# CHAPTER I – WILDLIFE RESTORATION AND MONITORING: CONCEPTS AND DEVELOPMENT

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# CHAPTER I – WILDLIFE RESTORATION AND MONTIOROING: CONCEPTS AND DEVELOPMENT

## LAKE TAHOE BASIN RESTORATION

In an effort to improve ecosystem function of meadow areas within the Lake Tahoe Basin, the USFS is embarking on a major restoration effort. Six meadow and riparian systems (High Meadow, Cookhouse, Big Meadow, Sunset Reach, Meeks Creek, and Blackwood Creek) within the Lake Tahoe Basin are currently slated for restoration aimed at enhancing the hydrologic function and ecological condition of these areas (Appendix 1.1).

Numerous activities, such as logging, fire suppression, grazing, and human development have altered wildlife communities within the Basin (Murphy and Knopp 2000) requiring the need for restoration. Logging during the Comstock Era (1850–1900) greatly reduced the proportion of old-growth forest in the Lake Tahoe Basin from approximately 55% to 5% (Murphy and Knopp 2000). Moreover, logging has shifted forest composition and structure from Jeffrey pine (*Pinus jeffreyi*) to fir (*Abies* spp.) and incense cedar (*Calocedrus decurrens*) dominated stands with higher tree densities (Murphy and Knopp 2000). Fire suppression has also altered forest structure and composition, resulting in densely packed trees that are susceptible to insect and disease outbreaks and catastrophic fires as a result of increased fuel loads (Murphy and Knopp 2000). Unregulated cattle and sheep grazing in the 1860s and 1870s resulted in severe overgrazing in several meadow and lake-level areas throughout the Lake Tahoe Basin (Lindstrom 2000). Although grazing was limited to allotments in the 1930s, grazing pressure was still heavy at that time and continued to be relatively widespread into the late 20$^{th}$ century, leaving a lasting mark in some areas (Harris and Barker 1988, Lindstrom 2000).

Development pressures also have decreased the natural diversity and integrity of ecosystems in the Lake Tahoe Basin. The post Comstock Era (1900 to present) saw rapid development and habitat degradation. By 1905, 10 communities were established along the shores of Lake Tahoe and by 1925 a road encircling the lake was built leading to further development and recreation pressures. During the post Comstock Era, non-native species introductions began. Fourteen million non-native fish were introduced into Lake Tahoe from 1944 to 1960 (Manley et al. 2000).

Continued urbanization pressure (1990 to present) resulted in further habitat degradation. For example, approximately 75% of the marshes and 50% of the meadows were substantially degraded as a result of development that occurred between 1969 and 1979 (Manley et al. 2000). Housing developments increased from 500 homes in 1960 to 19,000 homes in 1980. Water quality within Lake Tahoe also substantially decreased during this period due to pollution and sewage runoff (Manley et al. 2000). These factors, in part, led to the degradation and reduction of ecologically important ecosystems such as marshes, bogs, fens, aspen groves, meadows, and riparian areas. Because these areas currently encompass a small proportion of the Basin (Murphy and Knopp 2000) and support a disproportionate number of species, there is interest in restoring these areas.

## RESTORATION GOALS AND OBJECTIVES

The Sierra Nevada Ecosystem Plan (SNEP) concluded that riparian and meadow ecosystems are among the most degraded ecosystems within the Sierra Nevada (SNFPA 2004). To address these degraded ecosystems the SNFPA has identified wildlife and habitat goals specifically for aquatic, riparian and meadow ecosystems and associated species that are supported in planned restoration projects. These wildlife and habitat related goals include:

1. Species Viability: Maintain and restore habitat to support viable populations of native plants, invertebrates, and vertebrate riparian-dependent species. Prevent new introductions of invasive species. Where invasive species are adversely affecting the viability of native species, work cooperatively with appropriate State and Federal wildlife agencies to reduce impacts to native populations.
2. Plant and Animal Community Diversity: Maintain and restore the species composition and structural diversity of plant and animal communities in riparian areas, wetlands, and meadows to provide desired habitats and ecological functions.
3. Special habitats: Maintain and restore the distribution and health of biotic communities in aquatic habitats (such as springs, seeps, vernal pools, fens, bogs, and marshes) to perpetuate their unique functions and biological diversity.
4. Watershed Connectivity: Maintain and restore spatial and temporal connectivity for aquatic and riparian species within and between watersheds to provide physically, chemically, and biologically unobstructed movement for their survival, migration, and reproduction.
5. Floodplains and Water Tables: Maintain and restore the connections of floodplains, channels, and water tables to distribute flood flows and sustain diverse habitats.

Based on these goals, more specific Riparian Conservation Objectives (RCO) were developed as part of a strategy for attaining the above stated goals (SNFPA 2004). Those objectives that directly relate to wildlife restoration and monitoring goals in the Lake Tahoe Basin include:

1. RCO #2 – "Maintain and restore: (1) the geomorphic and biological characteristics of special aquatic features, including lakes, meadows, bogs, fens, wetlands, vernal pools, and 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."
2. RCO #3 – Ensure a renewable supply of large down logs that: (1) can reach the stream channel and (2) provide suitable habitat within and adjacent to the RCA.
3. RCO #4 – Ensure that management activities, including fuels reduction actions, within RCAs and CARs enhance or maintain physical and biological characteristics associated with aquatic- and riparian-dependent species.
4. RCO #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 those areas."

5. RCO # 6 – "Identify and implement restoration actions to maintain, restore, or enhance water quality and maintain, restore, or enhance habitat for riparian and aquatic species."

These goals and objectives have been adopted by the restoration program established by the Lake Tahoe Basin Management Unit and are the central guidance used to direct restoration project proposed actions.

## CONCEPTUAL FRAMEWORK

In this section we outline a general conceptual framework of ecosystem processes and functions, which is the essential first step in designing a restoration project (Hobbs and Norton 1996). Development of this framework involves a process of feedback between the desired ecological condition and what is ultimately feasible to implement and maintain given current environmental conditions, budgetary constraints, and legal mandates. In other words, we must place our ecological goals within the boundaries of required legal and other planning mandates as well as funding and logistical constraints. For any restoration project, such a framework also must consider the surrounding environmental conditions because successful restoration is unlikely if immigration and emigration are impossible, or if predators or competitors cannot be managed either within the project area or on surrounding lands. Developing a sound restoration design and framework is key to the successful implementation of restoration activities that will likely have a positive effect on wildlife species (Morrison 2002).

An essential component of this framework is incorporation of the ecological requirements of key animal species. While developing and maintaining a functioning ecosystem in the desired condition will provide habitat and niche components for the majority of species, it is unlikely that all key requirements for targeted species can be achieved in this manner given the degraded environments that exist. For example, unnatural numbers of native predators and exotic species can prevent restoration of essential niche components for some targeted species regardless of the restored condition of the physical habitat. Thus, in addition to rehabilitation of vegetative structure and hydrologic functions, additional actions may need to be considered as part of the restoration actions or subsequent management actions to account for the niche components of targeted animal species. Site-specific (e.g., elevation) and species-specific (e.g., dispersal distance) limitations need to be considered prior to developing desired species conditions. Additionally, because of legal and administrative mandates for conservation of threatened endangered and sensitive species, individual species or small groups of similar species (e.g., surrogate species) must usually be incorporated into this framework.

Prior to development of a successful restoration plan, participants must be aware of the distinction between habitat and niche factors, and their relevance to the viability of animals, because failure to recognize wildlife niche requirements can preclude successful restoration (see Morrison et al. 1998 for review). By definition "*habitat*" is a species-specific concept and should not be confused with "*habitat type*", which is closely related to vegetative associations. Habitat is simply a description of the physical attributes of the environment in an observer-defined area around an individual animal (Morrison 2002). Typical habitat variables include the structure and species composition of vegetation (all layers), type and coverage of ground cover (e.g., gravel, bare soil), various special features such as down logs and rocky outcrops, type and coverage of water (e.g., wet depression, pond), and a host of other factors. Habitat factors vary continually as an individual moves through the environment, and over the course of a season.

