

# **Multiple-Species Inventory and Monitoring 2002 Monitoring Report**

**Lake Tahoe Basin Management Unit**

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# MANAGEMENT SUMMARY

## Project Description and Objectives

The Multiple Species Inventory and Monitoring (MSIM) protocol was conceived as part of the Sierra Nevada Framework Project as a means of monitoring the large number of species of concern throughout the Sierra Nevada in an effective and cost efficient manner. The MSIM protocol consists of a feasible number of standardized, commonly employed, non-lethal survey techniques for each class of vertebrates that detect the presence of a diversity of taxa at each monitoring site. The MSIM protocol is an efficient way to meet legal requirements to monitor vertebrate Management Indicator Species (MIS) and species of concern. In short, multi-species monitoring is designed to (1) provide data on the status and change of many species within the basin, including many species of concern, (2) provide a means to assess the status and change in species diversity in the basin (i.e., trend monitoring), (3) help to determine whether there are 'focal species' in a system that have indicator or umbrella function, and (4) be useful in developing multi-scale habitat models as a basis of assessing the status and change of habitat conditions. The characterization of habitat conditions where populations are sampled is also a component of the protocol.

The MSIM project was designed to meet the following specific objectives:

- 1) Support Land Management Plan revision. This monitoring effort will provide data on:
  - a. Status of populations and habitat
  - b. Habitat relationships
  - c. Identification and evaluation of indicators
  - d. How to design and implement LRMP MIS monitoring
- 2) Contribute information to threshold standard revision by coordinating development and revision of USFS LMRP with associated TRPA regional plan. The MSIM data will provide a valuable source of information to evaluate the value of current threshold standards for terrestrial and aquatic vertebrate (non-fish) and plant species and communities.
- 3) Contribute to Adaptive Management in the Lake Tahoe basin, by generating results and information from the survey effort that enter the feedback loop into management decision making and direction.
- 4) Contribute to Regional and National Direction. The MSIM protocol was developed as part of the Sierra Nevada Framework Adaptive Management Strategy. The MSIM protocol was identified by the Regional Leadership Team as a high priority for funding, but is not yet being implemented throughout the Sierra Nevada. Thus, the LTBMU is paving the way for successful implementation on other Forests in the Sierra Nevada and potentially elsewhere in the Region and other Regions.

## **Contribution of 2002 Effort to MSIM Project**

The 2002 MSIM survey effort, and associated results and summaries reported here, have contributed approximately 30% to completion of the MSIM core sample. Forty of the 100 terrestrial sample sites were surveyed using 9 standardized survey protocols, and 46 aquatic sites were surveyed using 3 standardized protocols. Preliminary analyses were completed targeting Objective #1 (Support Land Management Plan revision) and partially satisfying Objectives #2-4. In regard to Objective #1, we used data collected during 2002 to characterize the current status/distributions of populations and habitats within LTBMU, to refine protocol design, based on analyses of protocol efficiencies, and for directing future implementation of MSIM at the forest-wide scale.

In 2004, we have begun to utilize the 2002 and 2004 MSIM datasets in combination with other basin-wide datasets of biological resources to identify and evaluate indicators of biological integrity and habitat condition. However, this analysis will not be complete until the complete MSIM dataset of 100 points has been acquired in 2005. Preliminary indicators/focal species list should be available in early to mid 2005. Starting December 2004 we will also begin development of species-habitat modeling approaches and upon generation of candidate indicators or focal species, will use the 2002/2004 dataset for generating such models. Finally, during 2005 we will utilize the complete MSIM dataset (100pts surveyed during 2002-2005) in order to evaluate how best to design LRMP focal species population trend monitoring at the forest wide scale in the future.

Objective 2 (Contribute to threshold standard revision) will be further addressed when the 2002 and 2004 efforts are combined and integrated into Pathway 2007 and the TRPA regional plan revision process. This is intended to occur intensively throughout FY05 and perhaps at reduce levels thereafter.

Objective 3 (Contribute to Adaptive Management) will also be addressed when the 2002 and 2004 MSIM datasets (and again with the completed dataset in fall 2005) are combined and analyzed to evaluate species population trend monitoring design. Recommendations for the most efficient monitoring design for LTBMU will then be incorporated into the Adaptive Management Strategy portion of the revised Forest Plan during Pathway 2007. Preliminary results on trend monitoring design will be available in February/March 2005.

Objective 4 (Contribute to Regional and National direction) was partially met during 2002 with successful implementation of the first survey effort associated with the MSIM protocol across all of Region 5. The MSIM protocol was originally developed as part of the Regional SNFPA Adaptive Management Strategy, and pilot implementation of MSIM on the LTBMU during 2002 was the first step toward demonstrating the benefits of this protocol to region wide population monitoring. Additionally, results from the 2002 effort (protocol logistics, efficiencies and cost estimates) were incorporated into a National Technical Guide for the MSIM protocol intended for use as a guide to species population trend monitoring across the nation at the ecoregional scale. Finally the MSIM project, as implemented on the LTBMU during 2002 and 2004, is already serving as a model to Region 3 as they are planning future implementation of MSIM.

## 2002 Sampling Design and Methodologies

The LTMBU monitoring program during 2002 was two part: (1) establish a network of 100 terrestrial monitoring points throughout the Lake Tahoe basin, and then sample 40 of those points; and (2) resample approximately half ( $n = 46$ ) of an existing set of 88 lentic habitat units that were sampled in 1997-98. Sampling design at terrestrial monitoring points was intended to be most efficient for long-term population trend monitoring and intended to survey 40 points each year for a total of 3 consecutive years, with each year contributing towards a 10% annual re-sample ( $n = 10$  points re-sampled each year after the first). In 2002, a total of 9 standardized protocols were conducted across the 40 terrestrial monitoring points during 2002 (7 vertebrate protocols, 1 botany and 1 habitat survey protocol), 4 of which were conducted at all 40 points, and 5 of which were conducted at a systematic subset of points (Appendix A). A total of 3 survey protocols (aquatic herpetofauna perimeter surveys, aquatic bird surveys and habitat) were conducted at the 46 aquatic monitoring sites. Per point cost estimates were generated for each survey protocol. These costs represent maximum costs given that they include costs of all personnel (including oversight), office space, housing, and rental of all vehicles.

### 2002 Preliminary Results by Protocol

#### *Point Counts*

##### Current status of populations and habitat

- Ninety-eight bird species (44% of all species expected to occur in the basin) were detected at the 40 monitoring points, with an average of 31.8 species detected per point and 10.3 species per count.
- A total of 12 MIS, Forest Service Sensitive, TRPA special interest species and California species of special concern were detected: Blue Grouse, Mallard, Pileated Woodpecker, Northern Goshawk, Common Merganser, Canada Goose, American Coot, Osprey, Ruddy Duck, Yellow Warbler, Sharp-shinned Hawk and Cooper's Hawk.
- Savannah Sparrow (*Passerculus sandwichensis*), thought to be extirpated from the Lake Tahoe Basin (Murphy and Knopp 2000), was detected during this survey effort, and during additional survey efforts during 2001 and 2003.
- The median observed point occupancy for detected bird species was 20%.
- The median observed probability of detection for all bird species was 0.3.

##### Protocol efficiency and monitoring design

- The recommended sampling design for bird point counts is a minimum of 4-5 survey stations and 3 survey visits at each monitoring point and a total of 10 minutes of survey time to each survey station per visit.
- Based on relative detection frequencies, bird surveys appeared to be conducted over an appropriate time period. We recommend bird point counts to be

conducted in the Tahoe basin from late May or early June through early to mid July.

- Points counts are not the primary sampling method for mammals, however yellow-bellied marmot, pika and Douglas squirrel were detected at greater frequencies with point count sampling than with small mammal trapping, suggesting these additional species should be recorded during all point count surveys.
- Survey costs: \$1100 per point

### *Sherman live-trapping*

#### Current status of populations and habitat

- Twenty-three small mammal species (79% of all species expected to occur in the basin) were detected at the 40 monitoring points.
- No MIS, Forest Service Sensitive, TRPA special interest species or California species of special concern were detected with Sherman trapping, however, none were expected to be captured given the large body size of most special status species (e.g., American marten, Fisher, Sierra Nevada red fox, etc.)
- Several small mammals detected with Sherman live-trapping have been identified as important prey items to special interest species in the basin (e.g., Northern Goshawk, California Spotted Owl, American marten: *Martes americana*) and may be considered higher priority for monitoring efforts including the following: northern flying squirrel, Douglas' squirrel and deer mouse.
- The median observed point occupancy for small mammals detected in this effort was 15%.
- The median observed probability of detection for all small mammal species was 0.6.

#### Protocol efficiency and monitoring design

- The recommended sampling design for Sherman live trapping is a minimum of 79 Sherman live traps (e.g., XLK model) checked twice per day for a total of 7 trap checks.
- Due to lack of and minimal capture of some of the larger squirrel species, it is recommended that in future trap efforts every other trap be replaced with a larger sized Sherman live trap (e.g., XLF15 model).
- Based on relative detection frequencies, trapping surveys appeared to be conducted over an appropriate time period. We recommend Sherman trapping to be conducted in the Tahoe basin from mid June through August or early September.
- Survey costs: \$1485 per point (excluding the cost of purchasing traps). This cost is likely to be reduced based on the reduced sampling array (79 traps recommended as opposed to the 103 traps used in 2002).

## *Track Plates and Cameras*

### Current status of populations and habitat

- Five mammal species (39% of all species expected to occur in the basin) were detected at 22 monitoring points surveyed.
- A total of 2 MIS, Forest Service Sensitive, TRPA special interest species and California species of special concern were detected: Black bear (MIS) and American marten (Forest Service Sensitive and California species of special concern).
- The median observed point occupancy for detected bird species was 18%.
- The median observed probability of detection for all bird species was 0.35.

### Protocol efficiency and monitoring design

- The recommended sampling array for track plate and camera surveys is a minimum of 3 track plate and 3 camera stations checked every other day for a total of 10 total survey days.
- Based on relative detection frequencies, track plate and camera surveys appeared to be conducted over an appropriate time period during 2002. We recommend track plate and camera surveys to be conducted in the Tahoe basin from late May or early June through September for sampling of summer distributions.
- Survey costs: \$2580 per point (excluding the cost of purchasing cameras and track plate boxes). This cost is likely to be lower with the recommended reduced sampling array.

## *Bat Mist-netting*

### Current status of populations and habitat

- Nine bat species (56% of all species possibly occurring in the basin) were detected at 22 monitoring points.
- A total of 4 special interest species (Federal Species of Special Concern) were detected: long-eared myotis, long-legged myotis, fringed myotis and western red bat (acoustic detections).
- The median observed point occupancy for detected bat species was 30%.
- The median observed probability of detection for all bird species was 0.25.

### Protocol efficiency and monitoring design

- The recommended sampling design for bat mist-netting surveys is a minimum of 3 stations surveyed per monitoring point, each station surveyed a minimum of 2 times per season, and surveys each lasting a minimum of 3 hours.
- We recommend bat surveys to be conducted in the Tahoe basin from mid June through August to early September.
- Survey costs: \$4600 per point.

## *Pitfall and Coverboards*

### Current status of populations and habitat

- A total of 12 small mammal, amphibian and reptile species were detected with pitfall traps at the 9 points surveyed during 2002, with a mean of 3 species detected per point.
- Three species were detected uniquely with pitfall trap arrays and were not detected with any other survey protocol employed during 2002: northern alligator lizard (*Elgaria coeruleus*, n = 2 ind.s), sagebrush lizard (*Sceloporus graciosus*; n = 3 ind.s), and the mountain pocket gopher (*Thomomys monticola*, n = 12 ind.s).
- No special status species were detected with pitfall trap arrays (MIS, TRPA SIS, T&E or SSC).

### Protocol efficiency and monitoring design

- The presence of twine in pitfall traps (escape mechanism for small mammals) was associated with reduced detections of all taxonomic groups, not solely small mammals, therefore use of twine is not a recommended to reduce small mammal mortality in the Tahoe basin when herpetofauna detections are rare and are one of the targeted species groups for detection with pitfall traps.
- The use of bait appeared to be associated with reduced mortality of small mammals in pitfall traps overall, but not for shrews in particular, therefore, the use of rolled oats, peanut butter and seed bait is not sufficient to reduce shrew mortality in pitfall traps in the basin.
- Based on relative detection frequencies, pitfall trapping appeared to be conducted over an appropriate time period. We recommend pitfall trapping to occur in late spring, just after snowmelt, through August.
- Overall, sampling with pitfall traps was extremely time and labor intensive given the effectiveness to detect unique species. An alternative protocol, vertebrate area searches, used in the 2001 pilot test of the MSIM project, was much less costly in time and effort and is effective at detecting many species not detected with the other primary protocols (e.g., bird point counts, trapping, track plates and cameras) including the 3 species detected uniquely with pitfall traps. Therefore, we recommend future implementation of the vertebrate area search protocol as an alternative to pitfall trapping in the Tahoe basin.
- Survey costs: \$1000 per point.

## *Plants and Habitat*

### Current status of populations and habitat

- We detected a total of 13 tree species, 34 shrub species, 27 grass species and 224 species of herbs at 40 monitoring points.

- Mean tree species richness was the highest in eastside pine habitat ( $\bar{x} = 4$ , s.d. = 1.41 species per point). The white fir habitat type had the next highest tree species richness ( $\bar{x} = 3.72$ , s.d. = 1. species per point).
- Mean shrub species richness was the highest in white fir habitat ( $\bar{x} = 2.50$ , s.d. = 2.81 species per point). The Jeffrey pine habitat type had the next highest shrub richness ( $\bar{x} = 1.79$ , s.d. = 2.74 species per point).
- Mean herb species richness was greatest in the subalpine conifer habitat type ( $\bar{x} = 20$ , s.d. = 12.3 species per point). The red fir habitat type had the lowest herb species richness ( $\bar{x} = 9.78$ , s.d. = 8.7 species per point).
- Mean density of trees in the extra-large diameter class was greatest in red fir habitat ( $\bar{x} = 23.24$ , s.d. = 11.57 stems/ha). White fir had the next highest density of the largest trees ( $\bar{x} = 17.47$ , s.d. = 9.45 stems/ha). Aspen and shrub habitat types had the lowest density of trees in the largest size class.
- Mean snag densities of the largest sized snags (> 60.5 cm dbh) were relatively low compared to large tree densities. White fir habitat had the greatest mean large snag densities in both hardness classes (2.3 hard snags/ha and 9.0 soft snags/ha).
- Volume of hard logs was low across all habitat types varying from a high in aspen habitat of 41.22 m<sup>3</sup>/ha (s.d. = 11.65) to eastside pine, wet meadow and shrub dominated habitat types which all contained no hard logs. Volume of soft logs was generally much higher, with red fir habitat having the highest at 300.38 m<sup>3</sup>/ha (s.d. = 150.79) and white fir to follow ( $\bar{x} = 233.86$  m<sup>3</sup>/ha, s.d. = 89.29).

#### Protocol efficiency and monitoring design

- The 4 survey techniques used for measuring plant species composition at monitoring points in 2002 (15 minute search, quadrats, line transects and 1/16 acre subplots) each differed in their relative effectiveness at detecting species assemblages per point. No single method was effective at detecting the complete species assemblage detected by all survey methods combined. Therefore, the combination of multiple survey techniques is most effective.
- Two survey visits aided in the detection of additional plant species not detected during first visits. Due to wide differences in flowering phenology in herbaceous plant species, 2 survey visits are recommended for determination of total plant species composition.
- Survey visits conducted during 2002 started slightly late and continued later than is generally recommended for complete botanical surveys at elevations as high as the Tahoe basin. We recommend future surveys to be conducted from early June through mid July.
- Survey costs: \$1325 per point (for plant and habitat surveys).

## *Aquatic Amphibians and reptiles*

### Current status of populations and habitat

- A total of 4 amphibian (80% of all amphibians in the basin) and 6 reptile species (63% of all reptile species in the basin) were detected across the 46 lentic sites surveyed.
- No special status amphibians or reptiles were detected at lentic sites. Currently no amphibians or reptiles that occur in the Lake Tahoe basin are listed at the federal or state level as threatened or endangered, and none are listed as Forest Service Management Indicator Species (MIS) or as TRPA indicator species. Only one amphibian in the basin, *Rana muscosa* (mountain yellow-legged frog), is listed as a California species of special concern. This species was not detected during 2002, but was detected in 2003 at a single location.
- Mean amphibian species richness was greatest in wet meadows ( $\bar{x} = 1.0$ , s.d. = 0.8), followed by medium, then small, and lastly large lakes/ponds.
- Average reptile species richness was greatest in medium and large sized lakes/ponds ( $\bar{x} = 0.8$ , s.d. = 0.8)
- The median observed point occupancy for amphibians was 13% and for reptiles was 3%
- The median observed probability of detection for amphibians was 0.7, and was 1.0 for reptiles.

### Protocol efficiency and monitoring design

- We recommend two survey visits to all lentic sample units in future efforts to increase the probability of detecting and monitoring a wider array of species that exist at aquatic sites throughout the Tahoe basin.
- We recommend that pole seining be used when possible to increase the probability of detection, but it should be used after the visual encounter survey, and all detections obtained with seining need to be specifically identified for the purposes of calculating probability of detection.
- Given that amphibians in the basin have varied patterns of phenology, and warrant multiple survey visits, the most appropriate survey timing should remain fairly similar to that conducted during 2002, but perhaps end sooner; mid May through August.
- Survey costs: \$450 per site.

## *Aquatic Birds*

### Current status of populations and habitat

- A total of 20 bird species within the basin were detected during the time-constrained bird surveys at the 46 lentic sites, 14 of which are aquatic-associated species (22% of aquatic associated species expected to occur in the Tahoe basin).

- We detected 12 (19%) of the TRPA SIS in this effort, and one aquatic-associated California state species of special concern, California Gull. No federal or state listed T&E species or species of special concern were detected.

#### Protocol efficiency and monitoring design

- Targeting aquatic sites in addition to forest wide monitoring point locations for bird surveys increased the array of bird species we could effectively detect within the Tahoe basin. However, surveying a greater proportion of lentic sites in the basin, and surveying for all bird species is recommended to detect and effectively monitor a greater array of aquatic associated bird species.
- We recommend surveying for aquatic associated species during sample period June through August, however, if riparian species detections are also desired, survey timing should be restricted to early June through early to mid July.
- Despite the low frequency of second visits conducted in this effort, we recommend multiple survey visits (minimum of 2) in future efforts to increase the probability of detecting a wider array of species that exist at aquatic sites throughout the Tahoe basin.
- Survey costs: \$200 per point.

#### **Future Direction**

Given the uncertainty of funding after 2002 for this project (no funding was available during 2003), it was determined that the most beneficial sampling design to meet short term goals of MSIM in LTBMU (e.g., current status of species, development of indicators, habitat model development, etc) was to focus additional survey efforts on unique sites each year (i.e., no annual re-sample to strengthen trend analysis) to maximize the potential to meet or exceed the target sample size of 100 core sites. Due to the funding support for FY05-FY06 (SNPLMA), MSIM implementation in 2005 may include a modest level of re-sampling effort in order to aid in assessment and evaluation of long-term monitoring design in the Tahoe basin for incorporation into Pathway 2007.

Based on review comments received from supporting statisticians, we abandoned the stratification by habitat type. Habitat type maps are not highly accurate, and the number of sample points in the basin made it impossible to represent the proportion of each habitat type in exact proportion to its occurrence. Therefore, we reselected the remaining 60 of the 100 core sites such that each FIA hexagon has 4 sample points.

The MSIM sample effort is scheduled for completion in March 2006 at which point a final report will be produced summarizing results that address all mentioned project objectives. Knowledge gained from MSIM project implementation and data analysis will then be used to direct initiation of basin-wide programmatic monitoring of identified “focal” species and indicators, and to aid in the initiation of project level biological monitoring (i.e., implementation, effectiveness and validation) across LTBMU.

## **A. Introduction**

The adaptive management program in 2002 for the Lake Tahoe Basin Management Unit (LTBMU or otherwise referred to as the basin) was intended to begin active engagement in adaptive management by: (1) implementing status and change and cause and effect monitoring, (2) preparing for plan revision (USFS and Tahoe Regional Planning Agency (TRPA)) by filling important information gaps over the next 2 years, including completing inventories, investing in administrative studies, and evaluating monitoring efforts to inform future monitoring programs, (3) identifying restoration needs and opportunities, (4) contributing to the development of a multi-agency guide to adaptive management in the basin, (5) building on the foundation of adaptive management provided by the Sierra Nevada Forest Plan Amendment and the Lake Tahoe Watershed Assessment (Murphy and Knopp 2000), and (6) working collaboratively with other agencies in the pursuit of all objectives. The adaptive management program for FY2002 included a number of investments, one being the implementation of multiple-species monitoring.

The Multiple Species Inventory and Monitoring (MSIM) protocol was conceived as part of the Sierra Nevada Framework Project as a means of monitoring the large number of species of concern throughout the Sierra Nevada in an effective and cost efficient manner. The MSIM protocol is now being developed as a national protocol that has the potential to meet the monitoring needs of every Region (see [www.fs.fed.us/research/monitoring Vertebrate.html](http://www.fs.fed.us/research/monitoring Vertebrate.html)).

The MSIM protocol was a logical choice for LTBMU to meet their short- and long-term information needs pertaining to wildlife populations and their habitats. The MSIM protocol consists of a feasible number of standardized, commonly employed, non-lethal survey techniques for each class of vertebrates that detect the presence of a diversity of taxa at each monitoring site. The MSIM protocol is an efficient way to meet legal requirements to monitor vertebrate Management Indicator Species (MIS) and species of concern. In short, multi-species monitoring will (1) provide data on the status and change of many species within the basin, including many species of concern, (2) provide a means to assess the status and change in species diversity in the basin, (3) help to determine whether there are 'focal species' in a system that have indicator or umbrella function, and (4) be useful in developing multi-scale habitat models as a basis of assessing the status and change of habitat conditions. The characterization of habitat conditions where populations are sampled is also a component of the protocol.

## **B. Objectives**

The program of work in 2002 year was a combination of the LTBMU multiple-species monitoring program plus some additional efforts directed at testing and refining the MSIM protocol for National application. The LTBMU monitoring program was two parted: (1) establish a network of 100 monitoring points throughout the Lake Tahoe basin, and then sample 40 of the points; and (2) resample half ( $n = 44$ ) of an existing set of 88 lentic habitat units that were sampled in 1997-98. The addition of a sample of lentic habitats to the monitoring program was based on a number of considerations: (1) lentic habitats were identified in the Lake Tahoe Watershed Assessment (Murphy and Knopp 2000) as ecologically significant in terms of supporting biological diversity in the basin and a habitat type that is at great risk of declining in

condition. The monitoring network only included a few points that occurred in lentic habitat, and thus aquatic and riparian associated species were likely to have low detections and sample sizes would be too small to address the condition of lentic habitats. In 1997, a study was conducted to evaluate the condition of lentic habitat types in the basin and investigate basic ecological relationships between the composition and structure of aquatic-associated biota and environmental conditions in lentic habitats. This probabilistic sample represented the population of lentic habitats within the basin and provided a valuable opportunity to augment the new monitoring network with lentic habitat monitoring units, as well as evaluate change in these sites over the intervening five-year period. Finally, eight of 12 sites sampled in 2001 as part of the Region's pilot program for developing the MSIM protocol for the Sierra Nevada were resampled in 2002 to generate measures of inter-year variability that could be used to inform sample size estimates for trend monitoring. The combination of these efforts was designed to accomplish the following objectives.

1. Support Land Management Plan revision

The monitoring effort will provide data on (1) status of populations and habitat, (2) habitat relationships, (3) the identification and evaluation of indicators, (4) how to design and implement LRMP MIS monitoring. Status information will consist of presence or abundance data of species detected and habitat conditions described at each of the monitoring points. In this first year, only 40 monitoring points plus 44 additional lentic sites were visited, and most species were not detected at every site. Even though the number of points with detections was relatively low for most species, habitat relationships may still be discernable for some species, especially after all 100 points have been sampled by September 2005. The combination of the terrestrial and lentic sites will inform descriptions of affected environments. Presence and abundance data can be used to describe the status of populations, particularly MIS species identified in the current Forest plan. Habitat relationship data can be used to identify habitat for MIS and other species within the Lake Tahoe basin, and then evaluate how habitat for MIS changed over the planning period. These two pieces of information – status of MIS and fate of habitat over the past planning period – have been identified as critical for plan revision and many appeals have targeted the lack of this information as fatal problems in attempted plan revisions. Patterns of covariance among species and with environmental conditions can help identify new species to be used as MIS and then their habitat relationships information can be used to evaluate the effects of various planning alternatives on habitat conditions and populations over the planning period. Finally, implementation of the protocol will refine the most efficient and effective approach to obtaining population and habitat data for species of interest and concern in the basin and for assessing biological diversity.

2. Contribute information to threshold standard revision

Threshold standards are in the process of being revised, and the intent of the USFS and TRPA is to have their plans coordinated, if not integrated into one plan. Much like the evaluation of MIS species and desired conditions for LRMP plan revision, TRPA is in the process of evaluating current threshold standards and recommending new threshold standards and indicators. The MSIM data will provide a valuable source of information to evaluate the value of current threshold standards for terrestrial and aquatic vertebrate (non-fish) and plant

species and communities. Thus, the data set generated by the MSIM protocol can be jointly evaluated to identify threshold standards and indicators for both agencies. The information provided by even two years of implementation of the MSIM protocol will also jointly inform TRPA and LTBMU as to how to best design and implement population and habitat monitoring.

### 3. Contribute to Adaptive Management in the Lake Tahoe basin

Adaptive management in the basin is being forged through a collaborative relationship among agencies and active interest groups. One product of this collaboration is the Lake Tahoe Watershed Assessment (Murphy and Knopp 2000). The Adaptive Management chapter of the Watershed Assessment identified basin-wide monitoring as a critical informational need. Further, the MSIM protocol was originally developed to address information needs for many species across the Sierra Nevada, and the Lake Tahoe basin also has a large number of species of interest and concern, as identified in the Lake Tahoe Watershed Assessment. The MSIM protocol is well suited to meet these recognized information needs. Implementation of the MSIM protocol in the Lake Tahoe basin is designed to facilitate collaboration in data collection across administrative boundaries while remaining flexible enough to provide data for the LTBMU even if other agencies cannot implement monitoring in part or full. Data from the MSIM protocol will help inform population and habitat management across administrative boundaries and will encourage a comprehensive basin-wide monitoring system.

### 4. Consistent with and a Contribution to Regional and National Direction

The MSIM protocol was developed as part of the Sierra Nevada Framework Adaptive Management Strategy. Its implementation in the Lake Tahoe basin exemplifies a seamless integration of local and bioregional information needs. The MSIM protocol was identified by the Regional Leadership Team as a high priority for funding, but is not yet being implemented throughout the Sierra Nevada. Thus, the LTBMU is paving the way for successful implementation on other Forests in the Sierra Nevada and potentially elsewhere in the Region and other Regions. The LTBMU as and is contributing to this national development by partnering with the Region and WO in testing some elements of the protocol in the course of this first year of implementation during 2002.

## C. Study Area

The Lake Tahoe basin is located in California and Nevada (Figure 1). The 880 km<sup>2</sup> (88,000 ha) Lake Tahoe basin, once considered for designation as a National Park, contains the largest alpine lake in North America and is bounded by the crest of the Carson Range on the east and the Sierra crest on the west. The majority of the basin, approximately 80% of the land area is occupied by National Forest System lands as part of the Lake Tahoe Basin Management Unit. The basin encompasses an elevational range from 2000 to 3000 m (6229 to 10881ft). Based on a review of the primary sources of data for the basin, Manley et al. (2000) determined that 312 vertebrates and 1077 vascular plants were present in the Lake Tahoe basin. The vertebrates consisted of 217 bird and 59 mammal species, with the remainder consisting of a small number of amphibians ( $n = 5$ ), reptiles ( $n = 8$ ), and fish ( $n = 23$ ) species. The Lake Tahoe basin is

located on the east–west boundary of 2 major biogeographic provinces (the Sierra and the Great Basin; Udvardy 1975), and in the vicinity of the north–south juncture of 4 smaller-scale bioregions (Mono-Inyo to the southeast, South Sierra to the southwest, North Sierra to the northwest, and Modoc Plateau to the north; Welsh 1994). The location of Lake Tahoe basin at this confluence of zoogeographic zones results in a diversity of environmental conditions and a unique array of flora and fauna around the basin, as well as some distinct distributions of biota around the basin.

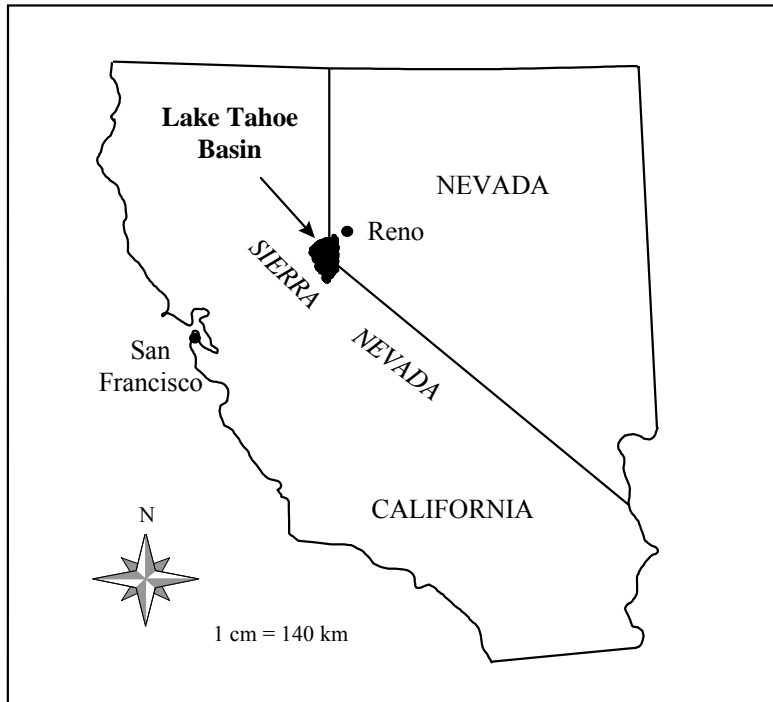


Figure 1. Location of the Lake Tahoe basin monitoring area.

Manley et al. (2000) described the basin as having 3 vegetation zones lower montane (<2,200 m), upper montane (2,200- 2,600 m) and subalpine (>2,600 m). Within the 3 vegetation types these authors outlined 5 major forest types, based on the area covered by each type. In the lower montane vegetation zone the most common forest type is mixed conifer, followed by the white fir, Jeffrey pine and Lodgepole pine forest types. The most common forest type within the upper montane vegetation type is Jeffrey pine, followed by the white fir, red fir and Lodgepole pine types. The only forest type in the subalpine vegetation zone is subalpine woodland. The forest types listed above are defined by the classification system of Sawyer and Keeler-Wolf (1995). The mixed conifer forest type contains white fir (*Abies concolor*), Jeffrey pine (*Pinus jeffreyi*), sugar pine (*Pinus lambertiana*), and incense cedar (*Calocedrus decurrens*) at densities such that no species is dominant. The Jeffrey pine forest type is dominated by Jeffrey pine but also contains white fir and incense cedar at lower densities.

## D. Sampling Design

### FIA-based Terrestrial Monitoring Network

Site selection for 100 LTBMU monitoring network points was based on the FIA hexagonal grid system (consistent with the foundation of the Sierra Nevada Framework Adaptive Management Strategy) with additional consideration of the distribution of sites among habitat classes. Each grid hexagon occupies a 2400 ha (6000 ac) area, with a FIA point randomly located within each hexagon. A total of 67 hexagons containing some NFS lands occurred in the basin and no one hexagon was completely occupied by NFS lands. Many of the FIA points within the 67 hexagons were not located on NFS lands; a total of 25 FIA points occurred on NFS lands. The 25 FIA points that occurred on NFS lands were automatically considered part of the 100-point sample.

We established an additional 75 monitoring points to improve the precision of estimates of population and habitat conditions and trends. The selection of the additional monitoring points entailed multiple steps. First, we used the boundaries of hexagons to approximate the established delineation (Manley et al. 2000) of the 4 basin orientations (north, south, east, west). We then calculated the total NFS land area in each orientation, and allocated the number of monitoring points to each orientation in proportion to the relative amount of NFS land in each. Varying numbers of hexagons occurred in each orientation: east = 15, north = 16, west = 14, south = 22. The average proportion of each hexagon occupied by NFS lands also differed by orientation, with the north and east orientations having approximately half the occupancy as occurred in the west and south (26.8% [s.d. = 26.65] in the east, 27.0% [s.d. = 22.68] in the north, 45.3% [s.d. = 29.28] in the west, and 47.0% [s.d. = 32.59] in the south). The following allocation of points resulted: north = 18 points, east = 17 points, south = 40 points, and west = 25 points. Based on a total sample size of 100 points and acreage of NFS lands in the basin, 4 monitoring points were allocated to each 2400 ac hexagon. Given that none of the hexagons were entirely occupied by NFS lands, the actual number of points allocated to each hexagon was based on the percent of the hexagon occupied by NFS lands: 0 to 12% = no points, 13 to 37% = 1 point, 38 to 62% = 2 points, 63 to 87% = 3 points, and > 87% = 4 points. These intervals represent the mid-points of quartiles, slightly reducing the density of points that would result from allocating one point per quartile interval.

