbird species every 3-5 days beginning in late May through early August.

### Monitoring recommendations

*Lagoon restoration and conifer removal*

1. Because nest parasitism by brown-headed cowbirds exceeded 30% for Wilson's warblers and warbling vireos and because few nests were located we recommend that survey efforts be intensified to increase the number of nests monitored to more accurately determine parasitism rates when monitoring post-restoration conditions, and consider initiating a

Basin-wide cowbird assessment to determine impacts on riparian communities in the Tahoe basin and potential strategies for controlling those impacts if necessary.

## Owls

### Recommended restoration actions

*Conifer removal*

1. Maintain a variety of snags in different size classes to provide nesting opportunities owls.

### Monitoring recommendations

*Conifer removal*

1. Owls have rarely been detected at Meeks Creek in the three years of surveys at that site. 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 Meeks Creek 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.

## Bats

### Recommended restoration actions

*Lagoon restoration and conifer removal*

1. Where possible, preserve riparian habitat corridors, cottonwood, willow and alder woodlands, areas with open water to provide foraging opportunities for bats.
2. Restoration should emphasize re-establishment of dense stands of mature cottonwood in the Meeks Meadow area to provide roost sites for bats.
3. Because snags are a potential source of roost sites for bats, efforts should be made to determine if the number of snags with cavities is sufficient to meet the needs of bats in the Basin (or specifically at Meeks Creek).

### Recommended restoration objectives

*Lagoon restoration and conifer removal*

1. Increase species richness and detection frequency of desired condition bat species at Meeks Creek.
    - Metric: Richness (total number of species detected) and detection frequency (average proportion of detections per visit per species)
    - Methods: Three surveys throughout the summer using ultrasonic bat detectors.

### Monitoring recommendations

*Lagoon restoration and conifer removal*

1. Continue current survey methods for bats.
2. We suggest continued monitoring of bat species at Meeks Creek, 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, to determine if other factors are limiting bat distribution or abundance.

## Small mammals

### Recommended restoration actions

*Conifer removal*

1. 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 and meadow-associated small mammal species, and to deter chipmunks from depredating bird nests located in meadow areas.

### Recommended restoration objectives

*Conifer removal*

1. Increase species richness and abundance of desired condition small mammal species Meeks Creek.
    - Metric: Richness (total number of species detected across all visits per year) and relative abundance (number of unique individuals captured per 100 trap nights).
    - Methods: Trap and mark small mammals.

### Monitoring recommendations

*Conifer removal*

1. Continue current survey methods for small mammals.
2. Include in future analysis the metric of percent composition (i.e., number of individuals per species), along with relative abundance, as an indication of change in community composition after restoration.

## Vegetation and hydrology

### Recommended vegetation actions and objectives

*Conifer removal*

1. Increase in total willow cover in areas where conifer is being removed to approximately 60% of the meadow area where possible (Bombay et al. 2003). This recommendation is based on surveys of meadows with willow flycatchers (Bombay et al. 2003). 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.
    - Metric: Spatial location of willow clumps pre- and post-restoration
    - Methods: Record location, size, and height of willows using a global positioning system (GPS).
2. Willows planted within the treated area should be planted in patches with a mean size of 375 $m^2$ (Bombay-Loffland, unpublished data). Recommendation is based on average spatial arrangement of willows within 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).

3. Increase proportion of wet meadow area within the conifer removal area.
    - Metric: Percent of meadow with standing water and saturated soil throughout summer
    - Methods: Bi-monthly meadow wetness transects

**Vegetation monitoring recommendations**

*Lagoon restoration*

1. If willows will be planted in the area east of Hwy 89, we recommend that willow mapping occur both pre- and post-restoration.
2. Willow mapping pre-restoration should take place once prior to restoration.
3. Willow mapping post-restoration should take place every other year.

*Conifer removal*

1. Evaluate meadow wetness and vegetation features (e.g., willows) at Meeks Creek both prior to restoration and after restoration. Monitoring should be conducted within the areas where conifer removal and willow planting is to occur.
2. Meadow wetness and willows should be evaluated once prior to restoration and every other year post-restoration.

# CHAPTER IV – MEEKS CREEK RESTORATION PROJECT

## INTRODUCTION

Meeks Creek is a narrow glaciated watershed approximately 11.2 km long covering 2250 ha (Appendix 4.1). Elevations range from 1900 m at Lake Tahoe to approximately 3000 m at the headwaters in the Desolation Wilderness. The lower one third of the watershed was historically a barrier beach system, but now contains a marina and campground. Meeks Creek contains several different vegetation types including semi-wet meadows, mixed-conifer forest, and ponded areas created by over bank flooding and beaver (*Castor canadensis*) activity. Willow (*Salix* spp.), mountain alder (*Alnus incana*), lodgepole pine (*Pinus contorta*), and annual and perennial grasses and forbs dominate these areas. Jeffrey pine (*P. jeffreyi*), white fir (*Abies concolor*), lodgepole pine, and deciduous shrubs are the dominate species in the upland area on the north side of Meeks Creek. Several disturbances within the Meeks Creek watershed impede ecological function and are the target of restoration efforts, including (1) improperly constructed bridge and grade controls that alter water flow and impede fish movement, (2) incised channels near the crossing with US Hwy 89 due to grade control at the bridge and the marina, (3) altered land use resulting in habitat loss (e.g., marina and campground), (4) lodgepole pine encroachment in the lower meadow area, (5) trampling and erosion associated with human use, and (6) increased human use that disrupts wildlife breeding and wintering activities.

## 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 Meeks Creek 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 Meeks Creek.

Compliance with the SNFPA 2004 AMS goals is a principle objective of adaptive management at Meeks Creek. 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 Meeks Creek will be assessed in part by the biological integrity of its ecosystem. Measures to assess this integrity may include:

- Wildlife surveying, monitoring, and tracking of wildlife assemblages and desired condition wildlife species to document and assess wildlife diversity and viability.
- Measurement and comparison of restoration/disturbances on the biotic integrity of the aquatic environment, including assessment of desired aquatic species such as amphibians.

- Measurement and documentation of anthropogenic influences on ecosystem health, including reestablished Washoe Tribal land stewardship practices.

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 Meeks Creek.

## PROJECT GOALS

Restoration goals in the Meeks Creek watershed focus on increasing the amount of wetland habitat, restoring natural fluvial geomorphic processes that sustain healthy ecosystem function, and enhancing riparian vegetation. 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. Special Habitats: Maintain and restore the distribution and health of biotic communities in special aquatic habitats (such as springs, seeps, vernal pools, fens, bogs and marshes) to perpetuate their unique functions and biological diversity.
2. Floodplains and Water Tables: Maintain and restore the connections of floodplains, channels, and water tables to distribute flood flows and sustain diverse habitats.
3. 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 Meeks Creek 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)

**Hydrological and vegetation project goals and objectives (not addressed in this report)**

The complete restoration is designed to improve the wetland lagoonal system and meadows within Meeks Creek drainage towards the desired conditions stated in the goals below. It is expected that restoration of wetlands and meadows will enhance other ecological functions as described in the more specific project goals below:

1. Enhance wetland communities
2. Raise the seasonal groundwater table elevation and reduce seasonal variation in the level of groundwater
    a. Increase water retention in soil for groundwater recharge
3. Reestablish natural sedimentation patterns and restore historic surface sedimentary characteristics and nutrient uptake capability
4. Remove lodgepole encroachment into meadow
5. Control future lodgepole pine encroachment by means of mechanical thinning
6. Reduce runoff of nutrient concentrations to improve the quality of water leaving Meeks Creek
7. Restore natural soil moisture conditions in the meadow
    a. Increase water retention in soil for groundwater recharge
8. Maintain or increase wet meadow environment
    a. Increase water retention in soil for groundwater recharge
    b. Increase duration and extent of wet meadow
9. Maintain or increase woody shrub stand area
    a. Increase woody shrub (e.g., willow)

## PLANNED RESTORATION ACTIONS

1. Remove encroaching lodgepole from meadows.
2. Introduce fire to meadows.
3. Reconstruct a lagoonal wetland system at the mouth of Meeks Creek.
4. Replace the Hwy 89 bridge to allow fish passage.

NOTE: it is likely that this project will be split into 2 phases (Actions 1 and 2 together in a few years from now, and 3 and 4 together at a much later date).

## DEVELOPMENT OF DESIRED SPECIES CONDITIONS

The desired condition for Meeks Creek was based on two fundamental analyses (existing conditions – based on pre-restoration data collected from 2004 – 2007 and historical conditions) that are presented in detail in Chapter I (Please see pages 9 – 12 in Chapter I). This analysis was conducted for songbirds, reptiles, amphibians, bats, and small mammals. Due to the lack of historical datasets for reference, desired condition butterfly species were selected as species that

rely on montane meadows and riparian areas and those species that have specific host-plant requirements because these are expected to be the most vulnerable and sensitive species. Species identified through these analyses comprise the *desired condition species* for Meeks Creek and should be present pending successful restoration (Appendix 4.2-4.5); although the inability to detect a desired conditions species following restoration does not necessarily indicate restoration failure. However, presence of additional species that are relatively common on other meadow/riparian sites throughout the Basin (e.g., Wilson's warbler [*Wilsonia pusilla*]) but not at Meeks Creek will also be used to gauge the progress of restoration. Final designation of desired species for the Meeks Creek restoration project is contingent on Forest Service decisions.

## CONTROL SITE DESCRIPTION

Control sites were selected in association with the Meeks Creek 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 in terms of gross vegetation features to the restoration site and be located near the restoration site but far enough away to be considered an independent unit (Block et al. 2001). General Creek (Sugar Pine Point State Park) serves as a control site for Meeks Creek. We surveyed an area approximately 3.5 km long on the south side of General Creek which ranges in elevations ranging from 1900 m at Lake Tahoe to 2000 m (Appendix 4.6). Dominate vegetation along General Creek includes lodgepole pine, Jeffrey pine, and white fir, with dense patches of alder, dogwood (*Cornus* spp.), and willow lining the creek bank.

## EFFECTIVENESS MONITORING METHODS

Project effectiveness monitoring will be used to measure the effectiveness in meeting the project objectives. Metric used to assess effectiveness include species (1) richness, (2) abundance, (3) distribution, and (4) productivity. The distribution metric was not used to address any specific objectives from 2005 - 2007, but information on distribution of desired condition species will be used to assist in developing restoration plans. Post-restoration monitoring may want to consider collecting data on distribution. We will monitor changes in species richness and abundance butterflies, 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 due to restoration actions. We will also monitor productivity for focal songbird species to determine whether wildlife productivity is being maintained. Pre-restoration monitoring occurred in 2004 (all species groups), 2005 (only songbirds), 2006 (all species groups), and 2007 (songbirds, owls, bats, small mammals).

## PRE-RESTORATION OBJECTIVES AND ASSOCIATED WILDLIFE METHODS, METRICS, AND ANALYSIS

### BUTTERFLIES

*Pre-restoration objective 1.* Determine richness and abundance of butterflies and desired condition butterfly species at Meeks Creek pre-restoration.