Niche factors relate to the behavioral activities of an individual within the habitat typically determined by where an animal spends its time. Niche factors include various resources, such as the type and size of food required and the constraints on the acquisition of those resources, by the activity of predators and competitors. For example, regardless of appropriate vegetation structure, the presence of brown-headed cowbirds (*Molothrus ater*), a nest parasite, usually results in breeding failure of the songbird host (Robinson et al. 1995*a*). In addition, species interactions also need to be considered in restoration planning. For example, foraging patterns of insectivorous birds were altered by elk browsing on quaking aspen (*Populus tremuloides*) (Bailey and Whitham 2003). The consumption of aspen shoots by elk reduced the quantities of galls produced by sawflies, the presence of which had significant effects on the species richness and abundance of other arthropod species (Bailey and Whitman 2003). Thus, regardless of the apparent appropriateness of habitat, an animal may be absent from an area because niche factors are inappropriate. Models based solely on vegetation factors often result in poor predictions because niche requirements are not met even though the vegetation appears suitable. Therefore, it is necessary to incorporate both habitat and niche models into restoration.

Although a thorough evaluation of niche relationships increases time and effort to the front-end planning of a restoration project, such work substantially improves the efficacy of the final restoration plan and drives anticipated post-restoration management activities. For example, if initial analyses indicate that willow flycatchers (*Empidonax traillii*) experience high nest parasitism by brown-headed cowbirds and thus poor breeding success, there would be little reason to attempt to restore habitat (i.e., wet meadows) specifically for willow flycatchers unless an analysis of cowbird management options was an integral part of the restoration plan. Although restoring wet meadow may be important for other reasons, creating wet meadows may not benefit willow flycatchers if data indicate that levels of parasitism are negatively impacting productivity. Additionally, if analyses indicate that predation pressure by mammals or Steller's jays is severe, management and restoration plants must also consider ways to reduce predation risk to allow for an increase in productivity. Although it is not feasible to resolve all ecological relationships in a restoration project, identifying key ecological attributes, including key species and associated niche requirements, will result in a comprehensive plan that has a higher probability of achieving desired ecological conditions and maintaining biological integrity.

## RESTORATION MONITORING PROCESS

The following are *sequential* steps to take in developing the predicted response of wildlife to restoration within a specific watershed or other planning area and outlines the wildlife restoration monitoring process. The steps include establishment of existing wildlife conditions, the identification of desired conditions and specific habitat and niche features that must be provided during the restoration process (Appendix 1.2-1.5). This sequence leads to the development of a conceptual framework and wildlife monitoring strategies (See Appendix 1.6 and 1.7 for site specific planning phase).

1. Pre-restoration monitoring/Establish existing wildlife conditions
    a. Identify ecosystem restoration project goals and objectives as they relate to existing Forest Plan direction
    b. Create a conceptual model of key ecosystem attributes and stressors, including key animal species and associated niche and habitat factors where relevant

    c. Plan pre-restoration survey locations and species groups to be sampled based on project goals and objectives and conceptual model
    d. Follow survey plan for up to three years at each restoration project site and control site(s) (or until NEPA project initiation)
2. Desired condition development for wildlife
    a. List individual species or species groups that are characteristic of the desired conditions (i.e., desired condition species) using pre-restoration monitoring data and historic data (e.g., Orr 1949, Orr and Moffitt 1971) (Appendix 1.2-1.5)
    b. List key natural history traits of each desired condition species or species group using information from the literature and pre-restoration data collection (Appendix 1.2-1.5)
    c. Identify key constraints (e.g., disturbance, predation, and parasitism) that might impact species using information from the literature and pre-restoration data collection (Appendix 1.2-1.5)
    d. Identify species by current abundance categories (e.g., abundant, rare) and evaluate relative to their overall range and range within the Lake Tahoe Basin using pre-restoration monitoring data and historic data (e.g., Orr 1949, Orr and Moffitt 1971)
    e. Develop list of potential desired condition species that should be considered in restoration planning based on being a species of key importance in the ecosystem or showing evidence of population declines from historic conditions (Appendix 1.2-1.5)
        - Include desired conditions for special status species as well as overall wildlife habitat and wildlife species conditions (e.g., willow flycatcher and northern goshawk)
3. Develop recommended project management actions
    a. Identify recommended management actions that meet the needs of selected desired condition species or species groups (as determined in #2 above) based on the conceptual model, information from the literature or pre-restoration data collection
    b. Specify direct linkages between recommended management actions and affected desired condition species, species groups or ecosystem metrics. Describe the links from objectives and management actions, resultant habitat conditions produced or affected, and the potential wildlife effects
    c. Work with project leaders to develop detailed on the ground prescriptions that meet the intent of the recommended management actions and that will fulfill the wildlife objectives
4. Develop a monitoring plan
    a. Provide rationale for monitoring metrics chosen based on wildlife objectives and expected effects of project management actions
    b. Determine appropriate metric for each species (e.g., species richness, abundance, productivity)
    c. Develop thresholds and triggers within adaptive management context that are based on predicted (and desired) wildlife response to restoration. Note that some species will be expected to decrease in abundance and distribution following restoration (e.g., brown-headed cowbirds and bullfrogs)

        - Species additions and deletions
        - Changes (increases and decreases) in distribution and abundance
    d. Develop monitoring plan after project development, but possibly before completion of the NEPA decision document using pre-restoration data, site potential, and desired conditions documents
    e. Confirm that pre-restoration survey locations are suitable for "effectiveness" monitoring. Make adjustments in survey/sampling locations and recommend accordingly
    f. Base monitoring plan on project wildlife objectives that addresses habitat and niche requirements of desired condition species
    g. Develop a specific post-restoration monitoring plan including:
        - Written project wildlife objectives
        - Metrics used to monitor wildlife objectives
        - Temporal frequency of sampling
        - Thresholds of success or intervention if known
5. Reporting of Results
    a. Write final wildlife project effectiveness report after all years of pre- and post-restoration monitoring surveys are complete
    b. Indicate whether target objectives were met, if continued monitoring is necessary, or if additional actions are necessary to meet intended objectives

## DESIRED CONDITIONS

Documents describing restoration intentions for the Basin (e.g., Harris and Barker 1988, CER 2006) often regard restoration as the improvement of current conditions. While many envision the desired state as that which existed prior to European settlement (Elliott-Fisk et al. 1997), exact replication of those conditions is unrealistic. Changes in land-use, human population growth, and climate prevent the full achievement of pre-European conditions (Murphy and Knopp 2000). Restoration goals must be realistic and set within the context of these large-scale changes. Desired conditions, as specified by the LTBMU Forest plan (Harris and Barker 1988), Sierra Nevada Forest Plan Amendment (SNFPA) (SNFPA 2004) and the Tahoe Regional Planning Agency (TRPA 2007), are diverse yet encompass the renewal or maintenance of healthy, self-sustaining ecosystems. In addition, to these general desired conditions, specific desired conditions should be developed for wildlife species.

### Desired condition wildlife species

*Desired condition species are species that have been identified by comparing existing conditions with historic conditions in the Basin. Species that (1) have declined in abundance based on this analysis and (2) should occur at each project site based on location or expected habitat conditions following restoration, but are currently absent comprise the desired condition species*. Desired condition species can also incorporate special status species, public interest species, and management indicator species (Table 1.1). These categories and the resulting species list also relate closely to the Pathway 2007 program that is currently under development in the Basin. The list of desired condition species then become the focus of restoration actions and objectives.

Table 1.1. Definition of desired condition species.

Desired condition species are species that have been identified by comparing existing conditions with historic conditions in the Basin. Species that (1) have declined in abundance based on this analysis and (2) should occur at each project site based on location or expected habitat conditions following restoration, but are currently absent comprise the desired condition species. In addition to those species that have declined in abundance, desired condition species also include the following:

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

Desired condition species are also used to provide management recommendations. For example, because willow flycatchers have declined in abundance across the basin, we can use information about the species life history and habitat requirements to provide recommendations for restoration. Selecting desired condition species is also useful for determining the effectiveness of restoration because monitoring wildlife responses to restoration is an effective way to determine the success of a restoration project (Block et al. 2001, Morrison 2002). Therefore, desired condition wildlife species must be identified to facilitate comparisons between pre- and post-restoration actions and to determine if restoration actions are meeting project objectives.

**Desired condition species analysis**

Vertebrate species representative of desired ecological conditions were identified based on two fundamental analyses: existing conditions and historic conditions (See below). This analysis was conducted for songbirds, reptiles, amphibians, bats, and small mammals. Species identified through these analyses comprise the *desired condition species*. Species identified through this analysis are species that should be present pending successful restoration. However, presence of additional species that are relatively common on other meadow sites throughout the Basin (e.g., Wilson's warbler [*Wilsonia pusilla*]) but not at other project sites will also be used to gauge the *progress* of restoration. Final designation of desired condition species is contingent on Forest Service decisions. Selection of desired species should be based on the below analysis as well as site potential.