The selection of monitoring points was further constrained by habitat classes. Eight habitat classes were derived from the combination of similar CalVeg types (Table 1). Terrestrial habitat classes were based on CalVeg types as represented in the 1997 version of the USFS vegetation coverage. Each habitat type represents one or more CalVeg types (the few polygons having no vegetation types or indicated as bare ground or "ub" were not assigned to a habitat class). Lentic and lotic habitat was designated by a 50 m buffer around the perimeter of all lentic and lotic units (all vegetation types within the buffer area were assigned to the lentic or lotic unit area). The resulting 8 habitat classes were montane conifer, subalpine conifer, lodgepole, aspen, shrub, meadow, lentic, and lotic. Monitoring points allocated to each orientation were stratified by habitat classes in proportion to their occurrence on NFS lands (Table 2).

Table 1. Habitat classes and their associated CalVeg types.

Habitat Class	CalVeg Type	Calveg Code
Lentic riparian	Lake, water	L, WA
Lotic riparian	Stream, mountain alder	S, TA
Meadow	Wet meadow, perennial grass/forb, annual grass/forb	HJ, HM, HG
Shrub	Cushion plant, mixed alpine shrub, basin sagebrush, huckleberry oak, upper montane mixed shrub, upper montane mixed chaparral	AC, AX, BS, CH, CM, CX
Montane conifer	Jeffrey pine, mixed conifer, white fir	JP, MF, WF
Subalpine conifer	Red fir, subalpine conifer	RF, SA
Aspen	Quaking aspen	QQ
Lodgepole	Lodgepole pine	LP

Table 2. Number of monitoring points selected within each orientation and each habitat class.

Orientation	Lentic riparian	Lotic riparian	Meadow	Shrub	Montane conifer	Subalpine conifer	Aspen	Lodgepole	Total
North	1	1	1	3	8	1	1	2	18
East	1	2	1	1	8	2	1	1	17
South	1	3	2	6	13	6	1	8	40
West	1	2	1	5	7	5	1	3	25
Total	4	8	5	15	36	14	4	14	100

The 75 remaining monitoring points were then located using the following process. Data collection at FIA points was off-set 100m in a random direction so data collection would not affect the integrity of FIA points. The random off-sets were confined to a direction that kept the point within the same hexagon and on NFS lands. Once the off-set points were established, the habitat classes sampled by FIA points in each orientation were determined, and the remaining points needed per orientation, per habitat class, and per hexagon were calculated. The remaining monitoring points per habitat class per orientation were located by randomly selecting UTM coordinates associated with each habitat class in that orientation, starting with the rarest habitat classes. All points randomly located were specified to be a minimum of 500 m away from any other point previously selected to maintain spatial independence of points. Once the total number of points allocated to a given hexagon was reached, no additional points were located within it.

The 100 monitoring network points were assigned to one of four panels for sampling. We used an augmented serial alternating panel (ASAP) design in order to achieve the greatest possible power to detect change given the limited number of points that could be sampled each year (30 to 40 points). Based on previous simulation modeling (generated by Monitoring Team for the Sierra Nevada Forest Plan Amendment), it appeared that an allocation of 20 to 30% of the sample to an annual panel provided the greatest statistical power to detect a trend in the proportion of sites occupied. We took into consideration that future budget constraints might require monitoring to be suspended for periods of time, and decided to forfeit some statistical power for greater certainty that all 100 sites would be sampled at least once and over a relatively

short period of time. Thus, we allocated only 10% of the points ( $n = 10$ ) to the annual panel and split the remaining 90 points into three panels (30 points each) to be sampled over a three-year period, for a total annual effort of 40 points per year. The foundation of the ASAP design is that each year's panel is an unbiased representation of all points in all panels. In assigning points to panels, we considered representation of orientation and habitat classes as important in each panel.

### **Aquatic Monitoring Network**

The 46 lentic habitat units sampled in 2002 were part of a sample of 88 lentic units consisting of lakes, ponds and wet meadows that were sampled over the course of two years in 1997 and 1998. The addition of aquatic associated habitat monitoring was intended to increase the number of detections of aquatic-associated amphibians and reptiles, which occur in low densities in the basin and would otherwise be detected too infrequently to address status and change or habitat relationships. Given that we resampled them five years later using the same methodology, the survey effort in 2002 provided valuable status/trend data. Lake sites in the sample were randomly selected from 12 elevation-orientation-size classes based on the USGS digital map of all lakes in the Lake Tahoe basin, and the sample represents roughly an equivalent number of sites in various orientation, size, and elevation classes (Manley and Schlesinger 2001). Alternatively, wet meadow sites represent size and disturbance in proportion to their occurrence in each of four elevation/orientation classes (same classes used for lake selection). We randomly selected four, 1 mi<sup>2</sup> sections in each of the four elevation/orientation classes, selected one wet meadow in each section for a total of 16 wet meadows. Thus, the lake and wet meadow sample did not represent sizes, orientations, and elevations in proportion to their occurrence. The sample needs to be weighted in analysis to reflect the probability of selection (see analysis section). For a detailed description of site selection see Manley and Schlesinger (2001).

### **2001 Resample Points**

Eight of the 12 points sampled as part of the pilot monitoring effort in 2001 (Manley et al. 2002) were resampled in 2002. The 12 points were located along an elevational gradient from about 3000 ft on the west slope of the Sierra Crest on the Eldorado National Forest to about 8500 ft on the east slope of the Sierra Crest on the Lake Tahoe Basin Management Unit. The points were arrayed along the elevational gradient in three clusters of four points. The low and high clusters were selected for resample because they represented the extremes in terms of climate and species composition. Sampling effort at each of these resample points is indicated concurrent with each plant and animal survey protocol described in the section below. Detailed data summaries and analysis of this data are not reported here, but will be presented in the final Multi-species Inventory and Monitoring Report expected in March 2006.

## **E. Plant and Animal Survey Protocols**

We used a set of 10 standardized multiple-species detection protocols for population monitoring: points counts, Sherman trapping, bat mist netting, bat acoustic monitoring, aquatic vertebrate surveys, covered track plates with cameras, pitfall traps and cover boards (for

amphibians and reptiles and shrews), plant surveys, and habitat conditions (Table 3). Two detection protocols were conducted in 2002 that were not conducted in 2001: track plate and camera stations, and pitfall and coverboard arrays. Tomahawk traps were used in the 2001 pilot test effort (Manley et al. 2002), but capture rates were low and we assumed that the track plate and camera detection protocol would detect many of the same species but with higher detection rates. The effort put toward each protocol in 2002 (e.g., number of traps, number of visits, area searched) was informed by the results of the 2001 MSIM pilot test (Manley et al. 2002). The general arrangement of all sampling protocols at each monitoring point is shown in Figure 2. The allocation of protocols to points is provided in Appendix A. We generally surveyed at lower elevations earlier and higher elevations later in the season.

Table 3. Protocols selected to evaluate the multi-species monitoring approach including 6 sites resampled from 2001 sample on the Eldorado National Forest (ENF) and Lake Tahoe Basin Management Unit (LTBMU), and 2 sites of overlap between the 2001 survey period and 2002 panel.

Protocol	2002 Panels	2001 Resample Sites 4 ENF, 2 LTBMU	2002/2001 Overlap Sites, 2 LTBMU
Point counts	7 stations (PCS) in hexagon pattern, 2-3 visits, detections recorded in distance intervals	4 stations in triangular pattern around FIA monitoring point only	11 stations (7 in hexagon pattern and 4 in triangular pattern). Any two stations within 10 m of each other were combined into one single station.
Live trapping (Sherman-long traps)	103 Sherman traps in hexagonal pattern connecting PCS, and one transect connecting north and south PCS, 15 m spacing, checked twice daily for 3 days and nights	17 Sherman and 9 Tomahawk traps along each of 3 transects arranged as spokes radiating from a central FIA monitoring point (78 traps), 15 m spacing, checked twice daily for 4 nights and 3 days.	Sampled using the 2001 protocol unless Sherman trap stations overlap within 10m of station at the co-located 2002 point.
Covered track plates and camera surveys	At 20 randomly chosen monitoring points, 6 covered track plates, 4 cameras randomly co-located with track plate stations, visit every other day for 5 visits	No	N/A

Protocol	2002 Panels	2001 Resample Sites 4 ENF, 2 LTBMU	2002/2001 Overlap Sites, 2 LTBMU
Mist netting	20-25 primary sampling units (PSUs), each surrounding an individual point, 3 net sites within each PSU, 2 visits to all sites, 4 visits to at least one site at 15 of the 2002 points (no 2001 sites), one site per 18 of the 2002 points desirable	3 sites, 2 visits, no extra visits	Same as 2002, except no 4 visit sites
Acoustic survey for bats	120 min per night, two nights per site	60 min at least, up to 120 min per night, two nights per site	Same as 2002
Pitfall array	At 10 randomly chosen monitoring points (subset of track plate points) - one array located due west 30 m from the monitoring point and another array 70 m due east. Checked once to twice per week.	No	N/A
Cover boards	2m <sup>2</sup> cover board located 10 m away from pitfall array in a random direction	No	N/A
Aquatic vertebrate surveys	Surveyed 46 lentic sites from set of sites surveyed in 1997 and 1998 (Manley and Schlesinger 2001). One visit minimum to all sites, 2 visits preferred.	No	N/A
Plants	Three 25 m transects, 4 subplots and 12, 1m <sup>2</sup> quadrats surveyed at each of 4 PCS at each site.	Subplots and quadrats as per 2001 protocol. No transects surveyed	2002 protocol (2002 protocol is inclusive of 2001 protocol)

Protocol	2002 Panels	2001 Resample Sites 4 ENF, 2 LTBMU	2002/2001 Overlap Sites, 2 LTBMU
Habitat descriptions	FIA based protocol conducted at 4 PCS at each terrestrial monitoring site, and at 3 bat monitoring stations and 10 track plate/camera stations at a subset of 22 terrestrial monitoring sites. Aquatic habitat surveys were conducted at 44 lentic sites.	No	N/A

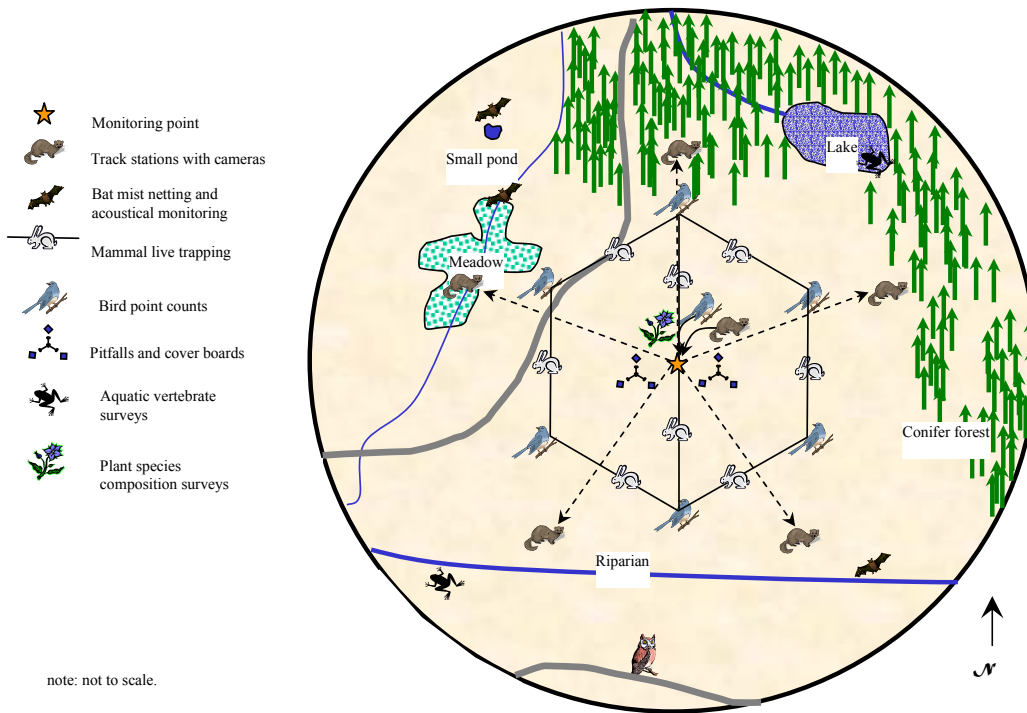


Figure 2. Spatial array of monitoring protocols associated with each FIA point.

Three detection protocols conducted in the 2001 pilot test and considered part of the MSIM protocol were not conducted in 2002 because of budget and time constraints: nocturnal broadcast surveys for detecting nocturnal birds, vertebrate area searches for detecting terrestrial reptiles and amphibians, diurnal raptors, medium and large bodied mammals, and fish species surveys (Manley et al. 2002). Ideally, all these protocols would be conducted as part of the MSIM monitoring protocol, given that they broaden the suite of species detected and detect a number of species of special interest and concern.

### **Point Counts**

All 40 of the points monitored in 2002 were surveyed using point counts. In addition, 8 points from 2001 were re-surveyed. Six of these 8 additional points were not included in the 2002 panel of points, and two were within 100m of points included in the 2002 panels (i.e., 2001/2002 overlap points). The protocol for 2002 points is described in detail below, and details differing at 2001 resample points and 2001/2002 overlap points noted. The spatial arrangement of point count stations differed in the 2001 pilot test, but the point counts followed the same protocol as 2002 (Manley et al. 2002).

### Spatial Arrangement

Six point count stations were located in a hexagonal array around a central point station for a total of seven point count stations (Figure 2). All stations were 200 m apart. When any count station fell in dangerous, extremely noisy, or otherwise unsuitable terrain (e.g., on cliffs, near loud creeks or rivers, in lakes), the station was located in the nearest suitable location in a direction away from other stations, maintaining a 200m minimum distance between stations. The same configuration was used at aquatic habitats, with the central point moved up to 15 m away from streams if noise from the stream impeded detectability. If lentic habitats were more than 200 m across such that a count station would be located in the water, the point was moved further out generally along the same trajectory away from the center point to the nearest shore up to 50m away. In situations that required moving the station greater than 50 m away in order to maintain the same trajectory and place the station on the ground, the station was shifted off of the original trajectory, but in a fashion that maintained a minimum of 200 m from any other station

### Survey Protocol

Point counts were conducted in June and July, with surveys at lower elevations conducted first -- observers worked up in elevation to ensure that counts spanned the breeding season similarly across elevational bands. All count stations associated with a given point were surveyed on the same day, starting at fifteen minutes after sunrise and finishing no later than 4 hours after sunrise. Counts lasted 10 minutes, with data recorded in 3 time intervals: the first 3 minutes, the next 2 minutes, and the final 5 minutes and 3 distance intervals: 0-50m, 51-100m, and > 100m. Counts were not conducted if precipitation was occurring or if the wind was greater than a slight breeze (leaves and small twigs moving). Three visits were conducted to each point and were separated by at least 1 week. No more than two visits were conducted by the same observer at a given point, and observers intermixed the timing and location of counts among stations at points.

Observers recorded all birds detected to species, as well as Douglas' squirrels (*Tamiasciurus douglasii*). Other species detected were recorded as incidental sightings. The time interval and location of each individual relative to the three distance intervals were recorded. Birds were recorded as occurring in the location where they were first detected. Fly-over detections were always assigned to the area outside 100m. All individuals detected at each count station were recorded even if they were detected at another count station during the same morning. Additional information recorded included the following: date, cloud cover, wind conditions, observer, start time, and any notable events or conditions including incidental sightings of non-target species. Observers carried tape players to record calls or songs that could not be identified to species in the field.

#### 2001 Resample Points and 2001/2002 Overlap Points

Only 4 central point count stations were surveyed at all 2001 resample points (L2, L4, L5, L6, and H3). The central four points were located as follows: one point at the center of the FIA plot at the FIA point, and the other three points at a distance of 200 m in the following directions: north (0°), southeast (120°) and southwest (240°). At the 2001/2002 overlap points (H1, H2, and H4 overlapping with S19, S20 and S88, respectively), point counts were conducted at all 11 count stations, unless stations were less than 10 m apart in which case a single station's data was used for all stations. Only one observer conducted the counts for a given visit; if two days were required to complete the visit, they were consecutive.

#### Equipment Used

Binoculars, clipboard, field guide to birds, bird tapes, blank tapes, tape player, stopwatch, blank datasheets, and notebook.

#### **Sherman Live Trapping**

All 40 of the monitoring points were surveyed using Sherman live traps. In addition, seven points from 2001 were also surveyed using a reduced trapping array from 2001. The protocol for 2002 points is described in detail below, and details differing at 2001 resample points and 2001/2002 overlap points are noted. The spatial arrangement of trapping transects and trap types used (e.g., Sherman traps only) during 2002 differed from the 2001 pilot test. Sherman trap protocols, however, (including bait and trap checking schedules) were consistent between years (Manley et al. 2002).

#### Spatial Arrangement

Sherman traps were deployed along transects, each 200 m long, arranged in a hexagonal pattern that is bisected down the middle. Trapping transects connected point count stations around the central monitoring point (Figure 2). Traps were placed 15 m apart along each transect, starting at each point count station and ending 20 m before the next point count station, for a total of 13 traps along each transect. Thus, a total of 78 traps were located around the hexagon, and 25 additional traps located down the middle of the hexagon (400 m north to south,

with the trap at the center point used as the first trap for both the transect heading north from the center and south from the center) for a total of 103 traps.

### Survey Protocol

Live trapping occurred from early June through early September, with surveys at lower elevations and the east side of the basin conducted first. Traps were placed within two meters of the intended location at habitat features such as logs, burrows, the base of trees, runways and, always, in areas that provide cover from weather (e.g., under shrubs, in tall grass). Sherman traps were baited with a mixture of rolled oats, birdseed with sunflower seeds, peanut butter, and small mealworms (approx. 3 cm in length) to provide a high-energy food source to shrews. Mealworms were frozen prior to use in order for them to remain inside traps after being baited. Bait for Sherman traps contains approximately one part oatmeal to one part birdseed. A total of ½ cup peanut butter and approximately 900 mealworms were to be mixed together with 2 gallons of oat/seed mix. Polystyrene batting was placed in every Sherman trap to provide warmth. Each trap station was uniquely numbered on brightly colored pink clothes pins located in a visible location near the trap in a fashion consistent across all points. Transects were numbered 101-113, 201-213, 301-313, 401-413, 501-513, 601-613, 701-713 starting from the center heading due north and continuing clockwise around the hexagon, and 802-813 for the final transect heading due south of the central monitoring point (trap 101). All traps were set, opened and baited in the afternoon of the first day, and checked twice daily (early morning to be completed by 10 am, late afternoon to be completed before 8 pm) starting on the morning of the second day for three consecutive days. Traps were checked and removed during the last trap check on the afternoon of the fourth day. Observers checked-off a box for each trap checked to ensure that no traps were missed during any given check. Traps were re-baited as necessary and mealworms were added separately where needed to ensure availability to shrews.

Captured animals were identified to species, sexed, aged (as juveniles or adults), examined for breeding status (NOTE: pregnant animals have swollen pink nipples and have enlarged abdomens, lactating animals have darkened nipples), marked by cutting a patch of hair near the base of the tail, weighed and then released. Additional information was recorded for uncertain species identifications including relevant body measurements such as hind foot length, ear length, tail length and head/body length in order to discern similar species within the genera *Tamias*, *Peromyscus*, *Microtus*, and *Sorex*. Observers indicated in the comments section of the data sheet each trap number that is sprung (door closed but empty), disturbed (knocked out of position or damaged), or robbed (materials pulled out but door not sprung). Trap mortalities were collected and frozen as soon as possible, labeled with date and location of capture, the observer names, habitat type at location of trap, and project name. Species identification was confirmed and then animals were donated to a museum collection.

All traps were cleaned and disinfected after the survey was complete at each point. Traps were emptied of all loose bait, organic material and polystyrene batting before being placed into a mild bleach/water solution (approx. two cups of bleach to 30 gallons water) where they remained for a minimum of five minutes. Any traps that remain soiled after soaking were scrubbed with brushes using the mild bleach solution until traps were clean. Traps were then rinsed with water and allowed to dry fully before being packed into backpacks in preparation for the following trapping survey.

## 2001 Resample Points

Only three center transects radiating from the central monitoring point were surveyed at all 2001 resample points (L2, L4, L5, L6, and H3). These three transects radiated out from the center point in the following directions: north (0°), southeast (120°), and southwest (240°). Transects started 9 m from the center point and continued along the path to the respective point count station and beyond for a total length of 240 meters. Sherman traps were placed every 15 m for a total of 17 traps. Tomahawk traps were co-located with every other Sherman trap, starting at the first trap station 9 m from the center point, for a total of 9 Tomahawk traps per transect. At 2001/2002 overlap points (H1 and H4, overlapping with S19 and S88), both 2001 and 2002 protocols were followed unless a Sherman trap station from one protocol fell within 10m of another station from the other protocol. In these cases, a single Sherman trap was set and the data collected from that trap were included in both data sets.

## Equipment Used

103 Sherman traps (plus a few extra traps), clip board, trap bait (oat/seed, peanut butter, and mealworms), polystyrene batting (about 2 inch diameter piece per trap per point), 1 gallon plastic bags (Ziploc bags preferred), scales up to 300 grams, field rulers, small scissors, mammal field guides or keys, rubber gloves, backpacks for carrying traps (one per transect), hand lens (shrew identification), respirators and hand sanitizer (for protection from Hantavirus). Equipment clean-up requires two 30-gallon garbage cans, water supply, bleach, hose with nozzle, scrub brush, protective eyewear and a large flat area to spread out traps while drying.

## **Track Plate and Camera Surveys**

Covered track plate and Trail Master camera station surveys were conducted at 22 monitoring points that were a random subset of the 40 monitoring points sampled in 2002, sampled in proportion to their occurrence by orientation. Sampling was limited to half of the points because of expense [note: We provide this recommendation for reducing costs, such that the cost per point for this protocol is equitable to that of other protocols]. Six covered track plates and four camera stations were established at each sample point.

## Spatial Arrangement

One covered track plate station was placed within two meters of the monitoring point and five other stations were arrayed at 72 ° angles and 500 m away from the center point (Figure 2). The center track plate was labeled TP1, the track plate station 500 m at 0 ° was TP2, and the other stations were numbered in a clockwise direction ending with TP6 at 288 °.

Track plate boxes were constructed of a two-piece, black, high-density polyethylene cover and an aluminum track plate. The polyethylene cover had the dimensions 70 cm (28 in) long x 40 cm (16 in) wide x 1/3 cm (1/8 in). The boxes were assembled in the field using duct tape. The track plate bottom trays were constructed of 5052 aluminum (30 long x 8 x 0.032 inches). The aluminum track plates were made of 22 gauge galvanized sheet metal that measured 70 cm (30 inches) long x 27.5 cm (11 in) wide. The front entrance of the box remained unobstructed and was 27 cm (10.75 in) wide x 28.5 cm (11.4 in) tall. The back of the

box was covered by 1.25 cm-mesh steel screen that was attached to the bottom tray with binder rings and secured at the top using standard duct tape. Track plates collected track impressions in the form of soot on all white Con-tact paper. Approximately 35 cm (14 in) of one end of the track plate was covered in soot, 30 cm (12 in) by Con-tact paper, and 10 cm (4 in) on the opposite end remained uncovered for placement of the bait. Soot was applied to the plates using an acetylene torch without compressed oxygen. Chicken drummets were used as bait and one drummet was located inside at the back of each track plate box.

Four Trail Master camera stations were co-located with 4 randomly chosen track plate stations. The other two track plate stations did not have an associated camera station. Camera stations were approximately 100 m away from the track plate station at a randomly chosen azimuth. The exact location of the camera station is determined based on availability of a tree to which the camera and bait can be attached. The camera stations were labeled with the same number as the associated track plate station but with the prefix TM. For example, if there was a camera at the center point (TP1) it was labeled TM1.

Camera stations consisted of a 35mm Cannon Sureshot A1 camera in conjunction with a Trail Master TM550 passive infra-red detector. The film was 35mm ISO 400 and a flash was used throughout the survey. Settings for the Trail Master TM550 passive infrared were P = 5, and Pt = 2.5 such that five full windows had to be interrupted for at least 2.5 seconds for the camera to be triggered and the camera delay between photo events is 2.0 minutes. The camera and Trail Master were attached to a tree or other suitable substrate. They were arranged vertically on the same tree or upon adjacent trees. Cameras and detectors were attached to trees using a tripod and various combinations of nylon straps, and 22-gauge wire, and duct tape. Camera stations were baited with one-half of a chicken (approximately two pounds), frozen and contained in a basket made of two-inch chicken wire. Bait was attached to the tree using 22-gauge wire and/or duct tape. A 10 x 15 cm note card displaying the station number was placed above the bait and attached to the tree with pushpins or 22-gauge wire. Bait was placed between 0.5 and 1.5 m from the ground.

For both camera and track plate stations a mixture of Gusto (M & M Furs, Inc. Bridgewater, SD), a skunk scent gland derivative, and lanolin was used as long-distance attractant. The Gusto mixture was prepared by combining 1 oz jar of Gusto with 32 oz of heated lanolin in liquid form. Approximately 1 T of Gusto mixture was placed within 4 m of the station upon a substrate such as a tree branch. The Gusto mixture was applied on the setup day and was not reapplied or removed for the duration of the survey

### Survey Protocol

Each track plate and camera station survey was conducted over a 10-day period. Stations were visited every other day for a total of five visits. The bait and/or track plate were replaced on each of the five visits to each station only if tracks were detected or the station was damaged by events such as precipitation. Camera stations were active immediately after station setup, verified by a test shot, and recorded events 24-hours a day for 10 days. Camera stations were visited on the same days as the track plate stations were visited. Film was replaced any time 18 exposures or more were recorded on any given visit. Bait was replaced if it was absent or, as the observer deemed necessary. For each track plate and camera station, excluding the central monitoring point, a habitat was characterized (see "Habitat Protocols" section). All tracks and images were keyed to species whenever possible.

## Equipment Used

*Camera stations:* 4 cameras, 4 Trail Masters, 4 wires, 100 feet of 22 gauge bailing wire, 4 4x6 note cards, permanent marker, 8-12 pushpins, 4 chicken wire baskets, 4 half chickens, 4 tbsp Gusto/lanolin, 4 rolls ISO 400 35mm film, necessary batteries. *Track plate station:* 6 bottom trays, 6 front covers, 6 back covers, 6 mesh screens, 12 binder rings, 100 feet duct tape, 6 sooted track plates with Con-tact paper, 6 frozen chicken drummets, 4 tbsp Gusto/lanolin.

## **Bat Mist Netting**

Bats were surveyed at 22 of the 40 monitoring points sampled in 2002. Ideally, all points would be monitored for bats, but funding limitations and logistical constraints (availability of qualified and certified field personnel) resulted in data collection being restricted to half of the points. The 22 sites consisted of all lentic and lotic-centered monitoring points plus a random selection of the remaining points in proportion to their occurrence per orientation for a total of 22 monitoring points (Appendix A).

In addition, 5 resample points from 2001 (L2, L4, L5, L6, and H3), and 3 2001/2002 overlap sites (H1, H2, and H4, overlapping with S19, S20 and S88) were surveyed. The protocol for 2002 sites is described below, and details differing at 2001 resample sites are noted. The selection of survey sites and the detection protocol per visit were consistent between 2001 and 2002, but the number of visits to each site differed between years, with a minimum of 3 visits and a maximum of 6 visits per site in 2001 (Manley et al. 2002).

## Spatial Arrangement

Bat mist netting and acoustic surveys were conducted at 3 sites in association with every point. These sites were chosen by searching for the nearest suitable habitat within a 1 km radius circle from the primary sampling unit – (PSU). A diversity of sites was desired at each point. Six types of habitat were considered suitable for survey: streams, ponds, lakes, meadows, and roads. Streams and ponds were considered the best habitat for sampling, and at least one site per point was a stream or pond if one is available. The remaining two sites were randomly selected from the remaining suitable habitat types, with the objective of having 3 different habitat types per point if possible. Each selected site was visited to confirm suitability and reselected if determined to not be suitable for some reason (as documented). When two sites of the same habitat type were selected for surveying, the distance between sites within the PSU was maximized. Observers (multiple per site, if possible) ranked the suitability of sites at each point prior to data collection to evaluate the reliability of preconceived notions of relative habitat suitability.

Based on 2001 data analyses, 3 visits to 3 sites per PSU is expected to yield the most species (Table 4), however this level of effort is both inefficient and expensive. By decreasing efforts to 2 visits to 3 sites (which is the same level of effort as 3 visits to 2 sites, but yielded 8% more species) an acceptable balance is found between the estimated number of species detected and an increase in PSUs being surveyed annually. Further, 3 sites are likely to improve the diversity of habitats surveyed. Selecting sites in a variety of habitats enhances species accumulation based on their differential use by various species.

Table 4. Proportion of the bat species assemblage at a primary sample unit (PSU) estimated to be detected with various combinations of sample sites per PSU and visits per site.

Number of sites	Number of visits							
	1	2	3	4	5	6	7	8
1	23.9	36.1	43.3	48.2	51.2	53.9	55.4	56.9
2	39.0	53.9	61.9	67.4	71.1	73.2	74.8	76.1
3	49.1	64.9	72.2	77.2	79.7	81.7	83.2	83.4
4	56.0	71.8	78.4	82.4	84.4	85.4	86.7	87.1
5	61.9	76.6	82.6	85.5	86.9	87.7	88.6	88.8
6	66.5	80.1	85.1	87.2	88.3	89.0	89.3	89.4

### Survey Protocol

All 3 sites at a point were surveyed in the same or consecutive nights. Each site was surveyed on 2 separate occasions (i.e., visits). One randomly selected site associated with each of 15 of the 22 points received 4 visits. The additional visits were used to more precisely estimate the probability of detection. Repeat visits to individual sites were conducted a minimum of 6 days apart to spread their occurrence across the breeding season. The 3 high elevation points sampled in 2001 and again in 2002 were not considered for inclusion in random selection for sites that went to 4 visits. Thus, a total of 18 points remained for the selection of one site per point to go to 4 visits.

Each survey night at each site consisted of setting up 3 nets, varying in length from 6 to 18 meters depending on what the site could accommodate. Nets were monitored approximately every 10 minutes. On nights with little to no bat activity, the nets were checked less often, every 15 minutes approximately. Nets were opened at sunset and kept open for 3.5 hours. Netting did not occur on nights with precipitation.

Bats were removed from nets by inserting a gloved index finger under the chin and a thumb at the base of the neck with left hand (if right handed), grasping the wings close to the body with the remaining fingers. Using the right hand the net was removed first from the head, wings, body, and then feet. Bats were placed in cotton drawstring bags and brought to a central processing station.

Data collected on all bats included: time and net captured, temperature (Celsius) at capture time, species (four-letter code: first two letters of genus and species), sex, reproductive status (males: descended testes, not descended, juvenile, unknown; females: pregnant (full round belly with swollen pink vulva and/or mammary glands), lactating (large pendulous mammarys with fur removed from immediate area), post-lactating (mammarys appear dry or shrunken), non-reproductive, juvenile, unknown), age (by checking epiphyses of third and fourth metacarpal for full or partial ossification), and forearm length (mm). In addition, comments regarding the potential stage of reproduction for females were noted and include a physical description of the condition of nipples and vulva, as well as indications that the animal had never bred (i.e. mammarys extremely small and difficult to locate). All *Myotis* species were measured for ear, thumb, and foot length (mm), and the calcar was checked for a keel to confirm species

identification. Additional identifying characteristics were noted to distinguish between similar *Myotis* species.

Acoustic surveys, using Pettersson ultrasound detectors (minimum model: D240), were conducted at all sites for at least one visit, and for both visits whenever possible. Each night, a minimum of 120 minutes (2 hours) of recording were conducted, starting at or near the time nets are open and completed before nets are closed. It is most important that surveys take place during the first hour after sunset, when bat activity is at its peak. Each crew had detectors that could be used in either one of two ways: 1) attached to a laptop with cable/connector and recording then viewing each call on laptop, keeping only quality calls (those with distinct shape and intensity (red on the SonoBat display), with little to no background interference (i.e., blue noise that obscures call); or 2) attached to a voice-activated tape recorder with cable/connector, which allowed observers to record calls without the aid of a computer (heavy to carry and not always available) and to walk around the survey area, when safe to do so, recording calls in a variety of habitats that may be different from the immediate netting area. The ability to move around was limited because trails and roads were limited and thus conditions were too hazardous to move around at night. Simultaneous acoustic surveys were conducted and compared to determine if the ability to identify species differed between the two methods. No difference in identification ability was found.