*Methods.*—We conducted visual encounter and sweep-net butterfly surveys at Meeks Creek and associated control site, General Creek, to determine species richness and relative abundance of butterflies in 2004 and 2006. Observers worked in teams of two-to-three and walked slowly in a zigzag pattern through the entire survey area scanning for butterflies. The riparian area was divided into six survey areas to allow us to assess species distribution (Appendix 4.1 and 4.6). Observers recorded the species and the number of individuals detected in each survey area. In addition, we 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 nectar, we also recorded the plant species the individual butterfly was feeding on. Butterflies that we could not identify from a distance were captured with a sweep net and released after identification. We conducted butterfly surveys twice a month in July 2004 and from June to August 2006.

*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

*Pre-restoration objective 2.* Determine richness of desired condition reptile and amphibian species at Meeks Creek pre-restoration.

*Methods.*—We conducted visual encounter surveys for amphibians and reptiles at Meeks Creek, and General Creek 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 4.1 and 4.6). We conducted visual encounter surveys between mid-to-late morning. We surveyed each site once during June in 2004 and 2006. 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.

*Data analysis.*—We calculated richness as the number of species detected across all surveys for each year. We also report the location or distribution (general survey area) for each species we detected. Distribution data was only collected in 2006.

## SONGBIRDS

*Pre-restoration objective 3*. Determine richness and abundance of songbirds and desired condition songbird species at Meeks Creek pre-restoration.

*Methods.*—We established avian point-count stations at Meeks and General Creek to assess bird species richness and abundance (Appendix 4.1 and 4.6). We established 12 point-count stations 250 m apart at Meeks Creek and General Creek. We conducted avian point-counts at each site in June from 2004, 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 10 minutes at each point within 50 m of the point-count station. 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 number of individuals detected within 50 m of point-count stations across the three surveys and then divided by the number of points sampled to correct for differences in the number of points surveyed at each site.

*Pre-restoration objective 4*. Determine productivity of focal bird species pre-restoration.

*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 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. Nests were monitored May–June 2004, 2006, and 2007. Nests were checked 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 one cowbird and 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.

Parasitism that exceeds 50% has lead to endangerment in four species (reviewed in Robinson et al. 1995) and other studies suggest that parasitism that exceeds 30% may cause population instability (Laymon 1987), thus we established at threshold of 30% parasitism. If parasitism exceeds 30% we recommend that additional studies be carried out to determine the cause of excessive parasitism or initiate studies to investigate the feasibility of cowbird control.

## OWLS

*Pre-restoration objective 5.* Assess owl richness at Meeks Creek pre-restoration.

*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 4.1 and 4.6). With each survey separated by at least one week, we conducted two surveys in July 2004, three surveys from May to June 2006, and three surveys from March to May 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

*Pre-restoration objective 6*. Determine richness and detection frequency of desired condition bat species pre-restoration.

*Methods.*—We conducted acoustic surveys for bats using Pettersson ultrasonic detectors (model D240X) to assess bat species richness. We placed Pettersson recorders in suitable openings, near habitat transition zones, or in likely movement corridors (Appendix 4.1 and 4.6–4.7). Bats were recorded on three different nights separated by at least one week from July to September 2004, and from June to August 2006 and 2007. We placed detectors in different locations upon subsequent visits; each location was at least 100 m apart. We did not set up bat detectors during inclement weather.

*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 frequency of use.

## SMALL MAMMALS

*Pre-restoration objective 7*. Determine species richness and abundance of desired condition small mammal species at Meeks Creek pre-restoration.

*Methods.*—We conducted small mammal surveys at Meeks Creek and General Creek (control site) using Sherman Live Traps to quantify species richness and abundance July–August 2004, 2006, and 2007. We placed Sherman Live Traps along 250 m transects that ran parallel to the creek and located between songbird point-count stations (Appendix 4.1 and 4.6). We placed traps every 25 m along each transect and keeping the traps 25 m from the creek channel. 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 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; neither species were shaved in 2004. In 2007, we continued to mark vole species by clipping their fur, whereas deer mice were tagged with ear tags.

*Data analysis.*—In addition to the number of desired condition species detected in each year, 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. Deer mice were not marked in 2004, thus we report the maximum number of mice captured in one visit over the

entire trapping session. The maximum number captured in one visit usually underestimates abundance; to allow comparisons of deer mice numbers between years, we also calculated the maximum number of mice captured in one visit over the entire trapping session.

Because the number of traps varied among years and sites, we calculated for each species 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.

## RESULTS AND DISCUSSION

### BUTTERFLIES

*Pre-restoration objective 1.* Determine richness and abundance of butterflies and desired condition butterfly species at Meeks Creek pre-restoration.

Total richness of butterfly species was consistent across years and sites (Fig. 4.1). Similarly, richness of desired condition butterfly species (Appendix 4.2) showed similar patterns across years and sites (Fig. 4.2). Abundance of desired condition butterfly species increased by 81% from 2004 to 2006 (Fig. 4.3); however, abundance estimates are not comparable across years because surveys in 2004 were completed only during July while in 2006 surveys took place twice a month beginning in June. Abundance of desire condition butterfly species remained consistent across years at the control site.

Species richness was greatest in survey areas 2 ($n$ = 22) and 4 ($n$ = 22) (Appendix 4.1), thus restoration actions should focus on creating conditions similar to conditions found within these areas elsewhere within Meeks Creek. The vegetation community within these areas generally consisted of open wet meadows with abundant flowering plants. Survey areas that supported the fewest species included areas 1 ($n$ = 3), 3 ($n$ = 17), 5 ($n$ = 19), and 6 ($n$ = 12) (Appendix 4.1). Survey areas 3 and 5 contained encroaching lodgepole pine, therefore, we recommend that encroaching lodgepole pine be removed from these areas to increase butterfly species richness. Survey area 1 which supported the fewest species is located on the east side of Hwy 89 by the marina where wet meadow conditions do not exist. Because one of the goals of the Meeks Creek Restoration Project is to create a lagoon within this area we did not develop recommended restoration actions or restoration objectives because lagoonal systems will likely not support butterflies.

#### Recommended restoration actions

*Conifer removal*

1. Because we detected few butterfly species and individuals within survey areas 1, 3, 5, and 6 restoration actions should seek to improve soil moisture which is expected to improve conditions for flowering plants that butterflies rely on to complete their life-cycles.

2. Survey areas 3 and 5 contained encroaching lodgepole pine; therefore, we recommend that encroaching lodgepole pine be removed from these areas to improve conditions for flowering plant species and butterflies
3. Emphasize the following plant species in seed mixes where opportunities exist for revegetation on floodplain surfaces to provide maximal potential for enhancing butterfly diversity: wandering daisy (*Erigeron peregrines*), yarrow (*Achillea millefolium*), western aster (*Aster occidentalis*), penstemon (*Penstemon* spp), pennyroyal (*Monardella* spp.), pussypaws (*Calyptridium umbellatum*), bistort (*Polygonum bistortoides*), pearly everlasting (*Anaphalis margaritacea*), shooting star (*Dodecatheon* spp.), yellow composite species, violets (*Viola* spp.), thistle (*Cirsium* spp.), clover (*Trifolium* spp.) Nettles *(Urtica spp*.), and fruiting shrubs. These species represent important host and nectar plant species for desired condition butterflies.

**Recommended restoration objectives**

*Conifer removal*

1. Increase richness and abundance of butterflies and desired condition butterfly species within the meadow.
    - Metric: Richness (number of species detected within survey areas) and abundance (number of individuals detected within survey areas).
    - Methods: Visual encounter sweep net surveys conducted twice a month from June through August.

**Monitoring 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. Collecting more specific data such as this will give us a better understanding of ecological features required by butterfly species that will help the Forest Service make better restoration decisions. Additionally, no surveys have been initiated to determine flowering plant composition within survey areas. Thus, we cannot determine if lack of butterflies is due to the absence of host plants or due to other factors. Although no pre-restoration data exist, we suggest that a pilot study be conducted to help determine key ecological requirements of butterflies. The costs to complete such a survey are unknown.
2. We recommend that an additional year of pre-restoration butterfly surveys take place to allow for effective comparisons of pre- and post-restoration data as well as to better develop desired condition species.

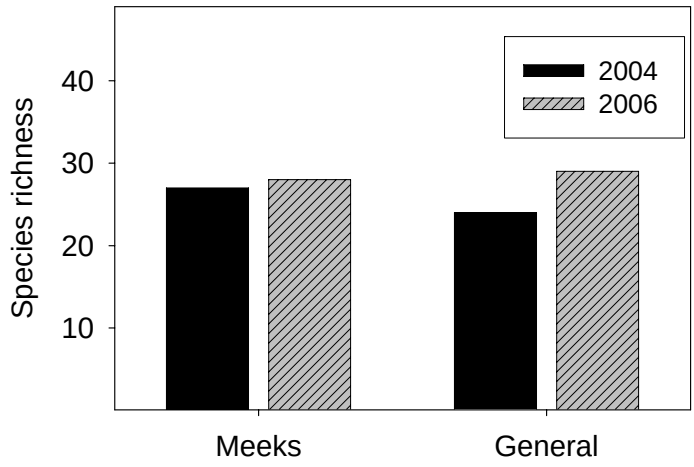


Figure 4.1. Total number of butterfly species detected at Meeks Creek and the control site (General Creek) in 2004 and 2006. Species richness was similar across years and sites.

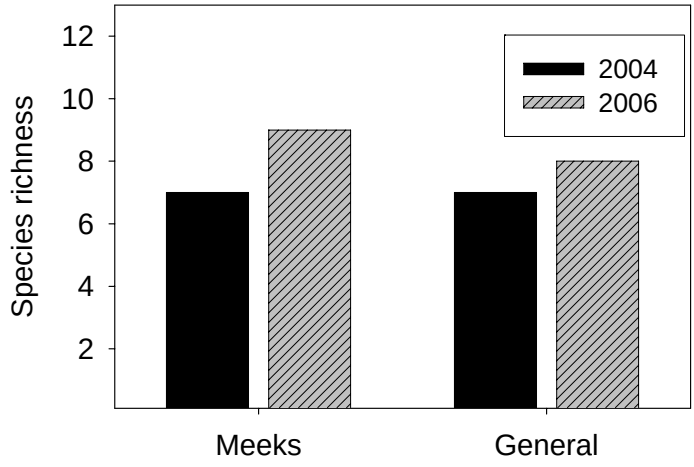


Figure 4.2. Number of desired condition butterfly species detected at Meeks Creek and the control site (General Creek) in 2004 and 2006. Richness of desired condition butterfly species increased at both sites from 2004 to 2006.

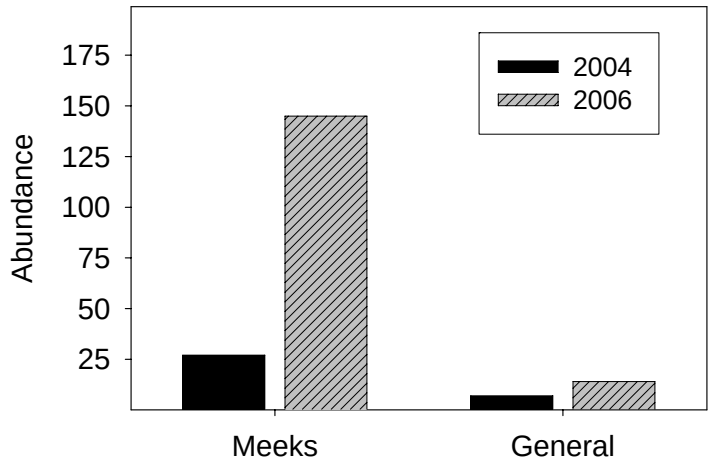


Figure 4.3. Total number of desired condition butterfly species detected per ha at Meeks Creek and General Creek adjusted for the amount of area surveyed (3.75 ha at each site).