Desired condition butterfly species were selected based on habitat requirements and life-history traits of butterfly species that occur in the Lake Tahoe Basin because little historic data exists for butterflies. We selected butterfly species that are strongly associated with wet meadow and/or riparian areas and species that have strong host-plant specificity (e.g., nectar or lay eggs on one or two specific plants).

Existing conditions: We used pre-restoration data from the wildlife restoration and monitoring project (Morrison, unpublished data) to assess the existing conditions of wildlife species (songbirds, reptiles, amphibians, small mammals, and bats) at each project site. We also used knowledge of general species distributions in the Basin based on other data sets, to develop the preliminary analysis presented below.

Based on existing pre-restoration data, we developed a list of all species that occurred on meadows throughout the Basin on our other restoration and reference sites (e.g., Big Meadow, Fountain Place, etc). This overall list of species was then ranked by abundance and overall percent community composition and was compared with the pre-restoration data for each project site. We then identified species from this list that (a) *should* occur at each project site based on location or expected habitat conditions following restoration, but are currently absent; (b) *could* occur at each project site, but were unlikely to do so (e.g., large home range requirements); and (c) were unlikely to occur at a project site due to poor site potential. Species that should occur at each project site will be the focus of monitoring for wildlife responses to restoration. Thus, this subset of species comprises the desired condition species (Appendix 1.2-1.5).

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

We compared historic records (Orr 1949, Orr and Moffitt 1971) to recent records (e.g., Watershed Assessment, MSIM, and wildlife restoration and monitoring data) to identify species that have apparently declined in abundance within the Basin. We termed these as *desired condition species* in this document because they are a focus of restoration efforts. Desired condition species might occur on a restoration site such as High Meadow, occur on one or more of our other sampling sites, or not occur at all on any sampled site in the Basin. Desired condition species that should occur at each project site were identified and could require special management efforts (e.g., cowbird control) to ensure their occurrence and productivity. These species are not considered indicators of the presence of other more common species, and the presence of common species is not required for restoration to be considered successful. This is because relatively common species are widely distributed throughout the Basin and are not considered at risk of substantial declines at this time. As such, an overall increase in species diversity will not mean that restoration is successful per se.

**Additional species to monitor**

Additional songbird species were added to the list of desired condition species based on Partners in Flight (PIF) assessment scores (Panjabi et al. 2005) because we feel that these species may be sensitive and the Forest Service may want to consider monitoring these species as well to improve conditions for these species. Although these species are not considered, desired

condition species, per se, research conducted outside of the Basin, suggest that these species may be at risk and their status should be monitored during restoration. We chose to include species based on PIF assessment scores because these species may be at risk within the Sierra Nevada and attention should be directed at improving conditions for these species in pro-active manner. Partners in flight categorizes priority species if meet 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) greater than 10% of the breeding population is in the Sierras. We also included songbird species identified by the Riparian Habitat Joint Venture (2004) identified potential at-risk California riparian species based on (1) the use of riparian vegetation during the breeding season, (2) species status (e. g., threatened), (3) the reduction in historical breeding range, (4) abundance of the species to allow for adequate sample sizes, and (5) species that represent all successional stages within riparian areas. Inclusion of these species into restoration monitoring plans is contingent on Forest Service decisions.

**Focal species**

While presence/absence information will be collected for all desired condition species (see Wildlife Monitoring section), more detailed data will be collected on a smaller suite of species. Additional data on productivity will be collected to determine if niche components for species are being met because abundance does not always correlate with habitat quality or reproductive success (Van Horne 1983). For example, regardless of appropriate vegetation structure, the presence of brown-headed cowbirds, a nest parasite, usually results in breeding failure of the songbird host (Robinson et al. 1995*a*). Therefore, it is important to monitor productivity to ensure that restoration actions are actually improving conditions for species and not creating ecological traps (Purcell and Verner 1998, Schlaepfer et al. 2002). We will monitor productivity for a small group of species we refer to as focal species. ***Focal species* in this document are defined as species that we monitor to acquire more precise demographic data.** Focal species are often used as surrogates for other species to allow us to make inference to the larger population of species that share similar life-history traits. For example, we will monitor productivity of Wilson's warblers, a ground-nesting passerine that shares similar nest-site characteristics with Lincoln's sparrows (*Melospiza lincolnii*). Data on productivity of Wilson's warblers can then be used to make inference on the success of Lincoln's sparrows or other ground-nesting passerines.

Since the commencement of monitoring in 2004, we selected six focal songbird species: willow flycatcher, dusky flycatcher (*Empidonax oberholseri*), warbling vireo (*Vireo gilvus*), yellow warbler (*Dendroica petechia*), MacGillivray's warbler (*Oporornis tolmiei*), and Wilson's warbler. We searched for and monitored the nests of these species to quantify productivity. We chose these focal species because (1) their nests are easily monitored (nests typically located < 5 m high), (2) they are a species of concern (e.g., willow flycatcher), or (3) are associated with riparian areas and montane meadows. Although willow flycatchers and yellow warblers are not abundant within the project sites, we choose to monitor productivity of these species because of their endangered species and species of special concern status.

## WILDLIFE MONITORING AND ADAPTIVE MANAGEMENT

Monitoring is an essential component of restoration projects (Manley et al. 2000, Lake 2001). Monitoring can be used to inform decisions related to the effect of the management actions as well as allow for adaptive management practices (Lake 2001, Morrison 2002). In the past, the National Forest Service was criticized for not monitoring the results of management actions as monitoring is a required component (SNFPA, Appendix E 2001; as adopted in SNFPA 2004). The SNFP requires that both implementation and cause-effect or effectiveness monitoring programs be established to determine whether objectives and goals of specific projects are being met. Implementation monitoring occurs immediately post-construction to assess if the project was implemented according to plan and in accordance with management direction and intent (i.e., standards and guidelines). Effectiveness monitoring generally utilizes before and after comparisons to assess the success of the restoration activities at meeting project objectives. Wildlife monitoring will be conducted to address the following implementation and effectiveness monitoring questions.

*Implementation Monitoring*

1. Was the project constructed according to design?

*Effectiveness Monitoring*

2. To what degree was the project successful in achieving project goals and objectives including improving riparian and meadow habitat, and enhancing wildlife community richness and health?

The focus of wildlife restoration monitoring falls under effectiveness monitoring. Effectiveness monitoring is defined as monitoring that determines "if plans, prescriptions, projects, and activities are effective in meeting management objectives, standards, and guidelines" (SNFPA 2004). In addition to effectiveness monitoring, monitoring should also address status and change of conditions following management activities within an adaptive management framework. Status and change monitoring is needed to determine if desired conditions are being achieved and can also provide early warning of unanticipated impacts of management activities. The adaptive management framework also allows for the identification of key research questions aimed at filling the gaps in our knowledge that may contribute to project success (SNFPA Appendix E 2001). Several questions were identified that relate to wildlife restoration projects including evaluating species-habitat relationships and determining the effectiveness of using certain species as indicators of environmental conditions. Some key questions that will be addressed that are directly related to the wildlife restoration and monitoring projects in the Lake Tahoe Basin include: (1) Does brown-headed cowbird abundance predict the risk of nest parasitism? (2) Does small mammal abundance predict the risk of nest predation? (3) What are the mechanisms that drive nest predation in songbirds? (4) Is floral diversity related to butterfly diversity and abundance? and (5) what are the habitat relationships of small cavity-nesting owl species? Answering these questions will provide information to improve the success of current and future restoration projects. We will address questions 1-5 above in Chapter IX.

**The importance of control sites**

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 or restored) 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 Morrison et al. 2001, 2008). 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 the conclusion that restoration actions were responsible for the trend or change observed (Fig 1.1). Comparing individual restoration sites to multiple controls is ideal because one can tease out the amount of variation that is inherent in environmental data. The use of multiple control sites over multiple years allows researchers to distinguish between natural temporal variability on the restored site compared to control sites (Block et al. 2001). "If the variation among controls in both space and time is less than the variation within the restored site, then it is deduced that the change detected in the restored site is greater than expected based on just natural variability and results from the effects of the restoration treatment (Block et al. 2001:298)."

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). We selected one control site per restoration project site that meets the above criteria because funds were not available to monitor additional control sites. If additional funds are made available, multiple control sites that consist of similar features could also be compared to the restoration project site to improve the ability to detect an effect of restoration.