### 2001 Resample Points

To enhance our understanding of between-year variation associated with sites and points, all low (n = 4) and high (n = 4) elevation points sampled in 2001 were resampled in 2002. Each site was visited only twice. At the 3 overlap sites (H1, H2, and H3) the same sites were surveyed in 2002 as were surveyed in 2001, given that they all occurred within the 1 km radius PSU of both the FIA point and the offset point.

### Equipment Used

*General* - Headlamps, batteries, GPS unit, compass, thermometer (Celsius), cordage and tent stakes, flagging/sharpie, data sheets/pencil, sunset/sunrise chart for area, small metric rulers, thin leather glove such as batting or golf glove, bat keys (various sources), waders, river sandals or felt-soled boots. *Netting* - poles (3-sectioned poles make packing easier), 5/8" x 40" sections (4 tops and 2 bottoms = one set), bat mist nets (38mm mesh, 2.6m high, 4 shelves with less bag than for birds), bat holding bags (small cotton; use ones from GSA called 'mailing bags', 8 x 10", 50 quantity). *Acoustic* - Pettersson ultrasound detector (minimum model: D240), headphones, Pentium laptop computer with at least 128 MB of RAM, SonoBat software, digital (batteries last longer) or tape recorder, connector (basic stereo plug) between computer and detector.

### **Pitfall Traps and Cover Boards**

Pitfall traps and cover boards were tested in 2002 to evaluate their effectiveness in detecting amphibians, reptiles, shrews, and fossorial mammals (e.g., gophers, moles), species not well detected by any other protocol. Two arrays of pitfall traps and 6 cover boards were

established at each of 10 monitoring points ( $n = 20$  arrays), a subset of the points sampled using track plates.

### Spatial Arrangement

Each array consisted of 6 pitfall traps set in a triangular pattern, with the pitfall traps connected by drift fences (Figure 3). Two arrays were established at each point, one with the center of the array 30 m due west and the other 70 m due east of the central monitoring point. Pitfall traps consisted of a 1.5 gallon plastic bucket sunk in the ground so the top of the bucket was at ground level. Plastic buckets were used in this study because they do not conduct heat as would the more commonly employed metal cans, and thus survival may be improved. Pitfall traps were paired on either side of the end of each drift fence. Covers consisting of cedar shingles were placed over the top of the trap during sampling to entice individuals to crawl under the cover and fall into the trap. Covers were propped-up on one side with a small diameter (1 to 2 cm diameter) object.

A handful of duff and soil was put into each bucket to provide some warmth to captured animals. In addition, twine and food were used experimentally to evaluate their effect on survival and capture rates (Karraker 2001). One of the two buckets at the terminus of each fence line was equipped with a length of twine that was attached to the cover and reached the bottom of the bucket. Twine was hung from the edge of underside of the cover (tied) to facilitate the escape of small mammals. In the eastern array, a mix of grains and mealworms (same mixture used in Sherman traps) was provided (approximately 0.1 L).

The drift fence was made out of aluminum flashing, 0.3 m tall and 5 m long from the center of the array to the pitfalls. The drift fence was sunk into the ground 2 to 5 cm and then soil was pressed along each side of the fence along its length to ensure that animals could not crawl under. A few wooden stakes were used to steady the fence vertically and staples were used to secure the fence to the stakes.

Cover boards consisted of  $1\text{m}^2$  sheets of thin plywood or pressboard. Each cover board was cut into 4, 0.5 m square pieces for transport to the point. One cover board was placed in each of 6 pie-shaped sections of the hexagon, along the same azimuths at which point count stations were established (Figure 2). At due north and continuing clockwise every  $60^\circ$  cover boards were located 30 m out from the center monitoring point. Cover boards were oriented along the slope such that the edges of the board were parallel and perpendicular to the fall line (to better intersect individuals moving up or down the slope).

### Survey Protocol

Pitfall traps and cover boards were established in the spring as soon as snow melted enough to access points and the ground, and were checked twice per week through August. In August the traps were closed using plastic lids that snap tight to the buckets, with additional materials placed on the lid (e.g., rocks) to ensure that lids remain in place. The traps were reopened in late September for two weeks to evaluate the value of late-season trapping. After the September sample period, fences were taken down and buckets closed for the remainder of the winter season.

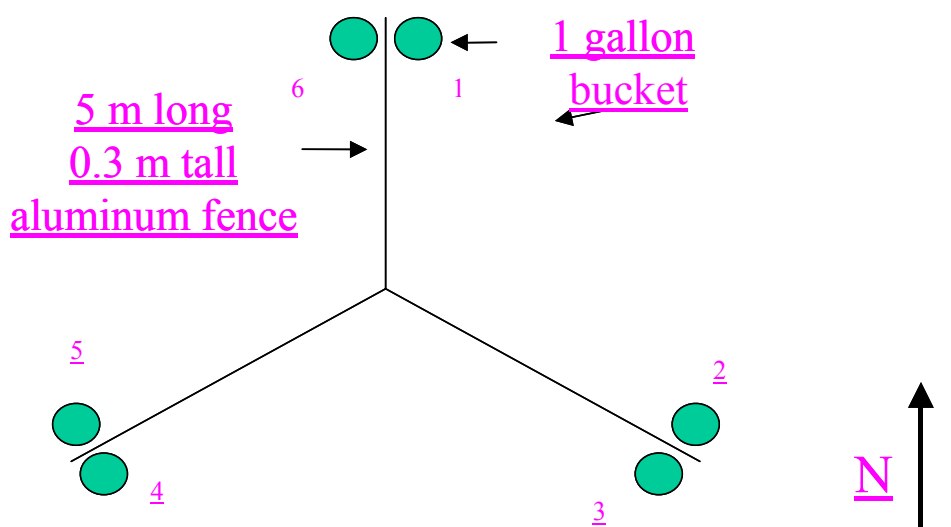
Pitfall checks consisted of lifting the cover and taking stock of the contents of the bucket. All animals were removed with each visit. Poisonous invertebrates, such as scorpions, were

removed with care using thongs or long tweezers. Target taxa were removed one at a time, processed and released. Captured animals were identified to species, weighed (grams) and marked. The length of snakes was also recorded in millimeters. Shrews and other mammals were marked by cutting a small patch of fur on their back above the base of the tail. Reptiles were marked by placing a dab of fingernail polish on their lower backs. Snakes were marked by cutting a small v-shaped notch on the first full scale away from the vent. Amphibian captures were expected to be very low, and, given the concern for amphibians in the basin and elsewhere, we did not mark amphibians. Amphibians need to be handled with caution, given their sensitivity to toxins. Observers' hands were clean - free of all chemical and lotions. A clean, unused bag was used to handle each amphibian, but could be used subsequently to handle reptiles.

Cover board checks consisted of slowly lifting up the cover board and capturing all individuals present. Observers processed individuals in order of decreasing likelihood of escape. Individuals were processed the same as described for pitfall traps. Individuals were not placed back under the cover board but were released next to it.

Equipment Used per Point

6, 2 gallon plastic buckets with lids, 30 m of aluminum flashing, wooden stakes, heavy duty staple gun and staples, shovel (to sink buckets), plastic bags (quart and gallon sized), long-handled thongs or tweezers, leather and rubber gloves, pesola scales (10, 30, and 100 gram), amphibian, reptile, and small mammal keys, small scissors, finger nail polish, headlamp



(optional), knee pads (optional), clipboard.

Figure 3. Pitfall trap array configuration.

## **Aquatic Vertebrate Surveys**

Aquatic vertebrate surveys were conducted at 46 of the 88 lentic habitats sampled in 1997 and 1998 as part of the lentic ecosystem study (Manley and Schlesinger 2001).

Although not accomplished this year, it would be ideal if entire watersheds were selected within which all lentic and a subset of lotic habitats were sampled for aquatic vertebrates (plants and invertebrates, as well). The basin-scale sample unit is consistent with the Sierra Nevada Framework project monitoring approach for amphibians, and would provide information on the persistence of species within drainages in contrast to their persistence at individual habitat units. Basin-wide surveys are intended to reflect occupancy at the basin scale and the dynamics of occupancy within a basin.

### Survey Protocol

Every aquatic monitoring point was visited twice, but less than half of the 46 the additional lentic sites were visited twice; all visits were separated by at least two weeks. In 1997 and 1998, lentic study sites were only visited once, however these sites now serve as monitoring sites and higher probabilities of detection are desired. Walking surveys in lentic and lotic habitats were conducted by walking 100% of their perimeters (plus the interior for wet meadows). The entire perimeter of lake, pond, seep and spring habitats was surveyed. When two observers were present at a lake, they began at the same point and survey in opposite directions until they meet. In meadow habitats, observers zigzagged from side to side covering the entire width of the meadow with each new trajectory. In meadows, when standing water is too deep to walk through, observers walked the perimeter of the water body. When multiple observers surveyed a meadow, the meadow was divided among the observers so that the entire meadow was covered.

Aquatic surveys at lotic-associated monitoring points were conducted on 1000 m reaches extending upstream (noting the 500 m mark in data set) from the monitoring point. Streams were surveyed by observers walking along the stream bank; in larger streams where both banks could not be surveyed simultaneously by one observer, observers surveyed each side of the stream.

Surveys were conducted between 0800 and 1700 hrs. At lentic habitats, one observer first spent 30 min visually surveying the aquatic habitat for water associated birds (Appendix B) and mammals. The observer minimized disturbance to the site upon approach and observed from a discrete location so that approaching birds did not avoid the area. If a lentic habitat unit was too large to see 100% of the area from a single location, the observer moved to multiple locations. Survey time only pertained to time spent observing the water, not moving between observation sites. When changing viewing stations around a lentic unit, observers made wide arcs away from shore (i.e., not moving along shore) to avoid disturbing amphibians and reptiles that may be present. Lentic habitat units over 10 ha in size occasionally required multiple observers to survey 100% of the area. Water-associated birds were recorded in lotic habitats during the course of the standard survey, since 100% of the stream is visible during these surveys (unlike some lentic habitats) and disturbance along the stream was minimized to increase the likelihood of detecting vertebrate species.

In all habitat types, observers spent approximately 15 minutes per 100 m surveyed, with the clock stopped when extra time was needed to identify species, count tadpoles, or maneuver around obstacles. Observers spent most of the time walking in the water, searching through

emergent vegetation with a long-handled dip-net and overturning rocks, logs, and debris to reveal amphibians and reptiles (Fellers and Freel 1995).

All amphibian and reptile species seen or heard were recorded, including species, life stage (egg, tadpole, juvenile, adult), and number of individuals (or egg masses); associated substrates were also recorded. The species and number of all water associated birds and mammals were also recorded (see Appendix B for bird species list). The presence or absence of fish was recorded during amphibian and reptile surveys, identifying them to the lowest taxonomic level possible. Meadows were visually scanned for fish from above the water surface, as observers could readily see the bottom. If no fish were observed during bird or amphibian and reptile surveys, then the aquatic unit was snorkeled (mask, snorkel, and fins). In larger lotic habitats, snorkeling was conducted from an inflatable raft. Lakes were snorkeled until fish were observed or for a maximum of 10 min for lakes less than 1 ac with two additional minutes per acre (for a maximum of 30 min) for larger lakes. Habitat was characterized once during the sampling season using the methodology described in the aquatic habitat section below.

### 2001 Resample Points

In 2001, two lentic and two lotic sites within 1 km of the FIA point were sampled twice during the spring and summer. In 2002, only one visit was conducted to these sites, and only the visual survey along the perimeter of the habitat units was conducted (no 30 min observation period at lentic sites, no seining, no electroshocking).

### Equipment Used

Binoculars, dip net, clipboard, field guides for birds, amphibians and reptiles, field key for mammals.

### **Plant Surveys**

Plant surveys were conducted at all 40 monitoring points. The objectives of plant surveys, in order of priority, were plant species composition, frequency of occurrence, and cover. In addition, 5 resample points from 2001 (L2, L4, L5, L6 and H3) and three 2001/2002 overlap points (H1, H2, and H4, overlapping with S19, S20 and S88, respectively) were surveyed. The protocol for plant surveys at the 2002 monitoring points is described below. Differences in 2001 resample and 2001/2002 overlap sites are noted.

### Spatial Arrangement

Plant populations were characterized using a combination of FIA and additional measures. FIA measures consist of 12, 1m<sup>2</sup> quadrats imbedded in 4, 7.2 m (24 ft) radius subplots (three quadrats per subplot). Presence and cover are recorded for all vascular plants, identified to species, within each quadrat, and presence and cover of woody plants (also identified to species) are recorded within each subplot. In addition to the FIA measures, the following measures were conducted. Species composition of all plant species was recorded within the subplots, but cover estimates were restricted to woody plants.

Four subplots were established at each monitoring point (these same subplots are used for habitat measurements – see habitat section). Subplots were 7.2 m (24 ft) radius circles arranged in an inverted Y shape with the first subplot centered on the point, and the other three subplots placed 36.4 m (120 ft) from the center at 120°, 240°, and 360° azimuths (Figure 4). Within each subplot, three 1 m<sup>2</sup> “quadrats” were established (Figure 5). From subplot center, three quadrats were located on the right sides of lines at azimuths of 30°, 150°, and 270° for a total of 12 quadrats per point. Two corners of each quadrat were permanently marked at 4.57 and 5.57 m (15 and 18.3 ft) horizontal distance from the subplot center.

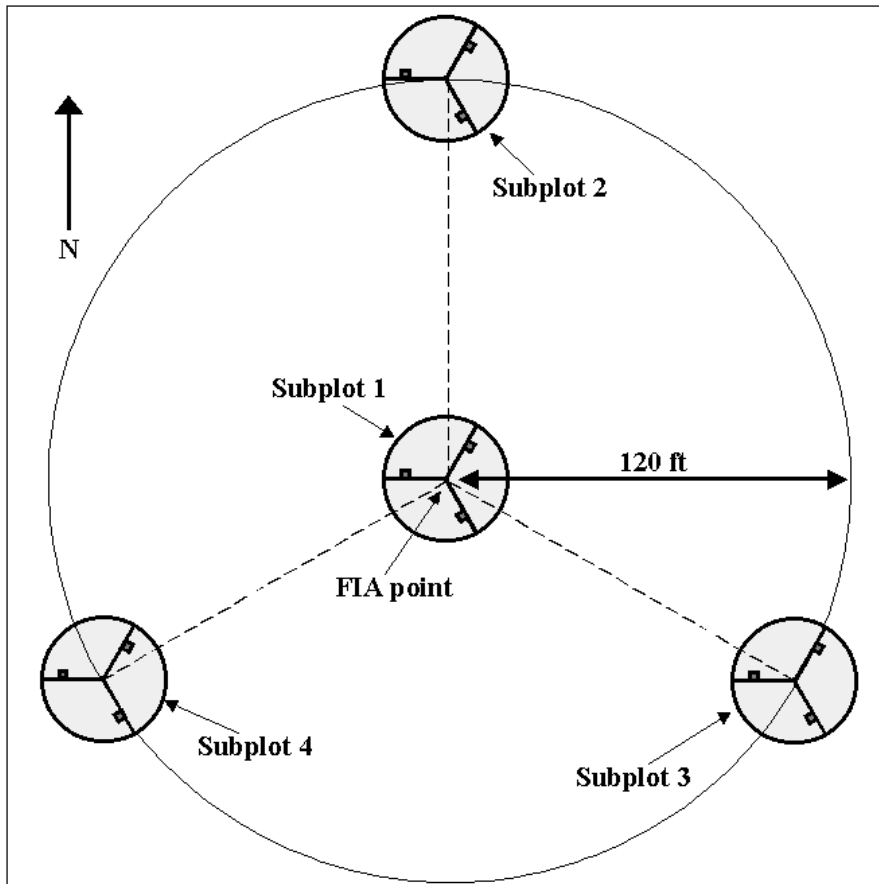


Figure 4. Layout of subplots at a monitoring point (USDA 2002)

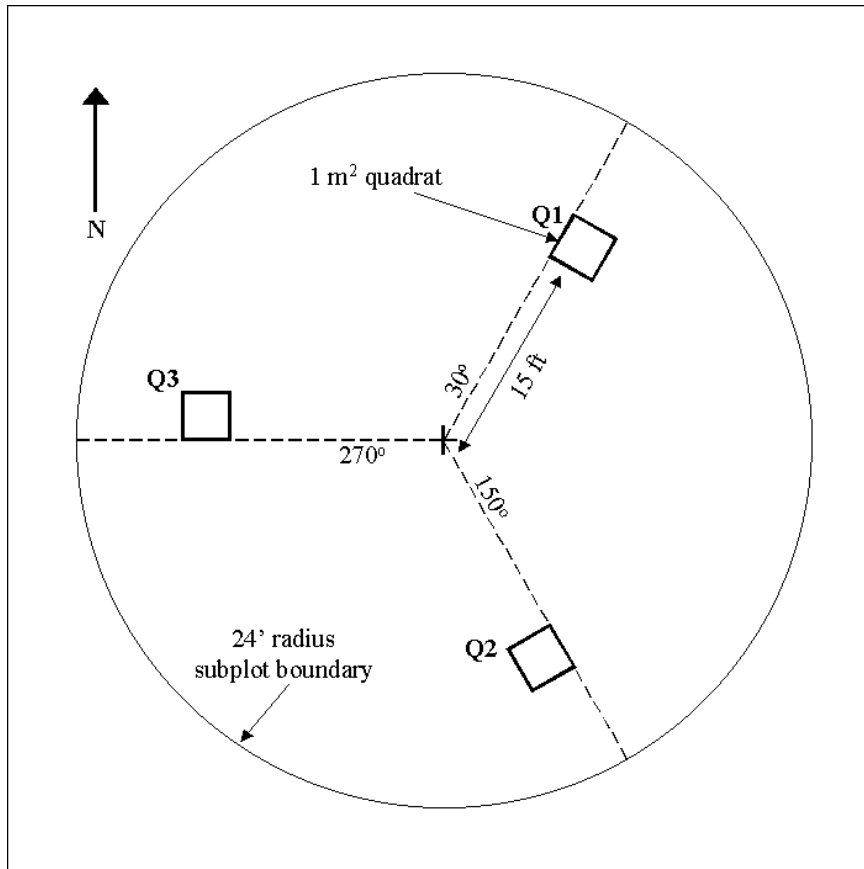


Figure 5. Layout of subplot showing location of quadrats and subplot boundary (USDA 2002).

### Survey Protocol

Quadrat frames were carefully placed at each designated location along the transect. The first measurement requires the installation of permanent pins to mark the corner locations of each quadrat. Each quadrat was leveled prior to measurement, when necessary, by propping up the quadrat corners. When a quadrat was located on a steep slope the observer positioned himself or herself next to or downhill from the quadrat to prevent sliding or falling into the quadrat. Quadrats were often located in areas of thick vegetation cover. When this occurred, the quadrat frame was gently threaded through the vegetation. One habitat type code was assigned to each quadrat:

- 1 Forest land
- 2 Small water (1-4.5 ac. standing water, or 30-200 ft. wide flowing water)
- 3 Large water (standing water >4.5 ac., or flowing water >200 ft. wide)
- 4 Agriculture (cropland, pasture, orchard, Christmas tree plantation, etc.)

- 5 Developed-cultural (business, residential, urban buildup, etc.)
- 6 Developed-rights-of-way (improved roads, railway, power lines, canals, etc.)
- 7 Rangeland
- 8 Hazardous (cliffs, hazardous/illegal activity, etc.)
- 9 Other (beach, marsh, etc.) (explain in comments)

When a quadrat contained more than one habitat type, the observer assigned the code for the habitat type that occupied the greatest area in the quadrat. When the quadrat could not be physically occupied (e.g., hazardous, large water) the corresponding habitat type number was entered and the remaining quadrat items were left blank.

Cover of each species was estimated to the nearest 1% for plants or portions of all vascular plants that fell inside the quadrat frame and were less than 6 feet above the ground. For each plant species, cover was estimated based on a vertically projected polygon described by the outline of each plant, ignoring any normally occurring spaces that exist between the leaves of a plant when the canopy is full. This measure reflects the plant's above- and below-ground zone of dominance. The only exception to this technique was for species represented by plants that were rooted in the quadrat, but had canopies that did not occur in the quadrat or that were more than 6 feet above the ground; cover for these species was estimated based on their basal area. Percent cover estimates were based on the current years' growth, by including both living and dead material from the current year. Overlap of plants of the same species was ignored such that plants of the same species were grouped together into one cover estimate. Occasionally the canopy of different plant species overlapped. Therefore, the total cover for a quadrat sometimes exceeded 100%. All trace cover estimates were recorded as 1%. The percent cover was recorded for the exact amount present at the time of the plot visit. The percent cover was not adjusted for the time of year during which the visit was made (i.e., for immature or wilted plants). The boundary and cover estimates within the quadrats are aided by using actual frames to define quadrat boundaries, having each quadrat frame calibrated (painted in 10 cm sections) (Figure 6), and reference cover examples (Figure 7).

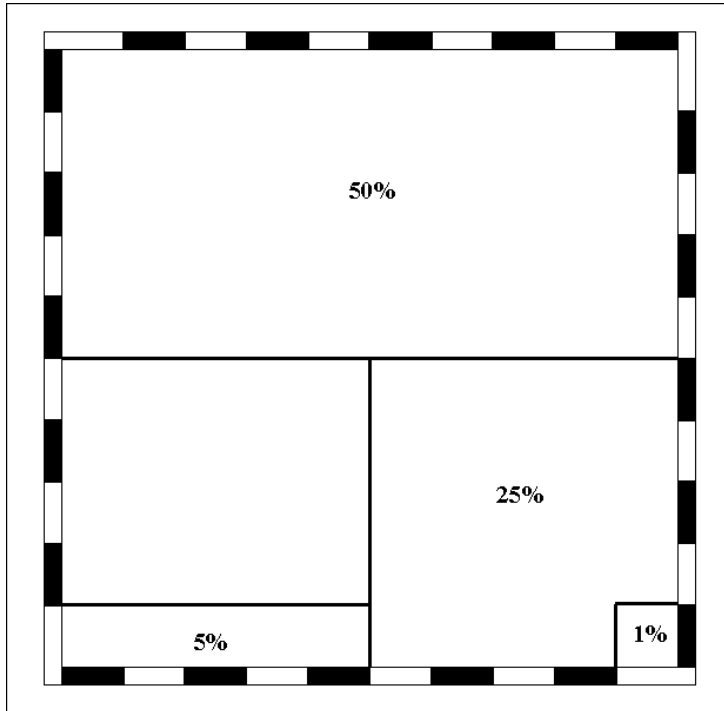


Figure 6. Diagram of 1m x 1m quadrat frame painted in 10 cm intervals and cover levels for different areas (USDA 2002).

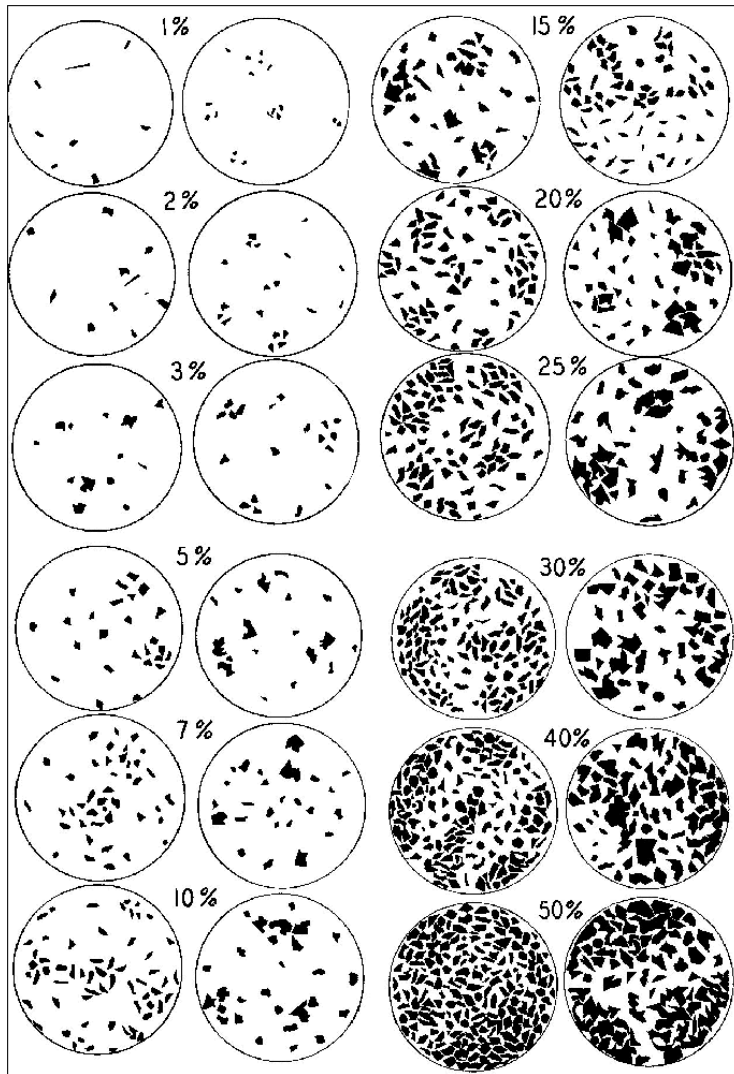


Figure 7. Reference plots for cover estimation (USDA 2002).

In addition to the quadrat measurements, plant species data were collected within each subplot. First, the species composition and cover of wood plants was estimated to the nearest 1% within each subplot. Then, one observer spent an additional 15 minutes searching for as many different plant species as possible. Time spent recording plant species within subplots was restricted to a 15 minute search period and it was strictly timed. Search time did not include time required to estimate and record cover for all woody plant species (conducted before the search begins) nor did it include time required to identify or collect plant species. Observers recorded

as many different plant species as possible within the search time. Only one observer conducted each search.

Points in the lowest elevations were visited first, starting in early June. We did not have the personnel to visit all sites twice nor did it seem a prudent use of time to revisit sites with little or no herbaceous understory. Points were visited a second time only if one or more plant species were unidentifiable during the first visit or the site supported multiple herbaceous species (indicating that additional species could emerge later in the season). In 2002, we established 3 priority classes for site revisitation: high = points with multiple plant species that could not be identified on the first visit but could be more readily identified to species later in the season (n = 12 in 2002); moderate = points with only one or two species that could be more readily identified at a later date (n = 8 in 2002); and low = points with all species being identifiable during the first visit and a low likelihood of additional plant species appearing after the first measurement based on the presence of few herbaceous species (n = 20 in 2002). All high priority sites were visited a second time, and 4 of each of the moderate and low priority sites were also visited a second time (random selection of sites stratified by orientation and elevation). The moderate and low priority sites were revisited to quantify the error of our assumption that plant species were not missed at these sites as a result of a single visit.

The survey protocol for the second visit consisted of surveying the three 1 m<sup>2</sup> quadrats and the 15 minute search in each of the four subplots. Remeasurements occurred regardless of the species composition of each quadrat, so the plant list simply helped speed species identification during the second visit. In addition to plant species composition and cover, the following information was recorded at each visit: date, observer(s), monitoring point number, subplot number, and quadrat number.

Species codes were used to represent each plant species found in the quadrat. Cal Flora species codes used as per the national Natural Resource Conservation Service PLANTS database (USDA, NRCS. 2000. The PLANTS database [<http://plants.usda.gov/plants>], National Plant Data Center, Baton Rouge, LA 70874-4490). PLANTS database contains cross-references to synonyms and older species names that occur in plant identification field guides.

Unidentifiable plants were assigned a unique and novel code and a specimen outside the quadrat was collected for later identification. Not all plants were readily identifiable to species because of growth stage, missing plant parts, and animal and human disturbance. The most complete specimen available was collected, including as much as possible of roots, stem, leaves, fruit, seeds, or cones. When an unidentified plant species was very uncommon in the plot area (i.e., fewer than 5 individuals found) it was not collected and the species genus was entered as the PLANT code in place of the species code when possible or the unknown code "UNRARE" is entered. When no live plants were found within the quadrat, the code "NOPLANTS" was entered and all other information pertaining to that quadrat was recorded.

In addition to plant species composition and cover, the following information was recorded at each visit: date, observer(s), monitoring point number, subplot number (1 = Center subplot, 2 = North subplot, 3 = Southeast subplot, 4 = Southwest subplot) and quadrat number (where applicable) (1 = Quadrat with closest corner located 15 ft on 30° azimuth from subplot center, 2 = Quadrat with closest corner located 15 ft on 150° azimuth from subplot center, 3 = Quadrat with closest corner located 15 ft on 270° azimuth from subplot center). Data are also collected on trampling conditions. Trampling is defined as damage to plants or as disturbance of the ground layer by humans or wildlife. A trampling code was assigned to each quadrat: 1 =

Low: 0-10% of quadrat trampled, 2 = Moderate: 10-50% of quadrat trampled, 3 = Heavy: >50% of quadrat trampled.

#### 2001 Resample Points

At 2001 resample points (L2, L4, L5, L6, and H3), only subplot and quadrat data were collected in 2002. At 2001/2002 overlap points (H1 and H4, overlapping with S19 and S88), the 2002 protocol was employed, as it was identical to the 2001 protocol with the addition of 3 transects.

#### Equipment Used

1-gal sealing plastic bags for unknowns, 1-m<sup>2</sup> calibrated quadrat frame, hand lens, local flora keys and species lists, newspaper and cardboard, chaining pins or stakes to mark quadrat, countdown timer, plant press, folding hand trowel, Ziploc bags, access to dissecting scope with illuminator and associated tools (one scope per two-person team), PLANTS code book with cross-reference to alternative species names and codes.

### **F. Habitat Protocols**

A summary of habitat variables derived from field and remotely-sensed data are provided in Table 5. The range of variables described at survey sites differed among detection protocols. Field protocols are described in detail first, followed by remotely-sensed data sources.

Table 5. Habitat variables described at monitoring network points in the Lake Tahoe basin. Transformations apply where x = the untransformed variable. Dashes indicate no transformation was used. Source: FLD = field data, C

Environmental variable	Metric	Source	Sample site:		
			Center point	Point count stations	Bat sites
<i>Abiotic environment:</i>					
Elevation	m	GIS	X	X	X
Precipitation	cm	GIS	X		X
Orientation to Lake Tahoe	east, west, north, south	GIS	X		
Slope	Percent	GIS/FLD	X	X	X
Aspect	Azimuth	GIS/FLD	X	X	X
Distance to water within 100 m	m	FLD	X	X	X
UTM coordinates			X	X	X
<i>Vegetation:</i>					
Tree density by size class	stems per ha	FLD	X	X	X
Tree decadence	frequency by type	FLD	X	X	X
Canopy cover	%	GIS/FLD	X	X	X
Ground cover by type	% per type	FLD	X	X	X
Litter depth	cm	FLD	X	X	X
Log density	m/ha	FLD	X	X	X
Snag density by size class	Stems/ha	FLD	X	X	X
Vertical vegetation profile		FLD	X	X	X
Tree diameter	Average dbh and basal area	FLD	X	X	X
Plant species composition	Species list	FLD	X		
Plant species richness	Species list plus	FLD	X		

Environmental variable	Metric	Source	Sample site		
			Center point	Point count stations	Bat sites
	unique genera not include in species list				
Proportion of sites occupied by each plant species	%	FLD	X		
Cover of each plant species	%	FLD	X		
Occurrence of veg by height interval	Freq. of occurrence	FLD	X	X	X
Aspen	% area within 100, 300, and 1000 m	GIS	X	X	X
Meadow	% area within 100, 300, and 1000 m	GIS	X	X	X
Mixed conifer	% area within 100, 300, and 1000 m	GIS	X	X	X
Shrubs	% area within 100, 300, and 1000 m	GIS	X	X	X
Subalpine conifer	% area within 100, 300, and 1000 m	GIS	X	X	X
Wooded riparian	% area within 100, 300, and 1000 m	GIS	X	X	X

Environmental variable	Metric	Source	Sample site		
			Center point	Point count stations	Bat sites
Deciduous-coniferous riparian	1000 m % area within 100, 300, and 1000 m	GIS	X	X	X
<i>Lentic unit characteristics:</i>					
Area	ha	FLD			X
Perimeter	m	FLD			X
Depth	m	FLD*			X
Wetness index	0 to 1	FLD			X
Wet	0 to 1	FLD			X
Bedrock	% of transects	FLD			
Boulders	% of transects	FLD			
Cobbles	% of transects	FLD			
Pebbles	% of transects	FLD			
Sand	% of transects	FLD			
Silt	% of transects	FLD			
Fish species presence		FLD			
Habitat type	Manley et al. (2000)	FLD			X
Log frequency	% of transects	FLD			
Emergent vegetation	% of transects	FLD			
Woody debris density	logs/m of shoreline	FLD			

Environmental variable	Metric	Source	Sample site		
			Center point	Point count stations	Bat sites
<i>Human disturbance:</i>					
Distance to nearest road		GIS/FLD	X	X	X
Road and trail area within 30 m	Square meters	FLD	X	X	X
Paved surfaces and compacted/impermeable surfaces within 10 m of lentic units	Square meters	FLD			X
Disturbance index within 100, 500, 1000 m (all sites)	weighted index of roads, trails and development	GIS	X		X
Fragmentation index	index of development, patch size, and isolation	GIS	X		X

\* sample unit depths for known permanent water bodies taken from Schaffer (2002)

## Field Measurements

Data on species composition, vegetation structure, ground cover, and canopy cover were collected at the central monitoring point, and a reduced set of measurements were also taken at a sample of the more remote sampling locations (point count, bat survey sites, track plate stations). Field data collection at the center point is described first, followed by the reduced set of measurements at the remote sampling locations.