## REPTILES AND AMPHIBIANS

*Pre-restoration objective 2.* Determine richness of desired condition reptile and amphibian species at Meeks Creek pre-restoration.

A total of five species (including incidental observations) have been detected at Meeks Creek (Long-toed salamander, western toad, Pacific treefrog, western fence lizard, rubber boa, common garter snake, and western terrestrial garter snake). Of particular interest were our detections of a western toad and a rubber boa at Meeks Creek in 2004 and long-toed salamander in 2006; few individuals of these species were detected elsewhere at our study sites in the Basin. We do not have location data for individuals detected in 2004; therefore, we cannot make restoration recommendations based on the location of long-toed salamanders, western toads, or Pacific treefrogs. The common garter snakes and western terrestrial garter snakes were observed most frequently in survey area 5 (Appendix 4.1). This area in near the semi-permanent pond and the meadow within the survey generally supports saturated soil conditions.

Based on historic data and current survey results (Schlesinger and Romsos 2000), the desired herpetofauna includes long-toed salamander, western toad, western aquatic garter snake, western terrestrial garter snake, common garter snake, and pacific treefrog (Appendix 4.3).

Lack of detection of other species at Meeks Creek does not mean that other reptiles and amphibians do not occur at Meeks Creek. More than likely the visual encounter surveys we conducted were not sufficient to detect additional species. In addition, Meeks Creek was searched only two times during the month of June 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.

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.

**Recommended restoration actions**

*Lagoon restoration*

1. Create ephemeral pools to provide locations and opportunities for amphibians to lay eggs.

*Conifer removal*

1. Removing encroaching conifer should improve soil moisture conditions that should in turn, benefit reptile and amphibian species.

**Recommended restoration objectives**

*Lagoon restoration and conifer removal*

1. Increase the distribution of desired condition reptile and amphibian species at Meeks Creek
    - Metric: Richness (number of species detected) and distribution (location of individuals detected within Big Meadow).
    - 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. To obtain distribution data, surveys should be intensified, locations of individuals should be marked with a GPS, and vegetation associations should be recorded where the individual was detected.

**Monitoring recommendations**

1. Re-evaluate restoration objectives for reptiles and amphibians.
2. Restoration objectives should also consider that natural colonization of reptiles and amphibians following restoration may be dependent on distance of Meeks Creek from a source population and ability of reptiles and amphibians to move across the landscape.

3. To evaluate changes in distribution of reptiles and amphibians we recommend that survey intensity be increased or that surveys focus on a limited number of species. Locations of detected individuals should be marked with a GPS.
4. Reptile and amphibian surveys should be conducting during the breeding season (late May and June).

## SONGBIRDS

*Pre-restoration objective 3.* Determine richness and abundance of songbirds and desired condition songbird species richness at Meeks Creek pre-restoration.

Songbird species richness at Meeks Creek and the control site (General Creek) was consistent across years (Fig. 4.4). Compared to the control site, richness was greater at Meeks Creek in all years; on average, 10 additional species were detected at Meeks Creek (Fig. 4.4).

Songbird species representative of desired ecological condition detected at Meeks Creek included common merganser, spotted sandpiper, Wilson's snipe, yellow warbler, red-breasted sapsucker, pygmy nuthatch, house wren, calliope hummingbird, and Lincoln's sparrow (Fig. 4.5 and Appendix 4.4). However, relative abundance of these desired species was low in all years; desired condition songbird species comprised <5% of the total detections at Meeks Creek (Appendix 4.8). At the control site (General Creek) desired songbird species also made up <5% of detected in all years (Appendix 4.9). Desired songbird species richness also declined from 2004 to 2007 at both Meeks and General Creek (Fig. 4.5). Reasons for the loss of richness of over the years are unknown.

Based on low detections of birds associated with riparian areas and montane meadows, restoration efforts should focus on improving the willow component for yellow warblers, calliope hummingbirds, and willow flycatchers. Restoration efforts could focus on improving the structural diversity of the understory plant community to benefit the species listed above. Increasing structural diversity increases the number of available nest sites and increases the amount of foliage concealing the nest site, which may reduce predation risk. In the Sierra Nevada, aspen, willow, snowberry (*Symphoricarpos albus*), number of snags, and herbaceous and grass ground cover have been found to positively influence breeding bird species richness (Riparian Habitat Joint Venture 2004). Other restoration efforts could focus on retaining medium to large snags for red-breasted sapsuckers, Williamson's sapsuckers, and pygmy nuthatches. Increasing the willow component also will benefit red-breasted sapsuckers that rely on the sap from willows during the breeding season. Providing appropriate habitat for northern flickers may also improve conditions for other species because the cavities they excavate are often used by secondary cavity-nesters (Raphael and White 1984). Decreasing stream incision and improving meadow wetness will likely benefit spotted sandpipers, common mergansers, and Wilson's snipes.

### Recommended restoration actions

*Lagoon restoration and conifer removal*

1. Based on low detections of desired condition songbirds associated with riparian areas, restoration efforts should focus on improving the willow component and structural diversity of the understory plant community to enhance nesting and foraging opportunities for yellow warblers, calliope hummingbirds, Lincoln's sparrows, willow flycatchers, and red-breasted sapsuckers.

*Conifer removal*

1. We recommend utilizing prescribed fire within the meadow as planned, as burning the meadow is expected to increase forb regeneration which may increase vegetation cover at nest sites for songbirds, which may subsequently reduce predation risk and enhance productivity in the long run. Control burns should take place outside the breeding season (May- August), however, to minimize disturbance that could negatively affect nesting success in the short term.
2. Maintain snags in areas slated for conifer removal to provide nesting and foraging opportunities for olive-sided flycatcher, white-headed woodpecker, red-breasted sapsucker, white-breasted nuthatch, and Williamson's sapsucker.
3. Maintaining snags with cavities during thinning and burning operations, and/or installing nest boxes which should be beneficial for mountain bluebirds, house wrens, white-breasted nuthatch and other secondary cavity nesters which are often limited by insufficient cavities for nesting.
4. Increase willow density in areas slated for conifer removal. Increase total willow cover within treated areas to approximately 60% of the area (Bombay et al. 2003). Recommendation is based on average willow cover in occupied willow flycatcher territories within the Sierras (Bombay et al. 2003, Bombay-Loffland, unpublished data).
5. Willows planted within the treated area should be planted in patches with a mean size of 375 $m^2$ (Bombay-Loffland, unpublished data). Recommendation is based on average spatial arrangement of willows within willow flycatcher territories (Bombay-Loffland, unpublished data).

**Recommended restoration objectives**

*Lagoon restoration and conifer removal*

1. Increase richness and abundance of songbirds and desired condition songbird species that inhabit the meadow/riparian community at Meeks Creek
    - Metric: Richness (number of species detected across all survey points per year) and abundance (total number of individuals detected across all survey points per year).
    - Methods: Point-count surveys three times a month during June

**Monitoring recommendations**

1. Continue current survey protocols post-restoration as part of effectiveness monitoring.

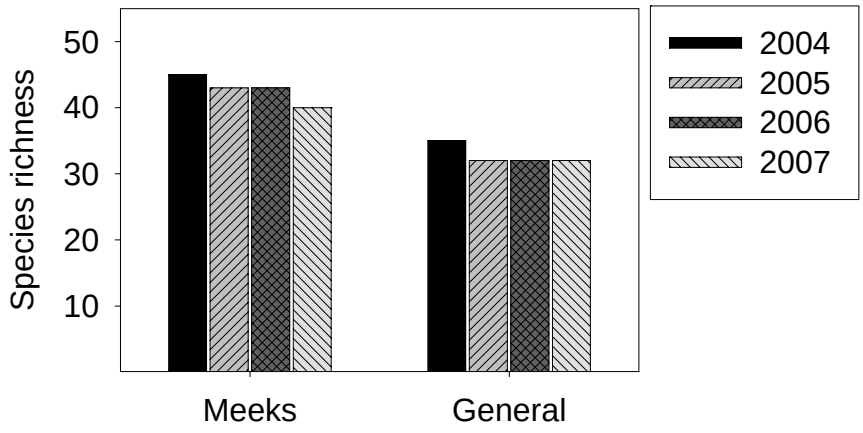


Figure 4.4. Songbird species richness at Meeks Creek and the control site, General Creek, from 2004 to 2007. Species richness was consistent across years at both sites, although species richness was higher at Meeks Creek.

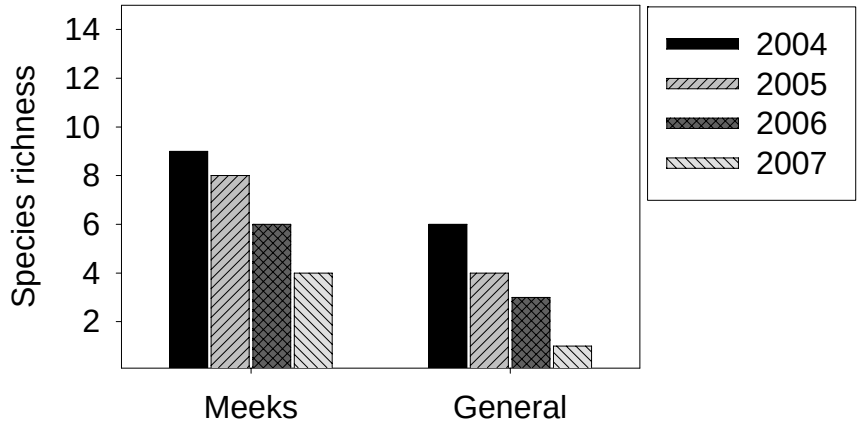


Figure 4.5. Desired condition songbird species richness at Meeks Creek and General Creek from 2004 to 2007. Richness of desired condition songbird species declined at both sites from 2004 to 2007.

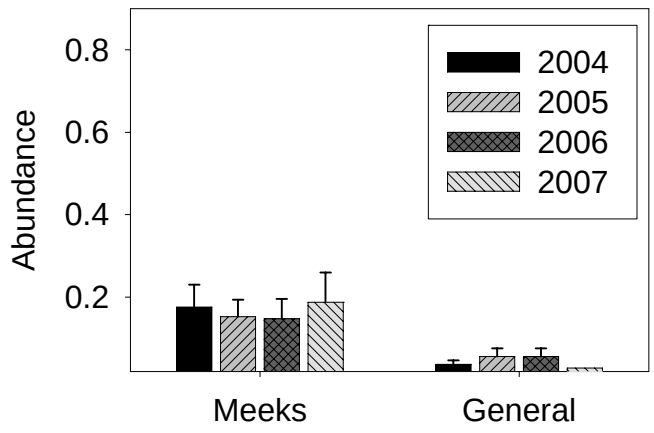


Figure 4.6. Abundance of desired condition songbird species (adjusted for number of points surveyed) detected within 50 m of point-count stations at Meeks and General Creek from 2004 to 2007. Abundance increased slightly at Meeks Creek over the years, while abundance decreased at General, although few individuals were detected in any year.