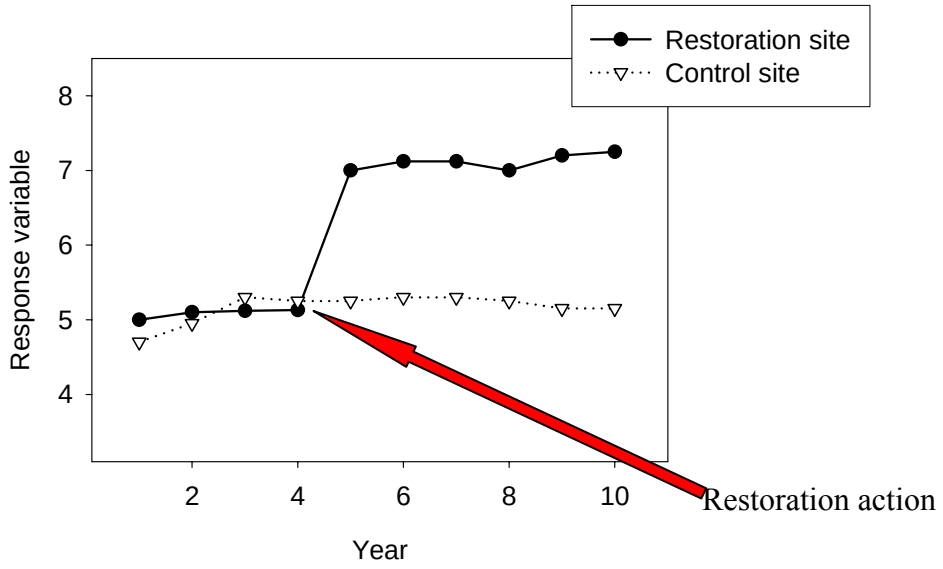


Figure 1.1. Conceptual figure showing levels of a response variable (e.g., abundance) at a restoration and control site three years pre-restoration and the increase in the response variable following restoration at the restoration site and not at the control site, suggesting that restoration actions caused an increase in the response variable.

**The importance of pre-restoration data**

Pre-restoration data are used to (1) determine the present status (i.e., existing condition) of wildlife metrics and desired condition species of interest (see Defining Metrics below) and (2) establish pre-restoration trends and associated variability of wildlife metrics at both restoration and control sites (see review in Morrison et al. 2001, 2008), and (3) determine if restoration activities have had the intended effect on wildlife metrics and desired condition species. For example, accurate assessments of changes in abundance recorded only following restoration activities tells us nothing about the magnitude of change or if a change even occurred from pre-restoration conditions. Thus having pre-restoration data is essential to determine if restoration activities have met project objectives and goals.

Pre-restoration data can also be used to estimate how much change would be expected in the metrics of interest following treatment. For example, if pre-restoration data locates a few individuals of a desired condition species, estimates can be made of the maximum increase (e.g., based on territory size) to be expected following treatments that are expected to positively impact the desired condition species. The primary advantage of pre-treatment data is, however, the matching of such data with comparable data from control sites. The comparison of treatment and control data is relative and thus allows conclusions to be made on treatment effects regardless of the inherent variability in the parameter of interest.

Pre-restoration data are also used to inform us about site potential. Pre-restoration monitoring tells us if desired species occur on the restoration sites and where desired species are located on the project site. This information can then be used to develop management prescriptions based on the conditions that are present where the species is located. Additionally, this information can be used to assess the potential of a specific location within a site to support the desired species. For example, pre-restoration data collection found that willow flycatchers are present along reach six at Blackwood Creek and restoration prescriptions are focusing on improving conditions in that area because this area has the greatest site potential (willow flycatchers occur there in low numbers, therefore it is expected that improving conditions in this area following restoration should increase the abundance of willow flycatchers in this area). Alternatively, restoration actions could focus on mimicking conditions found along reach six in other areas at Blackwood Creek. However, because reach six already supports limited numbers of willow flycatchers, improving conditions that will likely increase the number of pairs present will increase the likelihood of meeting restoration objectives. At other sites (e.g., Tallac Marsh) we documented the existence of large numbers of bullfrogs (*Rana catesbeiana*), indicating that efforts to enhance populations of western toads or reintroduce mountain yellow-legged frogs (*Rana muscosa*; a desired conditions species) at this site may be limited by bullfrogs or may not succeed, and other restoration alternatives should be investigated.

**How many years of pre-restoration data are needed to determine restoration success?**

The amount of data to be collected both pre- and post-treatment is specific to each study based on study goals. Although no specific guidelines are available for this study, a general consensus indicates; however, that two to three years of pre-treatment data are usually needed in studies of terrestrial animal species. For example, guidelines developed for quantifying the impact of wind-energy developments on birds and bats recommend a *minimum* of two years of pre-treatment data (Anderson et al. 1999, Kunz et al. 2007). The wind-energy guidelines recommend multiple years of data because of the variability in wild animal populations due to changes in environmental conditions (e.g., weather, food availability, competitors and predators,

and disease). Thus, collecting at least three years of pre-restoration data allow us to determine the annual variation in species abundance and richness for multiple wildlife species. Three years of pre-treatment data are also beneficial because multiple years of data aids in teasing out natural variability that can exist in all wildlife populations.

If only one or two years of pre-restoration data can be collected, we recommend that surveys be conducted for one or two years pre-restoration to improve the ability to accurately detect a response of the wildlife community to restoration. Three years are better than one year of pre-treatment data to account for natural variability in the system and improve one's chances of attributing changes seen to restoration actions, but one year of data is better than none. Without pre-restoration data, no impact assessment can be made and effectiveness monitoring cannot be completed.

Different species respond to changing environmental conditions in various ways, thus one must consider species-specific responses to environmental variation as well as life-history characteristics that influence temporal responses. In general, small mammal species are often subject to large-scale population fluctuations, thus sampling small mammals for more than two years during pre and post-restoration is recommended. Bird species typically show less annual variation in abundance than small mammals and could possibly be sampled less frequently, although we still recommend a minimum of three years pre-treatment data collection. Butterfly species are also sensitive to climatic shifts and generally exhibit population fluctuations. Therefore, we recommend that sampling for butterflies occur for a minimum of three years to account for natural variation in population size. Data collected in the Lake Tahoe Basin since 2004 illustrate the fluctuations of desired condition species and lend credence to the need for multi-year pre- and post-restoration monitoring.

## DEFINING METRICS

The goal of wildlife monitoring is to determine whether desired conditions are being achieved with respect to restoration wildlife objectives. To determine if this goal is being met, metrics need to be chosen to monitor the response of wildlife species to restoration activities. Four metrics were selected to monitor shared project objectives across restoration sites as well as provide additional natural history data on species habitat requirements necessary for adequately developing desired conditions and recommended management activities (Table 1.2). The four metrics are species: (1) richness, (2) abundance, (3) distribution, and (4) productivity. Although we can develop a list of species representative of the desired conditions, it is not possible to specify precise numerical targets for most species. Animal numbers vary across time based on a host of environmental factors; thus, only a range of abundance can be specified. Additionally, no rigorous data exist for the Lake Tahoe Basin that can be used to specify numerical targets. Orr and Moffitt (1971), for example, reported the status of birds in the Basin in qualitative categories, such as common or uncommon, and thus prevent estimations of target population sizes. Therefore, restoration success will be judged based on increases or decreases in specific metrics in relation to control sites (See Defining Restoration Success below for more details).

**Richness**

Species richness is determined by presence/absence data that can be collected by conducting point-count surveys for song birds, trapping small mammals, conducting sweep-net surveys for butterflies, and conducting acoustic sampling for bats. This type of data will be used to determine if species richness increases or decreases on the restoration sites compared to controls and pre-restoration levels. The species richness metric will be used to assess (1) butterfly richness and desired condition butterfly richness, (2) reptile and amphibian richness, (3) songbird and desired condition songbird richness, (4) desired condition bat richness, and (5) richness of desired condition small mammal species.

**Abundance**

Abundance is calculated as the number of individuals per species in a given area. Abundance estimates can be used to address if population sizes have changed as a result of restoration activities. Abundance data can also be used to examine trends in populations across years and can be used as an early indicator system. For example, if the abundance of a common species showed significant declines during pre-restoration monitoring, managers may want to investigate the potential causes for the species decline and add this species to the list of desired condition species. Abundance data can be collected by conducting point-count surveys for songbirds, trapping and marking small mammal species, and conducting butterfly surveys. We will collect abundance data for songbirds, small mammals, and butterfly. We are unable to collect abundance data for reptiles, amphibians, and bats.