### Center Point

FIA protocols served as the primary habitat measurements at center points. In addition to FIA measurements, measurements for canopy cover and vegetation height and layering were taken. Habitat measurements at the center point encompassed the plant composition sites, pitfall and cover board sites, one point count, one track plate station, and 8 Sherman traps. As per FIA, 3 nested, circular plots centered on the point were used to describe habitat conditions: 1 ha (2.54 ac; 56.4 m or 186 ft radius), 0.1 ha (0.25 ac; 17.6 m or 58 ft) cir, and 0.017 ha (0.0625 ac; 7.3 m, 24ft radius) plots. For more detailed descriptions of measurement protocols, refer to the 2002 FIA field instructions manual. The perimeter of each plot was estimated based on a few taped measurements to establish the bounds of the plots. At the center point, the following information was recorded:

- CWHR vegetation type was estimated (Mayer and Laudenslayer 1988)
- Slope angle was measured two times with a clinometer, recording uphill and downhill readings from plot center
- Slope aspect was determined with compass bearing from plot center
- Two coarse woody debris transects were established, one along the 180° azimuth, and one perpendicular to it, either at 90° or 270° (randomly choose location of second transect). Each transect was 25 m long and runs from the center of the plot outward. It is important to lay out the transect in a straight line to avoid biasing the selection of pieces and to allow the remeasurement of transect lines and tally pieces for future change detection. Along each transect, the following information was recorded for each log > 3" in diameter at the large end that touched the transect line: diameter at small end, diameter at large end, length to the nearest 0.5 m, and decay class (Table 6). For logs that were broken into portions, each separate portion was considered a single log, provided that the pieces were completely separated.
- Along each woody debris transect, the vertical diversity of vegetation was described. Transects served as point intercept lines, where at every meter, starting at 1 m, the observer recorded all plant species intersecting the left side of the tape at any height above the tape. For each plant that intersected the vertically projected point, the species and height interval of the intersect was recorded in 1 m intervals up to 10 m, and then in 5 m intervals over 10 m (i.e., each meter from 0 to 10 m, 10.1 to 15 m, 15.1 to 20.0m, 20.1 to 25.0 m, and so on). These data are used to calculate relative frequency of plant species and vertical diversity of vegetation.
- In addition, ground cover measurements along each woody debris transect were recorded (as a check for the subplot estimates). At every 5 m (at 0, 5, 10, 15, and 20

- m) for 1 m length, the percentage of the 1 m length along the left side of the tape occupied by each of 7 ground cover types were estimated: herbaceous plant, grass, shrub, tree, rock, litter, bare soil. All plants were identified to species.
- Three litter depth measurements were taken along both woody debris transects at 2.4, 4.8 and 7.3 m (8, 16, and 24 ft, respectively) from plot center. Litter depth was measured by digging a small hole through the litter (can use finger) and down into the mineral soil, with care not to compress the litter around the edge of the hole. The depth of litter at the edge of the hole was measured with a pocket ruler. Litter depth was measured perpendicular to the ground surface. Areas where litter was collected for the trapping protocol were avoided.
  - Canopy cover estimates were taken with a densiometer, with 4 readings being taken (in each of the 4 cardinal directions) in each of the 4 cardinal directions at the perimeter of the 0.017 ha subplots for a total of 16 measurements per plot.
  - Disturbance was described within 30 m of the center point
    - Area of each type of road (m<sup>2</sup>) within 30 m - hwy, paved road, primary use dirt road, secondary dirt road
    - Area of trails (m<sup>2</sup>) within 30 m
    - Additional area (m<sup>2</sup>) of compacted soil and impermeable surfaces within 30 m
  - The distance to water within 100 m (to the nearest 5 m) and type of water were recorded from the center of the plot
    - 1 = stream
    - 2 = lake ( $\geq 0.5$  ha in area)
    - 3 = pond ( $< 0.5$  ha in area)
    - 4 = bog
    - 5 = seep or spring
  - The distance to nearest road or trail within 100 m (nearest 5 m) of the center of the plot and type of road were recorded.
    - 1 = primary highway (4 lanes, paved)
    - 2 = secondary highway (2 lanes, paved)
    - 3 = paved road
    - 4 = unpaved road
    - 5 = OHV trail
    - 6 = hiking trail

Within each 0.017 ha (0.0625 ac) subplot, the following information was recorded:

- An ocular estimate of percent cover of the following: litter, vegetation (including trees), rock, soil/sand (should add up to 100%)
- For each tree  $\geq 12.5$  cm (5 in) diameter, the species, diameter at breast height, and height to the nearest meter, and all decadence features (Table 7)
- For each snag  $\geq 12.5$  cm (5 in) diameter, the species, diameter at breast height, height estimated to the nearest meter and decay class (Table 6)

Within each 0.1 ha (0.25 ac) plot, the following information was recorded:

- For each tree  $\geq 28$  cm (11 in) in diameter, the species, diameter at breast height, height estimated to the nearest meter, and all decadence features (Table 7).

- For each snag  $\geq 12.5$  cm (5 in) diameter, the species, diameter at breast height, height estimated to the nearest meter and decay class (Table 6).

Within each 1 ha (2.54 ac) plot, the following information was recorded:

- For each tree  $\geq 60$  cm (24 in) diameter, the species, diameter at breast height (at 1.4 m or 4.5 ft as measured using a Biltmore stick), and decadence (Table 7) were recorded. All decadence and damage features observed were recorded and the approximate number of each per tree.
- For each snag  $\geq 30.5$  cm (12 in) diameter, the species, diameter at breast height, height estimated to the nearest meter, and decay class (Table 6) were recorded. A clinometer was used to measure the height of a subset of snags or trees in each height class, with the remaining heights being estimated. Snag heights were measured as the distance from the ground straight up, parallel to the line of gravity, to the top of the tree such that the height of leaning trees was not recorded as the length of the trunk.

Table 6. Decay classes for a) snags and b) logs.

a)

Decay class Code	Limbs and branches	Top	% Bark remaining	Sapwood presence and condition	Heartwood condition
1	All present	Pointed	100	Intact; sound, incipient decay, hard, original color	Sound, hard, original color
2	Few limbs, no fine branches	May be broken	Variable	Sloughing; advanced decay, fibrous, firm to soft, light brown	Sound at base, incipient decay in outer edge of upper bole, hard, light to reddish brown
3	Limb stubs only	Broken	Variable	Sloughing; fibrous, soft, light to reddish brown	Incipient decay at base, advanced decay throughout upper bole, fibrous, hard to firm, reddish brown
4	Few or no stubs	Broken	Variable	Sloughing; cubical, soft, reddish to dark brown	Advanced decay at base, sloughing from upper bole, fibrous to cubical, soft, dark reddish brown
5	None	Broken	Less than 20	Gone	Sloughing, cubical,

soft, dark brown, OR  
fibrous, very soft, dark  
reddish brown, encased  
in hardened shell

b)

Decay Class	Structural integrity	Texture of rotten portions	Color of Wood	Invading roots	Branches and twigs
1	Sound, freshly fallen, intact logs	Intact, no rot; conks of stem decay absent	Original color	Absent	If branches are present, fine twigs are still attached and have tight bark
2	Sound	Mostly intact; sapwood partly soft (starting to decay) but can't be pulled apart by hand	Original color	Absent	If branches are present, many fine twigs are gone and remaining fine twigs have peeling bark
3	Heartwood sound; piece supports its own weight	Hard, large pieces; sapwood can be pulled apart by hand or sapwood absent	Reddish-brown or original color	Sapwood only	Branch stubs will not pull out
4	Heartwood rotten; piece does not support its own weight, but maintains its shape	Soft, small blocky pieces; a metal pin can be pushed into heartwood	Reddish or light brown	Through-out	Branch stubs pull out
5	None, piece no longer maintains its shape, it spreads out on ground	Soft; powdery when dry	Red-brown to dark brown	Through-out	Branch stubs and pitch pockets have usually rotted down

Table 7. Decadence codes for live trees.

Decadence code	Decadence feature
1	Conks
2	Cavities greater than 6 inches in diameter
3	Broken top
4	Large (> 12 inches in diameter) broken limb
5	Loose bark (sloughing)

### Point Count Stations

Habitat measurements were taken at 3 of the 6 point count stations forming the hexagon around the center (point count station due north (0°), southeast (120°) and southwest (240°). Habitat protocols at the 3 point count stations were almost identical to those used at the center point. The exception pertained to the line transect, where plant species along the transect and at each intercept were only recorded to genus. This allowed field crew members with lesser botanical skills to collect habitat data (critical to obtaining habitat data).

Data collected differently along line transects compared to center point:

- Along each woody debris transect, the vertical diversity of vegetation was described. Transects served as point intercept lines, where at every meter, starting at 1 m, the observer recorded all plant species intersecting the left side of the tape at any height above the tape. For each plant that intersected the vertically projected point, the plant species (genus if shrub or tree, graminoid if grass, herbaceous if herbaceous plant) and height interval of the intersect were recorded in 1 meter intervals up to 10 m, and then in 5 m intervals over 10 m (i.e., each meter from 0 to 10 meters, 10.1 to 15 m, 15.1 to 20.0m, 20.1 to 25.0 m, and so on).
- Ground cover measurements were recorded along each woody debris transect (as a check for the subplot estimates). At every 5 meters (at 0, 5, 10, 15, and 20 m) for 1 m length, the percentage of the 1 m length along the left side of the tape occupied by each of 7 ground cover types were estimated: herbaceous plant, grass, shrub, tree, rock, litter, bare soil. All shrubs and trees were identified to species, and other plant types are identified to species when possible.

### Bat Monitoring Stations

The same habitat protocol was used at bat monitoring sites as was used at point count stations. At lentic and lotic sites, the center of the habitat plots was placed 17.6 meters from the waters edge where the center mist net was placed, such that the 0.1 ha plot did not include the water body. A description of each water body was obtained using the following descriptors.

- Lentic habitats were described in the same manner as for aquatic habitats (see aquatic habitat measurements). If the lentic unit was dry, the habitat type was described and the area based on the maximum observed waterline was recorded.
- Lotic habitats were described within 150 m of either side of the center mist net (total of 300 m reach). Along the reach, the same information was recorded as described for aquatic habitats (see aquatic habitat measurements). In addition, all channel types (riffle, pool, cascade, run, step run, etc.) were record by walking the length of the 300 m reach, recording each habitat type in sequence (as per the USDA-PSW FHR Currents Stream Habitat Classification bulletin (McCain et al. 1990) or a similar guideline (see Rosgen habitat type field key), their length, average width (based on the width at 3 evenly spaced intervals along the habitat type – recording max width if a pool). If the stream was dry, then all possible channel measurements were recorded.

## Track Plate Stations

Habitat sampling at track plate stations followed sampling designed for fisher and marten surveys. It contained a combination of FIA measurements and additional habitat measures. In general, habitat measurements were limited to rapid measures based on the fact that track and camera stations were baited with food and attractants, so detections are not necessarily a reflection of habitat conditions in the immediate vicinity. The center of each habitat survey was 1 meter north of the bait at camera stations and at the open end of the track plate box at track plate stations. Measurements included a combination of three basic survey methods and multiple ocular estimates. Specifically, the following information was recorded at each track plate and Trailmaster camera station.

- Elevation
- Percent slope measured using a clinometer and averaging both uphill and downhill slope measurements from plot center
- Slope aspect measured at plot center
- The specific slope position was recorded based on local topography at the site, using the following acronyms:
  - DB- draw bottom
  - CC- concave slope (~ lower slopes)
  - B- bench or even slope (~ mid slopes)
  - CV- convex slope (~ upper slopes)
  - RT- ridge top (~ ridge tops of drainage boundaries)
- Distance to nearest flowing or standing water within 100 m. Record > 100 m for anything greater than 100 m away.
- Distance to the nearest road was recorded in the following distance categories: 0-50 m, 50-100 m and > 100m, and type of road was indicated as
  - 1 = primary highway (4 lanes, paved)
  - 2 = secondary highway (2 lanes, paved)
  - 3 = paved USFS road
  - 4 = unpaved USFS road
  - 5 = OHV / skid trail
  - 6 = foot trail
- The quantity of downed logs along 2, 25 m transects, one established at a random azimuth from the plot center and the other perpendicular to the first was recorded. Logs of decay class 1, 2, 3, or 4 only (do not count decay class 5 logs) were sampled using line intercept transects. Any log that touches the transect line and has a diameter at the large end of 15 cm or greater was recorded. Logs were recorded into four size classes based on the diameter of the large end (15-30 cm; 30-60 cm, 60-90 cm, and > 90 cm) [Note: in 2003, FIA log protocols will be used at these survey stations]
- The three dominant overstory, understory and woody shrub species were recorded.
- The total percent cover of each of the 3 dominant shrub species, all shrubs combined, total overstory, and total understory was estimated.
- Percent ground cover estimates for litter, soil/sand, rock and herbaceous plants were estimated visually within the 25 m radius circular plot around the center of the plot

[Note: in future years, these measurements will be confined to a 0.1 ha plot, as per the FIA protocol]

- Canopy cover readings using a densiometer were taken to determine average percent coverage of the overstory and understory combined. Four readings were taken (in each of the four cardinal directions) at 25 m away from the center of the plot at the end of each of the in each of the four cardinal directions, for a total of 16 readings. [Note: in future years, densiometer readings will be taken in each of the 4 cardinal directions at the perimeter of the 0.1 ha plot]
- A 20-factor prism was used to select live trees and snags for identification of species, diameter at breast height, height, condition, distance from plot center and azimuth from plot center. Condition class was recorded for each tree (Table 7) as described by Thomas (1979). [Note: in future years, decadence and decay class codes as per habitat plots will be used at track plate and camera stations.]

#### Aquatic Monitoring Network Sites

Habitat and disturbance features were described at each aquatic site regardless of its association (center monitoring point, bat survey site, lentic site).

At lentic sites, the following data were recorded:

- Habitat type. Every lentic site was classified according to a modified version of Moyle's classification (Manley et al. 2000).
- Unit area. Observers estimated area by estimating average length and width, and pacing the circumference (meters). Field measurements were checked against digital data. Sample unit area and perimeter were obtained from digitized USGS topographic maps or from USGS (1994) for wet meadows derived from that source.
- Maximum depth. Values for sample units with known depths (generally the larger lakes) were obtained from Schaffer (2002) or from knowledgeable individuals. For other sample units, observers waded when possible to the deepest part of the sample unit and measured the depth to the nearest 0.1 m using a PVC pipe or other measuring device. For deeper sample units up to 30 m, observers employed a reel with a lead sinker attached to a heavy fishing line on which 1 m increments were delineated. Depth was determined by lowering the line to the bottom from an inflatable raft. Maximum lake depth was recorded as the greatest depth (to the nearest 0.5 m) obtained from 5 measurements in locations likely to be at or near the deepest part of the sample unit.
- Shoreline depth and substrate. Thirty transects were characterized at each lentic unit to quantify shoreline depth, substrate, and emergent vegetation. For lakes and ponds, each transect was a 0.25m-wide line running perpendicular to the shoreline and extending 3 m into the water from the existing shoreline. For wet meadows and bogs, a randomly determined starting point was selected for a straight line across the longest dimension of the meadow. Observers walked from that point to the opposite end of the meadow, determining transect starting points by pacing the distance between points to ensure that 30 transects were conducted per habitat. For each transect, observers recorded the maximum depth, the average depth within 3 m of the shoreline (end of the transect), the percent of transect occupied by each of 6 substrate

types (silt, sand [particle size <2 mm], pebbles [2 to 75 mm], cobbles [5 to 300 mm], boulders [>300 mm], or bedrock), and emergent vegetation. Transects were placed at equal intervals around the shoreline.

- Disturbance. Disturbance was described within 30 m of the high watermark in lentic habitats:
  - area of each type of road (m<sup>2</sup>) within 30 m of shore - hwy, paved road, primary use dirt road, secondary dirt road
  - area of trails (m<sup>2</sup>) 30 m of shore
  - additional area (m<sup>2</sup>) of compacted soil and impermeable surfaces within 10m of the shoreline.
  - Based on the field data and GIS maps, a road density index around each sample unit was calculated (see Habitat measurements at terrestrial monitoring points).

### **Remotely Sensed and Additional Data**

Physiographic features of each point were described using remotely-sensed data, with some variables being duplicates of those collected in the field. The duplicity was intended to determine if remotely-sensed sources were reliable for these data, and if so, field measurements were dropped from the protocol for future years. Six features were described at each point: elevation, orientation to Lake Tahoe, mean annual precipitation, percent slope, aspect, and disturbance level (Appendices C and D). Elevation was obtained from 1:24,000 USGS topographic maps. To assess orographic differences in environmental relationships, 4 categories of basin orientation were used for data analysis. Each terrestrial monitoring point was assigned to an orientation to Lake Tahoe based on geological patterns that divided regions around the basin: north, south, east, or west side, as per the boundaries defined by FIA hexagons (Appendix C) and each lentic monitoring site was assigned orientation based on a similar delineation (Appendix D). Precipitation was derived from digital spatial data digitized from limited surveys conducted between 1920 and 1970 by TRPA. Spatial Analyst was used to interpolate a grid based on contours from the digitized precipitation data. Mean annual precipitation was reported as the average rainfall occurring within 400 m of each terrestrial monitoring point and within 200 m of each lentic monitoring site.

Slope and aspect were derived from both remotely sensed data and field measurements. Slope and aspect polygon maps were derived by interpreting topographic isoclines based on 10-meter digital elevation models (DEMs; USGS, 1998). The dominant (or majority) aspect and mean slope within 400 m radius of terrestrial and 200 m radius of lentic monitoring points were then calculated using ArcView Spatial Analyst. This method yields an average value for the area surrounding each sample unit. Field measurements for slope angle were calculated as the average percent slope from uphill and downhill measurements across all 4 stations for each terrestrial monitoring point. Slope aspect was calculated as the average aspect (0°- 359°) recorded at the 4 stations per terrestrial monitoring point (see Habitat Protocols section).

Dominant terrestrial vegetation type was derived with remotely sensed data and field measurements for terrestrial monitoring points only (Appendix C). Dominant

CWHR habitat type was determined as the vegetation type present at the majority of the 4 stations surveyed at each point in the field and also based on remotely sensed data (eveg\_97\_4). At points with no majority habitat type across the 4 stations (n = 2 points), the habitat type was recorded as a composite of codominant types (e.g., Jeffrey pine/White fir). Habitat types at lentic sites were derived slightly differently (Manley et al. 2000), and these classes may be used for the purpose of investigating change over time at lentic units (Appendix D).

Disturbance index values for terrestrial points were calculated as the percent of the total area within 400 m of the central monitoring point covered by human caused disturbances. Human caused disturbances were defined by the following attributes: forest roads, trails, recreation areas (including golf courses, campgrounds, athletic fields, visitor centers, public beaches, picnic areas, public parks, marinas, trailheads) and impervious surfaces as defined in the IKONOS dataset. Disturbance measures at lentic sites were defined by the Recreational Opportunity Spectrum (ROS) designations for the Tahoe basin and followed that described in Manley and Schlesinger (2001).

## **G. Data Analysis Procedures**

### **All Vertebrate Protocols**

Species composition, richness and average abundances per species were summarized for each protocol per monitoring point, per habitat class surveyed, per orientation around Lake Tahoe (north, south, east or west) and across all 40 monitoring points. The relationship between survey date and point elevation was depicted for all protocols. The following habitat classes were used: lower montane conifer (any coniferous forest as determined by CWHR classification system  $\geq 10$  % canopy cover at elevations  $< 7000$ ft (2134m)); upper montane conifer (any coniferous forest  $\geq 10$  % canopy cover at elevations from 7000 to 8500ft (2134 – <2591 m)); subalpine conifer (any coniferous forest  $\geq 10$  % canopy cover at elevations  $\geq 8500$ ft ( $\geq 2591$  m)); shrub habitat (combination of all shrub CWHR habitat types at all elevations) and meadow/riparian (combination of wet meadow, aspen and montane riparian CWHR habitat types at all elevations). Habitat classes were assigned to each of the 40 monitoring points, using field collected data, based on the dominant habitat type across four point counts surrounding the central monitoring point (see Habitat Surveys in Results section). For points showing co-dominance with respect to habitat type at the four point count stations, we assigned the habitat class most representative of the area within 300 m around the monitoring point, based on field verification.

Detections of Management Indicator Species (MIS), Forest Service sensitive species, California species of concern and any federal or state listed threatened or endangered species were noted and discussed.

We calculated the observed and estimated proportion of points occupied (i.e., percent of points occupied) and the probability of detection per species for each protocol in which we completed multiple survey visits to a single monitoring point (Table 8). Estimated proportion of points occupied (ppo) and probability of detection (pd) were determined using PRESENCE (McKenzie et al. 2002), which uses information about

species detectability across multiple sampling occasions to each point (probability of detection) to generate estimates of actual points occupied. Table 8 lists metrics used as sampling occasions and the associated maximum number of sampling occasions possible for each protocol for which this analysis was conducted.

Table 8. Sampling occasion metrics for each protocol or combination of protocols and their associated maximum values across all points surveyed in 2002.

<b>Protocol</b>	<b>Sampling Occasion</b>	<b>Maximum sampling occasions</b>
Point counts	Survey visit	3
Sherman live traps	Trap night	3
Track plates	Site check (every other day)	5
Cameras	Site check (every other day)	5
Track plate and cameras	Site by protocol check (every other day)	10
Pitfall traps and coverboards	Site check (1-2x per week)	22
Aquatic bird surveys	Survey visit	2
Aquatic reptile and amphibian surveys	Survey visit	2

For species detected with multiple protocols during 2002 ( $n = 30$ ; Appendix E), we generated estimates for *pd* and *ppo* independently for each protocol.

Estimated proportion of points occupied is a reliable monitoring metric that can be used to measure trends in species occurrences over time if points are resampled periodically with the similar protocols. Therefore, we estimated the proportion of points occupied for most protocols. We used two algorithms for estimations. For sampling protocols that consisted of a single sample location or a cohesive array (i.e., Sherman trapping) at each point, we use the program PRESENCE developed by Patuxent Wildlife Research Center (McKenzie et al. 2002). For sampling protocols that consisted of multiple sample locations at each point (i.e., bat surveys, point counts), we used a program developed by Jim Baldwin at Pacific Southwest Research Center (Jim Baldwin, pers. comm). We will be using the observed and estimated proportion of points occupied data to evaluate sample size adequacy for detecting trends in the final report.

Protocol efficiency was evaluated in a number of ways. First, we calculated the percentage of the target vertebrate assemblage detected within National Forest Lands in the Lake Tahoe basin for each survey protocol (e.g., trapping, point counts). Murphy and Knopp (2000) published a list of all vertebrate species ever recorded in the Lake Tahoe basin. We used a subset of this list, species currently present in the Tahoe basin, for our analysis. Additionally, only those taxonomic groups targeted with each protocol (e.g., small mammals small enough to be reasonably expected to fit in a Sherman live trap were expected to be detected by the trapping protocol) were included in the efficiency analysis for the respective protocol. The vertebrate list generated by Murphy and Knopp (2000) was based on all habitat types occurring in the Tahoe basin, not only those on National Forest lands (LTBMU). We did not, however, account for differential representation of habitat types in our sample (LTBMU land only) relative to what occurs across all land types in the basin. Table 9 illustrates the slight differences between habitat representation

on National Forest lands and all land area within the Lake Tahoe basin (excluding Lake Tahoe itself). Habitat type distributions on NFS lands in the basin are fairly similar to that in the basin as a whole without consideration of Lake Tahoe itself, however, montane conifer and urban types are slightly underrepresented.

Table 9. Percentages of land area within the Lake Tahoe basin and National Forest system lands alone represented by 8 main habitat types, and the percentage of points in the 2002 sample within each habitat type.

<b>Habitat Type</b>	<b>Lake Tahoe basin</b>	<b>National Forest lands (LTBMU)</b>	<b>2002 sample</b>
Montane conifer	46.9	41.6	32.5
Shrub	15.9	17.6	12.5
Lodgepole	13.5	16.9	15
Sub-alpine conifer	12.7	16.1	15
Meadow/grass	3.7	3.6	5
Barren	2.4	2.7	0
Lentic riparian	1.6	0.6	5
Aspen	0.5	0.5	5
Lotic riparian	0.1	0.1	10
Urban	2.6	0.2	0
Unmapped	0.1	0.1	0

Second, we evaluated the number and proportion of additional species detections with increments of additional effort (e.g., point count stations, trap nights, visits). We also investigated whether species detected with the multi-species monitoring protocols were representative of all species expected to occur in the Tahoe basin with regard to their life history traits. We determined whether there were any obvious relationships (e.g., biases, gaps) between the frequency of detection of species targeted by each protocol and associated life history characteristics (Table 10).

Life history characteristics evaluated for representation in each protocol's dataset were derived from the Sierran All Species Information (SASI) terrestrial vertebrate database (USDA 1999).

Table 10. Description of life history characteristics used to evaluate protocol efficiencies and biases of species re data set

Life History Characteristic	Species Group	Description	Source Document
Taxonomic Class*	Aves Mammalia Amphibia Reptilia	Class of vertebrate organism	
Habitat specificity	Highly specific Moderately specific Habitat generalist	Proportion of CWHR vegetation type – structural/canopy cover classes (Mayer and Laudenslayer 1988) ranked with a low, medium or high index value relative to the total number of classes possible in the Sierra Nevada for a species	CDFG 2000
Old growth dependency	requires old growth uses old growth does not use old growth		
Riparian dependency	Requires riparian habitat Uses riparian habitat Does not use riparian habitat		
Habitat association	Terrestrial Semi-aquatic Aquatic		Zeiner et al. (1988, 1990a, b)
Trophic level	Carnivore Scavenger Omnivore Herbivore Nectar-eater		Amphibians, reptiles and mammal: et al. (1988, 1990b) Birds: Ehrlich et al. (1988)

Life History Characteristic	Species Group	Description	Source Document
Home range size	Small = <0.1 ha Medium = 0.1 to <40 ha Large = 40 to <500 ha Extensive = ≥ 500 ha		Zeiner et al (1988, 1990a, b)
Body mass	Small = <0.20 kg Medium = 0.2 to ≤ 0.68 kg Large = > 0.68 to ≤ 0.523 kg Very Large = > 523 kg		Bird: Dunning (1984) Mammals: Burt and Grossenheider Herpetofauna: G. Fellers unpubl. I Welsh and A. Lind unpubl. Data, I unpubl. Data, Licht 1965, Kaufman Gibbons 1975, Lewke 1979, Parm 1981, Kline 1985, Whittier and Cr Meienberger et al. 1993, Talbot an 1993, Holland 1994
Species of concern	Listed as threatened or endangered at state or federal level, Forest Service Sensitive, or California state species of concern Not listed as above		USDI Fish and Wildlife Service, Sacramento, California California Department of Fish and Sacramento, California USDA Forest Service, Vallejo, Cal
Management indicator status	Management indicator species (MIS) Not an MIS		USDA Forest Service, Lake Tahoe management unit, South Lake Tah California
Endemism	Sierra Nevada or California endemic Neither endemic to Sierra Nevada or California, but not exotic to these regions Exotic to Sierra Nevada		Zeiner et al (1988, 1990a, b) Gaber (1996)
Migratory status	Non migrant Short distance migrant = exhibits seasonal/annual shifts		Mammals and herpetofauna: CWH Birds: Davidson and Manley 1993

Life History Characteristic	Species Group	Description	Source Document
Reproductive potential	in elevation or habitat, but remain in Sierra Nevada Long distance migrant = all or part of population moves out of Sierra Nevada seasonally Nomadic = exhibiting irregular movements, sometimes remaining in Sierra Nevada year-round, and other times ranging out of Sierra Nevada seasonally  0-9 offspring/female/year 10-22 offspring/female/year 23 – 150 offspring/female/year > 150 offspring/female/year		Mammals and herpetofauna: CWH Miller and Robbins 1954 Birds: Ehrlich et al 1988

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\*Variable used in analysis with all protocols combined only

## Point counts

For all point count data summaries, detections of birds at all distances from the point count station and of all species within the 10 minute survey time period were included in the dataset unless otherwise noted. All abundance values were calculated by averaging the number of individuals detected per point across count stations, and then across all visits (2-3 visits) per point. Points with three survey visits were nearly evenly distributed across all four basin orientations (n, s, e and w) and five habitat types (according to GIS; *evcg\_97\_6*), hence, abundance estimates presented by orientation and habitat groups were not biased by including all visits. All species richness calculations, however, were derived using only the first two survey visits to points in order to accurately reflect the relative richness among points by standardizing survey effort per point. Hutton's Vireo was detected by a single observer at five count stations during 2002; these data were excluded from the data set as occurrence of the Hutton's Vireo is considered unlikely (not known to occur in the Tahoe basin). Detections were possibly mistaken for Cassin's Finch, which were detected by other observers at three of these five locations.

Sampling bias and efficiency were evaluated based on the number of species detected, species composition, and species abundance relative to life history characteristics, the number of visits per point, number of count stations per point, observers, and date. This analysis allowed us to evaluate 1) whether life history traits of birds detected during 2002 were representative of life history traits of all birds occurring in the Tahoe basin (see All vertebrate protocols section above), 2) whether observers were biased with regard to species detections or abundances, 3) the appropriateness of survey timing during the breeding season in the basin and 4) the effectiveness of multiple survey visits and count stations at increasing species detections.

Observer bias was explored by comparing the number of species detected and detection rates between the three main observers. We counted the number of species uniquely detected, and missed by each observer over the course of the summer, and compared the average number of bird detections per point count between observers using ANOVA.

To evaluate whether our surveys were appropriately timed to detect a maximal assemblage of species during the breeding season, we first investigated the relationship between bird abundance (all species detections) and survey date to determine if bird abundance declined during any portion of the survey season. Abundance changes were interpreted with regard to their influence on possible detections of species. Second, we focused on individual species responses during the survey period. We determined how many and which species were detected uniquely during the first, second and third portion of the survey season (each portion is an equal number of sequential surveys when arranged chronologically) to indicate any species with a potentially limited period of detection. We also investigated per species patterns of abundance (detections per count) with survey date. Patterns of abundance were evaluated separately for points at low (< 2134 m), mid (2134 m – < 2576 m) and high ( $\geq$  2576 m) elevations in an attempt to eliminate the confounding effects of elevation with survey timing. We looked for any predominating patterns across species of either increasing or decreasing trends in

abundance with date that might indicate whether the survey period should be adjusted in future efforts. For each of the three elevational groups of points, per species abundance changes were calculated as the mean abundance per count during each of 3 roughly equal time periods over which all surveys in each elevational group were conducted. Time periods were 13 – 28 June, 29 June – 14 July and 15 – 29 July for low elevation points; 19 June – 2 July, 3 – 15 July and 16 July – 5 August for mid elevation points; and 2 – 12 July, 13 – 23 July and 24 July – 2 August for high elevation points.

We used maximum likelihood estimation to evaluate the relative contribution of sample stations and visits on the accumulation of species detected to determine the most efficient combination of stations and visits for detecting bird species.

To evaluate the benefit of additional survey time for increasing species detections (i.e., species accumulation), we determined whether there was an increase in cumulative mean species richness with each additional time period surveyed at each point. To evaluate the effects of the survey period length on detection of additional species, we averaged cumulative species richness (per minute of survey time) after 3, 5 and 10 minutes of survey time.

### **Sherman Live Trapping**

Abundance estimates per species per point were calculated as the number of first captures (i.e., unmarked individuals) per 100 trap days. A trap day was defined as one trap set out for a 24-hour period of time including one morning and one evening check, for a total of 3 trap days. Trap days per point were calculated as the number of traps set per point ( $n = 103$ ) multiplied by the number of days of trapping ( $n = 3$  days) less one half the total number of non-functional traps discovered during both morning and afternoon trap checks. A trap that was non-functional for both one morning and one afternoon trap check was considered a non-functional for a single trap night (or trap day). Non-functional traps included traps that were tripped with no animals in them, traps at which bait was stolen and no animal captured, destroyed traps and traps that were missing or disappeared. Mortality rates (i.e., trap deaths/total number of individuals captured) were summarized per species across all points surveyed.