*Pre-restoration objective 4.* Determine productivity of focal bird species pre-restoration.

Daily nest survival of focal bird species was consistent across years and sites (Fig. 4.7); however, the number of nests monitored per focal species per year was often quite low. Low nest numbers could be due to observer quality, however and not due to fewer breeding pairs. Continued monitoring will provide additional information regarding productivity of focal species.

The percentage of nests parasitized by brown-headed cowbirds varied across sites, years, and species (Fig. 4.8). The percentage of Wilson's warbler nests parasitized by brown-headed cowbirds was >30% (Threshold level established, see Chapter 1) at Meeks in 2007 and at the control site in 2004 and 2007 (Fig. 4.8a). However, the number of nests monitored in each year was less than five (except at General Creek in 2007), thus our ability to accurately estimate parasitism levels is low. Parasitism of warbling vireo nests was >30% at Meeks Creek in 2007 and at the control site in 2004 and 2007 (Fig. 4.8b). However, accurately detecting parasitism at warbling vireo nests is difficult as nests are generally >3 m tall making it difficult to see into the nest cup. Although the number of nests monitored at each site makes estimating parasitism levels difficult, we recommend an increase in monitoring efforts to get a better handle on parasitism rates at Meeks Creek. Continued monitoring will allow us to determine if additional restoration actions need to incorporate measures to reduce cowbird parasitism.

**Recommended restoration actions**

*Lagoon restoration and conifer removal*

1. Because we detected few breeding pairs of the focal species restoration actions may want to focus on improving the willow component and structural diversity of the understory plant community to enhance nesting and foraging opportunities for yellow warblers, Lincoln's sparrows, willow flycatchers, MacGillivray's warblers, and Wilson's warblers.

*Conifer removal*

1. We recommend utilizing prescribed fire within the meadow as planned, as burning the meadow is expected to increase forb regeneration which may increase vegetation cover at nest sites for songbirds, which may subsequently reduce predation risk and enhance productivity in the long run. Control burns should take place outside the breeding season (May- August), however, to minimize disturbance that could negatively affect nesting success in the short term.
2. Maintain snags in areas slated for conifer removal to provide nesting and foraging opportunities for olive-sided flycatcher, white-headed woodpecker, red-breasted sapsucker, white-breasted nuthatch, and Williamson's sapsucker.
3. Maintaining snags with cavities during thinning and burning operations, and/or installing nest boxes which should be beneficial for mountain bluebirds, house wrens, white-breasted nuthatch and other secondary cavity nesters which are often limited by insufficient cavities for nesting.
4. Increase willow density in areas slated for conifer removal. Increase total willow cover within treated areas to approximately 60% of the area (Bombay et al. 2003). Recommendation is based on average willow cover in occupied willow flycatcher territories within the Sierras (Bombay et al. 2003, Bombay-Loffland, unpublished data).
5. Willows planted within the treated area should be planted in patches with a mean size of 375 $m^2$ (Bombay-Loffland, unpublished data). Recommendation is based on average spatial arrangement of willows within willow flycatcher territories (Bombay-Loffland, unpublished data).

**Recommended restoration objectives**

*Lagoon restoration and conifer removal*

1. Maintain or increase productivity of focal songbird species.
    - Metrics: Daily nest survival (Mayfield 1961) and brown-headed cowbird parasitism rate (% of nests parasitized per species)
    - Methods: Search for (daily) and monitor nests of focal songbird species every 3-5 days beginning in late May through early August.

**Monitoring recommendations**

*Lagoon restoration and conifer removal*

1. Because nest parasitism by brown-headed cowbirds exceeded 30% for Wilson's warblers and warbling vireos and because few nests were located we recommend that survey efforts be intensified to increase the number of nests monitored to more accurately determine parasitism rates when monitoring post-restoration conditions, and consider initiating a Basin-wide cowbird assessment to determine impacts on riparian communities in the Tahoe basin and potential strategies for controlling those impacts if necessary.

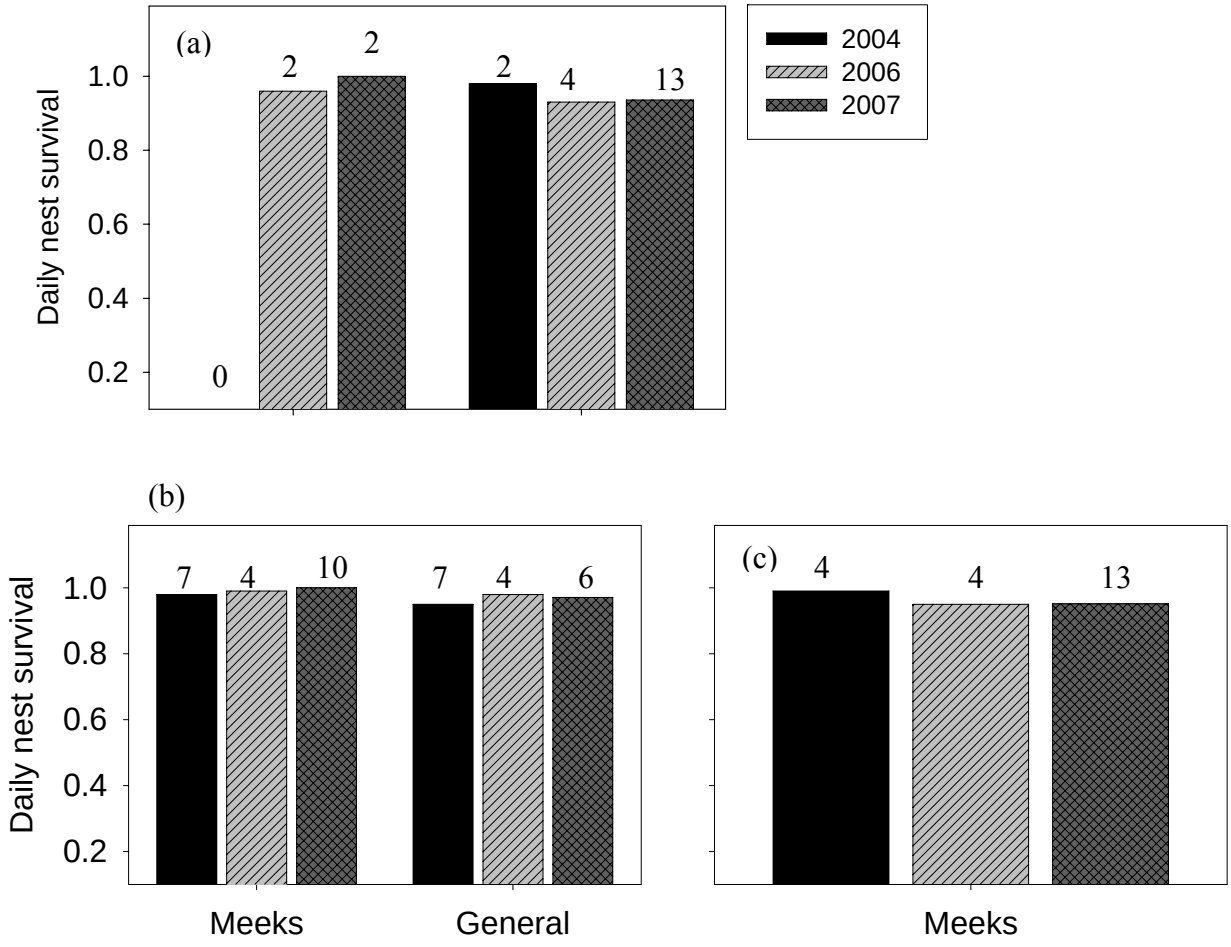


Figure 4.7. Daily nest survival of Wilson's warblers (a), warbling vireo (b), and yellow warbler (c) nests monitored at Meeks and General Creek in 2004, 2006, and 2007. Number above the bar indicates the number of nests monitored.

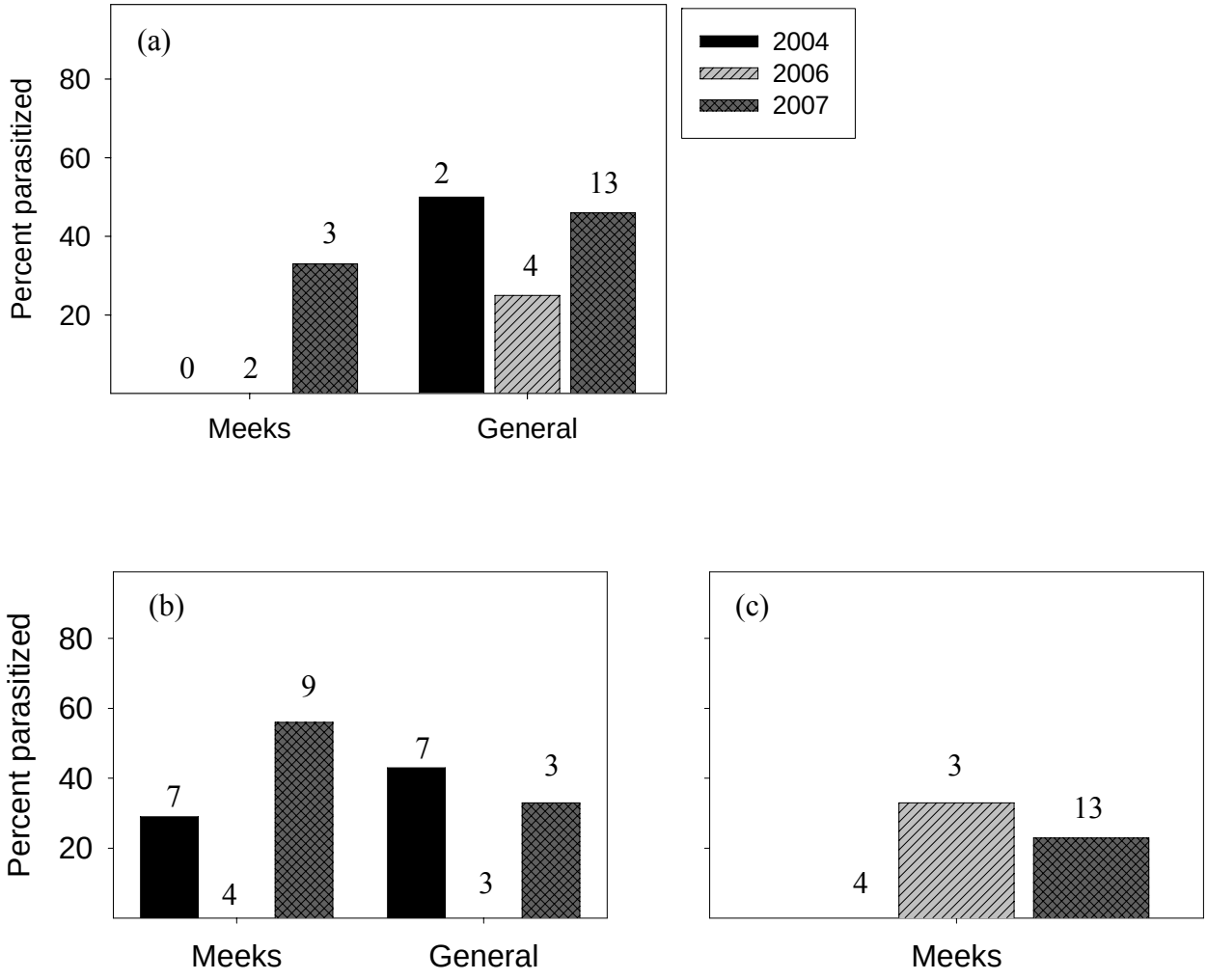


Figure 4.8. Percentage of Wilson's warbler (a), warbling vireo (b), and yellow warbler (c) nests parasitized by brown-headed cowbirds at Meeks and General Creek in 2004, 2006, and 2007. Numbers above the bar indicate the number of nests monitored.