**Distribution**

Distribution of the spatial location of species can be determined by marking the location of individuals detected with Global Positioning Systems (GPS) and mapping Universal Trans Mercator (UTM) coordinates on site maps. Distribution can also be assessed by examining where within a project site a species was detected based on spatially indentified survey areas. This information is useful for developing management recommendations as well as designing the restoration project. For example, if surveys indicate that the majority of willow flycatchers occur in the north section of the site, managers should (1) examine the conditions present in that area and try to replicate those conditions elsewhere on the site and (2) consider restoration activities for improving conditions where willow flycatchers already exist if necessary. Distribution data can be gathered from spatially reference point-count surveys for songbirds, small mammal trapping, reptile and amphibian surveys, and butterfly surveys. Determining distribution of bat species with current monitoring techniques is difficult because bats typically move over large distances and we do not have information on bat movements and territories. No specific restoration objectives are tied to distribution because sampling points are not independent units. Distribution data is being collected solely to determine where species are located within a site and to provide management recommendations based on location.

**Productivity**

Productivity (i.e., reproductive success) is often assessed for songbirds because reproductive sites (i.e., nests) are easy to locate and determine the number of young successfully produced. Productivity is defined as the number of young produced per female. More generally productivity is the ability of individuals to successfully reproduce and is typically displayed as average daily survival or daily nest survival. Daily nest survival is the probability of an

individual clutch surviving one day and is the preferred method for calculating reproductive success because estimates of daily survival account for the fact that successful nests are more likely to be found than nests that fail early in the season and hence provide less-biased estimates of nest success (Mayfield 1961). Determining average daily survival helps us address whether species are able to successfully reproduce. This is a critical component of monitoring data especially for songbirds because presence and abundance measurements do not always correlate with reproductive success (Van Horne 1983). For example, individuals may occur in large numbers at a site but may not be successfully reproducing. Thus this site is acting as a sink or ecological trap and without reproductive success data we would be unable to determine this. This information is vital for restoration success. In addition to quantifying reproductive success, monitoring nests also allows us to determine the rate of nest parasitism. Brood parasitism by brown-headed cowbirds reduces host breeding productivity because (1) brown-headed cowbirds often remove host eggs and (2) cowbird young typically hatch before and develop faster than host young, which often leads to increased provisioning by adult hosts at the expense of the host young (Robinson et al. 1995*a*). 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). For example, Wilson's warblers in parts of coastal California are experiencing high levels (33%) of parasitism and predation (73%) which, without immigration could result in local extirpation (Michaud et al. 2004). Thus, monitoring nest parasitism is important because nest parasitism by brown-headed cowbirds reduces host songbird reproductive success and can lead to population declines in some species. A threshold of 30% parasitism has been established as a threshold for this restoration project based on the previous studies listed above.

Table 1.2. Definition of monitoring metrics and survey methods used in relation to general questions these data can address for different suites of species.

| Metric | Definition | Question metric addresses | Survey methods and species groups |
|---|---|---|---|
| Richness | Defined as the number of species present for each animal group being monitored | Does species richness differ between control and treatment sites? | • Point-count surveys for songbirds<br>• Broadcast surveys for owls<br>• Small mammal trapping<br>• Butterfly sweep-net surveys<br>• Acoustic sampling for bat species |
| Distribution | Location of a species at observation points | What is the spatial distribution of a species pre- and post-restoration? | • Spatial location (UTMs) of species detected via point counts, broadcast surveys, trapping, or sweep-net surveys |
| Abundance | Number of individuals per species detected or observed | How many individuals of a particular species are present at a site? | • Point-count surveys for songbirds<br>• Small mammal trapping<br>• Butterfly sweep-net surveys |
| Productivity | Successfully produce offspring measured as daily nest survival | Are individuals successfully reproducing? | • Nest searching and monitoring songbirds |

## SPECIES ASSEMBLAGES TO MONITOR

### Butterflies

Butterflies are sensitive to small-scale changes in their environment and have the potential to respond rapidly to environmental change (Kremen et al. 1993, Fleishman et al. 2005). Butterflies are also excellent species to monitor because they inhabit a diverse array of niches (Kremen et al. 1993), allowing us to determine the effect of restoration across multiple niche spaces. Therefore, we chose to monitor the effects of restoration actions using butterfly species. We also selected butterflies because many of these species occur in wet meadow and riparian communities and rely on willows and forbs present in wet meadow communities.

### Reptiles and amphibians

We chose to monitor reptiles and amphibians because this group of species relies on wet meadow or aquatic communities for part or all of their life-cycle. Given that restoration actions aim to improve wet meadow conditions, we concluded that monitoring reptiles and amphibians would be appropriate.

**Songbirds**

We chose to monitor the response of songbirds to restoration using species richness and abundance metrics because songbirds (1) can serve as indicator species (O'Connell et al. 2000), (2) are easily monitored with simple methods (Hutto 1998), and (3) studies have shown that birds are sensitive to landscape-scale disturbances (Robinson et al. 1995*b*). We choose six focal species to monitor reproductive success; willow flycatcher, dusky flycatcher, warbling vireo, yellow warbler, MacGillivray's warbler, and Wilson's warbler to quantify nest success and brown-headed cowbird parasitism.

**Owls**

Multi-species broadcast surveys for owls have been conducted periodically in the Basin, although the surveys covered relatively small areas (Manley et al. 2002, Roth et al. 2004, P. Manley, personal communication). Moreover, ongoing California spotted owl surveys (Hodge and Romsos, 2000) provide limited information on other owl species in the area. Thus, due to the relative paucity of information on all owl species in the Basin, we chose to conduct multi-species broadcast surveys to add to the overall list of avian species (i.e., quantify species richness). As some restoration projects include alteration of upland areas, we also chose to examine the relationship between small, cavity-nesting owls and certain surrounding habitat variables (e.g., snag characteristics).

**Small mammals**

Small mammal species are sensitive to forest disturbances (e.g, logging) (Waters and Zabel 1998) and occupy a variety of niches, thus monitoring this group of species may indicate changes in the environment (Steele et al. 1984). Furthermore, because many small mammal species in the Basin have shown recent declines (See list of desired small mammal species in Appendix 1.5), we wanted to incorporate this group into monitoring efforts with the hope of improving conditions via wet meadow and riparian restoration to increase species richness and abundance. Given that small mammals are potential nest predators of songbird nests, monitoring small mammals may also provide information regarding their influences on reproductive success of songbirds (Angelstam 1986, Rodewald and Yahner 2001).

**Bats**

Bats represent a relatively large portion of mammal species found in the Basin. Their diverse foraging and roosting requirements, plus the relative ease of acoustic sampling, made them good candidates for monitoring (Medellín et al. 2000). Bats detected during sampling add to the overall small mammal species richness and provide us information on their distribution in the Basin. Furthermore, 3 species are listed as federal species of special concern (long-eared myotis, fringed myotis, and Yuma myotis) (Manley et al. 2000) and an additional 2 species are listed as state species of special concern (Townsend's big-eared bat and spotted bat) (Williams 1986).

## DEFINING RESTORATION SUCCESS

The success of restoration can be measured by a host of interrelated factors that relate to the desired ecological functions and specific conditions. The success of wildlife restoration in the Basin will be determined by monitoring the status and trends via effectiveness monitoring in wildlife assemblages thought to be typical of the desired ecological condition. We will also assess reproductive success for six focal bird species at restoration sites where this is a project objective. Restoration success will be determined by comparing the magnitude of change of the four metrics outlined above between control and treatment sites. We have not established specific effect sizes or changes in species abundance that we expect to see following restoration because we do not know what the population size was historically at these sites prior to degradation (Block et al. 2001).

## TARGETS FOR POPULATION PERFORMANCE

### Target establishment

Establishing targets for the distribution (presence/absence), abundance, and reproductive performance of species within the Basin is complex given the diversity of natural history traits, difference between historic and current distribution, and desired future condition of species and vegetation communities. Additionally, the attainment of a desired condition for a species is often dependent on successful implementation of management activities, including habitat restoration, control of exotic species, and removal of human disturbance. Finally, there is little quantitative data available on the distribution, and especially the abundance, of most species in the Basin, rendering establishment of a target population level problematic. We made the assumption that the current population abundance in appropriate habitats (throughout the Basin) approximates that in similar habitats historically and can be extrapolated to the desired future condition (planned) for habitat in the Basin (e.g., following restoration).

### Desired condition species targets

The following targets will indicate that the desired condition for a species *are being met*. If values do not meet established targets this will trigger development of additional evaluation and management actions (see Triggers section below).