Seasonal patterns in species composition and abundance were investigated to evaluate: 1) the appropriateness of survey timing during summer 2002 as indicated by consistent capture rates over the course of the summer; and 2) whether individual species were predominantly detected early or late in the season which might indicate biases in sampling effort. To accomplish these 2 objectives, we; 1) compared first and last capture dates per species across all points to the first and last dates of trapping surveys during summer 2002; 2) conducted regression analysis to determine if there was a linear relationship between mean capture rates of small mammals (i.e., first time captures of all species combined) per day per point and survey date; and 3) qualitatively compared the mean capture rates per species across each month of surveys. All captures were identified to species, with the exception of some shrews. Vagrant and montane shrews (*Sorex vagrans* and *S. monticolus*) are nearly indistinguishable in the field (dissection required for identification to species) and therefore were treated as a single unique taxonomic group for all analyses completed.

Trap effort required to effectively detect small mammal species assemblages at every point was investigated using species accumulation curves. We qualitatively evaluated the efficiency of multiple levels of trap effort by comparing increases in proportion of the species assemblage detected per point with each additional transect (13 traps each) from 1 to 8 transects and with each additional survey day from 1 to 3 days. To do this, we determined the average cumulative proportion of the species assemblage detected per point per effort level across three random orderings of the 8 transects and the 3 survey days.

### **Track plates and Cameras**

Analysis of track plate and camera data focused on detections of target species groups. Target species were medium and large bodied carnivores occurring in the Tahoe basin including species likely to be detected with track plates and cameras (Appendix F). Detection frequencies of all target species were summarized by detection method (e.g., track plates, cameras) and across both track plates and cameras combined. Additional species detections (e.g., rodents, birds) were noted. Detection frequencies per species were calculated as the number of station visits per point at which each species was detected. Detection frequencies varied between 0 and a maximum of 30 for track plates alone (6 track stations x 5 visits to each over 10 day sample period), between 0 and 20 for camera stations alone (4 stations x 5 visits), and between 0 and 50 for track plates and cameras combined (10 track plate and camera stations x 5 visits). Detection frequencies were not intended to be a surrogate for abundance values, but instead to indicate the detectability of a particular species given the method of detection.

To evaluate whether species detected with track plate and camera survey protocols were representative of all carnivore species expected to occur in the Tahoe basin with regard to their life history traits (see All Vertebrate Protocols section above), we used the suite of species detected between  $> 5$  and  $\leq 50\%$  of points, since no species were detected at  $> 50\%$  of points.

Seasonal patterns in species composition were investigated to evaluate whether any species were predominantly detected early or late in the season, perhaps indicating biases in sampling effort based on survey timing during the summer season. To accomplish this, we compared first and last capture dates per species across all points relative to the first and last survey dates in 2002.

To further evaluate the effectiveness of track plate and camera methods at detecting target species, we compared the latency of first detection for each species with each method. Latency of detection was defined as the minimum number of days from camera or track station set up to the first detection of a species at a given point.

Species accumulation was investigated for track plates (tp) and TrailMaster® cameras (tm) separately and combined for increasing numbers of stations (1-6 for tp, 1-4 for tm, 1-4 paired sites for tptm) using a similar method to that described for point counts and Sherman live trapping above. The number of stations were randomly ordered 3 times and the average cumulative number of species detected per point with each increasing number of stations (1-4, or 1-6) was calculated from the three random samples. Similarly, we additionally determined species accumulation with increasing number of checks from 1-5 checks at tptm paired sites only (4 paired stations). For all species

accumulation analyses, only points with at least one species detection were included (tp, n = 13, tm n = 10, tptm, n = 16).

### **Bat mist-netting and Acoustic surveys**

Data from 8 points surveyed in 2001 and re-sampled in 2002 were used to inform and evaluate habitat type associations (the four basin points only), sampling efficiency and inter-year variation only. All other analyses only use data from the 22 monitoring points.

A chi-square Goodness of Fit analysis was conducted for all bat species and the habitat types they were detected in to determine if species were found at habitats in proportion to their occurrence.

A chi-square Likelihood Ratio analysis was utilized to explore potential correlations between a set of life history characteristics relevant for bats and their frequency of detection. We assigned all species whose range includes the Lake Tahoe basin (n=16) to one of three frequency classes: low (captured at <10 points, actual 2-6), high (captured at >10 points, actual 10-13), or not captured (expected but not detected, see below). Life history characteristics included migratory status, population size, and aspect ratio to wing loading ratio. Migratory status and population size data were retrieved from the Sierran All Species Information database (USDA 1999), where categories for migratory status were non-migratory, short-distance migrant, or long-distance migrant; population categories were <1000, 1,001-10,000, and >10,000 individuals. Aspect ratio to wing loading values have been used by researchers to generally infer the type of foraging behavior a species employs and, consequently, which habitats may be more suitable for foraging. Although values for aspect ratio (wingspan divided by wing area) and wing loading (a measure involving weight, flight speed, and wing area) are continuous, they are often categorized into low and high and represented as a ratio that places species into one of four possibilities: L:L, L:H, H:H, H:L (Norberg and Rayner 1987).

Linear regressions using SAS statistical package were used to examine the relationship between temperature at the time of net closure with the total number of individuals captured, and between total meters of net used with the total number of captures per site.

Prior to any netting activity bat biologists rated each site associated with a point on a scale from 1 (best) to 3 (fair) to help determine how well an experienced biologist is at predicting the most productive sites. Ratings were based on features such as the amount of open, calm water for drinking and foraging, and how well the surrounding vegetation assisted in directing bats to areas that could be thoroughly occupied with net. All points did not have associated sites rated by all biologists due to the inability to visit all sites prior to conducting surveys.

Acoustic surveys were conducted periodically during mist netting surveys so that a direct comparison could be made between the two techniques. We conducted acoustic surveys using a time expansion Petterson bat detector with Sonobat call analysis software. Bat

call files were analyzed by measuring characteristics such as call frequency, duration, and slope. Ranges of these measurement data were compiled for each species from positively identified reference calls, and a key using the most conservative ranges was developed. Call files were then identified to species or species couplet using this key and confirmed by comparing calls to those in the Sonobat reference library. In order to demonstrate the contribution acoustic surveys can make in more fully describing the bat community associated at the point or site level, results from the 2001 pilot study and the 2002 monitoring season will be reported. The pilot study consisted of 12 points distributed in clusters of four points each across three elevation gradients of low, middle, and high. Low and middle elevation points were located on the ENF and high elevation points on the LTBMU, with each point having three sites associated with it for conducting bat surveys. In 2001, simultaneous acoustic surveys were conducted on one to three occasions at most of the 36 sites, beginning on the first or second survey night when possible. No acoustic surveys occurred at two sites in low elevation and one each in middle and high elevations. In 2002, one or two simultaneous acoustic surveys occurred at 39 of the 60 LTBMU monitoring sites, and at 13 of the pilot study sites on ENF and LTBMU. One crew member (the acoustic monitor) recorded bat echolocations for a minimum of one hour starting at sunset, while other crewmembers removed bats from the nets and processed them. Occasionally, the acoustic monitor was required to assist with netting, in which case the acoustic monitor noted start and stop times of acoustic surveys. We attempted to acoustically monitor for at least 60 minutes per night in 2001 and 90 minutes in 2002. In both years every attempt was made to acoustically survey during the first hour of netting when bats are most active.

Survey effort and species captured were first summarized across sites, PSUs, habitat types, and elevation zones (four sites resurveyed in 2002 were in low elevation). Sampling efficiency was then evaluated using a non-parametric probabilistic estimator, as opposed to bootstrapped species accumulation curves that have been used to evaluate bat sampling efficiency in the past (Soberón and Llorente 1993, Moreno and Halffter 2000), because it enabled the calculation of species-specific detection probabilities. We reasoned that the probability that a species was observed at a particular site was influenced by:

$P$  = probability the species occurred at a site

$r$  = conditional probability that the species occurred at a site given that it occurred in the PSU

$p$  = conditional probability that the species was detected given that it occurred at a site

$q$  = conditional probability that the species was not detected given that it occurred at a site ( $q = 1 - p$ )

Thus, the unconditional probability that a species is detected at a site in  $s$  visits is given by  $P(1 - q^s)$ . We used a maximum likelihood approach to obtain estimates of  $P$ ,  $q$ , and  $r$  for each species where  $m_j$  was the number of sites at PSU $j$  with  $s_{jk}$  visits to site  $k$  in PSU $j$ . The number of visits with presence of a particular species at site  $k$  of PSU  $j$  was represented by  $y_{jk}$ . Given a realized value of  $P_j$ , the likelihood of observing counts  $y_{j,1}, y_{j,2}, \dots, y_{j,m_j}$  at PSU  $j$  is

$$L_j = 1 - P_j + P_j \prod_{k=1}^{n_j} (1 - r + rq^{m_{jk}}) \quad \text{if } \max_k(y_{jk}) = 0$$

$$= P_j \prod_{k=1}^{n_j} f_{jk} \quad \text{otherwise}$$

where

$$f_{jk} = 1 - r + rq^{m_{jk}} \quad \text{if } y_{jk} = 0$$

$$= r(1 - q)^{y_{jk}} q^{m_{jk} - y_{jk}} \quad \text{if } y_{jk} > 0$$

Maximum likelihood estimation was conducted using PROC NLMIXED in SAS v. 8.1. We used PROC NLMIXED rather than pre-packaged estimators of probability of detection and proportion of sites occupied, such as PRESENCE (MacKenzie et al. in press), because it allowed us to model multiple sites per PSU, and we were able to fit a more general model (Cam et al. 2002). This modeling approach required the following assumptions: 1) that species were correctly identified, and 2) that the probability of detecting one species was independent of the probability of detecting the another species during the same visit, the same species at a subsequent visit, and the same species at another PSU. We used all surveys to all sites to estimate parameters.

### **Pitfall and Coverboard Surveys**

Sampling efficiencies and biases were investigated differently for pitfall and coverboard surveys than other survey protocols. Species detections were not evaluated for whether they were representative of species occurring in the Tahoe basin with regard to life history traits; most species were detected too infrequently in this effort to make any preliminary conclusions. However, we did explore differences in species detections between pitfall traps with and without twine (used as an escape mechanism for small mammals; Karracker 2001) and with and without bait (used to increase small mammal survival rates) in an attempt to evaluate the effectiveness of pitfall traps at detecting target taxonomic groups while reducing impacts to small mammals. We focused our investigation on captures of shrews (*Sorex spp.*) alone, and on all small mammals combined.

### **Plant Species Composition and Habitat Conditions**

Both field and GIS data were combined for the generation of variables used to describe habitat condition and plant species composition per point. Habitat types were determined at monitoring points in two ways: 1) by using remotely sensed vegetation data based on Cal Veg for the Lake Tahoe basin (eveg\_97\_6, 1997); and 2) using tree species composition and canopy cover measurements from the field. Comparisons between habitat type assignments based on GIS and field data were made to evaluate the reliability of GIS generated habitat data.

The categorization of habitat at each of the monitoring points as tree dominated ( $>10\%$ ) or non-tree dominated ( $\leq 10\%$ ) was determined based on overstory canopy cover (Mayer and Laudenslayer 1988). Tree dominated habitat for each station per monitoring point was defined as any station with a mean  $\pm 1$  standard error overstory canopy cover  $> 10\%$ . For stations determined to be tree dominated, the overstory species composition was used to determine habitat type according to CWHR (Mayer and Laudenslayer 1988). If the habitat type did not have  $> 10\%$  overstory canopy cover then the percent of shrub and herbaceous cover as well as species composition was used to determine CWHR habitat type.

Plant species composition and richness of herbaceous vegetation was determined per monitoring point using the combined data from the quadrat, subplot, and line intercept components of habitat surveys at each of 40 center point locations. Species composition and richness for woody species was determined per monitoring point using the quadrat, subplot, circular plot and line intercept methods at center-points, plus the 3 surrounding stations at each monitoring point. Mean species richness per station was calculated for each identified CWHR habitat type ( $n = 10$ ).

Variables used to describe general habitat conditions were collected at center points and the 3 surrounding stations per monitoring point. Mean canopy cover per station was calculated from 16 measurements taken (Habitat protocols section). Given that canopy cover is highly variable among vegetation types, and that stations surrounding monitoring points often existed in different vegetation types, mean percent canopy cover was calculated across stations within similar CWHR vegetation types. Mean litter depth was calculated in the same manor as canopy cover with the exception that only 3 – 6 litter measurements were taken at each of the 4 stations per monitoring point.

Mean percent shrub and herbaceous cover were calculated for each of the 4 stations at each monitoring point using line intercept data collected along transects. Percent cover in each of 6 classes (rock, litter, coarse woody debris, herbaceous vegetation, tree and shrub) were calculated for each station per monitoring point, and then averaged by habitat type. Herbaceous cover included all non-woody stemmed vegetation and was not separated by life form (e.g., grasses, forbs, etc.) due to minimal species identification skills of field personnel.

Mean volume ( $m^3$ ) per hectare of coarse woody debris (e.g., logs) was calculated per habitat type and for each of 2 size and 2 hardness classes using data collected along 2 25 m transects at each of the 4 stations per monitoring point (Waddell 2002). Total volume of each log intersecting transects was calculated using the model of volume of a partial cone. All logs were classified as either small ( $\leq 30.5$  cm (12 in) diameter) or large ( $> 30.5$  cm diameter) or as both. Individual logs of which a portion was  $>30.5$  cm diameter were split into meters of large and small log and the volume split accordingly. Logs were also split into 2 categories of hardness based on the decay recorded in the field. Logs with a decay class of 2 or less as defined above (Habitat protocols section) were categorized as hard, those with a decay class of  $> 2$  were considered soft.

The density of live trees in 4 dbh classes and basal area per hectare was calculated for each habitat type using data from 3 circular plots of varying diameter at each of the 4 stations surrounding each monitoring point. Density of trees in each size class was calculated by multiplying the number of stems in that size class by the appropriate

multiplier for the size plot in which the trees were measured. The following multipliers were used: 40 (trees 12.5- 28.5 cm (5 – 11 in) dbh); 10 (trees >28.5- 60.5 cm (11-24 in) dbh); and 1 (trees >60.5- 76.5 (24-30 in) and >76.5 cm (>30 in) dbh). The total basal area per hectare was calculated by multiplying the per stem density, calculated using the same multipliers above, by the dbh of each stem and then generating the total for each point. Means of both tree density and total basal area per hectare were then calculated by habitat type.

The density of snags per hectare for 4 dbh by hardness classes were calculated for each habitat type using the same circular plots that were used to calculate tree densities. Snags were categorized by dbh into small (30.5-60.5 cm) and large (>60.5 cm) size classes. Number of small snags was multiplied by 10, and large snags by 1 to calculate stems per hectare. These snags were further divided into hard (decay class of  $\leq 2$ ) and soft (decay class  $>2$ ) classes. Mean density of each size by hardness class were then calculated for each habitat type.

### **Aquatic Vertebrate Surveys**

All values are reported based on data collected during first visits to lentic units only, unless otherwise stated. Evaluation of whether aquatic herpetofaunal detections were representative of herpetofauna in the Tahoe basin relative to life history traits was not completed extensively because nearly all aquatic species occurring in the basin were detected as expected.

Additional considerations of this dataset beyond that described in the All Vertebrate Protocols section include the investigation of seasonal patterns of species detections and discussion of the added efficiency of multiple visits to sites with regard to increased detections of species.

To evaluate whether bird species detected at lentic units were representative of all aquatic associated species expected to occur in the Tahoe basin with regard to their life history traits (All Vertebrate Protocols section), we used the suite of species detected between  $> 5$  and  $\leq 50\%$  of points, because no species were detected at  $> 50\%$  of points.

## **H. Terrestrial Monitoring Network Results**

### **Terrestrial Point Characteristics**

The majority of monitoring points ( $n = 37, 93.5\%$ ) were dominated by coniferous forest habitat, a single point was dominated by alpine dwarf shrub habitat and 2 were dominated by wet meadow habitat (Appendix C). Small perennial and ephemeral streams passed within 100 m of many monitoring points, resulting in riparian habitats being contained within the sampling units of 34 of the 40 points surveyed. Riparian habitat comprised an average of 15% of the area within 300 m of the 34 points where it occurred. Similarly aspen and wet meadow habitats were present at 6 and 10 monitoring points, respectively; these habitat types made up an average of 7 and 5% of the 300 m area around points where they occurred.

Abiotic characteristics varied considerably across monitoring points. Points ranged from 1902 m in elevation near the shores of Lake Tahoe up to 2987 m near the Tahoe Basin rim, and represented locations in all 4 basin orientations around Lake Tahoe (Figure 8). Sixteen points were located in the south, where the majority of national forest system land exists in the basin, 10, 7 and 7 points were located on the west, north and east portions of the basin, respectively. Mean annual rainfall ranged from 45 to 102 cm among points, and reflected the transitional nature of the climate in this region on the eastern side of the Sierra Nevada crest. Monitoring points also represented a variety of terrain within the basin, and were located on slopes that varied from flat (0% slope) to very steep (50.5%) and were distributed across all aspects (Appendix C), with 72.5% of points on slopes facing between 90-270°. Individual monitoring point characteristics are listed in Appendix C.

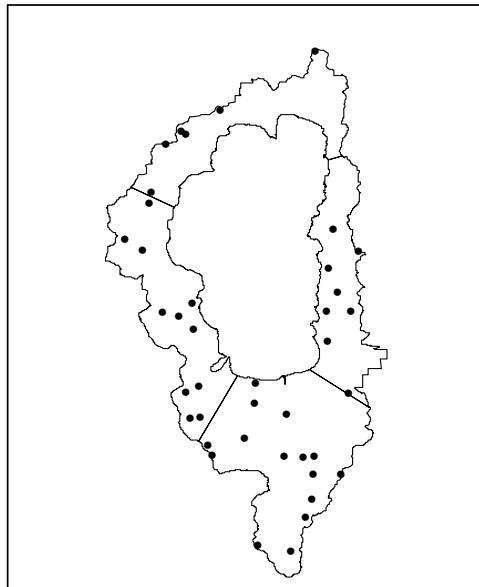


Figure 8. Locations and basin orientations of 40 terrestrial monitoring network sites surveyed in 2002 in the Lake Tahoe basin.

Of all 40 monitoring points surveyed, 21 had measurable amounts of permanent human disturbance or development (e.g., Forest roads, city roads, parking lots, golf courses, campgrounds, trailheads, and etc.) within 400 m of the central monitoring point (Appendix C). Most of the 21 points with associated development (90%) had less than 5% of the total area within 400 m as developed and only 2 points had greater than 5% total area developed (15 and 17%; Appendix C). The remaining 19 points had no associated permanent development. Non-permanent human disturbance (i.e., recreational use) was not measured at the 40 monitoring points, however, the presence of trails alone within 100 m of habitat survey plots (PC1, PC2, PC4 and PC6) provided a useful index of potential use and non-permanent human disturbances at the 19 sites mentioned above that had no measurable amounts of permanent human disturbance. At these 19 sites with no

permanent disturbance, 9 (47%) had the presence of one or more trails passing within 100 m of at least one of the 4 PC stations surveyed for habitat condition (Appendix C). This may suggest the potential for these 9 sites to be temporarily impacted by human disturbances (e.g., recreational use) compared to the remaining 10 sites with neither permanent nor temporary human disturbances.

## Point Counts

### Survey Effort

A total of 714 point count surveys were conducted from 13 June to 5 August 2002 at 40 monitoring points. Two visits were completed at 17 points, and three visits were conducted at the remaining 23 points. First visits were completed by 26 July, second visits started 21 June and were completed 2 August, and third visits began 11 July. Given that counts started at low elevation sites and moved up in elevation, visit number and date were both correlated with elevation (Figure 9). In addition to sampling the 40 monitoring points, eight monitoring points sampled in 2001 were resampled in 2002 between 25 May and 2 August.

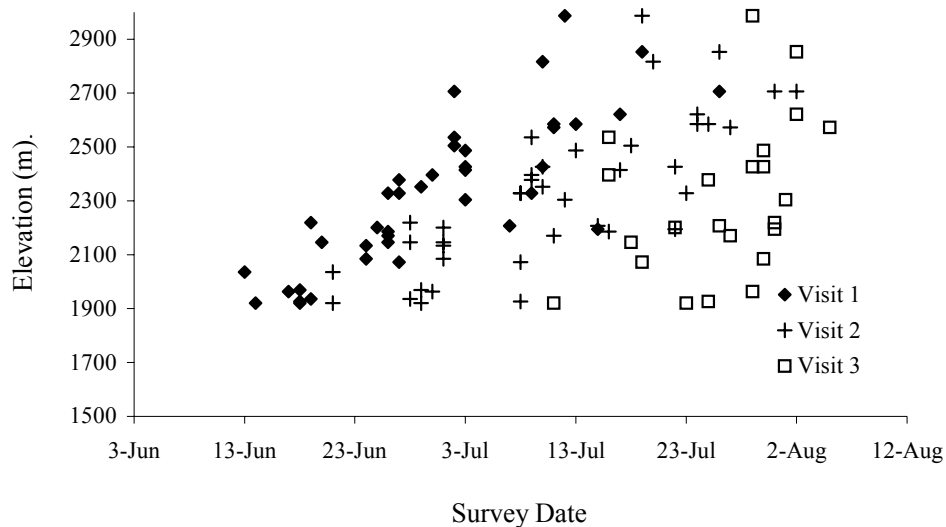


Figure 9. Relationship between survey date and elevation for all point count surveys conducted on 2-3 occasions (i.e., visits) to the 40 monitoring points during summer 2002.

## Species Occurrence and Abundance

Ninety-eight bird species were detected at the 40 monitoring points in 2002 (Appendix G), with an average of 31.75 species (s.d. = 6.0, min = 16, max = 46) detected per point and 10.3 species (s.d. = 3.3) per count (statistics based on first two visits to each point). Five bird species were detected during at least one visit at all 40 monitoring points: American Robin, Mountain Chickadee, Oregon Junco, Steller's Jay and Yellow-rumped Warbler. Approximately 32% of all species (n = 31) were detected at  $\geq 50\%$  of all points, 21% of the species were only detected at a single point, and the remaining 47% of the species were detected at 2 to 19 points.

Mean bird species richness was greatest in wet meadow habitat (37.0 species, s.d. = 12.7), followed by lower montane conifer habitat (33.4 species, s.d. = 4.8), and was lowest in subalpine conifer habitat (25.0 species, s.d. = 6.3; Appendix H). Additionally, mean species richness was greatest at points located on the east (33.9 species, s.d. = 3.3) and west (33.8 species, s.d. = 5.0) side of the Lake Tahoe basin and least at points in the southern portion of the basin ( $29.8 \pm 7.1$ ; Appendix I).

Four of the five most commonly occurring species were among the five most abundant species: Oregon Junco ( $\bar{x} = 2.0$  individuals/count/point, s.e. = 0.1), Mountain Chickadee ( $\bar{x} = 1.9$  individuals, s.e. = 0.1), Steller's Jay ( $\bar{x} = 1.7$  individuals, s.e. = 0.2), Fox Sparrow ( $\bar{x} = 1.0$  individuals, s.e. = 0.2) and the American Robin ( $\bar{x} = 1.0$  individuals, s.e. = .1) (Appendix H). Overall, we detected an average of 19.4 individuals (s.e. = 0.7) per count per monitoring point.

## Detections of Special Interest Species

Four of the eight currently listed bird Management Indicator Species (MIS) were detected during point count surveys (Appendix G): Blue Grouse (*Dendragapus obscurus*; n = 12 points), Mallard (*Anas platyrhynchos*; n = 7 points), Pileated Woodpecker (*Dryocopus pileatus*; n = 3 points) and Northern Goshawk (n = 1 point). Northern Goshawk is both an MIS and a TRPA special interest species. None of the 4 detected MIS were detected frequently enough to be effectively monitored (i.e., detect 20% decline with 80% power and confidence) over a 10-year planning period. Mallard was more frequently detected (n = 14 sites) during bird surveys at the 46 lentic habitat network sites (Aquatic Monitoring Network Results section), therefore surveys targeting lentic habitats serve as the primary method of detection for Mallard. A combination of both terrestrial and lentic habitat monitoring datasets will provide the greatest overall frequency of detection for Mallard and is more appropriate for monitoring Mallard in the Tahoe basin. Pileated woodpecker and Northern Goshawk were not detected frequently enough with point counts to be effectively monitored given the proposed sample (n = 100 pts) and methods. Broadcast calling techniques (Raley and Aubrey 1993, Fuller and Mosher 1987) offer a greater probability of detection for these species, although the Pileated woodpecker is so rare in the Lake Tahoe basin it is unlikely that population trend monitoring is feasible for this species.

MIS missed with point count sampling at monitoring points included: Bald Eagle (*Haliaeetus leucocephalus*), Peregrine Falcon (*Falco peregrinus*), Willow Flycatcher (*Empidonax traillii*) and California Spotted Owl (*Strix occidentalis*). A single incidental

sighting of a Peregrine Falcon was recorded on 1 July 2002 near Gilmore Lake. No breeding activity, however, has been recorded for Peregrine Falcon during recent surveys (1999-2002) in the Tahoe basin (Romsos pers. comm.), despite a reintroduction effort in the past decade. If re-establishment occurs for this species, effective monitoring efforts should target nest sites and include collection of demographic information (USFWS 2001). Bald Eagle occurs primarily as winter residents in the Tahoe basin (Sanchez pers. comm.), however breeding (e.g., 2 nests) has occurred in the basin recently. Bald Eagles generally limit nesting activity to within a few miles of large permanent bodies of water (USFWS 1986). Approximately 11 of the 40 points surveyed (28%) were within 2 miles of Lake Tahoe, however we did not detect Bald Eagles in this effort. Bald Eagle surveys have been conducted successfully (with detections) by the USFS LTBMU during winter by conducting point counts adjacent to the shores of Lake Tahoe (Sanchez pers. comm.). Focused perimeter surveys along the shores of large permanent lakes in the Tahoe basin (e.g., Marlette Lake, Fallen Leaf Lake, Lake Tahoe) in summer and winter may provide the greatest probability of detecting breeding eagles and monitoring their populations (Aquatic Monitoring Network Results section). Willow Flycatcher and Spotted Owl (as well as other owl species) are best detected with broadcast calling techniques (Fuller and Mosher 1987, USDA 1992), which are currently being used to detect these species in the Tahoe basin. Nocturnal broadcast surveys for multiple species were conducted in the 2001 pilot (Manley et al. 2002), and in association with another survey effort conducted in 2003 (Manley et al. 2004) and they were successful in detecting spotted owl, as well as a number of other owl species. These methods offer the best efficiency for monitoring these species.

Point counts detected 1 (25%) of 4 current Forest Service Sensitive (FSS) bird species, 5 (22%) of 25 California species of special concern (SSC), 2 (40%) of 5 non-aquatic and 5 of 41 aquatic TRPA special interest species (SIS) expected to occur in the Lake Tahoe basin (Murphy and Knopp 2000). Most species of special interest were detected at low frequencies with terrestrial point counts (Appendix J). Special status species (FSS, SSC, SIS) missed with terrestrial point counts were primarily raptors (e.g., buteos, accipiters, falcons, owls) and aquatic associated species (e.g., terns, swallows, ducks, shorebirds; Appendix J). Raptors (diurnal and nocturnal) are more effectively detected with broadcast calling techniques, which could be implemented as a supplementary survey method (Fuller and Mosher 1987). Aquatic-associated special interest species were detected with greater frequency at lentic habitat units, as expected, hence aquatic bird surveys should be the primary monitoring method for such species.

### Notable Detections

Three species detected once during the survey season were notable. Wrentit (*Chamaea fasciata*) had not been previously detected in the basin and is generally absent east of the Cascade-Sierra Nevada crest (CWHR 1990). Wrentit was detected in the southern portion of the basin at a site containing sagebrush scrub, wet meadow and open lodgepole pine forest. Blue-gray Gnatcatcher rarely appears in historical records, however this species is apparently expanding its range into northeastern California (CWHR 1990) and may currently migrate through the Tahoe basin. These species were only detected once, so their occurrence should be considered preliminary. Savannah

Sparrow (*Passerculus sandwichensis*) was thought to be extirpated from the Lake Tahoe Basin (Murphy and Knopp 2000), however this species has been detected a few times at Grass Lake during 2001 (Richardson, pers. comm.) and during this effort in 2002 (Schlesinger, pers. comm.) and again at 2 additional meadows during 2003 (Gibson, pers. comm.). These detections of Savannah Sparrow were restricted to the southern portion of the Tahoe basin.

Eight mammal species were detected during point count surveys: mule deer (*Odocoileus virginianus*) and black bear (*Ursus americanus*) at one point each (both are MIS species), California ground squirrel (*Spermophilus beecheyi*) and coyote (*Canis latrans*) at 2 points each, yellow-bellied marmot (*Marmota flaviventris*) at 4 points, pika (*Ochotona princeps*) at 9 points, and Douglas' squirrel (*Spermophilus douglasii*) at all 40 points. Points counts are not the primary sampling method for mammals, however yellow-bellied marmot, pika and Douglas squirrel were detected at greater frequencies with point count sampling than with small mammal trapping, which detected them at 0, 2 and 6 points, respectively. Thus, point count surveys can compliment Sherman live-trapping for the detection of these three mammal species.

### Sampling Biases and Efficiencies

Species detected with point counts comprised 44 % of the 217 bird species potentially occurring in the Lake Tahoe basin (Murphy and Knopp 2000). Most missed species (n = 121) generally fell into one of four categories: not likely to occur in the Tahoe basin (n = 30), aquatic associates (n = 60), shrub associates (n = 8) or raptors (n = 14). The 30 species unlikely to be present in the basin were either at the edge of the species range geographically or elevationally or the species does not typically breed within the Tahoe basin (Appendix K). Given that monitoring is targeting resident species (breeding season or year round), missing these species does not diminish the success of the monitoring effort.

The remaining 91 bird species missed were primarily riparian/aquatic associates (Appendix K). Monitoring efforts at lentic habitat sites were successful at detecting 6 of the 60 aquatic/riparian species (Aquatic Monitoring Network Results section). One missed raptor is a species of special concern (California Spotted Owl) and is more effectively surveyed with broadcast calling methods as opposed to point counts. The remaining raptors (e.g., hawks, falcons, etc.) inhabit open fields and meadows, which occupy a very small area of the Tahoe basin. Supplemental surveys targeting such habitats could allow for increased ability to detect these species, however, given the small proportion of area within the Tahoe basin occupied by such habitat, it is unlikely that these species could be detected at enough independent points to detect trends over time. Monitoring for such species may be more effective at a scale larger than the Tahoe basin.

Bird species detected frequently with point counts (> 50% point occupancy) were fairly representative of all species occurring in the basin with regard to their trophic level and old growth dependency, but were not very representative with regard to habitat specificity, riparian dependency, aquatic association, home range sizes, or special status (Appendix L). Point counts were biased against detection of the following species groups: habitat specialists, riparian dependent species, semi-aquatic and aquatic species, species with large and small home range sizes, and special status species. Point counts in

this effort were not intended to detect riparian or aquatic species well, due to the limited distribution of these habitat types relative to forested area within the basin. Aquatic based surveys (e.g. lotic and lentic sites) are more appropriate for detection of these species. For the remaining species groups not well represented with point count data, improved detection probabilities are needed. For example, the addition of supplemental protocols (e.g., broadcast calling), or increased survey intensity (e.g., greater number of survey visits, target suitable habitat) may be warranted to detect a more representative suite of species occurring in the basin.

Overall, negligible sampling bias existed with regard to species detections by individual observers. Four observers conducted all point counts, with three primary observers conducting an equivalent number and the majority of the counts. Observers conducting point count surveys each detected from 2 to 12 unique species over the course of their point counts ( $\bar{x} = 7.7$  unique species, s.d. = 5.1; Appendix M). Fewer species on average were uniquely missed by a given observer ( $\bar{x} = 4.3$ , s.d. = 0.6), and ranged from 4 to 5 species (Appendix M). Unique detections and misses by each observer is likely to be largely attributable to the fact that not all observers counted every point (those points with just two visits), and observers visited points at different times in the season. Two of the uniquely identified species were only recorded once: Wrentit and Blue-gray Gnatcatcher. A third species, Hutton's vireo, was recorded multiple times by one observer, and this species does not occur in the basin. Records for this species were considered inaccurate and were not included in any summary statistics or analyses.

Similarly, no observer bias with regard to bird abundance estimates was evident. The average number of birds detected per point count survey per observer (based on the 3 primary main observers) was 21.6 individuals (range = 19.4 – 22.6, s.d. = 7.8). Mean detection rates were similar among the 3 primary observers suggesting no strong observer bias with regard to bird abundances.

#### Within Season Changes in Composition and Abundance: Was survey timing appropriate?

Total bird abundance per survey, did not exhibit any obvious pattern over the duration of the survey period (Figure 10). However a reduced number of detections was observed for counts conducted on the last day of survey (Aug 5).

**Comment:** \*\*\*\* if sample size analysis is done for trends, above analysis can be changed to use the observed ppo value at which species are detected frequently enough to be monitored effectively  
\*\* insert sample size analysis for species adequately detected to detect a trend of 20% with alpha and beta 0.20 with n = 100 sample points – then evaluate based on life history characteristics.