## OWLS

*Pre-restoration objective 5.* Assess owl richness and Meeks Creek pre-restoration.

A California spotted owl and great horned owl were detected at Meeks Creek across the three years of surveys, although the spotted owl was detected only in 2004 (Table 4.1). Two additional species, northern saw-whet owl and northern pygmy-owl, were detected at General Creek (Table 4.1). (US Forest Service surveys for California spotted owls, however, have resulted in the detections of one northern pygmy-owl and one western screech-owl in 2006 and one flammulated owl in 2007 in Meeks Creek canyon). The detection of owl species does add to the overall avian species richness at Meeks Creek, 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.

### Recommended restoration actions

*Conifer removal*

1. Maintain a variety of snags in different size classes to provide nesting opportunities owls.

### Monitoring recommendations

*Conifer removal*

1. Owls have rarely been detected at Meeks Creek in the three years of surveys at that site. 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 Meeks Creek 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 4.1. Number of individual owls detected during nocturnal broadcast surveys at Meeks Creek and General Creek, 2004, 2006, and 2007. The table includes detections of common poorwills.

| Common Name | Scientific Name | Meeks Creek | | | General Creek | | |
|---|---|---|---|---|---|---|---|
| | | 2004 | 2006 | 2007 | 2004 | 2006 | 2007 |
| Northern pygmy-owl | *Glaucidium gnoma* | | | | 1[1] | | |
| Northern saw-whet owl | *Aegolius acadicus* | | | | 1 | | |
| Great horned owl | *Bubo virginianus* | | | 1 | 1 | 1 | |
| California spotted owl | *Strix occidentalis* | 1 | | | | | |
| Common poorwill | *Phalaenoptilus nuttallii* | | | | | 4 | 2 |

[1] Identification of this species was not certain.

## BATS

*Pre-restoration objective 6*. Determine richness and relative frequency of use of desired condition bat species pre-restoration.

A combined total of seven bat species were detected at Meeks Creek in the three years of surveys (Table 4.2). Overall species richness was 1–3 species lower at Meeks Creek than General Creek. One of the seven detected species are currently listed as special concern by various state and federal agencies (Bradley et al. 2006) and are included as desired condition species for Meeks Creek (Appendix 4.5): long-eared myotis (*Myotis evotis*). An additional two desired condition species (also of special concern) were detected at General Creek: fringed myotis (*Myotis thysanodes*), and Yuma myotis (*Myotis yumanensis*). The relative occurrence of long-eared myotis was low at Meeks Creek compared to General Creek (Table 4.2).

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). Yuma myotis likewise roost in caves or trees, but are also commonly found in man-made structures (Brigham et al. 1992). 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. All three 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, however, 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). Restoration should emphasize re-establishment of dense stands of mature cottonwood in the Meeks Meadow area. 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.

**Recommended restoration actions**

*Lagoon restoration and conifer removal*

1. Where possible, preserve riparian habitat corridors, cottonwood, willow and alder woodlands, areas with open water to provide foraging opportunities for bats.
2. Restoration should emphasize re-establishment of dense stands of mature cottonwood in the Meeks Meadow area to provide roost sites for bats.
3. Because snags are a potential source of roost sites for bats, efforts should be made to determine if the number of snags with cavities is sufficient to meet the needs of bats in the Basin (or specifically at Meeks Creek).

**Recommended restoration objectives**

*Lagoon restoration and conifer removal*

1. Increase species richness and detection frequency of desired condition bat species at Meeks Creek.
    - Metric: Richness (total number of species detected) and detection frequency (average proportion of detections per visit per species)
    - Methods: Three surveys throughout the summer using ultrasonic bat detectors.

**Monitoring recommendations**

*Lagoon restoration and conifer removal*

1. Continue current survey methods for bats.
2. We suggest continued monitoring of bat species at Meeks Creek, 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, to determine if other factors are limiting bat distribution or abundance.

Table 4.2. Relative frequency of use by bat species detected with Pettersson ultrasonic detectors at Meeks Creek and General Creek, 2004, 2006, and 2007.

| Common name | Scientific name | Meeks Creek | | | General Creek | | |
|---|---|---|---|---|---|---|---|
| | | 2004 | 2006 | 2007 | 2004 | 2006 | 2007 |
| Big brown bat | *Eptesicus fuscus* | 5.8 | 5.8 | | 30.8 | 1.3 | 5.1 |
| Western red bat | *Lasiurus blossevillii* | | | | 2.5 | | |
| Hoary bat | *Lasiurus cinereus* | 52.5 | | | 45.0 | 7.7 | |
| Silver-haired bat | *Lasionycteris noctivagans* | | 67.4 | 50.4 | | 67.9 | 77.9 |
| California myotis | *Myotis californicus* | | 0.6 | 0.5 | | | |
| Long-eared myotis[1] | *Myotis evotis* | | 0.3 | 0.5 | | 11.5 | 4.4 |
| Little brown bat | *Myotis lucifugus* | 41.7 | 19.3 | 45.9 | 18.3 | 10.3 | 9.9 |
| Fringed myotis[1] | *Myotis thysanodes* | | | | | 1.3 | 0.4 |
| Hairy-winged myotis | *Myotis volans* | | | | | | 1.1 |
| Yuma myotis[1] | *Myotis yumanensis* | | | | 0.8 | | 1.1 |
| Mexican free-tailed bat | *Tadarida brasiliensis* | | 6.6 | 2.7 | 0.8 | | |

[1] Desired condition species (Appendix 4.5)

## SMALL MAMMALS

*Pre-restoration objective 7*. Determine species richness and abundance of desired condition small mammal species at Meeks Creek pre-restoration.

In the three years of surveys, we trapped a total of 12 small mammal species at Meeks Creek and 10 General Creek (Appendix 4.10). Seven small mammal species are listed as desired condition species for the Lake Tahoe Basin (Appendix 4.9) and we detected two of those species at Meeks Creek (Table 4.3). Species richness and relative abundance of desired condition species were low each year. No desired condition species were detected at either site in 2007, although seven unidentified shrew species were trapped at Meeks Creek (Appendix 4.10).

Table 4.3. Relative abundance of desired condition small mammal species trapped at Meeks Creek and associated control site, General Creek, during the summers of 2004, 2006, and 2007.

| Common Name | Scientific Name | Meeks Creek | | | General Creek | | |
|---|---|---|---|---|---|---|---|
| | | 2004 | 2006 | 2007 | 2004 | 2006 | 2007 |
| Long-tailed weasel | *Mustela frenata* | | 0.19 | | 0.16 | | |
| Trowbridge's shrew | *Sorex trowbridgii* | | | | | 0.20 | |
| Vagrant shrew | *Sorex vagrans* | 0.47 | | | | | |
| Western jumping mouse | *Zapus princeps* | | | | | 0.20 | |

Long-tailed weasels are found in variety of vegetation types, primarily open coniferous or deciduous forests and shrubland (Sheffield and Thomas 1997). They typically nest in burrows created by other small mammals (e.g., chipmunks, ground squirrels), tree cavities, snags, or logs. Vagrant shrews are found primarily in patchy, open areas with wet micro-habitats (e.g., wet meadows, streambanks) (Findley 1999) and forage for insects and other invertebrates under moist leaf litter and duff (Gillihan and Foresman 2004). Trowbridge's shrews are more associated with open coniferous forests and drier ground (George 1989). 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). Maintaining open, wet meadows as described herein, along with retaining adequate downed woody debris and snags, should encourage the persistence of these desired condition small mammal species at Meeks Creek.

In addition to the desired condition species, we captured several meadow-associated vole and shrew species at Meeks Creek (Appendix 4.10). Shrews and voles were more abundant in Meeks Creek during the three years of surveys than General Creek (Fig. 4.9 and Appendix 4.10). 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 voles and shrews primarily in grass-covered areas of the meadows at Meeks Creek, with and without nearby conifer canopy cover. Most of the trapped shrews were located near willow or alder cover whereas voles were trapped more often in open areas of the meadow. Increasing willow cover at Meeks Creek, along with increasing open, wet meadow, may be beneficial to these species.

We also captured four species of chipmunks at Meeks Creek (Appendix 4.10). The relative abundance of chipmunks remained low at Meeks Creek compared to General Creek during the three years of surveys (Fig. 4.10 and Appendix 4.10). 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). Maintaining open meadows can be accomplished, in part, by reducing the encroachment of lodgepole pine into the meadows.

**Recommended restoration actions**

*Conifer removal*

1. 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 and meadow-associated small mammal species, and to deter chipmunks from depredating bird nests located in meadow areas.

**Recommended restoration objectives**

*Conifer removal*

1. Increase species richness and abundance of desired condition small mammal species Meeks Creek.
    - Metric: Richness (total number of species detected across all visits per year) and relative abundance (number of unique individuals captured per 100 trap nights).
    - Methods: Trap and mark small mammals.

**Monitoring recommendations**

*Conifer removal*

1. Continue current survey methods for small mammals.
2. Include in future analysis the metric of percent composition (i.e., number of individuals per species), along with relative abundance, as an indication of change in community composition after restoration.

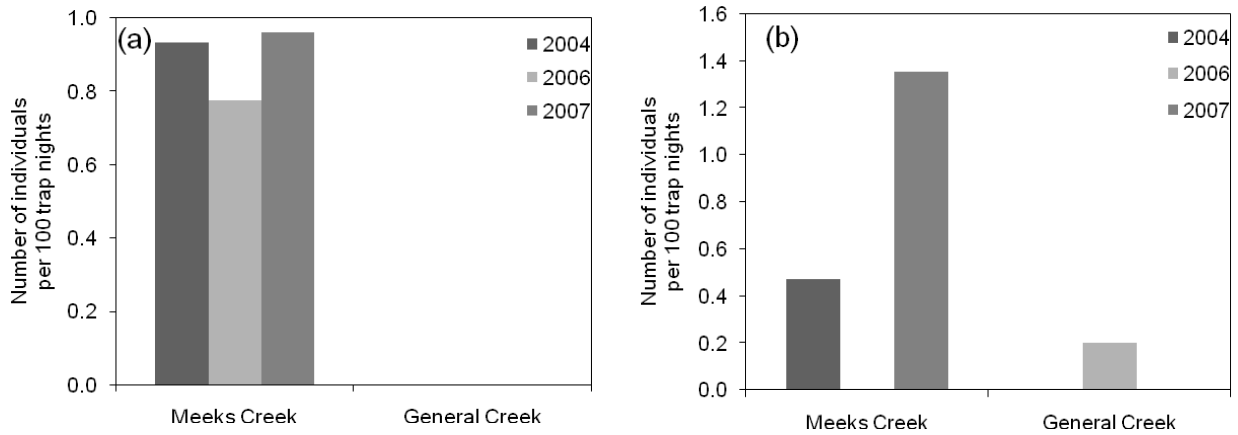


Figure 4.9. Relative abundance of (a) voles (*Microtus* spp.) and (b) shrews (*Sorex* spp.) trapped at Meeks Creek and associated control site, General Creek, in the summers of 2004, 2006, and 2007.