1. Species richness:
   a. Less than two individuals present on the site throughout the breeding season (e.g., a breeding resident is present throughout the breeding season)
2. Abundance:
   a. A decreasing abundance index for all species listed as desired condition species (or increasing for species desired to be reduced in abundance [e.g., brown-headed cowbird]).
3. Reproductive performance of songbirds:
   a. Nest success <30% (indicative of a population in decline because of local conditions)
   b. Cowbird parasitism: >30% cowbird parasitism in any monitored species (indicative of potential population problems caused by parasitism)

**Triggers**

Failure to attain targets will trigger modification of the structure and vegetation conditions as indicated for the desired condition species that have not begun to occupy the project site. The following actions will be initiated, depending on which targets are not met or if the trigger point is reached without target attainment.

1. Attain or increase beyond the target indicated by the vegetation or habitat structure (e.g., area of wet meadow and density of willows).
2. High parasitism frequency could trigger initiation of cowbird control. Such a treatment would only be initiated if a viable population of a desired species could be maintained.
3. High predation rates of meadow-nesting songbirds could initiate predator control and/or additional habitat modifications (e.g., additional water barriers).
4. Actively manage (i.e., reduce or eliminate) human activities in and around meadows, at least during the breeding season by enhancing methods of restricting human access (e.g., fencing, additional signage).
5. Evaluate the potential for actively introducing desired condition species to the project area.

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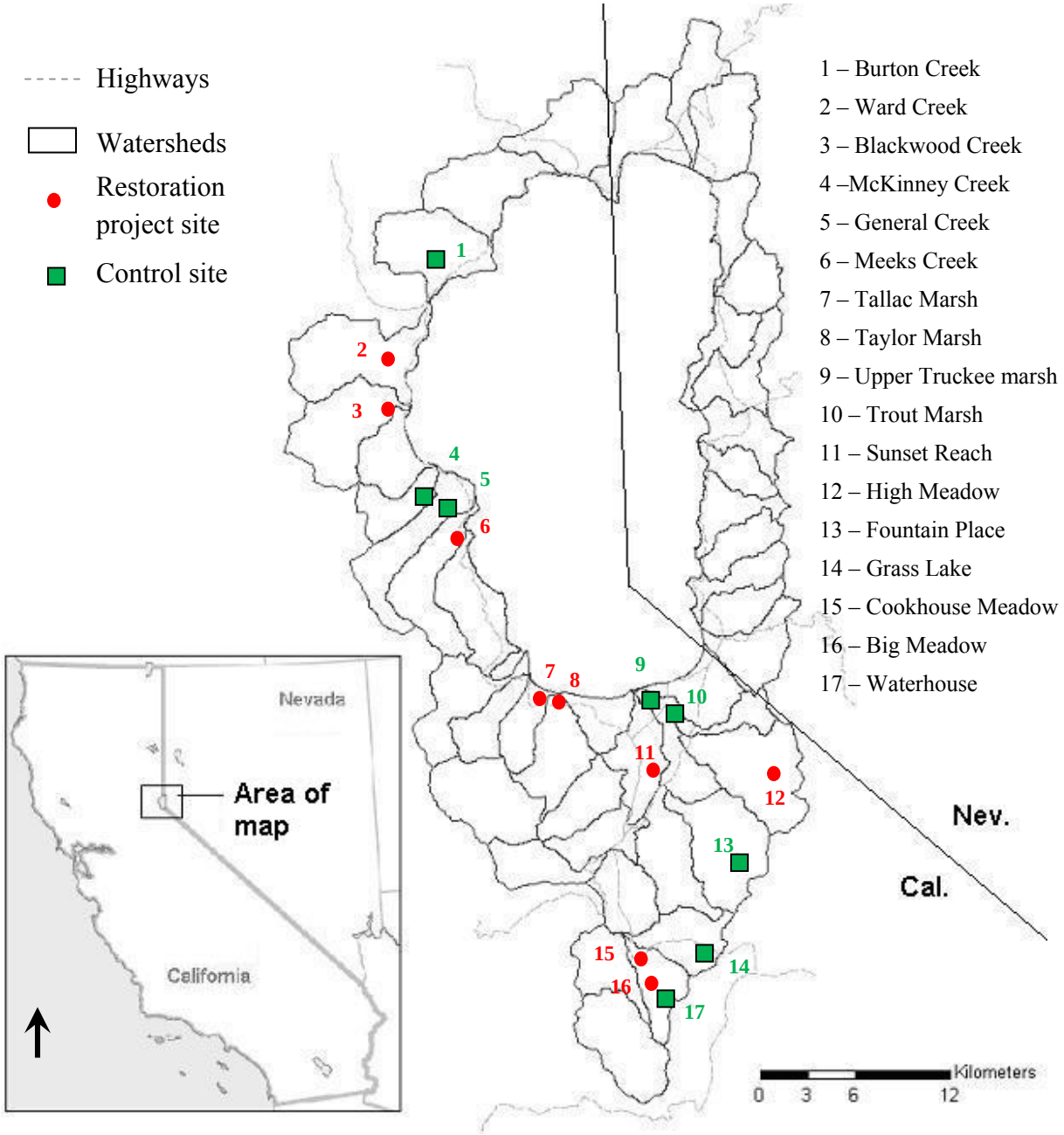
Appendix 1.1. Approximate locations of restoration project sites and control sites within the Lake Tahoe Basin, California.



Appendix 1.2. Reptile and amphibian representative of desired ecological conditions and potentially beneficial restoration activities based on habitat preferences. Up arrows suggest that restoration could focus on increasing or creating specified condition and down arrows suggest that restoration could focus on decreasing specified condition.

| Species | Desired condition species[1] | MIS[2] | Community | Potentially beneficial restoration activities[3] | Notes |
|---|---|---|---|---|---|
| Long-toed salamander (*Ambystoma macrodactylum*) | X | | Forest<br>Riparian<br>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 | | Riparian<br>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).<br>Potentially vulnerable terrestrial vertebrate (Manley et al. 2000). |
| Pacific treefrog (*Hyla regilla*) | X | | Forest<br>Riparian<br>Meadow | ↓ non-native trout, ↓ bullfrogs, ↑ shallow-water pools | Species with known population declines (Manley et al. 2000).<br>Potentially vulnerable terrestrial vertebrate (Manley et al. 2000). |
| Gilbert skink (*Eumeces gilberti*) | X | | Forest<br>Riparian<br>Meadow | ↑ downed-woody debris near riparian areas | |
| W. terrestrial garter snake (*Thamnophis elegans*) | X | X | Forest<br>Riparian<br>Meadow | ↓ non-native trout, ↑ downed-woody debris,<br>↑ marsh/wetland vegetation | Species with known population declines (Manley et al. 2000) |

Appendix 1.2 (Cont.)

| Species | Desired condition species[1] | MIS[2] | Community | Potentially beneficial restoration activities[3] | Notes |
|---|---|---|---|---|---|
| W. aquatic garter snake (*Thamnophis couchii*) | X | X | Meadow | ↑ number of shallow pools and wetland vegetation | Potentially vulnerable terrestrial vertebrate (Manley et al. 2000) |
| Common garter snake (*Thamnophis sirtalis*) | X | | Forest<br>Riparian Meadow | ↑ number of shallow pools and wetland vegetation | |

[1]Desired condition species are species that should be present following restoration data based on historic and current data.
[2]USDA Forest Service Management Indicator Species (MIS) identified in the Sierra Nevada Forest Plan Amendment – Final Supplemental Environmental Impact Statement.
[3]Sources:
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Appendix 1.3. Mammal species representative of desired conditions and USDA Forest Service Management Indicator Species (MIS) and potentially beneficial restoration activities based on habitat preferences. Up arrows suggest that restoration could focus on increasing or creating specified condition and down arrows suggest that restoration could focus on decreasing specified condition.

| Species | Desired condition species[1] | MIS[2] | Community | Potentially beneficial restoration activities[3] | 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 | | 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 | Riparian Meadow | ↑ old-growth conditions, ↑ ground litter and ground cover | |
| Broad-footed mole (*Scapanus latimanus*) | X | | Forest Riparian Meadow | ↑ moisture level in soils, ↑ duration of moist soil conditions | Potentially vulnerable terrestrial vertebrate (Manley et al. 2000) |
| Long-tailed weasel (*Mustela frenata*) | X | | Forest Riparian Meadow | ↑ areas with standing water, ↑ understory shrub density | |
| Belding's ground squirrel (*Spermophilus beldingi*) | X | | Meadow | ↑ proportion of succulent vegetation, ↑ areas with standing water, create meadow-like openings | Potentially vulnerable terrestrial vertebrate (Manley et al. 2000) |