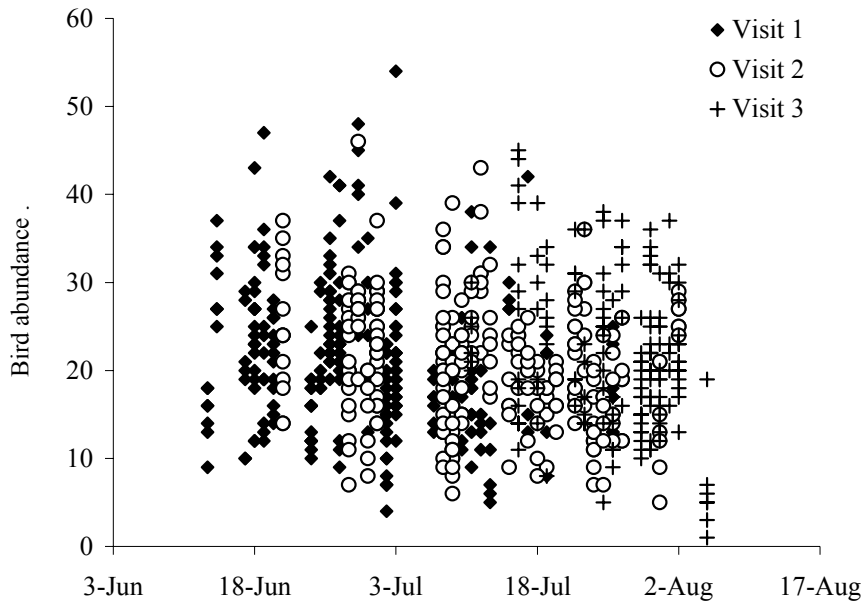


Figure 10. Relationship between survey date and total number of individual birds of all species detected during point counts conducted during summer 2002 within LTBMU (n = 719 point counts)

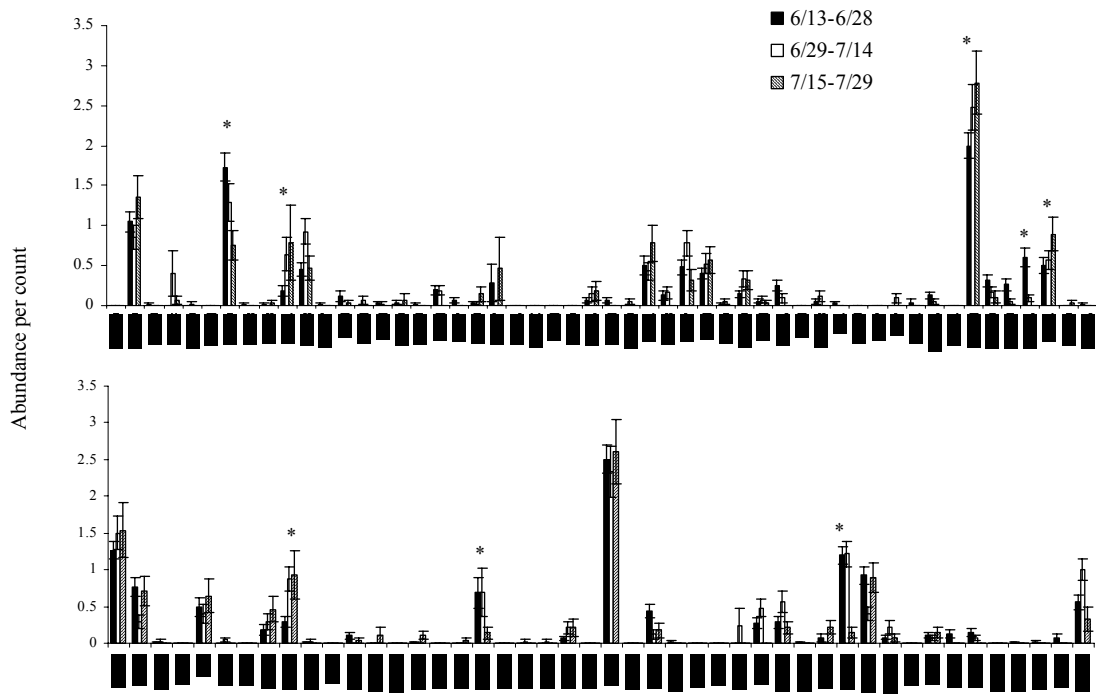
When looking at individual species patterns, several species exhibited variable detection rates across the survey season. Six species were detected only early in the season (13 June – 1 July), and four were detected only late in the season (21 July – 5 August) (Table 11). All 10 of these species were detected very infrequently (n = 1 – 5 total detections throughout summer; Table 11) and their patterns of detection may more likely reflect their rarity than any seasonality. Therefore, it is likely that all these species were present and detectable throughout the survey period with the exception of two migrant species not known to breed in the Tahoe basin and detected only early in the season (Ruby-crowned Kinglet, Townsend’s Warbler).

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Table 11. Bird species detected only during the first third (early season = 13 June – 1 July) and the last third (late season = 21 July – 5 August) of point count surveys conducted at 40 sites in the Lake Tahoe Basin in 2002. Total number of detections of each species during surveys in 2002 are in parentheses.

<b>Migratory Status</b>	<b>Early Season Detection</b>	<b>Late Season Detection</b>
Breeding Resident	None	Northern Goshawk (1) Rock Dove (3)
Breeding migrant	Anna's Hummingbird (1) Ruby-crowned Kinglet (3)	
Non-breeding migrant	Swainson's Thrush (1) Townsend's Warbler (2) Yellow-headed Blackbird (5)	Pacific Slope Flycatcher (2) Ruddy Duck (2)
Nomadic	House Finch (2)	

When we examined per species patterns of abundance at low (< 7,000ft, n = 8), mid (7,000 - <8,550 ft, n = 24) and high (> 8,550 ft, n = 8) elevation points separately, relatively few species (n = 16 or 16% of species) exhibited marked increasing or decreasing trends with time (Figures 11 - 13), suggesting that, overall, the timing of bird surveys in 2002 was appropriate. The sixteen species showing obvious increasing or decreasing abundance over the course of surveys suggest that surveys for these species are time sensitive. Species exhibiting significant increases in abundance with time were nearly all winter residents in the Tahoe basin (e.g., Northern Flicker, Brewer's Blackbird, Mountain Chickadee, Red-breasted Nuthatch and Cassin's Finch). Increases in abundance of resident species would be expected as fledged juveniles form family groups with adults at the end of the breeding season. If abundance data are used for monitoring, survey cut off dates should be identified for each species (based on detections of juveniles during survey visits) and surveys after those dates should be dropped from abundance estimation calculations or juveniles excluded from abundance estimations. Species showing significant declines in abundance with time were predominantly migratory (e.g., Nashville Warbler, Western Tanager, Hermit Thrush, Yellow-rumped Warbler). Migratory species would be expected to be less detectable late in the breeding season due to migration out of the Tahoe basin. In conclusion, while surveys were largely appropriately timed during 2002, it is suggested that future surveys be completed during a more condensed period spanning approximately late May (season permitting) through mid- July. Further, individual survey visits within each elevational band should be completed within no more than a one-week period.



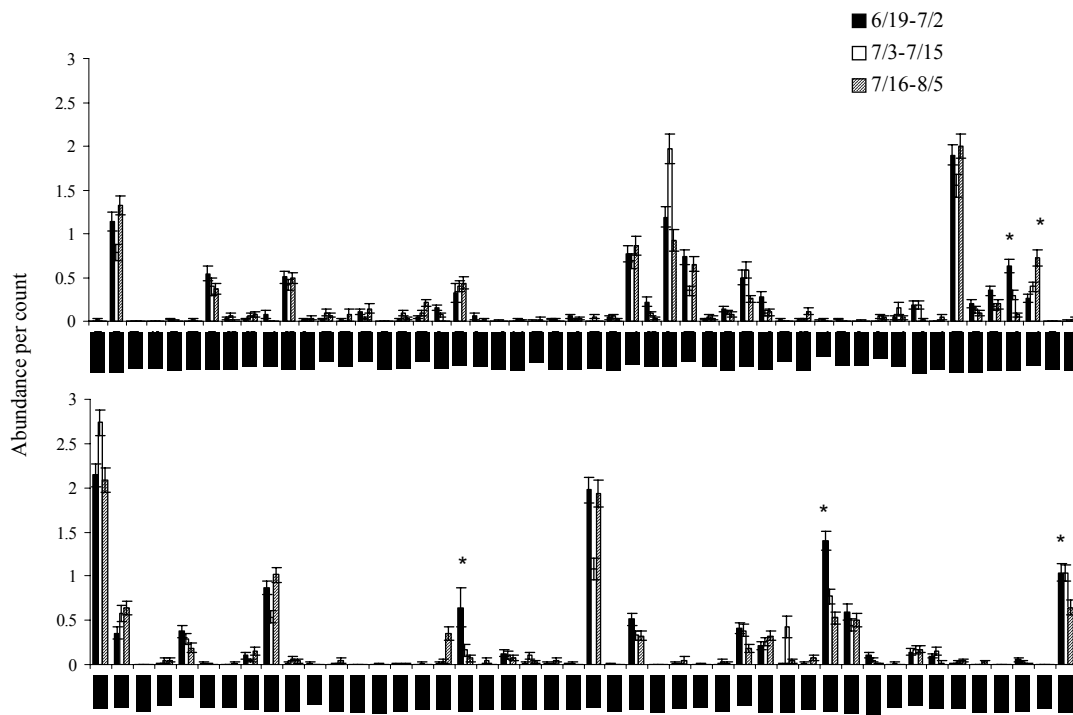


Figure 12. Mean (+/- s.e.) number of detections per point count per bird species detected during t 24 mid elevation points (7,000 - < 8550 ft). Asterisk (\*) indicates species with obvious increasing

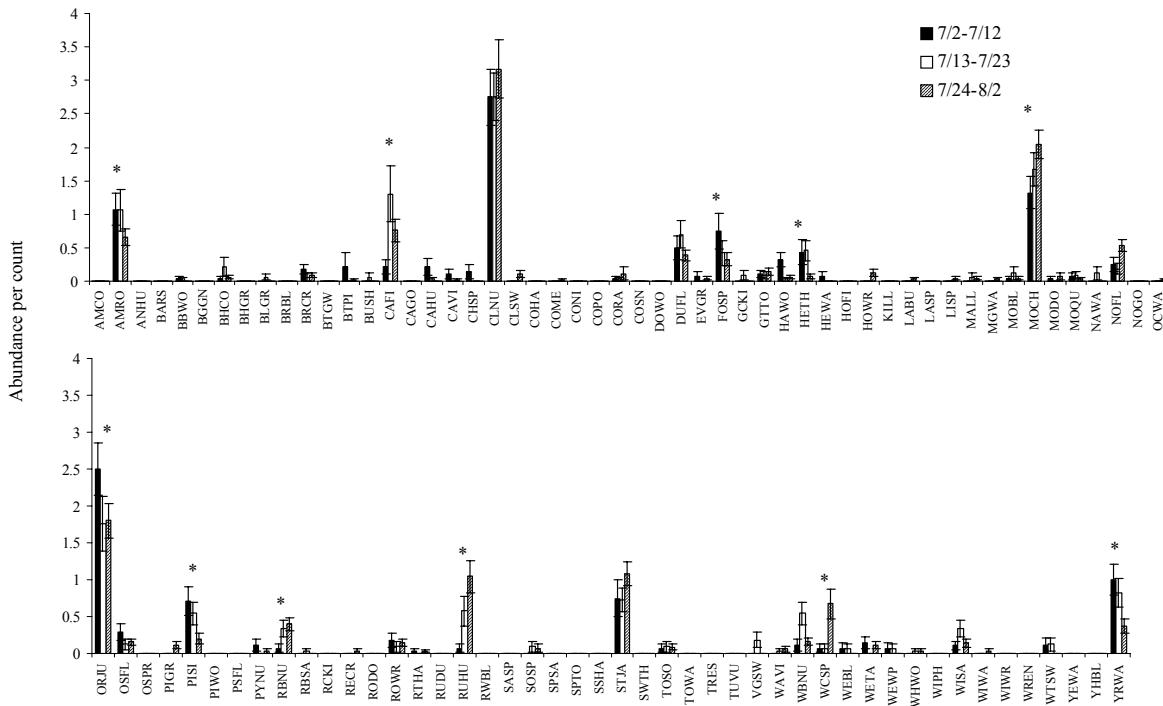


Figure 13. Mean (+/- s.e.) number of detections per point count per bird species detected during three surveillance points (> 8,550 ft). Asterisk (\*) indicates species with obvious increasing/decreasing trend.

### Species Accumulation with Effort

Individual species were detected at an average of 34.7 % (s.d. = 33.3%) of monitoring points. Only 67 species (68%) were detected sufficiently to estimate probability of detection and proportion of points occupied (Appendix G). Average probability of detection for these 67 species was 0.50 (range = 0.11 – 1.00, s.d. = 0.25), and mean estimated point occupancy was 64.6% (s.d. = 34.1).

The proportion of the assemblage detected with various levels of effort was estimated while taking into account that some species occupying the site were not detected (Table 12). Seven count stations visited three times during the season resulted in 84.1% of the bird assemblage at a given point being detected. The proportion of the assemblage detected declined faster with the elimination of visits compared to stations, so it is recommended that three visits continue to be conducted, but the number of stations could be reduced to 5 or 6 if efficiencies would be gained (e.g., additional surveys possible). We recommend a minimum of 4-5 stations to be surveyed in conjunction with every monitoring point. Surveying additional count stations per point, however, requires much less additional effort/cost than additional survey visits, hence it is recommended that monitoring efforts are designed to conduct 3 visits per point, and with the maximum number of count stations that can be feasibly surveyed on a given visit at every point based on overall site conditions, and travel time to points.

Table 12. Percent of the bird assemblage detected by point counts estimated to be observed with various numbers of count stations and visits conducted per monitoring point. Values for species with similar patterns of detection were used for species for which the probability of detection or proportion of points occupied values could not be estimated.

No. Count Stations	No. Survey Visits			
	1	2	3	4
4	54.7	69	75.8	80.2
5	59.9	73.4	79.7	83.1
6	63.8	76.4	82.3	85.3
7	67	78.9	84.1	86.9
8	69.8	80.9	85.5	88.2

The length of the survey time period was also positively related to the proportion of species assemblage detected at each point (Figure 14). The per minute increase in cumulative species detected was greater from 3 to 5 min ( $\bar{x}$  = 4.5% of assemblage per minute per point) than that from 5 to 10 min ( $\bar{x}$  = 2.6% per minute per point); however, the absolute increase in the proportion of the assemblage detected was greater from 5 to 10 minutes ( $\bar{x}$  = 13.1%, s.d. = 5.4) than the increase from 3 to 5 min. ( $\bar{x}$  = 9.0%, s.d. = 4.9). Since increases in survey time from 5-10 minutes per count station require minimal additional effort (e.g., only an additional 35 minutes per visit to each point and yield the maximal suite of species detections, a 10 minute survey period at each point is recommended. Surveying for the additional 5 min beyond the first 5 min is probably time well spent.

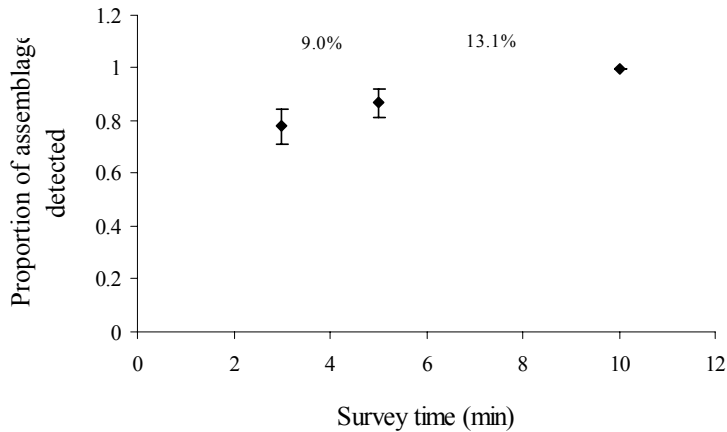


Figure 14. Mean (+/- s.d.) proportion of bird species assemblage detected per point with increasing length of the survey period. Percentages listed above each increase in effort represent the mean increase in the proportion of the species assemblage detected for the respective effort increase. Surveys were conducted at 40 monitoring points in the Lake Tahoe basin in 2002.

#### Cost Estimate

Point count surveys cost approximately \$1100 per point surveyed. This cost estimate reflects two weeks for site set-up (locating site and flagging count stations), a three week training period (including one week of mandatory forest wide training), one visit per observer per day, three visits to 7 stations per point, one vehicle per observer and vehicle rental costs of \$650 per month, per diem for occasional necessary camping on site and data entry into database.

#### **Sherman Live Trapping**

##### Trapping Effort

Sherman live-trapping was conducted at 40 monitoring points within LTBMU from 18 June to 13 September 2002; points at lower elevations were surveyed earlier and those at higher elevations were surveyed later in the season in an attempt to maintain similar animal breeding phenology across all points (Figure 15). Trapping effort consisted of 11,816 trap-opportunities for small mammals (# functional traps \* # checks per trap). Average trap success per effort in 2002 (number of captures/618 trap opportunities per point) was 34.6% (s.d. = 10.4%). A total of 544 trap opportunities (2.2%) across all 40 points were unavailable to small mammals due to tripped or non-functional traps. The corrected average trap success (number of captures/number of functional trap opportunities per point) was 35.5% (s.d. = 11.0%). At three points in LTBMU surveyed during both 2001 and 2002, trap success in 2002 ( $\bar{x} = 25.2$ , s.d. = 6.0) was nearly double that in 2001 ( $\bar{x} = 13.0$ , s.d. = 7.1).

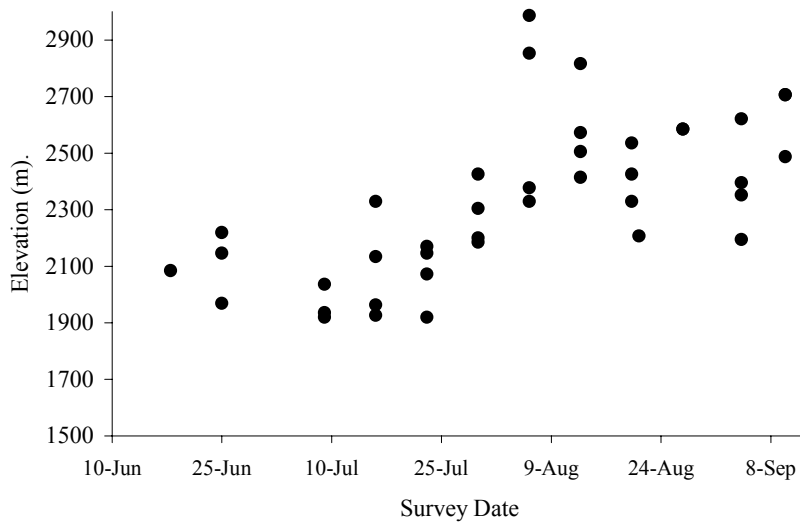


Figure 16. Relationship between survey start dates and elevation for each of the 40 monitoring points surveyed with Sherman live-traps during summer 2002.

### Species Occurrence and Abundance

During 2002, a total of 23 small mammal species were captured at 40 monitoring points (Appendix N) with an average of 6.7 species (s.d. = 1.7, range = 3 to 11), detected per point. Overall, we had an average of 71.0 (s.d. = 21.9) captures and 42.5 (s.d. = 14.6) unique individual captures per 100 trap nights per point. Deer mice (*Peromyscus maniculatus*) were the most commonly detected small mammals; captured at all 40 points. Five additional species were detected at 50% or more of points surveyed (*Spermophilus lateralis*, *Tamias amoenus*, *T. speciosus*, *T. senex* and *T. quadramaculatus*) and four species were detected at only a single point surveyed (*Neotoma lepida*, *N. cinerea*, *Spermophilus beldingi* and *Peromyscus truei*; Appendix N). Deer mouse was also the most abundant species captured across the study, with a mean of 17.0 (s.d. = 7.9) individuals captured per 100 trap nights per point (Appendix O). Chipmunk and ground squirrels (excluding Belding's ground squirrel, *Spermophilus beldingi*) were detected next most frequently with means between 0.9 and 7.2 individuals per 100 trap nights per point (Appendix O).

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Small mammal species richness did not vary substantially among habitat types or orientations, but was greatest on average in wet meadow ( $\bar{x} = 7.0$ , s.d. = 2.8, n = 2 points) and shrub habitat ( $\bar{x} = 7.0$ , s.d. = n/a, n = 1 point) and least in subalpine conifer habitat ( $\bar{x} = 5.8$ , s.d. = 1.3, n = 5 points; Appendix O). Small mammal species richness was greatest at points in the north ( $\bar{x} = 7.4$ , s.d. = 2.1), and least at points in the east part of the Tahoe basin ( $\bar{x} = 6.0$ , s.d. = 0.8; Appendix P).

## Notable Detections

The Great Basin pocket mouse (*Perognathus parvus*), was not previously known to occur in the Tahoe basin (Murphy and Knopp 2000), but occurs further south and north of the basin in arid shrubby areas (Grinnell et al. 1937). This species was captured in the basin in both 2001 (n = 1 individual) and 2002 (n = 2 individuals) in the Upper Truckee River drainage near Meiss and Showers Lakes and in Blackwood canyon near Twin Peaks. The identification of individuals in the Upper Truckee drainage has been confirmed (Longland, pers. comm.). These detections constitute a range expansion for this species.

Two small mammal species (pika; *Ochotona princeps*, and Douglas squirrel; *Tamiasciurus douglasii*) were detected more frequently with point count methods than with Sherman trapping (see Point Count results), suggesting that point counts may be the most effective method of detecting presence of these two species.

## Detections of Special Interest Species

No small mammals with special interest status (e.g., LTBMU MIS, Forest Service Sensitive, California Species of Special Concern or State/Federal T&E) were detected in this trapping effort. However, given the large proportion of small mammals detected with Sherman trapping, and the important role that they play in the environment suggests that small mammals would make good candidates for MIS species in future MIS selections. Several small mammals that have been identified as important prey items to special interest species in the basin (e.g., Northern Goshawk, California Spotted Owl, American marten: *Martes americana*) and may be considered higher priority for monitoring efforts are as follows: northern flying squirrel, Douglas' squirrel and deer mouse. Each of these species was detected relatively frequently (Appendix N), and will probably be effectively monitored with multi-species monitoring protocols, but see Appendix G for Douglas' squirrel as it is more effectively sampled with point count survey techniques.

## Sampling Efficiencies and Biases

Species detected during Sherman live trapping represented 79% of all 29 small mammal species potentially occurring in the Lake Tahoe basin (Murphy and Knopp 2000) and that would be likely detected with Sherman long traps based on size (Appendix Q). Species not detected in the basin (n = 6 species) included: 1) species with minimal habitat in the basin (least chipmunk, *Tamias minimus*), 2) species that are impossible to distinguish from related species under field conditions (Engilis, pers. comm.; vagrant and dusky shrew, *Sorex vagrans and monticola*, respectively), 3) predominantly cursorial species (broad-footed mole, *Scapanus latimanus* and mountain pocket gopher, *Thomomys monticola*), 4) primarily aquatic species (water shrew, *Sorex palustris*) or 5) species not best detected with Sherman live-traps of the size we used (Western gray squirrel, *Sciurus griseus*).

Small mammal species detected frequently with Sherman live-traps (> 50% point occupancy) were representative of species expected to occur in the basin with regard to riparian association, aquatic association and home range size, but were not as representative with regard to habitat specificity, old growth association or trophic level (Appendix R). Sherman live-trapping tended to miss detection of the following species groups: habitat specialists, old growth associated species, and carnivores. For species groups not well represented with trapping data, improved detection probabilities are desired. For example, the addition of supplemental protocols (e.g., pitfall trapping to detect pocket gophers and shrews), use of a larger trap size (to more readily detect the larger squirrels and possibly weasels) and/or increased survey effort in less common

habitat types in the basin (e.g., meadow/riparian areas, high elevation talus slopes, shrub dominated habitat) may be warranted to detect a more complete suite of species occurring in the basin.

Detections of small mammal species that were missed could be accomplished by a few additions and changes in the survey methodology. Increased survey effort in sagebrush habitat along the east side of LTBMU may increase the chances of detecting the least chipmunk, which was missed this year but was previously captured in the basin with Sherman long traps (Manley 2000). The addition of more extensive pitfall trapping or vertebrate area search methods might also increase species detections. Pitfall traps were more effective at detecting pocket gophers and shrews than Sherman live-traps in 2002 (see Pitfall/Coverboard results). We detected pocket gophers at 56% of points surveyed ( $n = 9$ ) with pitfall traps, suggesting that pitfall trapping could be a primary method for detecting pocket gophers and other fossorial small mammals. Shrews were detected at 44% of points with pitfall traps and only 20% of points with Sherman traps. Pocket gophers and moles, however, can also be detected with sign surveys (surveys that use visual detection of animal sign to indicate the presence of a particular species- see Manley et. al 2002), given that they leave conspicuous piles of dirt on the soil surface as a result of their digging behavior. During 2001 (Manley et. al 2002), pocket gophers were detected at 17% of points surveyed for sign within the Eldorado National Forest and LTBMU. Therefore, pitfall and vertebrate sign surveys may be effective additions to the suite of multi-species monitoring protocols, however vertebrate sign surveys may be most cost efficient.

Water shrew is an aquatic species that we missed. It inhabits areas within or immediately adjacent to clear, cold streams or bodies of water (Ingles 1965). Vertebrate sign searches are also effective at detecting a number of other species either not detected or detected infrequently with the protocols implemented in the Tahoe Basin during 2002 (e.g., mule deer, terrestrial herpetofauna, mountain lion and beaver), and they are inexpensive, easy to conduct and do not require intensive site preparation as do pitfall traps. Increased number of sample points in areas immediately adjacent to streams would increase detection rates of water shrew.

No substantial seasonal biases were apparent with regard to individual species detections during trapping surveys (Table 13). Woodrats (*Neotoma spp.*) were detected for a brief time period in July, however, similar Sherman trapping methods conducted at an adjacent forest (Eldorado National Forest) in 2001 detected woodrats from early June through late August, suggesting a greater detectability throughout the summer. A few other species were detected during only late July or later: pika, Great Basin pocket mouse, bushy-tailed woodrat, and Belding's ground squirrel (Table 13), however, these species were detected infrequently (< 15 individuals in 2002) and their detection dates may not represent any ecological phenomena. Elevation explains the later season detections of pika, since we surveyed higher elevations later in the summer (Figure 15) and pika reside only at high elevations within the basin.

Table 13. Dates of first and last detection of small mammal species surveyed with Sherman long live traps from 18 June through 12 September 2002 within the Lake Tahoe Basin Management Unit.

Taxa code	Scientific Name	Common Name	First Detected	Last Detected
GLSA	<i>Glaucomys sabrinus</i>	Northern Flying Squirrel	7/16	8/23
MILO	<i>Microtus longicaudus</i>	Long-Tailed Vole	6/26	9/12
MIMO	<i>Microtus montanus</i>	Montane Vole	6/25	9/6
MUER	<i>Mustela erminea</i>	Ermine *	7/31	8/28
MUFR	<i>Mustela frenata</i>	Long-Tailed Weasel	7/23	9/10
NECI	<i>Neotoma cinerea</i>	Bushy-Tailed Woodrat *	9/10	9/12
NELE	<i>Neotoma lepida</i>	Desert Woodrat	7/9	7/11
OCPR	<i>Ochotona princeps</i>	American Pika *	8/20	8/29
PEBO	<i>Peromyscus boylii</i>	Brush Mouse	7/23	9/6
PEMA	<i>Peromyscus maniculatus</i>	Deer Mouse	6/18	9/12
PEPA	<i>Perognathus parvus</i>	Great Basin Pocket Mouse *	8/20	9/6
PETR	<i>Peromyscus truei</i>	Pinon Mouse	7/9	7/9
SOTR	<i>Sorex trowbridgii</i>	Trowbridge's Shrew	7/9	9/11
SOVM	<i>Sorex vagrans/monticolus</i>	Vagrant Or Montane Shrew *	7/31	9/4
SPBE	<i>Spermophilus beecheyi</i>	California Ground Squirrel	6/20	8/22
SPBL	<i>Spermophilus beldingi</i>	Belding's Ground Squirrel	8/6	8/8
SPLA	<i>Spermophilus lateralis</i>	Golden-Mantled Ground Squirrel	6/18	9/12
TAAM	<i>Tamias amoenus</i>	Yellow-Pine Chipmunk	6/18	9/12
TADO	<i>Tamiasciurus douglasii</i>	Douglas' Squirrel	7/16	9/10
TAQU	<i>Tamias quadrimaculatus</i>	Long-Eared Chipmunk	6/18	9/12
TASE	<i>Tamias senex</i>	Allen's Chipmunk	6/18	9/12
TASP	<i>Tamias speciosus</i>	Lodgepole Chipmunk	6/18	9/12
ZAPR	<i>Zapus princeps</i>	Western Jumping Mouse	6/25	7/31

\* Species detected only late in survey season

Overall, survey timing appeared to be appropriate for the detection of all species present. Mean capture rates of small mammals (# captures/trapnight/point), however, were slightly lower during June ( $\bar{x} = 17.6$ , s.d. = 5.0, n = 12) and September ( $\bar{x} = 18.2$ , s.d. = 7.8, n = 21) than during mid summer months of July ( $\bar{x} = 22.3$ , s.d. = 11.1, n = 41) and August ( $\bar{x} = 22.7$ , s.d. = 10.4, n = 46), although, there was no significant linear relationship between capture rates and survey date ( $P = 0.6$ ; Figure 16). Most species were captured with greatest frequency during July (n = 8 species) followed by August and September (n = 6 species each; Table 14). Only 3 species were detected most frequently during June (*Zapus princeps*, *Microtus montanus* and *Tamias senex*; Table 14). Thus, no strong variation in capture probabilities during the summer was apparent.

Conducting surveys from mid June through early September in future trapping efforts is therefore recommended for detecting the maximum species diversity at any given point within the Lake Tahoe basin. Despite the fact that most species were predominantly detected later than June, species that were very common across all habitat types (e.g., deer mouse) did not appear to show much difference in detection rates with timing in the season (Table 14), suggesting that perhaps the differences in capture rates for other species were associated with differences in habitat types or disturbance levels surveyed in the given months (See Terrestrial Habitat results section).

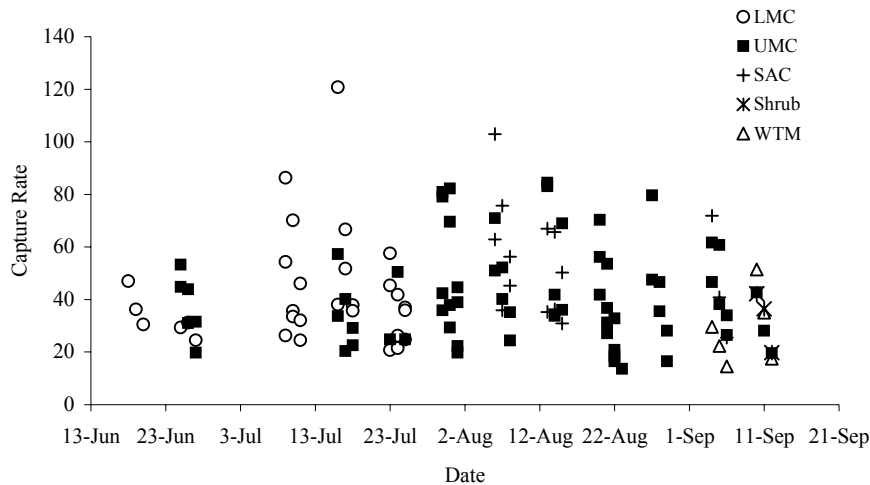


Figure 16. Capture rates (number of first captures/100 trap nights) per day per point for all small mammal species captured with Sherman live traps during summer 2002. [Note: Traps were checked for captures two times for every trap night, hence some capture rates appear to be greater than 1 individual captured per trap night]

Table 14. Mean ( $\pm$  s.d.) capture rates for small mammal species captured with Sherman live traps at 40 monitoring points in the Lake Tahoe basin during summer 2002. Capture rates were calculated as the number of first captures per 100 trap nights per point. Capture rates were then averaged across all survey days in each month.