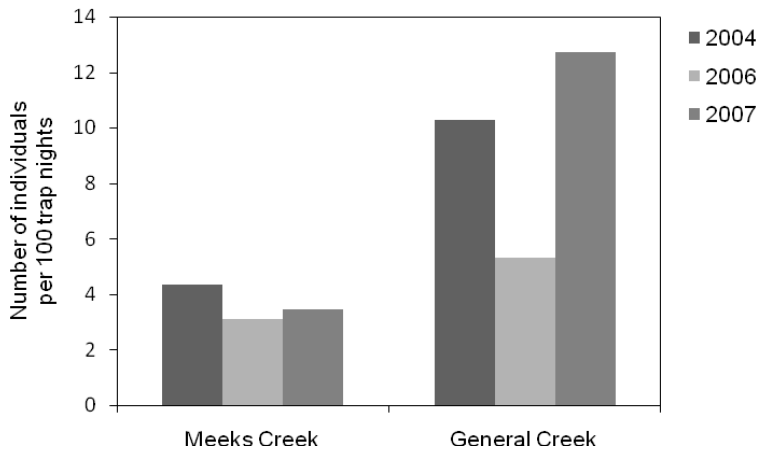


Figure 4.10. Relative abundance of chipmunks (*Tamias* spp.) trapped at Meeks Creek and associated control site, General Creek, in the summers of 2004, 2006, and 2007.

## VEGETATION AND HYDROLOGY

### Recommended vegetation actions and objectives

*Conifer removal*

1. Increase in total willow cover in areas where conifer is being removed to approximately 60% of the meadow area where possible (Bombay et al. 2003). This recommendation is based on surveys of meadows with willow flycatchers (Bombay et al. 2003). 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.
    - Metric: Spatial location of willow clumps pre- and post-restoration

    - Methods: Record location, size, and height of willows using a global positioning system (GPS).
2. Willows planted within the treated area should be planted in patches with a mean size of 375 $m^2$ (Bombay-Loffland, unpublished data). Recommendation is based on average spatial arrangement of willows within 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).
3. Increase proportion of wet meadow area within the conifer removal area.
    - Metric: Percent of meadow with standing water and saturated soil throughout summer
    - Methods: Bi-monthly meadow wetness transects

**Vegetation monitoring recommendations**

*Lagoon restoration*

1. If willows will be planted in the area east of Hwy 89, we recommend that willow mapping occur both pre- and post-restoration.
2. Willow mapping pre-restoration should take place once prior to restoration.
3. Willow mapping post-restoration should take place every other year.

*Conifer removal*

1. Evaluate meadow wetness and vegetation features (e.g., willows) at Meeks Creek both prior to restoration and after restoration. Monitoring should be conducted within the areas where conifer removal and willow planting is to occur.
2. Meadow wetness and willows should be evaluated once prior to restoration and every other year post-restoration.

## GENERAL MONITORING RECOMMENDATIONS

1. We suggest that an additional control site be monitored to compare post-restoration at Meeks Creek because General Creek supports very little wet meadow communities and the forested area along the creek is scheduled to be thinned in the near future. We recommend monitoring Antone Meadows to allow more effective comparisons of species in wet meadow communities. Although no pre-restoration data exists for Antone Meadows, there are limited sites to choose from to monitor post-restoration success at Meeks Creek. Some data; however, has been collected at Burton Creek and the lower portion of Antone Meadows (2 survey points). This data could be used to compare pre-restoration data with pre-restoration data at Meeks Creek. Additional post-restoration surveys could then be initiated at Antone Meadow and Burton Creek.

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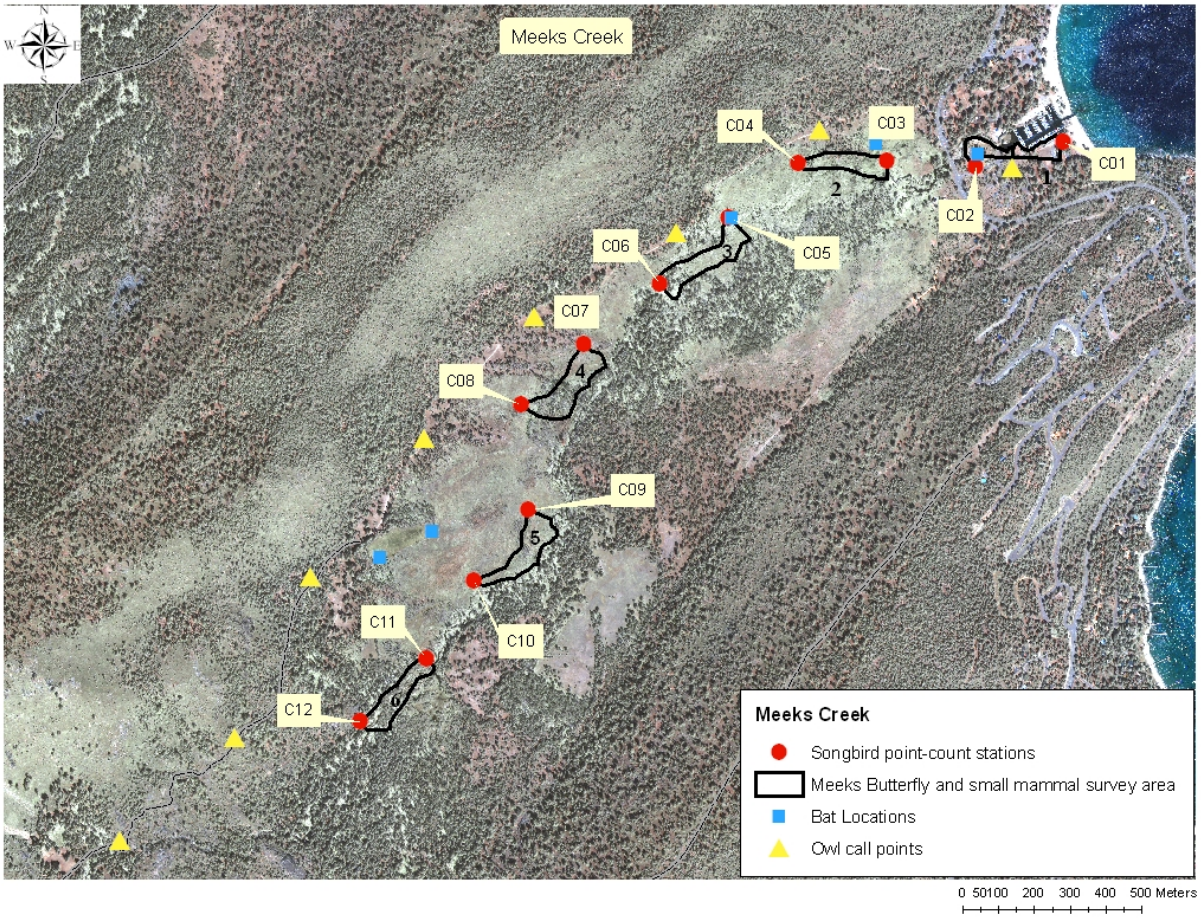
Appendix 4.1. Survey locations at Meeks Creek. Bat detector locations as indicated are for 2007 only.



Appendix 4.2. Desired condition butterfly species and potentially beneficial restoration activities based on habitat preferences that were detected at Meeks Creek. 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 at Meeks in 2004** | **Detected at Meeks in 2006** | **Community[1]** | **Potentially beneficial restoration activities[2]** |
|---|---|---|---|---|
| Northern Blue (*Lycaeides idas*) | Y | Y | Meadow | ↑flowers in the pea family (Fabaceae – *Lotus, Astragalus*, and *Lupinus* spp.) and yarrow (*Achillea millefolium*). ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies. |
| Greenish Blue (*Plebejus saepiolus*) | Y | Y | Meadow Riparian | ↑ in clover species (Fabacea family - *Trifolium* spp.). ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies. |
| Sierra Nevada Blue (*Agriades podarce*) | Y | Y | Meadow | ↑ in shooting star (*Dodecatheon* spp.), yellow composite species in the Asteraceae family, bistort (*Polygonum bistortoides*). ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies. |
| Great Spangled Fritillary (*Speyeria cybele*) | | | Meadow Riparian | ↑ in violets (*Viola* spp.), thistle species (*Cirsium* spp.) and clover species (Fabaceae family – *Trifolium* spp.). ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies. |
| Pacific Fritillary (*Boloria epithore*) | | Y | Meadow | ↑ in violets (*Viola* spp.). ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies. |
| Sonoran Skipper (*Polites sonora*) | Y | Y | Meadow | ↑ in grass species in the Poaceae family *(Festuca* spp.) and white-flowered thistle species (*Cirsium* spp.). ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies. |
| Western tiger swallowtail (*Papilio rutulus*) | Y | Y | Riparian | ↑ in cottonwood and aspens (*Populus* spp.) and willows (*Salix* spp.). ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies. |

Appendix 4.2 (Cont.)

| Species | Detected at Meeks in 2004 | Detected at Meeks in 2006 | Community[1] | Potentially beneficial restoration activities[2] |
|---|---|---|---|---|
| Purplish copper (*Lycaena helloides*) | Y | | Riparian | ↑ in species in the buckwheat family including smartweeds (*Polygonum* spp.), buckwheats (*Eriogonum* spp.), and docks (*Rumex* spp.). ↑ in cinquefoil species (*Potentilla* spp.) ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies. |
| Lilac-bordered copper (*Lycaena nivalis*) | | Y | Riparian | ↑ in species in the buckwheat family including smartweeds (*Polygonum* spp.), buckwheats (*Eriogonum* spp.), and docks (*Rumex* spp.). ↑ open forest patches. |
| Satyr comma (*Polygonia satyrus*) | | | Riparian | ↑ in nettle species (*Urtica* spp.), fruiting shrubs. ↑ open forest patches. ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies. |
| Mourning cloak (*Nymphalis antiopa*) | | Y | Riparian | ↑ in cottonwood and aspens (*Populus* spp.) and willows (*Salix* spp.). ↑ openings along riparian areas ↑patches of saturated soil should increase flowering plant diversity and benefit butterflies |
| Lorquin's admiral (*Limenitis lorquini*) | Y | Y | Riparian | ↑ in Bitter cherry *(Prunus emarginata*), cottonwood and aspens (*Populus* spp.), and willows (*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 4.3. Reptile and amphibian representative of desired ecological conditions that were detected at Meeks Creek in 2004 and 2006. Potentially beneficial restoration activities are 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 at Meeks in 2004** | **Detected at Meeks in 2006** | **Community** | **Potentially beneficial restoration activities[3]** | **Notes** |
|---|---|---|---|---|---|---|---|
| Long-toed salamander (*Ambystoma macrodactylum*) | X | | | Y | 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 | Y | | Forest Riparian Meadow | ↓ non-native trout, ↑ downed-woody debris, ↑ marsh/wetland vegetation | Species with known population declines (Manley et al. 2000) |

Appendix 4.3 (Cont.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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 | | Y | Y | 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]Source: Stebbins, R. C. 1985. A field guide to western reptiles and amphibians. Houghton Mifflin Company, Boston.