Appendix 1.3 (Cont.)

| Species | Desired condition species[1] | MIS[2] | Community | Potentially beneficial restoration activities[3] | Notes |
|---|---|---|---|---|---|
| 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 | | Forest Riparian Meadow | ↑ pine, ↓ coyotes | |
| Coyote (*Canis latrans*) | X | | Forest Riparian Meadow | ↑ early successional vegetation | |
| Mule deer (*Odocoileus hemionus*) | X | X | Forest Riparian Meadow | ↑ availability of succulent forage, ↑ early successional vegetation | |

[1]Desired condition species are species that should be present following restoration data based on historic and current data.
[2]USDA Forest Service Management Indicator Species (MIS) identified in the Sierra Nevada Forest Plan Amendment – Final Supplemental Environmental Impact Statement.
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Appendix 1.4. 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), in the Sierra Nevada. 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]** | **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 | ↑ semipermanent wetlands (>4 ha) with emergent grasses and sedges |
| Common Merganser (*Mergus merganser*) | X | | | | | Meadow Marsh | Provide nest boxes, ↑ snags near lakes and rivers bordered by forest |
| Wilson's Phalarope (*Phalaropus tricolor*) | X | | | | | Marsh | ↑ shallow water wetlands with emergent vegetation |
| Osprey (*Pandion haliaetus*) | X | | | | | Marsh | ↑ tall and isolated nesting platforms in close proximity (10-20 km) to shallow waters with abundant fish |

Appendix 1.4 (Cont.)

| Species | Desired condition species[1] | PIF[2] | RHJV[3] | MIS[4] | SAR[5] | Community[6] | Potentially beneficial restoration activities[7] |
|---|---|---|---|---|---|---|---|
| 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 |
| Northern Goshawk (*Accipter gentilis*) | X | | | | | Forest | ↑ mature forest trees, ↓ disturbance during the breeding season |
| Blue Grouse (*Dendragapus obscurus*) | X | | | X | | Forest | ↑ proportion of early successional vegetation, ↑ aspen regeneration, ↓ OHV use in areas with Blue Grouse |
| Mountain Quail (*Oreortyx pictus*) | | | | X | | Forest | ↑ shrubby vegetation |
| Sora (*Porzana carolina*) | X | | | | | Marsh | ↑ shallow water wetlands with emergent vegetation |
| Spotted Sandpiper (*Actitis macularia*) | X | | X | | | Meadow | ↓ stream incision, ↑ gravel bars and sinuosity |
| Wilson's Snipe (*Gallinago gallinago*) | X | | | | | Marsh Meadow | ↑ wet willow/alder thickets, ↑ duration of wet conditions, ↓ activities that compact soil |
| Forester's Tern (*Sterna forsteri*) | X | | | | | Marsh | ↑ deep water wetlands with open waters |
| Calliope Hummingbird (*Stellula calliope*) | X | | | X | | 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 |

Appendix 1.4 (Cont.)

| Species | Desired condition species[1] | PIF[2] | RHJV[3] | MIS[4] | SAR[5] | Community[6] | Potentially beneficial restoration activities[7] |
|---|---|---|---|---|---|---|---|
| Red-breasted Sapsucker (*Sphyrapicus ruber*) | X | | | X | | Riparian | ↑ snags (112 snags/100 ha to support 28 pairs) |
| Williamson's Sapsucker (*Sphyrapicus thyroideus*) | X | | | X | | Riparian | ↑ aspen regeneration, ↑ snags in groups |
| Hairy Woodpecker (*Picoides villosus*) | | | | X | | Forest | ↑ snags |
| Downy Woodpecker (*Picoides pubescens*) | | | | X | | Forest | ↑ snags |
| White-headed Woodpecker (*Picoides albolarvatus*) | X | X | | X | | Forest | ↑ snags, ↑ areas with 50-50% open canopy with sparse understory in coniferous forests |
| Northern Flicker (*Colaptes auratus*) | | X | | X | | Forest | ↑ snags (93 snags/100 ha), ↑ aspen regeneration, ↑ cottonwood density along creeks |
| Pileated Woodpecker (*Dryocopus pileatus*) | | | | X | | Forest | ↑ snags, ↑ old-growth conditions, ↑ canopy closure >60% |
| Olive-sided Flycatcher (*Contopus cooperi*) | | X | | | | Forest | ↑ proportion of late successional forests with <50% canopy cover, ↑ snags, ↑ use of prescribed fire |
| Western Wood-Pewee (*Contopus sordidulus*) | | X | | | | Forest | ↓ densely vegetated understories, ↑ standing dead trees, ↑ habitat type transition zones |
| Willow Flycatcher (*Empidonax traillii*) | X | X | X | | | Meadow | ↑ willow, ↓ parasitism risk, ↑ meadow wetness |
| Hammond's Flycatcher (*Empidonax hammondii*) | | | | X | | Forest | ↑old-growth conditions, dense fir and aspen |

Appendix 1.4 (Cont.)

| Species | Desired condition species[1] | PIF[2] | RHJV[3] | MIS[4] | SAR[5] | Community[6] | Potentially beneficial restoration activities[7] |
|---|---|---|---|---|---|---|---|
| Warbling Vireo (*Vireo gilvus*) | | | X | | | Meadow Riparian | ↓ parasitism risk, ↑ deciduous component |
| Violet-green Swallow (*Tachycineta thalassina*) | | X | X | X | | Meadow Riparian | ↓ tree density, ↑ snags |
| Bank Swallow (*Riparia riparia*) | | | X | | | Meadow Riparian | ↑ streams with low gradient meanders and eroding banks for nesting substrate |
| Mountain Chickadee (*Poecile gambeli*) | | X | | | | Forest | ↑ aspen, ↑ snags, maintain incense cedar for wintering forage, ↑ conifer diversity |
| White-breasted Nuthatch (*Sitta carolinensis*) | | | | X | | Forest | ↑ snags 30-38 cm dbh, ↑ mature forest with diverse conifer species |
| Red-breasted Nuthatch (*Sitta canadensis*) | | X | | X | | Forest | ↑ snags with existing cavities, ↑ mature deciduous forest |
| Pygmy Nuthatch (*Sitta pygmaea*) | X | | | | | Forest | ↓ stand density in Jeffery pine forests, ↑ snags, ↓ forest disturbances, ↑ heterogeneous mix of well-spaced pines of various ages |
| Brown Creeper (*Certhia americana*) | | X | | X | | Forest | ↑ proportion of old-growth forest conditions, ↑ snags (>40 cm dhb), preserve large trees (>100 cm dhb), |
| House Wren (*Troglodytes aedon*) | X | | | X | | Forest Riparian | Provide nest boxes, ↑ deciduous component along streams |
| Golden-crowned Kinglet (*Regulus strapa*) | | X | | | | Forest | ↓ logging, ↑ old-growth forest conditions |
| American Dipper (*Cinclus mexicanus*) | X | | | | | Meadow Riparian | Create streams with rocky bottoms, ↑ water clarity, create riffles in streams, ↓ pollution |

Appendix 1.4 (Cont.)

| Species | Desired condition species[1] | PIF[2] | RHJV[3] | MIS[4] | SAR[5] | Community[6] | Potentially beneficial restoration activities[7] |
|---|---|---|---|---|---|---|---|
| Swainson's Thrush (*Catharus ustulatus*) | X | | X | | X | Meadow Riparian | ↑ ground and shrub cover along streams, ↑ meadow wetness, ↑ aspen regeneration, ↑ forest tree density and canopy closure |
| Mountain Bluebird (*Sialia currucoides*) | X | | | X | | Meadow Riparian | ↑ snags >38 cm dbh |
| Orange-crowned Warbler (*Vermivora celata*) | | X | | | | Meadow | ↑ ground and shrub cover along streamsides |
| Yellow Warbler (*Dendroica petechia*) | X | X | X | X | | Meadow | ↑ willow, ↓ parasitism risk, ↑ meadow wetness |
| Hermit Warbler (*Dendroica occidentalis*) | X | X | | | | Forest | ↑ old-growth conditions with high canopy volume |
| Wilson's Warbler (*Wilsonia pusilla*) | | X | X | X | | Meadow Riparian | ↑ ground and shrub cover |
| Western Tanager (*Piranga ludoviciana*) | | X | | | | Forest | ↑ aspen regeneration, ↑ deciduous component along streams, create habitat type transition zones |
| Chipping Sparrow (*Spizella passerina*) | | X | | | | Forest | Provide open grassy areas in conifer forests, ↑ early succession community |
| Song Sparrow (*Melospiza melodia*) | | | X | X | | Meadow Riparian | ↑ meadow wetness and duration, ↑ willow and shrub component |
| White-crowned Sparrow (*Zonotrichia leucophrys*) | | | | X | X | Meadow | ↑ patches of open grassy meadow, ↑ density of shrubs |
| Lincoln's Sparrow (*Melospiza lincolnii*) | X | | | X | | Meadow Riparian | ↑ meadow wetness and duration, ↑ density of willow and shrub component, |
| Fox Sparrow (*Passerella iliaca*) | | | | X | | | Prefers shrubby component |