Scientific Name	June		July		August		September	
	Capture rate	s.d.	Capture rate	s.d.	Capture rate	s.d.	Capture rate	s.d.
<i>Glaucomys sabrinus</i>	0.00	0.00	0.14	0.41	0.04	0.20	0.00	0.00
<i>Microtus longicaudus</i>	0.08	0.28	0.20	0.53	0.26	0.65	0.28	0.45
<i>Microtus montanus</i>	0.33	0.64	0.13	0.35	0.04	0.29	0.28	0.77
<i>Mustela erminea</i>	0.00	0.00	0.02	0.16	0.04	0.20	0.00	0.00
<i>Mustela frenata</i>	0.00	0.00	0.02	0.15	0.00	0.00	0.09	0.29
<i>Neotoma cinerea</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.37	1.18
<i>Neotoma lepida</i>	0.00	0.00	0.05	0.22	0.00	0.00	0.00	0.00
<i>Ochotona princeps</i>	0.00	0.00	0.00	0.00	0.11	0.44	0.00	0.00
<i>Peromyscus boylii</i>	0.00	0.00	0.05	0.21	0.15	0.52	0.10	0.30
<i>Peromyscus maniculatus</i>	14.83	6.34	15.70	9.43	16.11	8.71	22.82	13.52
<i>Perognathus parvus</i>	0.00	0.00	0.00	0.00	0.02	0.15	0.05	0.21
<i>Peromyscus truei</i>	0.00	0.00	0.02	0.16	0.00	0.00	0.00	0.00
<i>Sorex trowbridgii</i>	0.00	0.00	0.02	0.15	0.00	0.00	0.14	0.35
<i>Sorex vagrans/monticolus</i>	0.00	0.00	0.02	0.15	0.04	0.30	0.05	0.22
<i>Spermophilus beecheyi</i>	0.25	0.45	2.30	4.83	0.20	0.55	0.00	0.00
<i>Spermophilus beldingi</i>	0.00	0.00	0.00	0.00	0.22	0.86	0.00	0.00
<i>Spermophilus lateralis</i>	4.89	9.29	4.09	5.22	6.75	5.53	1.35	2.31
<i>Tamias amoenus</i>	7.33	9.92	11.46	13.39	5.33	7.70	3.08	3.75
<i>Tamiasciurus douglasii</i>	0.00	0.00	0.12	0.40	0.02	0.14	0.05	0.21
<i>Tamias quadrimaculatus</i>	1.56	1.99	4.68	7.18	0.97	1.79	1.22	2.83
<i>Tamias senex</i>	5.02	3.54	3.71	4.38	1.84	3.96	2.21	3.71
<i>Tamias speciosus</i>	0.82	1.61	1.80	3.12	13.08	13.20	4.07	3.04
<i>Zapus princeps</i>	0.08	0.29	0.02	0.16	0.00	0.00	0.00	0.00

Trap mortalities per point during surveys in 2002 varied by species and by point (range+ 0-14 per species per point). The greatest mortality rates occurred for long-tailed weasels (0.5), Trowbridge's shrews (0.5), dusky/vagrant shrews (0.5) and pika (0.2), all of which had low detection frequencies (n = 2, 4, 4 and 5 individuals captured respectively). It is recommended that additional measures be taken to help reduce overall mortalities related to trapping effort (e.g., avoid trapping during periods of predicted extreme high or low temperatures, additionally cover traps with white coroplast covers during hottest portions of the summer for additional sun protection, etc.).

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### Species Accumulation with Effort

Individual small mammal species were detected, on average, at 28.8% (s.d. = 32.7%) of points (Appendix N) and were estimated to have occupied 37.2% (s.d. = 31.6%) of all points on average (PRESENCE; McKenzie et al. 2002). Of all 23 species detected with Sherman live-traps, only 16 (40%) were detected sufficiently across the 40 monitoring points to estimate proportion of points occupied; a metric essential to monitoring species occupancy trends over time (Appendix N).

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The average proportion of the small mammal species assemblage detected per point increased with increasing survey effort; increases in proportion of the assemblage detected were of greater magnitude in association with additional survey days (Figure 17) than with additional traps set (Figure 18). Proportion increases did not appear to level off with additional days surveyed up to 3 days (Figure 17), therefore, it is recommended that future trapping efforts continue for a minimum of 3 days for maximal detection of the species assemblage.

Species assemblage increases did, however, appear to level off beyond 78 traps (Figure 18), corresponding to 6 transects of 13 traps or approximately 8 transects of 10 traps (increase trap spacing to 20 m). An average of 95% (s.d. = 5.5%) of the species assemblage was detected with 78 traps. Therefore a reduction in the number of traps set per point to 78 traps is recommended for future efforts. However, it is important to maintain survey area coverage in order to best sample the small mammal community at each monitoring point, therefore we recommend maintaining 8 transects and increasing the trap spacing to 20 m (n = 79 traps total). Reducing trap effort per point by 24 traps will allow a single observer to be able to conduct surveys at one point within a standard 40 hour work week, with the addition of one person to help hike traps to and from the point location at the start and end of each survey. Surveys conducted during 2002 with 103 traps per point were very challenging to a single observer and often required more than 40 hours to complete. If the proposed reduction in trap effort to 79 traps would allow time to conduct a fourth survey day within the 40 hour work week, we would recommend lengthening the survey for an additional day due to proportionately greater benefits of lengthening the trapping period versus increasing numbers of traps (Figures 17 and 18).

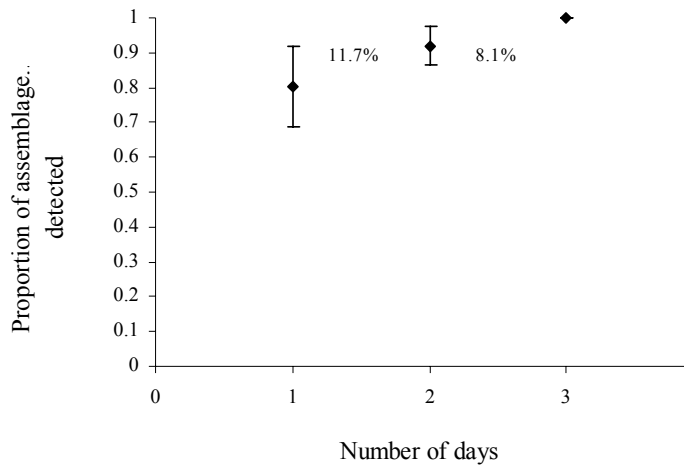


Figure 17. Increase in the mean proportion of the small mammal species assemblage detected per point (+/- s.d.) with additional days surveyed. Percentages listed above each increase in effort represent the mean increase in the proportion of the species assemblage detected for the respective effort increase. Surveys were conducted at 40 monitoring points in the Lake Tahoe basin in 2002.

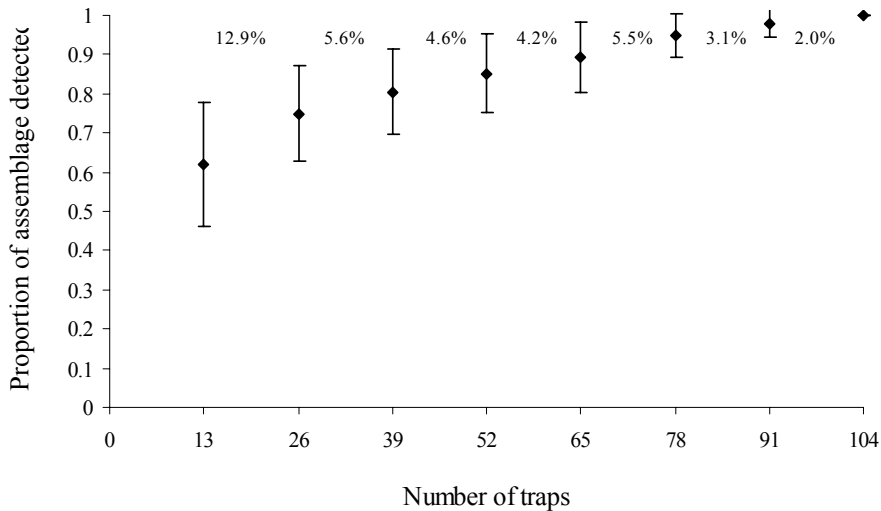


Figure 18. Increase in the mean proportion of the small mammal species assemblage detected per point (+/- s.d.) with additional trap effort. Increments in trap effort correspond to additional transects (13 traps per transect). Percentages listed above each increase in effort represent the mean increase in the proportion of the species assemblage detected for the respective effort increase. Surveys were conducted at 40 monitoring points in the Lake Tahoe basin in 2002.

## Sherman Trapping Cost Estimate

The approximate cost for Sherman live trap surveys during 2002 was \$1700 per point surveyed. This estimate included the cost of hiring and training field crews, site set up, all equipment needed to conduct trapping at 4 sites simultaneously (including 412 traps at \$20 per trap), truck rental (one truck per point surveyed simultaneously or per crew of two) at the rate of \$800/mo for 4.5 months, per diem costs of on site camping at 25% of points surveyed, and data entry. Traps constituted approximately \$215 of the \$1700/point cost. Thus, the cost per point in subsequent years would drop to \$1485/point.

## **Track plate and camera surveys**

### Sample Effort

During 2002, 22 points were sampled with 6 sooted track plate stations and 4 stations each, for a total of 132 track stations and 88 camera stations surveyed from 20 June to 20 September 2002. Points were surveyed in order of increasing elevation in an attempt to maintain similar seasonal phenology during sampling across all points (Figure 19). Twenty-one of these points were visited 5 times and one site was visited 4 times for a total of 109 visits at which track plates and cameras were checked for tracks and proper function (i.e., restock plates and film as needed). Each point was visited every other day over the course of ten days with the following exceptions; W28: only 1 day between visit 2 and visit 3; 9 days total, E40: only 4 visits total; 3 days between visit 2 and visit 3; 3 days between visit 3 and visit 4, W29: 3 days between visit 2 and visit 3; 11 days total, N13: 3 days between visit 2 and visit 3; 1 day between visit 3 and visit 4. Additionally, several camera wires were found chewed through upon visitation, creating an unknown period of time in which no photos were taken. Dysfunctional wires were replaced immediately upon discovery, thus the maximum period of time the associated camera was non-functional did not exceed 2 days. At 2 of the 22 points surveyed bait placement for camera stations was raised on the tree to approximately 1.5-2.0 m off the ground versus the normal 0.5-1.5m. We investigated qualitatively whether the change in bait height affected species detections at these two locations.

### Species detections - track plates only

A total of 5 target species (medium and large carnivores) were detected at 13 of 22 (59%) points surveyed with track plates during 2002 (Table 15); 0.7 (s.d. = 0.6, range = 0-2) target species were detected on average per point. American marten (*Martes americana*), a Forest Service sensitive (FSS) species, was the most commonly encountered species, detected with track plates at 36% of points surveyed with this protocol. Species in the family Canidae (*Canis latrans*, *Canis familiaris*) were the next most frequently detected taxonomic group, detected at 18% of points. Canids are only identifiable to genus based on tracks, however at one point location (S24 – upper montane conifer), photographic evidence confirmed *C. latrans* was present at the site. All other target species detected (*Procyon lotor*, *Spilogale gracilis* and *Ursus americanus*) were observed at only a single point (4.5%). The black bear (*Ursus americanus*), a Forest Service MIS species, was detected infrequently with track plate survey techniques. This is not surprising considering track plates were constructed with covers such that only animals of raccoon (*Procyon lotor*) size or smaller could easily fit inside the box to leave tracks. The black bear detected at a single track station destroyed the track plate station by pulling off the cover and inadvertently stepping on the track plate in the process. Black bear were detected with greater frequency at baited camera stations (n = 4 points) than with track plates (n = 1), as expected because detections at camera stations are not limited by animal size (see detections at camera stations below).

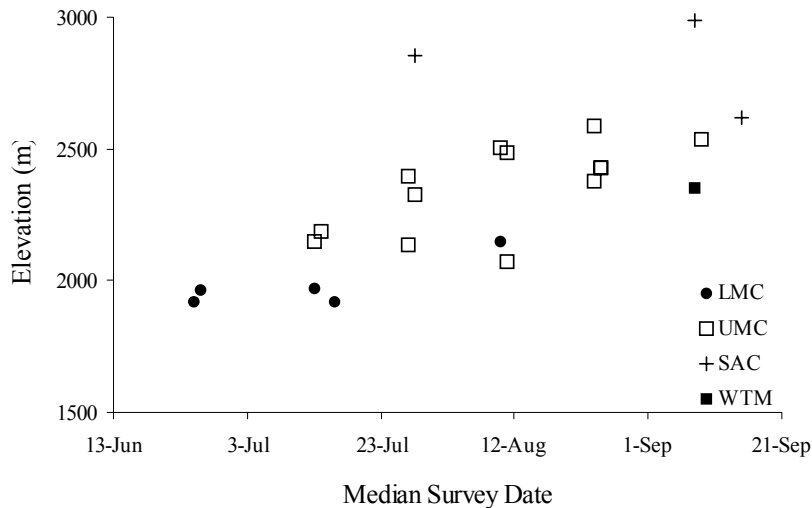


Figure 19. Relationship between median survey date and elevation for track plate and camera surveys conducted at 22 points within LTBMU during summer 2002. Median survey date is the date half way between the date of set up and removal of track plates and cameras at each point surveyed. Legend codes represent different habitat classes of points surveyed: LMC (lower montane conifer), UMC (upper montane conifer), SAC (subalpine conifer), WTM (meadow and riparian).

Estimated point occupancy per species based on track plate data, as determined by PRESENCE (McKenzie et al. 2002), was similar to observed point occupancy for marten, canids and spotted skunk (Table 15), but not for the raccoon or black bear, which were detected too infrequently to effectively estimate their estimated point occupancy. Similarly, the probability of detection with track plates for canids, American marten and the spotted skunk was fairly high (0.4, 0.6 and 1.0 respectively) and was very poor for black bear and raccoon (Table 15).

Several non-target species were detected with track plates. Species from the family Sciuridae were detected at all 22 points but were not identified with confidence below the family level. Small mammals within the family Cricetidae (e.g., mice) were detected at 95% of points (n = 21 points). Detections of small mammal species were not the focus of this protocol (see Sherman live trapping section), hence we only report information regarding target taxonomic groups here.

Table 15. Target species detected with track plates surveys conducted in LTBMU from 20 June to 20 September 2002, observed point occupancy per species (Pts. Occup and O%), estimated point occupancy (E%) and associated standard error (bootstrap s.e.), and the probability of detection for each species (Pd). Estimated point occupancy, bootstrap s.e., and probability of detection were determined using PRESENCE (McKenzie et al. 2002).

Taxa Code	WHRid	Scientific Name	Common Name	Pts. Occup	Point Occupancy (O%)	Point Occupancy (E%)	Bootstrap s.e.	Pd
CASP		Canis sp.	Canid species	4	18.2	20.6	38.3	0.355
MAAM <sup>a</sup>	M154	Martes americana	American marten	8	36.4	36.8	10.5	0.593
PRLO	M153	Procyon lotor	Raccoon	1	4.5	1	0	0.009
SPGR	M161	Spilogale gracilis	Western spotted skunk	1	4.5	4.6	4.7	1
URAM <sup>b</sup>	M151	Ursus americana	Black bear	1	4.5	1	0	0.009

<sup>a</sup> Forest Service Sensitive species

<sup>b</sup> Management Indicator Species

### Species detections - camera stations only

A total of 4 target carnivore species were detected with baited cameras at 10 of the 22 points surveyed with track plates and cameras during 2002 (Table 16); 0.6 (s.d. = 0.8 species, range = 0-2) target species were detected on average per point. Similar to the results of track plate data, American marten was the most frequently detected target species with cameras (observed at 5 points, 22.7%). The coyote and black bear (*Ursus americanus*) were the next most frequently detected species (both observed at 4 points, 18.2%). The probability of detection with camera surveys was greatest for canids and western spotted skunk (Pd = 0.4 each), followed by marten (Pd = 0.3) and black bear (Pd = 0.1). The probability of detection for canids was similar for track plates and cameras, whereas track plates had greater probability of detection for marten and western spotted skunk, and cameras had greater probability of detection for black bear.

Several birds and rodents were detected at camera stations (Table 16), however, these species were not the focus of this protocol (see Sherman live trapping and Point count survey sections), and therefore we only report information regarding target taxonomic groups. Non-target species had greater probability of detection with their primary protocol of detection (e.g., Sherman trapping for small mammals and point counts for birds). Camera stations were effective at increasing the frequency of detection for the following species: Turkey Vulture, Common Raven, California ground squirrel and golden-mantled ground squirrel. The Turkey Vulture and Common Raven were each only detected at a single point with camera stations, but were detected at points not detected with point count surveys, the primary survey method for these two species. *Spermophilus lateralis* was detected at 16 (73%) of the 22 points surveyed with cameras, one point at which the species was not detected with Sherman live traps, the primary survey method for this species. Similarly, California ground squirrels were detected at 4 (18%) of the points surveyed with cameras, 3 of which did not have detections with Sherman live traps, also the primary survey method for this species. This suggests that camera stations may help aid in detections of these two rodent species.

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Table 16. Target species detected with camera surveys conducted at 22 monitoring points on LTBMU from 20 June to 20 September 2002, observed point occupancy per species (Pts. Occup and O%), estimated point occupancy (E%) and associated standard error (bootstrap s.e.), and the probability of detection for each species (Pd). Estimated point occupancy, bootstrap s.e., and probability of detection were determined using PRESENCE (McKenzie et al. 2002).

Taxa Code	WHRid	Scientific Name	Common Name	Point		Point		Pd
				Pts. Occup	O%	Occupancy (E%)	Bootstrap s.e.	
CALA	M146	<i>Canis latrans</i>	Coyote	4	18.2	20.5	37.3	0.3555
MAAM <sup>a</sup>	M154	<i>Martes americana</i>	American marten	5	22.7	27.4	18.0	0.2991
SPGR	M161	<i>Spilogale gracilis</i>	Western spotted skunk	1	4.5	5.1	5.1	0.3555
URAM <sup>b</sup>	M151	<i>Ursus americanus</i>	Black bear	4	18.2	40.7	32.6	0.1118
CORA <sup>c</sup>	B354	<i>Corvus corax</i>	Common Raven	1	4.5	100.0	0.0	0.0092
TUVU <sup>c</sup>	B108	<i>Cathartes aura</i>	Turkey Vulture	1	4.5	4.6	4.5	0.7997
STJA <sup>c</sup>	B346	<i>Cyanocitta stelleri</i>	Stellar's Jay	10	45.5	65.4	19.8	0.2115
PEMA <sup>c</sup>	M117	<i>Peromyscus maniculatus</i>	Deer mouse	6	27.3	23.0	9.2	0.5929
SPBE <sup>c</sup>	M072	<i>Spermophilus beecheyi</i>	California ground squirrel	4	18.2	18.9	14.2	0.4805
SPLA <sup>c</sup>	M075	<i>Spermophilus lateralis</i>	Golden-mantled ground squirrel	16	72.7	73.47	9.35	0.6014
TADO <sup>c</sup>	M079	<i>Tamiasciurus douglasii</i>	Douglas' squirrel	2	9.1	100	0	0.0183

<sup>a</sup> Forest Service Sensitive species

<sup>b</sup> Management Indicator Species

<sup>c</sup> Non-target species

#### Species detections - camera and track plate stations combined

A total of 5 target species were detected at 16 of 22 points surveyed when both track plate and camera survey methods were combined (Table 17). An average of 1.1 (s.d. = 0.9, range = 0-3) species were detected per point

The marten was the most frequently detected species (40.9% of points with detections) when both data types were combined, and was estimated to occur at 41.4% of points. The black bear and coyote were the next most frequently detected species, 22.7% and 18.2% points with detections, respectively. The black bear was estimated to occur at 60.7% of points, and the coyote was estimated to occur at 20.6% of points. The least frequently detected species were the western spotted skunk and the raccoon, detected at 9.1 and 4.6% of points, respectively. The probability of detection for species with track plate and camera techniques together ranged from 0.01 (raccoon) to 0.70 (spotted skunk) (Table 17).

Table 17. (a) Target species detected with both track plate and camera surveys conducted at 22 monitoring points on LTBMU from 20 June to 20 September 2002, observed point occupancy per species (Pts. Occup and O%), estimated point occupancy (E%) and associated standard error (bootstrap s.e.), and the probability of detection for each species (Pd). Estimated point occupancy, bootstrap s.e., and probability of detection were determined using PRESENCE (McKenzie et al. 2002). (b) Mean detection rates per target species (number of stations x visits with detections per species per point) at points where each species was detected, across all 22 points surveyed, and across points within each of 4 habitat types surveyed. (C) Mean detection rates per target species across points within each of 4 orientations around Lake Tahoe.

**A)**

Taxa Code	WHRid	Scientific Name	Common Name	Pts. Occup	Point Occupancy (O%)	Point Occupancy (E%)	Point Occupancy Bootstrap s.e.	Pd
CALA	M146	Canis latrans	Coyote	4	18.2	20.6	38.0	0.3545
CASP		Canis spp.	Canid	4	18.2	44.3	30.4	0.2269
MAAM <sup>d</sup>	M154	Martes americana	American marten	9	40.9	41.4	10.8	0.5928
PRLO	M153	Procyon lotor	Raccoon	1	4.5	100.0	0.0	0.0092
SPGR	M161	Spilogale gracilis	Western spotted skunk	2	9.1	9.1	6.2	0.6981
URAM <sup>b</sup>	M151	Ursus americana	Black bear	5	22.7	60.7	30.3	0.0905

**B)**

Common Name	Ave. detect rate where present	Ave. detect rate overall	s.d. overall	Lower Montane Conifer (n = 5)		Upper Montane Conifer (n = 13)		Sub-Alpine Conifer (n = 3)		Meadow/Riparian (n = 1)		Pts. Occ. (%)	
				Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.		
Coyote	2.5	0.45	1.50	0.20	0.45	20.00	0.62	1.94	15.38	0.00	0.00	1.00	100.00
Canid	2.6	0.82	2.54	0.80	0.45	80.00	1.00	3.32	15.38	0.00	0.00	1.00	100.00
American marten	5.0	2.05	3.43	4.60	5.55	60.00	0.92	2.02	30.77	3.33	2.89	66.67	0.00
Raccoon	1.0	0.05	0.21	0.00	0.00	0.00	0.08	0.28	7.69	0.00	0.00	0.00	0.00
Western spotted skunk	4.5	0.41	1.53	0.00	0.00	0.00	0.54	1.94	7.69	0.00	0.00	2.00	100.00
Black bear	1.4	0.32	0.65	0.60	0.89	40.00	0.31	0.63	23.08	0.00	0.00	0.00	0.00
<b>Species Richness</b>		<b>1.1</b>	<b>0.9</b>	<b>1.8</b>	<b>0.8</b>	<b>0.8</b>	<b>0.8</b>	<b>0.7</b>	<b>0.6</b>	<b>2.0</b>			
<b>Total Richness</b>				<b>3</b>		<b>5</b>		<b>1</b>		<b>2</b>			

**C)**

Common Name	North (n = 5 pts)			South (n = 8 pts)			East (n = 4 pts)			West (n = 5 pts)		
	Mean Abund.	s.d.	Pts. Occup. (%)	Mean Abund.	s.d.	Pts. Occup. (%)	Mean Abund.	s.d.	Pts. Occup. (%)	Mean Abund.	s.d.	Pts. Occup. (%)
Coyote	0.0	0.0	0.0	1.0	2.4	25.0	0.0	0.0	0.0	0.4	0.5	40.0
Canid	0.0	0.0	0.0	1.8	4.2	37.5	0.5	0.6	50.0	0.4	0.5	40.0
American marten	3.4	5.3	40.0	2.0	3.3	50.0	0.0	0.0	0.0	2.4	2.9	60.0
Raccoon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	20.0
Western spotted skunk	0.0	0.0	0.0	0.3	0.7	12.5	0.0	0.0	0.0	1.4	3.1	20.0
Black bear	1.0	1.0	60.0	0.3	0.5	25.0	0.0	0.0	0.0	0.0	0.0	0.0
<b>Species Richness</b>	<b>1.0</b>	<b>0.7</b>		<b>1.3</b>	<b>1.0</b>		<b>0.5</b>	<b>0.6</b>		<b>1.4</b>	<b>0.9</b>	
<b>Total Richness</b>	<b>2</b>			<b>4</b>			<b>1</b>			<b>4</b>		

Generally, the combination of data from both methods allowed for greater detection frequencies per species (i.e., number of points with detections) compared to either survey method alone (Tables 15, 16 and 17a). Camera stations detected Canids, coyote in particular, and black bear more frequently than track plates (Table 18). However, track plates were more effective at detecting the raccoon, American marten and spotted skunk, detecting each species at a greater percentage of stations surveyed than did cameras (Table 18). Utilizing a combination of both methods is therefore most effective at detecting the greatest array of species and detecting species more frequently compared to either method used alone.

Table 18. Camera and track plate detections of target species. Point detections per species based on detections from cameras and track plates (Pts. Det.) and the percentages of camera and track plate stations with detections of each species at points where each species was detected by at least one method.

<b>Species</b>	<b>Pts. Det. Cameras</b>	<b>Pts. Det. Track plates</b>	<b>% Camera stations</b>	<b>% Track plate stations</b>
Canis latrans	4	1	31.3	4.2
Martes americana	5	7	21.9	35.4
Procyon lotor	0	1	0	16.7
Spilogale gracilis	1	1	12.5	25
Ursus americana	4	1	30	3.3

The greatest total number of species was detected in upper montane conifer habitat (n = 5 species), followed by lower montane conifer (n = 3 species), wet meadow (n = 2 species) and subalpine conifer (n = 1 species). Greatest mean species richness per point was in meadow/riparian habitat, however only one point was surveyed in this habitat type and it may not be representative of this habitat type in the Lake Tahoe basin (Table 17b). Mean carnivore species richness per point was greatest at points on the west side of Lake Tahoe and least on the east side, however total species richness was greatest in both the north and west sides of the basin (Table 17c).

#### Sampling efficiency and bias

Species detected during track plate and camera surveys represented 38.5% of the 13 medium to large carnivore species potentially occurring in the Lake Tahoe basin (Murphy and Knopp 2000; Appendix F). Of the 5 carnivore families found in the basin all but the *Felidae* (n = 2 species) were detected. The lack of detection of mountain lion (*Felis concolor*) and bobcat (*Lynx rufus*) may be due to the elusive nature of most Felids, however, bobcats and mountain lion have been detected at camera stations in the Sierra Nevada before (Sanchez, pers. comm., Campbell, pers. comm.). Additionally, the generally low numbers of deer (a major prey item) in the Tahoe basin may be resulting in low occurrence of mountain lion. Remaining species not detected in this effort include: mink (*Mustela vison*), fisher (*Martes pennanti*), ermine (*Mustela erminea*), long-tailed weasel (*Mustela frenata*), badger (*Taxidea taxus*), and striped skunk (*Mephitis mephitis*). Fisher probably do not occur in the Tahoe basin, as it is suspected they have been extirpated from the Sierra Nevada north of Yosemite (Zielinski et al. 1997), and their range generally does not extend to areas that receive extensive winter snowfall (Krohn et al. 1997). Mink are relatively rare in the Tahoe basin (due to past trapping activity) and rarely encountered unless camera or track stations are placed adjacent to water. Badger and striped skunk are also probably rare in the Tahoe basin. Ermine and long-tailed weasel were both present in the Lake Tahoe basin during 2002 (see Sherman live trapping results above); hence they were expected to be detected with track plate and

camera protocols. Improved detection of many of these species will likely occur with visitation to more survey locations in the Tahoe basin (e.g., increased sample size).

Carnivore species detected most frequently with track plates and cameras (>5 - ≤ 50% point occupancy) were fairly representative of species expected to occur in the basin with regard to riparian dependency, aquatic association, trophic level, home range sizes and listing status, but were not as representative with regard to habitat specificity or old growth dependency (Table 19). Track plate and camera surveys were not as effective at detecting the following species groups in the Lake Tahoe basin: 1) habitat specialists and generalists (moderates were over-represented), and 2) old growth dependent species and those not using old growth (species that utilize, but were not dependent open old growth were over-represented; Table 19). Increased number of points surveyed (only 22 surveyed in 2002) and breadth of habitat types surveyed as a result are likely to aid in increased detections of missed carnivores. The majority of surveys conducted during 2002 were in upper montane conifer habitat, which may explain the lack of detection of some of these target species.

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Table 19. Comparison of life history traits represented by medium and large carnivore species detected most frequently (>5 - ≤ 50% point occupancy) during 2002 and all species expected to occur in the Tahoe basin (Murphy and Knopp 2000) and be detected with either track plate or camera surveys (Appendix F).

Variable	Category Level	Freq. > 5% - Expected		Freq. > 5% - Expected	
		<50%	species	<50%	species
Habitat specificity	Habitat specialists	1	5	25.0	38.5
	Moderate specialists	2	2	50.0	15.4
	Habitat generalist	1	6	25.0	46.2
Late seral/ old growth dependency	Old growth dependent	0	1	0.0	7.7
	utilizes old growth	2	3	50.0	23.1
	doesn't use old growth	2	9	50.0	69.2
Riparian Dependent	Riparian dependent	0	2	0.0	15.4
	utilizes riparian habitat	1	1	25.0	7.7
	doesn't use riparian habitat	3	10	75.0	76.9
Aquatic Association	Terrestrial species	4	12	100.0	92.3
	Semi-aquatic	0	1	0.0	7.7
	Aquatic	0	0	0.0	0.0
Trophic Level	Carnivore	2	9	50.0	69.2
	Scavenger	0	0	0.0	0.0
	Omnivore	2	4	50.0	30.8
	Herbivore	0	0	0.0	0.0
Home Range Size	1-1000 m <sup>2</sup>	0	0	0.0	0.0
	1,001 - 400,000 m <sup>2</sup>	0	2	0.0	15.4
	> 400,001 m <sup>2</sup>	4	11	100.0	84.6
Listing Status	Federal, State listed Threatened or Endangered or California species of concern	1	2	25.0	15.4
	Not Federal or State listed	3	11	75.0	84.6

Target species varied with regard to their period of detection during 2002, probably due to the overall low detection frequencies. Most target species were detected within the first month of surveys (end June- end July) and over a period of 1.5 to 2.5 months thereafter. Raccoon and spotted skunk were exceptions, both first detected in August, 1.5 – 2 months after surveys had started. The raccoon was only detected on a single day throughout the entire summer (8 August 2002), and the spotted skunk was only detected during the last week in August and first week in September. The spotted skunk mates in autumn (Jameson and Peeters 1988) and may be more active and detectable during this period of time, perhaps explaining the detections starting late August 2002. The raccoon was detected so infrequently (n = 1 detection) that we cannot speculate why it may have been detected only in August and not earlier. The black bear was only detected from mid July through mid August. This pattern of detection was neither considered early or late in the season, but was shorter than the active season for bears within the basin. Bear may not have been detected later in the season due to the fact that surveys were conducted in progression from lower elevations to higher elevations, and bear are less likely to inhabit the exposed granite and subalpine conifer habitat types that exist at the higher elevations in the Tahoe basin.

We observed an average latency of detection (i.e., minimum number of days to first detection) per species of 4.0 (s.e. = 0.8, range = 2-6) days per target species at track plate stations (Table 20); this was similar to that observed by Foresman and Pearson (1998) for carnivores detected with a similar effort of track plates in western Montana ( $\bar{x}$  = 2.3 – 5.3 days per species). Latency of detection at camera stations averaged a slightly higher 4.8 days across all target species (Table 20) but was still shorter than the average latency observed by Foresman and Pearson (1998) at camera stations with similar effort ( $\bar{x}$  = 9.0 – 24 days). Black bear had the highest latency value of all target species at track stations (6 days), and the lowest at camera stations (4 days). Coyote, raccoon and spotted skunk had the shortest latency of detection at track stations (2 days)(Table 20), whereas with camera stations they varied from moderate to longest latency values (4.5 – 6 days; Table 20). American marten had a comparatively moderate latency of detection with both track plate and camera survey methods (4.4 – 4.6 days).

Table 20. Average latency of detection (days), standard deviation and number of points with detections (sample size) for target species detected at track plate stations across all points surveyed within LTBMU during 2002.

Species/Category	Track Plates			Cameras		
	Average Latency	s.d.	Sample size (n)	Average Latency	s.d.	Sample size (n)
<i>Canis latrans</i>	2.0	n/a	1	4.5	4.0	4
<i>Canis sp.</i>	5.3	4.2	3			
<i>Martes americana</i> *	4.4	3.3	7	4.6	3.6	5
<i>Procyon lotor</i>	2.0	n/a	1			
<i>Spilogale gracilis</i>	2.0	n/a	1	6.0	n/a	1
<i>Ursus americana</i> **	6.0	n/a	1	4.0	3.4	4
<b>Mean</b>	<b>4.0</b>			<b>4.8</b>		
<b>s.e.</b>	<b>0.8</b>			<b>0.4</b>		

\* LTBMU sensitive species

\*\* Management Indicator Species (MIS)

It is unclear whether there are any effects of bait height on species detections at camera stations. There were no recorded detections of target species at the 2 points with bait placed close to the ground (0.5-1 m), however at 50% of the remaining points with bait placed higher above the

ground (2 m), we also detected no target species. A larger sample size is required to adequately test the effects of bait height at camera stations on detections of carnivore species.