Appendix 4.4. Potentially beneficial management and restoration activities for bird species representative of desired ecological condition, 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), detected at Meeks Creek (2004-2007). 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]** | **2004** | **2005** | **2006** | **2007** | **Community[6]** | **Potentially beneficial restoration activities[7]** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pied-billed Grebe (*Podilymbus podiceps*) | X | | | | | | | | | Marsh | ↑ number of seasonal or permanent ponds >0.2 ha with dense stands of emergent vegetation and areas with submergent vegetation |
| Eared Grebe (*Podiceps nigricollis*) | X | | | | | | | | | Marsh | ↑ shallow lakes and ponds with emergent vegetation with 40-100% open water, ↑ water clarity |
| American Bittern (*Botaurus lentiginosus*) | X | | | | | | | | | Marsh | ↑ wetlands with tall emergent vegetation |
| Northern Pintail (*Anas acuta*) | X | | | | | | | | | Marsh | ↑ shallow wetlands with short vegetation, ↑ wet sedge and wet meadow areas |
| Redhead (*Aythya americana*) | X | | | | | | | | | Marsh | ↑ semi-permanent wetlands (>4 ha) with emergent grasses and sedges |
| Common Merganser (*Mergus merganser*) | X | | | | | Y | Y | | | Meadow Marsh | Provide nest boxes, ↑ snags near lakes and rivers bordered by forest |

Appendix 4.4 (Cont.)

| **Species** | **Desired condition species[1]** | **PIF[2]** | **RHJV[3]** | **MIS[4]** | **SAR[5]** | **2004** | **2005** | **2006** | **2007** | **Community[6]** | **Potentially beneficial restoration activities[7]** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wilson's Phalarope (*Phalaropus tricolor*) | X | | | | | | | | | Marsh | ↑ shallow water wetlands with emergent vegetation |
| Bald Eagle (*Haliaeetus leucocephalus*) | X | | | | | | | | | Marsh | ↑ mature forest trees <2 km from open and shallow waters, ↓ human disturbance, ↑ number of overstory canopy trees and snags |
| Osprey (*Pandion haliaetus*) | X | | | | | | | | | Marsh | ↑ tall and isolated nesting platforms in close proximity (10-20 km) to shallow waters with abundant fish |
| 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 |
| Sora (*Porzana carolina*) | X | | | | | | | | | Marsh | ↑ shallow water wetlands with emergent vegetation |
| Spotted Sandpiper (*Actitis macularia*) | X | | X | | | Y | Y | Y | | Meadow | ↓ stream incision, ↑ gravel bars and sinuosity |

Appendix 4.4 (Cont.)

| **Species** | **Desired condition species[1]** | **PIF[2]** | **RHJV[3]** | **MIS[4]** | **SAR[5]** | **2004** | **2005** | **2006** | **2007** | **Community[6]** | **Potentially beneficial restoration activities[7]** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wilson's Snipe (*Gallinago gallinago*) | X | | | | | Y | Y | Y | Y | Marsh Meadow | ↑ wet willow/alder thickets, ↑ duration of wet conditions, ↓ activities that compact soil |
| Forester's Tern (*Sterna forsteri*) | X | | | | | | | | | Marsh | ↑ deep water wetlands with open waters |
| Calliope Hummingbird (*Stellula calliope*) | X | | | X | | Y | Y | Y | 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 | Y | Y | Riparian | ↑ snags (112 snags/100 ha to support 28 pairs within 100 ha) |
| Williamson's Sapsucker (*Sphyrapicus thyroideus*) | X | | | X | | | | | | Riparian | ↑ aspen regeneration, ↑ snags in groups |
| Willow Flycatcher (*Empidonax traillii*) | X | X | X | | | | | | | Meadow | ↑ willow, ↓ parasitism risk, ↑ meadow wetness |

Appendix 4.4 (Cont.)

| Species | Desired condition species[1] | PIF[2] | RHJV[3] | MIS[4] | SAR[5] | 2004 | 2005 | 2006 | 2007 | Community[6] | Potentially beneficial restoration activities[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Warbling Vireo (*Vireo gilvus*) | | | X | | | Y | Y | 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 |
| House Wren (*Troglodytes aedon*) | X | | | X | | Y | Y | | | Forest Riparian | Provide nest boxes, ↑ deciduous component along streams |
| 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 | | | | Y | Y | Y | Y | Meadow | ↑ ground and shrub cover along streamsides |
| Yellow Warbler (*Dendroica petechia*) | X | X | X | X | | Y | Y | Y | Y | Meadow | ↑ willow, ↓ parasitism risk, ↑ meadow wetness |
| Wilson's Warbler (*Wilsonia pusilla*) | | X | X | X | | Y | Y | Y | Y | Meadow Riparian | ↑ ground and shrub cover |

Appendix 4.4 (Cont.)

| Species | Desired condition species[1] | PIF[2] | RHJV[3] | MIS[4] | SAR[5] | 2004 | 2005 | 2006 | 2007 | Community[6] | Potentially beneficial restoration activities[7] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Song Sparrow (*Melospiza melodia*) | | | X | X | | Y | Y | Y | Y | 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, |
| Black-headed Grosbeak (*Pheucticus melanocephalus*) | | X | X | | | | | | | Meadow | ↑ willow, ↑ cottonwood along creeks, ↑ aspen regeneration, create habitat type transition zones |
| Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) | X | | | | | | | | | Meadow Marsh | ↑ meadow wetness, ↑standing water, ↑ emergent vegetation, create deep-water palustrine wetlands |
| Brewer's Blackbird (*Euphagus cyanocephalus*) | | X | | | | Y | Y | Y | Y | Meadow Marsh | ↑ open areas with suitable perches |

[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]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.
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Appendix 4.5 Mammal species representative of desired ecological conditions and USDA Forest Service Management Indicator Species (MIS) and potentially beneficial restoration activities based on habitat preferences that were detected at Meeks Creek. 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 at Meeks in 2004 | Detected at Meeks in 2006 | Detected at Meeks 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*) | X | | | 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*) | X | | | | | 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*) | X | | | | | 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 | Y | | | 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) |

Appendix 4.5 (Cont.)

| Species | Desired condition species[1] | MIS[2] | Detected at Meeks in 2004 | Detected at Meeks in 2006 | Detected at Meeks in 2007 | Community | Potentially beneficial restoration activities[4] | Notes |
|---|---|---|---|---|---|---|---|---|
| Long-tailed weasel (*Mustela frenata*) | X | | | Y | | Forest Riparian Meadow | ↑ areas with standing water, ↑ understory shrub density | |
| Belding's ground squirrel (*Spermophilus beldingi*) | X | | | | | Meadow | ↑ proportion of succulent vegetation, ↑ areas with standing water, create meadow-like openings | Potentially vulnerable terrestrial vertebrate (Manley et al. 2000) |
| Northern flying squirrel (*Glaucomys sabrinus*) | X | X | | | | Forest | ↑ proportion of old-growth conditions | |
| Western jumping mouse (*Zapus princeps*) | X | X | | | | 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 | | | | | 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 | | | Y | | 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.

Appendix 4.5 (Cont.)

[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:

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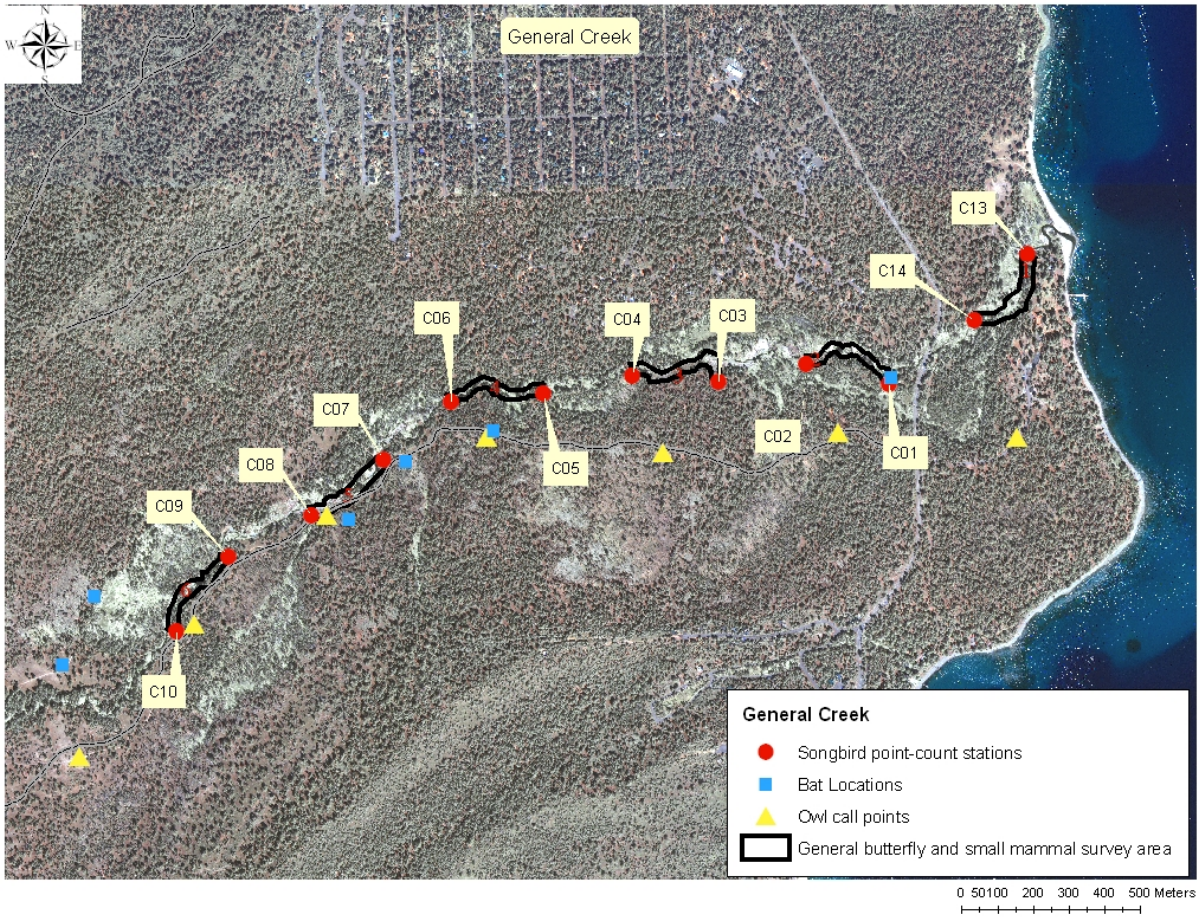
Watkins, L. C. 1977. *Euderma maculatum*. Mammalian Species 77:1-4.