Appendix 1.4 (Cont.)

| Species | Desired condition species[1] | PIF[2] | RHJV[3] | MIS[4] | SAR[5] | Community[6] | Potentially beneficial restoration activities[7] |
|---|---|---|---|---|---|---|---|
| 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 | | | | Meadow Marsh | ↑ open areas with suitable perches |
| Cassin's Finch (*Carpodacus cassinii*) | | X | | X | | Forest | ↓ tree density in coniferous forests |
| Evening Grosbeak (*Coccothraustes vespertinus*) | | X | | | | Forest | ↓ mixed conifer density to provide more open canopy |

[1]Desired condition species are species that should be present following restoration data based on historic and current data.

[2]Based on Partners in Flight assessment scores (PIF 2005). Species selected as priority species if they met any of the following criteria, (1) in need of management attention to reduce long-term population declines, (2) severe deterioration in the future of breeding conditions is expected due to vulnerability to human activities, habitat fragmentation or loss, or high levels of nest depredation or parasitism, (3) population trend exhibits a >15% decline, (4) regional stewardship is required to maintain or improve population, or (5) percent of the breeding population is >10% in the Sierras.

[3] Focal riparian area species selection based on (1) the use of riparian vegetation during the breeding season, (2) species status (e. g., threatened), the reduction in historical breeding range, (3) abundance of the species to allow for adequate sample sizes, and (4) species that represent all successional stages within riparian areas (Riparian Habitat Joint Venture 2004).

[4]USDA Forest Service Management Indicator Species (MIS) identified in the Sierra Nevada Forest Plan Amendment – Final Supplemental Environmental Impact Statement.

[5]USDA Forest Service Species At Risk (SAR) identified in the Sierra Nevada Forest Plan Amendment FEIS Appendix E.

[6]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 1.5. Desired condition butterfly species and potentially beneficial restoration activities based on habitat preferences. Up arrows suggest that restoration could focus on increasing the abundance of host plants. Species were selected based those that have specific host-plant preferences and are generally restricted to wet meadow and riparian communities.

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

Appendix 1.5 (Cont.)

[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 1.6. Planning phase for restoration project sites as of December 2007. Indicates the year each phase was completed or when each phase will be initiated.

| Site | Control site | Phase | | | | | |
|---|---|---|---|---|---|---|---|
| | | Pre-restoration monitoring[1] | Desired condition development | Goals and management development | Monitoring plan development | Implementation | Post-restoration monitoring |
| Big Meadow | Waterhouse[2] & Grass Lake | 4-years complete | 2008 | 2008 | 2008 | 2009 | 2010 |
| Blackwood | McKinney | 3-years complete | 2008 | 2008 | 2008 | 2008 | 2009 |
| Cookhouse | Big Meadow & Grass Lake | 3-years complete | 2006 | 2006 | 2007 | 2006 | 1-year complete |
| High Meadow | Fountain Plaice | 2-years complete | 2007 | 2007 | 2008 | 2008 | 2009 |
| Meeks Creek | General Creek | 3-years complete | 2007 | 2008 | 2008 | 2010 | 2011 |
| Sunset Reach | Trout Marsh | 1-year complete | 2008 | 2008 | 2009 | 2009 | 2010 |
| Taylor/Tallac | Upper Truckee Marsh | 2-years complete | - | - | - | - | - |
| Ward Creek | Burton Creek | 2-years complete | - | - | - | - | - |

[1]For details on which metrics and species groups were surveyed in each year at each site please see Appendix 1.7
[2]No pre-restoration control data exist for Waterhouse Meadow.

Appendix 1.7. Wildlife surveys conducted at restoration and control sites in Lake Tahoe Basin, CA, 2004–2007. Continued on next page.

| | **Butterfly** | | | | **Herptofauna** | | | | **Songbird Count** | | | | **Songbird Nest** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004 | 2005 | 2006 | 2007 | 2004 | 2005 | 2006 | 2007 | 2004 | 2005 | 2006 | 2007 | 2004 | 2005 | 2006 | 2007 |
| Big Meadow | Y | Y | Y | Y | Y | Y | Y | | Y | Y | Y | Y | Y | Y | Y | Y |
| Burton Creek | Y | | Y | | Y | | Y | | Y | | Y | | Y | Y | Y | |
| Blackwood Creek | Y | | Y | Y | Y | | Y | | Y | | Y | Y | Y | Y | Y | Y |
| Cookhouse Meadow | Y | Y | Y | Y | Y | Y | Y | | Y | Y | Y | Y | Y | Y | Y | Y |
| Fountain Place | | | Y | Y | | | Y | | | | Y | Y | | | Y | Y |
| General Creek | Y | | Y | | Y | | Y | | Y | Y | Y | Y | Y | | Y | Y |
| Grass Lake | Y | Y | Y | Y | Y | Y | Y | | Y | Y | Y | Y | Y | Y | Y | Y |
| High Meadow | | | Y | Y | | | Y | | | | Y | Y | | | Y | Y |
| McKinney Creek | Y | | Y | Y | Y | | Y | | Y | | Y | Y | Y | | Y | Y |
| Meeks Creek | Y | | Y | | Y | | Y | | Y | Y | Y | Y | Y | | Y | Y |
| Sunset Reach[1] | | | Y | | | | Y | | | | Y | Y | | | Y | |
| Taylor Marsh | Y | | Y | | Y | | Y | | Y | | Y | | Y | | Y | |
| Tallac Marsh | Y | | Y | | Y | | Y | | Y | | Y | | Y | Y | Y | |
| Trout Marsh[2] | | | Y | | | | Y | | | | Y | Y | | | Y | |
| Upper Truckee Marsh[3] | Y | | Y | | Y | | Y | | Y | | Y | Y | Y | | Y | |
| Ward Creek | Y | | Y | | Y | | Y | | Y | | Y | | Y | Y | Y | |

Appendix 1.7 (Cont.). Wildlife surveys conducted at restoration and control sites in Lake Tahoe Basin, CA, 2004–2007.

| | **Owl** | | | | **Bat** | | | | **Small Mammal** | | | | **Track Plate Survey** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004 | 2005 | 2006 | 2007 | 2004 | 2005 | 2006 | 2007 | 2004 | 2005 | 2006 | 2007 | 2004 | 2005 | 2006 | 2007 |
| Big Meadow | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | |
| Burton Creek | Y | | Y | | Y | | Y | | Y | | Y | | | | | |
| Blackwood Creek | Y | | Y | Y | Y | | Y | Y | Y | | Y | Y | | | Y | |
| Cookhouse Meadow | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | |
| Fountain Place | | | Y | Y | | | Y | Y | | | Y | Y | | | Y | |
| General Creek | Y | | Y | Y | Y | | Y | Y | Y | | Y | Y | Y | | Y | |
| Grass Lake | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | |
| High Meadow | | | Y | Y | | | Y | Y | | | Y | Y | | | Y | |
| McKinney Creek | Y | | Y | Y | Y | | Y | Y | Y | | Y | Y | | | Y | |
| Meeks Creek | Y | | Y | Y | Y | | Y | Y | Y | | Y | Y | Y | | Y | |
| Sunset Reach[1] | | | Y | | | | Y | | | | Y | | | | Y | |
| Taylor Marsh | Y | | Y | | Y | | Y | | Y | | Y | | Y | | Y | |
| Tallac Marsh | Y | | Y | | Y | | Y | | Y | | Y | | Y | | Y | |
| Trout Marsh[2] | | | Y | | | | Y | | | | Y | | | | Y | |
| Upper Truckee Marsh[3] | Y | | Y | | Y | | Y | | Y | | Y | | Y | | Y | |
| Ward Creek | Y | | Y | | Y | | Y | | Y | | Y | | | | | |

[1] Previously referred to as Upper Truckee Marsh

[2] Previously referred to as Truckee-Trout Marsh

[3] Previously referred to as Truckee Marsh