Appendix 4.6. Survey locations at General Creek. Bat detector locations as indicated are for 2007 only.



Appendix 4.7. UTM locations of bat ultrasonic detectors placed at Meeks Creek and General Creek in 2007.

| Site | Year | Visit | Zone | Easting | Northing |
|---|---|---|---|---|---|
| Meeks Creek | 2007 | 1 | 10 | 747301 | 4323402 |
| Meeks Creek | 2007 | 1 | 10 | 747443 | 4323472 |
| Meeks Creek | 2007 | 2 | 10 | 748963 | 4324525 |
| Meeks Creek | 2007 | 2 | 10 | 748680 | 4324553 |
| Meeks Creek | 2007 | 3 | 10 | 747893 | 4324107 |
| Meeks Creek | 2007 | 3 | 10 | 748280 | 4324346 |
| General Creek | 2007 | 1 | 10 | 747089 | 4325447 |
| General Creek | 2007 | 1 | 10 | 747177 | 4325640 |
| General Creek | 2007 | 2 | 10 | 748052 | 4326020 |
| General Creek | 2007 | 2 | 10 | 747893 | 4325858 |
| General Creek | 2007 | 3 | 10 | 748300 | 4326106 |
| General Creek | 2007 | 3 | 10 | 749417 | 4326256 |

Appendix 4.8. Average number of birds detected per point within 50 m of point-count stations (± SE) at Meeks Creek and the percentage of the avian community each species comprises. Data from 2007.

| Common name | Scientific name | Average number detected per point | SE | Percent composition |
|---|---|---|---|---|
| Canada Goose | *Branta canadensis* | 0.39 | 0.35 | 4 |
| Mallard | *Anas platyrhynchos* | 0.08 | 0.05 | 1 |
| Wilson's Snipe | *Gallinago gallinago* | 0.08 | 0.08 | 1 |
| Mourning Dove | *Zenaida macroura* | 0.11 | 0.03 | 1 |
| Calliope Hummingbird | *Stellula calliope* | 0.19 | 0.10 | 2 |
| Red-breasted Sapsucker | *Sphyrapicus ruber* | 0.08 | 0.05 | 1 |
| Hairy Woodpecker | *Picoides villosus* | 0.08 | 0.08 | 1 |
| White-headed Woodpecker | *Picoides albolarvatus* | 0.06 | 0.06 | 1 |
| Northern Flicker | *Colaptes auratus* | 0.06 | 0.06 | 1 |
| Olive-sided Flycatcher | *Contopus cooperi* | 0.11 | 0.11 | 1 |
| Western Wood-Pewee | *Contopus sordidulus* | 0.47 | 0.15 | 5 |
| Dusky Flycatcher | *Empidonax oberholseri* | 0.03 | 0.03 | <1 |
| Warbling Vireo | *Vireo gilvus* | 0.53 | 0.15 | 5 |
| Steller's Jay | *Cyanocitta stelleri* | 0.39 | 0.14 | 4 |
| Tree Swallow | *Tachycineta bicolor* | 0.11 | 0.11 | 1 |
| Barn Swallow | *Hirundo rustica* | 0.14 | 0.07 | 1 |
| Cliff Swallow | *Petrochelidon pyrrhonota* | 0.25 | 0.17 | 2 |
| Mountain Chickadee | *Poecile gambeli* | 0.53 | 0.29 | 5 |
| Red-breasted Nuthatch | *Sitta canadensis* | 0.08 | 0.08 | 1 |
| White-breasted Nuthatch | *Sitta carolinensis* | 0.03 | 0.03 | <1 |
| Brown Creeper | *Certhia americana* | 0.03 | 0.03 | <1 |
| Hermit Thrush | *Catharus guttatus* | 0.03 | 0.03 | <1 |
| American Robin | *Turdus migratorius* | 0.56 | 0.06 | 5 |
| Orange-crowned Warbler | *Vermivora celata* | 0.14 | 0.06 | 1 |
| Nashville Warbler | *Vermivora ruficapilla* | 0.39 | 0.10 | 4 |
| Yellow Warbler | *Dendroica petechia* | 0.39 | 0.06 | 4 |
| Yellow-rumped Warbler | *Dendroica coronata* | 0.06 | 0.03 | 1 |
| MacGillivray's Warbler | *Oporornis tolmiei* | 0.36 | 0.22 | 4 |
| Wilson's Warbler | *Wilsonia pusilla* | 0.14 | 0.10 | 1 |
| Western Tanager | *Piranga ludoviciana* | 0.06 | 0.03 | 1 |
| Chipping Sparrow | *Spizella passerina* | 0.03 | 0.03 | <1 |
| Fox Sparrow | *Passerella iliaca* | 0.03 | 0.03 | <1 |
| Song Sparrow | *Melospiza melodia* | 0.50 | 0.19 | 5 |
| Dark-eyed Junco | *Junco hyemalis* | 0.64 | 0.15 | 6 |
| Red-winged Blackbird | *Agelaius phoeniceus* | 1.14 | 0.54 | 11 |
| Brewer's Blackbird | *Euphagus cyanocephalus* | 1.08 | 0.21 | 11 |
| Brown-headed Cowbird | *Molothrus ater* | 0.69 | 0.19 | 7 |

Appendix 4.8 (Cont.)

| Common name | Scientific name | Average number detected per point | SE | Percent composition |
|---|---|---|---|---|
| Cassin's Finch | *Carpodacus cassinii* | 0.06 | 0.06 | 1 |
| Pine Siskin | *Carduelis pinus* | 0.03 | 0.03 | <1 |
| Evening Grosbeak | *Coccothraustes vespertinus* | 0.06 | 0.06 | 1 |

Appendix 4.9. Average number of birds detected per point within 50 m of point-count stations (± SE) at General Creek and the percentage of the avian community each species comprises. Data from 2007.

| Common name | Scientific name | Average number detected per point | SE | Percent composition |
|---|---|---|---|---|
| Canada Goose | *Branta canadensis* | 0.11 | 0.11 | 1 |
| Common Merganser | *Mergus merganser* | 0.03 | 0.03 | <1 |
| Hairy Woodpecker | *Picoides villosus* | 0.06 | 0.06 | 1 |
| White-headed Woodpecker | *Picoides albolarvatus* | 0.03 | 0.03 | <1 |
| Northern Flicker | *Colaptes auratus* | 0.06 | 0.03 | 1 |
| Olive-sided Flycatcher | *Contopus cooperi* | 0.14 | 0.03 | 2 |
| Western Wood-Pewee | *Contopus sordidulus* | 0.25 | 0.05 | 3 |
| Dusky Flycatcher | *Empidonax oberholseri* | 0.31 | 0.23 | 4 |
| Cassin's Vireo | *Vireo cassinii* | 0.03 | 0.03 | <1 |
| Warbling Vireo | *Vireo gilvus* | 0.44 | 0.10 | 5 |
| Steller's Jay | *Cyanocitta stelleri* | 0.53 | 0.15 | 6 |
| Tree Swallow | *Tachycineta bicolor* | 0.03 | 0.03 | <1 |
| Barn Swallow | *Hirundo rustica* | 0.03 | 0.03 | <1 |
| Mountain Chickadee | *Poecile gambeli* | 0.67 | 0.14 | 8 |
| Red-breasted Nuthatch | *Sitta canadensis* | 0.06 | 0.06 | 1 |
| Brown Creeper | *Certhia americana* | 0.42 | 0.13 | 5 |
| Golden-crowned Kinglet | *Regulus satrapa* | 0.31 | 0.07 | 4 |
| Townsend's Solitaire | *Myadestes townsendi* | 0.03 | 0.03 | <1 |
| American Robin | *Turdus migratorius* | 0.56 | 0.18 | 7 |
| Nashville Warbler | *Vermivora ruficapilla* | 0.44 | 0.12 | 5 |
| Yellow-rumped Warbler | *Dendroica coronata* | 0.19 | 0.07 | 2 |
| MacGillivray's Warbler | *Oporornis tolmiei* | 0.28 | 0.10 | 3 |
| Wilson's Warbler | *Wilsonia pusilla* | 0.47 | 0.07 | 6 |
| Western Tanager | *Piranga ludoviciana* | 0.28 | 0.07 | 3 |
| Fox Sparrow | *Passerella iliaca* | 0.28 | 0.07 | 3 |
| Song Sparrow | *Melospiza melodia* | 0.22 | 0.03 | 3 |
| Dark-eyed Junco | *Junco hyemalis* | 1.06 | 0.29 | 13 |
| Black-headed Grosbeak | *Pheucticus melanocephalus* | 0.06 | 0.03 | 1 |
| Red-winged Blackbird | *Agelaius phoeniceus* | 0.03 | 0.03 | <1 |
| Brown-headed Cowbird | *Molothrus ater* | 0.61 | 0.11 | 7 |
| Cassin's Finch | *Carpodacus cassinii* | 0.14 | 0.14 | 2 |
| Evening Grosbeak | *Coccothraustes vespertinus* | 0.19 | 0.10 | 2 |

Appendix 4.10. Number of small mammals trapped per 100 trap nights (i.e., relative abundance) at Meeks Creek and General Creek during summers of 2004, 2006, and 2007. An asterisk indicates a desired condition species.

| Common Name | Meeks Creek | | | General Creek | | |
|---|---|---|---|---|---|---|
| | 2004 | 2006 | 2007 | 2004 | 2006 | 2007 |
| Northern flying squirrel* | | | | | 0.20 | |
| Long-tailed vole | | 0.58 | 0.96 | | | |
| Montane vole | 0.93 | 0.19 | | | | |
| Long-tailed weasel* | | 0.19 | | 0.16 | | |
| Unknown weasel | | | | | | 0.23 |
| Deer mouse | 6.85[1] | 1.75 | 2.69 | 19.16[1] | 7.17 | 5.68 |
| Trowbridge's shrew* | | | | | 0.20 | |
| Vagrant shrew* | 0.47 | | | | | |
| Unknown shrew | | | 1.35 | | | |
| California ground squirrel | | | | 0.16 | 0.20 | 0.23 |
| Golden-mantled ground squirrel | 1.71 | 1.75 | 2.69 | 2.34 | 1.23 | 2.73 |
| Yellow-pine chipmunk | 0.62 | 2.33 | 0.96 | 2.18 | 1.23 | 1.14 |
| Long-eared chipmunk | 0.62 | | 0.77 | | 1.02 | 5.00 |
| Shadow chipmunk | 2.80 | | 0.38 | 7.32 | 1.02 | 1.82 |
| Lodgepole chipmunk | 0.31 | 0.19 | 0.38 | 0.62 | 1.02 | 3.18 |
| Unknown chipmunk | | 0.58 | 0.96 | 0.16 | 1.02 | 1.59 |
| Douglas squirrel | 0.16 | | | | | |
| Mountain pocket gopher | | | 0.19 | | | |
| Western jumping mouse* | | | | | 0.20 | |

[1] Individuals were not marked, therefore this number represents maximum number of individuals trapped in one visit and is an underestimate of abundance.