### Species Accumulation Curves

The average proportion of the carnivore species assemblage detected per point increased with increasing numbers of stations per point for track plates alone (Figure 20), camera stations alone (Figure 21) and both detection methods combined (Figure 22). Species detections also increased with increasing numbers of visits per point (maximum of 5 conducted during 2002; Figure 23). All species accumulation curves for track plate and camera detection methods (Figures 20 – 23) have fairly steep linear associations with increasing survey effort. Increases did not appear to level off with increasing numbers of stations for track plates (Figure 20), but did slightly after 3 stations for cameras (Figure 21). Increases in the proportion of the assemblage detected did appear to begin leveling off for both track plates and cameras combined at around 3 stations, and may indicate that 3 stations is the most efficient effort for track plates and cameras when used together. Increases in the proportion of the assemblage detected with increasing visits to track plate and camera stations remained steep (Figure 23), suggesting that future efforts should maintain at least a similar number visits as was conducted during 2002. However, these results should be interpreted cautiously; maximum carnivore species richness across all 22 points surveyed in 2002 was only 3 species and therefore the proportion of the assemblage detected with each level of effort was often based on detections of 0 or 1 additional species. A larger sample size of points is recommended to better evaluate these detection patterns.

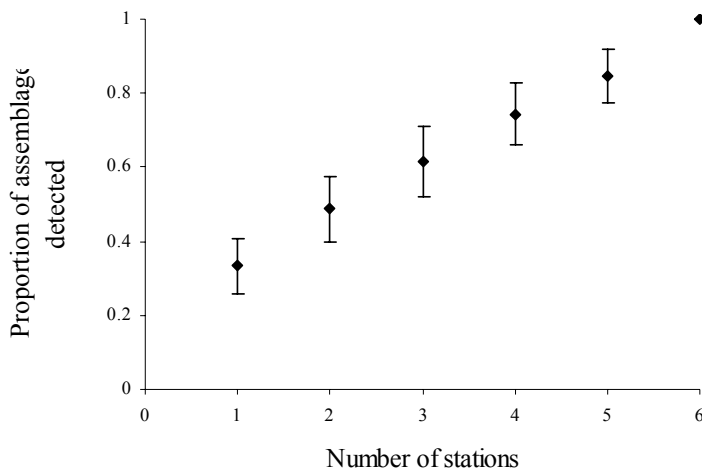


Figure 20. Mean proportion of the carnivore species assemblage detected per point (+/- s.e.) with additional track plate stations. Surveys were conducted at 22 monitoring points in the Lake Tahoe basin in 2002.

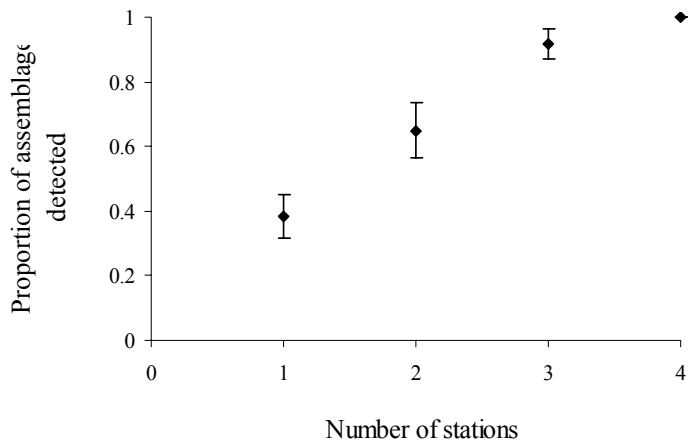


Figure 21. Mean proportion of the carnivore species assemblage detected per point (+/- s.e.) with additional Trailmaster camera stations. Surveys were conducted at 22 monitoring points in the Lake Tahoe basin in 2002.

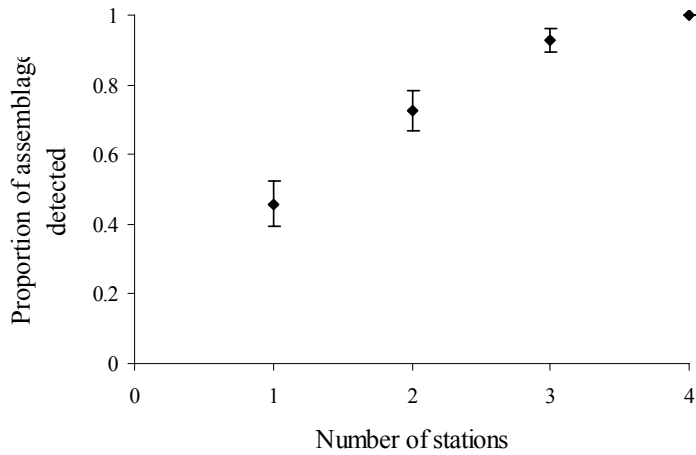


Figure 22. Mean proportion of the carnivore species assemblage detected per point (+/- s.e.) with each addition of paired track plate and Trailmaster camera station. Surveys were conducted at 22 monitoring points in the Lake Tahoe basin in 2002.

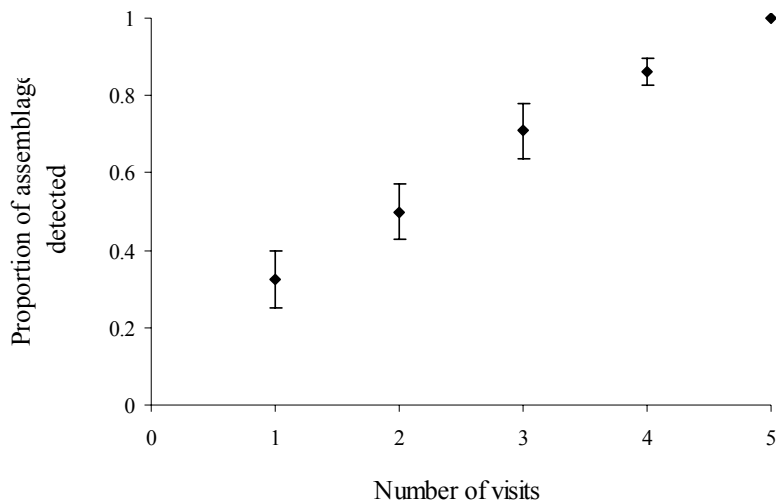


Figure 23. Mean proportion of the carnivore species assemblage detected per point (+/- s.e.) with increasing number of visits. Increments in effort correspond to additional site visits to points (visits occurred every other day after surveys began for up to a total of 10 days). Surveys were conducted at 22 monitoring points in the Lake Tahoe basin in 2002.

### Track plate and Camera Cost Estimate

The approximate cost of track plate and camera surveys during 2002 was \$2980 per point surveyed. This estimate included the cost of hiring and training field crews, site set up, equipment needed to conduct surveys (including track plate materials, cameras and electronic trigger mechanisms) at 4 points simultaneously, truck rental (one truck per crew of two) at \$800/mo for 5 months, salaries for field crews conducting surveys, and habitat data collection at stations. Track plate and camera devices costs attributed for approximately \$400/point, thus the cost for subsequent survey efforts would drop to \$2580/point.

### **Bat Mist-netting and Acoustic Surveys**

#### Mistnet Survey Effort

We conducted 150 mist net surveys between 16 May and 12 September 2002, at 20 monitoring points in the LTBMU. Each site was surveyed for 3.5 hours for a total of 14,101 meter hours of netting. In addition, six points that were surveyed in 2001 as part of a pilot study sampling effort were resurveyed in 2002; four points located on the ENF were surveyed between 13 May and 19 July, and two points on the basin between 3 June and 9 August. Each site associated with these points was surveyed two nights for a total of 36 mist net surveys and 3,129 meter hours.

#### Species Composition and Abundance

A total of 16 species of bats potentially occur in the Lake Tahoe region based on estimates of their geographic range (Table 21). It is expected that some of these species would occur either rarely or not at all in the basin due to elevation or other habitat-related constraints. The

vulnerability ratings (under Status column) are the result of an assessment conducted for all native terrestrial vertebrates in the Sierra bioregion for the purposes of objectively identifying species that were at greatest risk to loss of viability (USDA 2001). Some of the bat species with moderate and high risk have populations of <1,000 individuals or are unknown but suspected to be small, and all of them but the big brown bat have population trends that are either known or expected to be in decline.

Table 21. Potential species list and species captured at bat sites (n=60) associated with LTBMU monitoring points, observed and estimated proportion of points occupied (PPO), estimated probability of detection (*p*), and species status (Federal Special Concern; California Special Concern; Forest Service Sensitive; Low, Medium, High Vulnerability).

Common Name	Scientific Name	Acronym	Observed	Estimated	Estimated	Status
			PPO	PPO	<i>p</i>	
Long-eared myotis	<i>Myotis evotis</i>	MYEV	0.65	0.76	0.22	FSC, M
Big brown bat	<i>Eptesicus fuscus</i>	EPFU	0.60	0.76	0.25	M
Little brown bat	<i>Myotis lucifugus</i>	MYLU	0.55	0.66	0.50	M
Silver-haired bat	<i>Lasionycteris noctivagans</i>	LANO	0.50	1.00	0.36	M
California myotis	<i>Myotis californicus</i>	MYCA	0.30	0.64	0.08	L
Long-legged myotis	<i>Myotis volans</i>	MYVO	0.25	0.34	0.50	FSC, M
Fringed myotis	<i>Myotis thysanodes</i>	MYTH	0.15	0.23	0.48	FSC, M
Yuma myotis	<i>Myotis yumanensis</i>	MYUU	0.15	1.00	0.02	L
Hoary bat	<i>Lasiurus cinereus</i>	LACI	0.10	1.00	0.01	M
Pallid bat	<i>Antrozous pallidus</i>	ANPA	0	--	--	CSC, FSS, M
Townsend's big-eared bat	<i>Corynorhinus townsendii</i>	COTO	0	--	--	FSC, CSC, FSS, H
Spotted bat	<i>Euderma maculatum</i>	EUMA	0	--	--	FSC, CSC, M
Western mastiff bat	<i>Eumops perotis</i>	EUPE	0	--	--	FSC, CSC, M
Western red bat	<i>Lasiurus blossevillii</i>	LABL	0	--	--	FSS, H
Small-footed myotis	<i>Myotis ciliolabrum</i>	MYCI	0	--	--	FSC, M
Mexican free-tailed bat	<i>Tadarida brasiliensis</i>	TABR	0	--	--	M

A total of 9 species and 291 individuals were captured across all sites (Table 21). The most abundant species was the little brown bat (n=110), with the next most abundant species, silver-haired bat, totaling only 49 individuals. The long-eared myotis (n=47) and the big brown bat (n=44) were the next most numerous species captured, and the remaining five species ranged from two to 19 individuals.

Based on the average number of individuals captured per visit, our most productive sites were ponds. The highest elevation site bat surveys were conducted, N15A, captured the greatest number of individuals per visit (mean=10.25), and the most individuals during a single visit (n=18). Averaging nine individuals per visit, site E09C closely followed. Site averages then drop to 7.5 (W31B, a stream site) and continue to decline across the remaining sites. When comparing only the first two visits to all sites, the most individuals captured per point (n=35) were at N15 and N12. These two points, along with E09 and W31, were the most specious, with all four points capturing six species each.

### Reproduction

Reproductive adults and juveniles of both sexes were found at sites in all orientations around the basin. In general, bat species occurring in the basin mate in late autumn to early winter with females storing the sperm through winter (Zeiner et al. 1990). Because of this, males were not expected to display signs of reproductive activity during the sampling period, although some did (Figure 24). This was limited to three species, although only two species had a significant portion of their total captures displaying descended testes, silver-haired (25%) and big brown

(20%). The third species, little brown bat, along with silver-haired bat made up nearly 75% of total juveniles captured, which suggests juveniles of these species may have emerged from maternity roosts in the area.

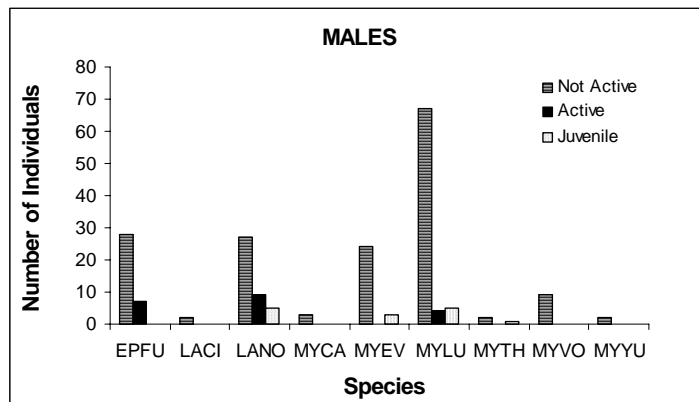


Figure 24. Number of adult males not reproductively active, active (descended testes), and male juveniles captured at bat sites (n=60), LTBMU.

Females ovulate during April and May and young are born May through July (Ziener et al. 1990). Because females are generally found to occupy lower elevations during reproduction, particularly in mountainous regions (e.g., big brown bat: Fenton et al. 1980; little brown bat: Fenton and Barclay 1980), it was unexpected when 32% of all captures were female and just over half of these were reproductively active (Figure 25). Seven of the nine total species detected during the sampling period included pregnant or lactating females. Captures of these same species also included post-lactating females, which are not counted as reproductive in the event they migrated into the area soon after their young became volant. Although there were several species for which reproductive females made up a significant portion of the total captures, the capture rates in general were quite low. For example, species that had the highest percent of reproductive females (25 to 60% of total female captures) had capture rates of four (California myotis), five (fringed myotis), six (silver-haired) and ten (long-legged myotis).

In contrast, the species with the highest female capture rate, little brown bat (n=26), included only one reproductive individual. This species also had the greatest number of juveniles (n=13), which were all captured at southern sites in the basin. Nine of these juvenile bats were captured at S06 over three surveys (eight captured during two surveys), again vaguely suggesting a maternity roost in the area, however, no reproductive or post-reproductive females were captured at this point. The remaining four juveniles were captured at sites associated with two other points, S20 and S26, where post-lactating females were captured during the same surveys. The silver-haired juvenile bats, seven in total, were dispersed over points in all basin orientations.

### ***Environmental Associations***

#### Habitat Type

Four habitat types were sampled: lotic (streams), lentic (ponds and lakes/bogs), forest (roads and trails) and meadow, with the number of sites per habitat type ranging from 5 to 24 (Table 22). Lotic and lentic sites were approximately equal in number and made up 77% of total sites, leaving the remaining sites distributed unequally between forest and meadow.

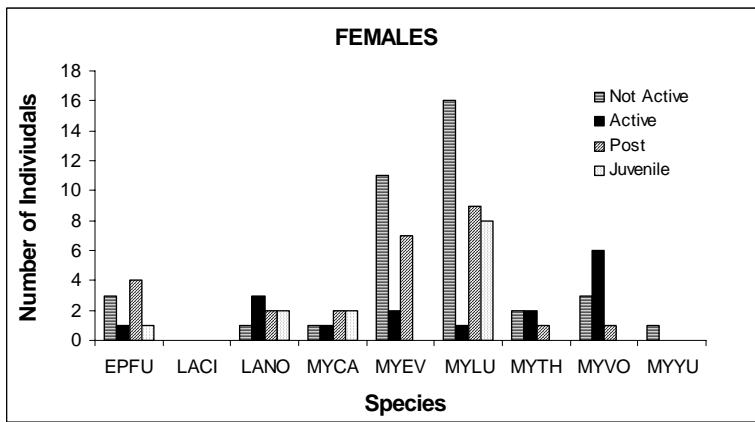


Figure 25. Number of adult females not reproductively active, active (pregnant or lactating), post-lactating, and female juveniles captured at bat sites (n=60), LTBMU.

Surveys at lentic sites captured the most individuals and the greatest number of species per survey per site compared to the other habitat types; lotic sites had the second highest capture rates and species richness (Table 22). Only at lentic habitats were all nine species captured at least once, and the greatest number of individuals captured during a survey (n=18) occurred at a lentic site. The greatest number of species captured during a survey (n=6) and species per site (n=7) occurred in both lentic and lotic habitats. Silver-haired bats (n=49), fringed myotis (n=8), and long-legged myotis (n=19) were captured only at lentic and lotic sites, and the two hoary bats were captured at lentic sites. Two species, Yuma myotis (n=3) and big brown bat (n=44), were found in all habitats except meadows, and California myotis (n=9), long-eared myotis (n=47), and little brown bats (n=110) were detected in all habitats.

Table 22. Number of sites, surveys, individuals and species, and average number of individuals and species captured per habitat type at bat sites (n=60), LTBMU.

Habitat	No. of Sites per Habitat Type	No. of Surveys per Habitat Type	Total Individuals	Total Species	No. of Individuals per Survey	No. of Species per Survey
Lentic	22	54	163	9	3.02	0.17
Lotic	24	62	116	8	1.87	0.13
Forest	9	18	8	5	0.44	0.28
Meadow	5	16	4	3	0.25	0.19
<b>Total</b>	<b>60</b>	<b>150</b>	<b>291</b>	<b>9</b>		

Results of a Goodness of Fit analysis to determine if species were captured at habitats in proportion to their occurrence are shown in Table 23. Three species had individual capture frequencies that were significantly different than expected based on habitat representation in the sample. Greater than 90% of all detections of big brown and little brown bats, and long-eared myotis were at lentic and lotic sites. When analyzing only these habitat types, little brown bats and, to a lesser degree, long-eared myotis, were strongly associated with only one aquatic type, lentic and lotic sites, respectively.

Table 23. Goodness of Fit tests for species observations across all habitat types (df=3), and between lentic and lotic habitat types only (df=1), LTBMU bat sites (n=60) and LTBMU resample bat sites (n=6). Some species observations were too low to generate expected values >5, a requirement for the test to be valid.

Species	Habitat Type	Observed (f)	Expected (f)	$(f - \hat{f})^2 / \hat{f}$	Lentic/Lotic Habitats Only
EPFU	Forest	3	6.5	1.92	
	Lentic	29	18.9	5.39	
	Lotic	16	18.9	0.45	
	Meadow	0	3.6	3.64	
	<b>Total</b>	<b>48</b>		11.39**	5.83
LACI	Forest	0	0.3		
	Lentic	2	0.8		
	Lotic	0	0.8		
	Meadow	0	0.2		
	<b>Total</b>	<b>2</b>			
LANO	Forest	0	7.0	6.95	
	Lentic	26	20.1	1.74	
	Lotic	25	20.1	1.20	
	Meadow	0	3.9	3.86	
	<b>Total</b>	<b>51</b>		13.76	2.94
MYCA	Forest	1	1.2		
	Lentic	2	3.5		
	Lotic	5	3.5		
	Meadow	1	0.7		
	<b>Total</b>	<b>9</b>			
MYEV	Forest	1	6.4	4.57	
	Lentic	13	18.5	1.64	
	Lotic	32	18.5	9.82	
	Meadow	1	3.6	1.84	
	<b>Total</b>	<b>47</b>		17.87***	11.46***
MYLU	Forest	2	17.2	13.41	
	Lentic	94	49.6	39.65	
	Lotic	28	49.6	9.43	
	Meadow	2	9.5	5.96	
	<b>Total</b>	<b>126</b>		68.46***	49.08***
MYTH	Forest	0	1.1		
	Lentic	2	3.2		
	Lotic	6	3.2		
	Meadow	0	0.6		
	<b>Total</b>	<b>8</b>			3.00
MYVO	Forest	0	2.7		
	Lentic	11	7.9		
	Lotic	9	7.9		
	Meadow	0	1.5		
	<b>Total</b>	<b>20</b>			1.40
MYYU	Forest	1	0.0		
	Lentic	1	0.0		
	Lotic	1	0.0		
	Meadow	0	0.0		
	<b>Total</b>	<b>3</b>			

\* p<0.05

\*\* p<0.01

\*\*\* p<0.001

## Basin Orientation

Habitat types were not evenly distributed among the four basin orientations, but rather their distribution was a function of availability within the randomly located PSUs within each orientation (Table 24). The east side of the basin was the only orientation where all nine bat species were detected (across all sites and surveys), even though it had the least number of sites (Table 24). The north side of the basin had the next lowest number of sites, and surveys there captured the most individuals. The east and north-sides of the basin are the driest (receiving less precipitation than the west and south sides) and the east side is the warmest, with mean daily minimum and maximum temperatures for the months of May through September being 1.4°C (minimum) and 2.4°C (maximum) warmer than the west-side (WRCC 2002). When mean survey temperatures (average of net open and net close temperatures) were compared by month and by basin orientation we found that throughout the sampling period temperatures on the east side were 1.5°C warmer on average than any other orientation.

Table 24. Number of sites in each habitat type and total number of individuals and species captured at bat sites (n=60) in each basin orientation, LTBMU.

<b>Orientation</b>	<b>Lentic</b>	<b>Lotic</b>	<b>Forest</b>	<b>Meadow</b>	<b>No. of Sites</b>	<b>No. of Individuals</b>	<b>No. of Species</b>
East	1	3	2	3	9	61	9
North	4	4	4	0	12	110	7
South	11	6	2	2	21	77	7
West	6	11	1	0	18	43	6

Approximately half of the silver-haired (51%) and long-eared (47%) bat captures were on the north side of the basin. The little brown bat, the most frequently detected species, was primarily captured on the north (36% of captures) and south side (46% of captures) of the basin. And, although capture numbers were low for the fringed myotis, all but one (88%) were detected on the east side of the basin.

## Elevation

Research has shown bat activity to be greater at lower elevations (Thomas 1988, Barclay 1991), and there are some species for which elevation may be a limiting factor. Indeed, species that are known to primarily occur, or are more abundant, at lower elevations (western red bat: Brylski 1997, USDA 1999, Yuma myotis: USDA 1999), or in arid regions of the Sierra (small-footed myotis: Zeiner et al. 1990, USDA 1999), are species that were captured rarely or not at all during this netting effort (Figure 26). There are a few bats considered to be high elevation species, such as big brown bat (Kurta and Baker 1990) and long-legged myotis (Warner and Czaplewski 1984), although in order of abundance these two species ranked fourth and fifth, respectively. The little brown bat, formerly known as the high Sierra bat (Grinnell and Storer 1929), was the most frequently captured bat and the most abundant species at the highest elevations in the study area, followed by the silver-haired bat (Figure 26). A search of elevation records for bat species in North America revealed that silver-haired bats and California myotis had not been recorded at the elevations we encountered them, which was at our highest site, the site that also captured the most individuals in the basin (N15A at 2740m, n=41 individuals).

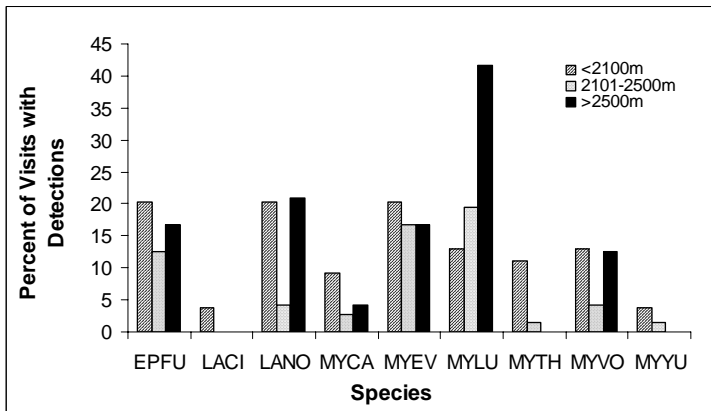


Figure 26. Percent of surveys in which species was captured at three elevation intervals, LTBMU.

Studies in North America have found that females tend towards lower elevations during reproductively active summer months (Cryan et al. 2000, Grindal et al. 1999), especially in mountainous regions where it may help to mitigate the energetic costs of reproduction by seeking overall warmer temperatures or more reliable food sources. Unequal sex ratios were certainly evidenced in the most frequently captured bats in the basin (Figure 27), although actual sexual segregation was less clear.

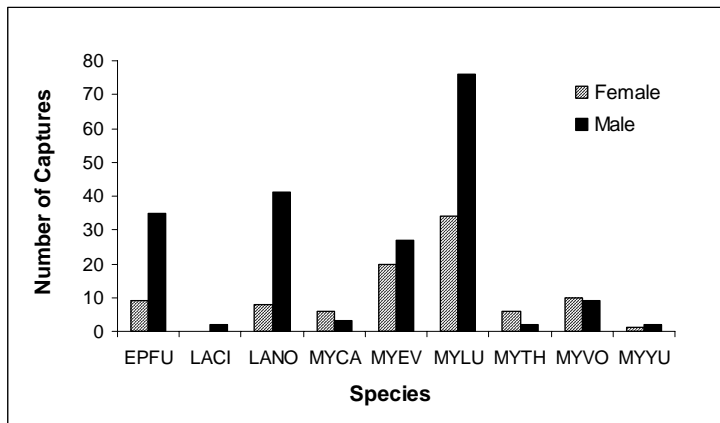


Figure 27. Comparison of female to male captures by species at bat sites (n=60), LTBMU.

When examining the data by site, the greatest unequal sex ratios (female:male) were demonstrated at N15A (1:40, 2740m), S06A (4:19, 2530m), N12A (4:17, 2260m), and N12B (1:13, 2290m). In general the little brown bat was the dominant male at all sites, and although female captures were low, they were of the same species as male captures.

When examining the data by species there were three sites, all >2260m, where only males of a species were captured. Two sites captured only little brown bats, one site (N15A) also captured silver-haired and long-legged myotis; individual capture rates ranged from 5 to 18. There was one site (E09A at 1950m) that captured only females (n=5) of three species. Sites associated

with this same point captured six of the 10 female long-legged myotis detected, and all were at <2040m, while 90% of the males were at >2260m.

There were four species with enough captures to observe any meaningful separation of sexes within a species; five of the nine species captured in the basin had less than 20 individuals each (range 2 to 19), and four had captures of greater than 40 individuals (range 44 to 110). Of these four, little brown, big brown, and silver-haired bats had male captures ranging from 70 to 84% of total captures. However, with the exception of the above mentioned sites, all occurred at sites with conspecific females. The remaining species, long-eared myotis, had nearly an equal sex ratio, with over 90% of the males captured at >2260m and 70% of the females at <2070m.

### Temperature

Surveys spanned a wide range of temperatures from 0 to 26°C, and bats were captured at temperatures ranging from 2 to 19°C. The distribution of capture temperatures show that over half (64%) of all individuals were captured when temperatures were between 8 and 13°C, with the remaining individuals distributed somewhat equally above or below this range (Figure 28). Based on 2001 pilot study data, where 47% of the captures occurred when temperatures ranged from 13 to 16°C, we would have expected more captures during the warmer nights in the basin. Further, examination of temperature at the time of net closure with the total number of individuals captured revealed no significant relationship between temperature and number of individuals captured ( $r=-0.016$ ,  $P=0.890$ ,  $n=60$ ).

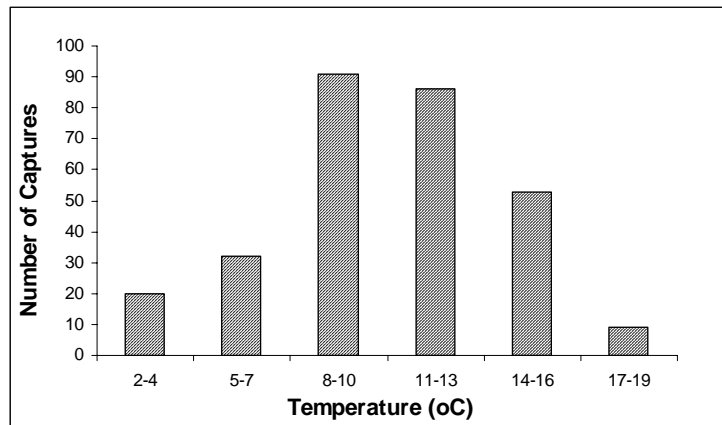


Figure 28. Distribution of temperatures at which bats were captured during surveys at bat sites (n=60), LTBMU.

Our highest elevation site captured the most individuals of any site and had a mean capture temperature of 11°C. All were male but one, a female long-eared myotis. Manning and Jones (1989) reported that long-eared bats demonstrated a preference for activity at relatively low temperatures; half of the captures for this species occurred at temperatures <10 °C.

**Life History Characteristics**

A Likelihood Ratio analysis was used to explore potential relationships between a set of life history characteristics relevant for bats and their frequency of detection (Table 25), with the intention of gaining some insight as to why we did or did not capture particular species.

Table 25. Frequency class, migratory status, population size, and aspect ratio to wing loading ratio for bat species expected to occur in LTBMU (n=16).

<b>Common Name</b>	<b>Acronym</b>	<b>Frequency Class</b>	<b>Migratory Status</b>	<b>Population Size</b>	<b>Aspect Ratio: Wing Loading</b>
Big brown bat	EPFU	H	short	>10,000	L:L
Hoary bat	LACI	L	long	1001-10,000	H:H
Silver-haired bat	LANO	H	long	1001-10,000	H:L
California myotis	MYCA	L	short	>10,000	L:L
Long-eared myotis	MYEV	H	short	1001-10,000	L:L
Little brown bat	MYLU	H	long	1001-10,000	L:L
Fringed myotis	MYTH	L	short	101-1000	L:L
Long-legged myotis	MYVO	L	short	101-1000	L:L
Yuma myotis	MYYU	L	short	>10,000	L:H
Pallid bat	ANPA	N	short	1001-10,000	L:L
Townsend's big-eared bat	COTO	N	short	1001-10,000	L:L
Spotted bat	EUMA	N	short	101-1000	unavailable
Western mastiff bat	EUPE	N	non	1001-10,000	H:H
Western red bat	LABL	N	short	101-1000	L:H
Small-footed myotis	MYCI	N	short	101-1000	L:L

Analysis resulted in no significant associations either between migratory status and frequency class (Likelihood Ratio  $\chi^2=6.023$ ,  $df=4$ ,  $P=0.185$ ) or population size and frequency class (Likelihood Ratio  $\chi^2=5.188$ ,  $df=4$ ,  $P=0.269$ ). However, when the percent of species in each category of migratory status were examined by their frequency class (Table 26) we found that of the species not captured, it was the short distance migrants we missed detecting most.

Table 26. Percent of expected bat species (n=16) in each migratory status category by frequency class (Low = detected at <10 points, High = detected at  $\geq 10$  points), LTBMU monitoring points (n=20).

<b>Migratory Status</b>	<b>Not Captured</b>	<b>Low Frequency Class</b>	<b>High Frequency Class</b>
Non-migratory	14.29	0.00	0.00
Short-distance migrant	85.71	80.00	50.00
Long-distance migrant	0.00	20.00	50.00

Although we wouldn't expect to have high captures of species that number less than 1000 in the Sierra Nevada (USDA 2000), we were surprised to have detected 40% of the species (fringed and long-legged myotis) with this low population size with some frequency (Table 27).

Table 27. Percent of expected bat species (n=16) in each population size category by frequency class, (Low = detected at <10 points, High = detected at ≥10 points), LTBMU monitoring points (n=20).

No. of Individuals	Not Captured	Low Frequency Class	High Frequency Class
<1000	42.86	40.00	0.00
1,001-10,000	42.86	20.00	75.00
>10,000	14.29	40.00	25.00

Because aspect ratio to wing loading ratios can be used to generally infer the foraging habitats of bats, we wanted to explore the possibility that species we failed to detect are perhaps those ill-adapted for foraging in forested environments. For example, species with high aspect ratios can afford continuous flight and those with low aspect ratios usually rest; species with high wing loading are fast fliers, while those with low wing loading are slow fliers (Norberg and Rayner 1987). It follows, therefore, that species with low aspect ratio and low wing loading typically feed by gleaning in or close to clutter (forest), and that the majority (67%) of the species we detected in the basin are in this category (Table 28). Conversely, the three species with high aspect ratio and high wing loading were rarely detected (hoary bat n=2) or not at all (western mastiff bat, Mexican free-tailed bat). Although analysis results found no significant associations between these ratios and frequency class (Likelihood Ratio  $\chi^2=6.189$ ,  $df=6$ ,  $P=0.402$ ), the majority of species captured were dominated by the L:L ratio category, which includes all but one of the myotis species that can be found in the basin. No ratio data were available for the spotted bat.

Table 28. Percent of expected bat species (n=15) in each aspect ratio to wing loading ratio category (L = low, H = high) by frequency class, (Low = detected at <10 points, High = detected at ≥10 points), LTBMU monitoring points (n=20).

Aspect Ratio:Wing Loading	Not Captured	Low Frequency Class	High Frequency Class
L:L	50.00	60.00	75.00
L:H	16.67	20.00	0.00
H:L	0.00	0.00	25.00
H:H	33.33	20.00	0.00

### *Temporal Variation in Frequency of Capture*

All bat species appeared to be present in the study area for the duration of the sampling period (Table 29). Surveys began in mid-May, but only three were conducted during that month, resulting in too small a sample size to attribute the lack of captures to the time of year.

Table 29. Dates of first and last capture of each species at bat sites (n=60), LTBMU.

	EPFU	LACI	LANO	MYCA	MYEV	MYLU	MYTH	MYVO	MYYU
Date of first capture	06 Jun	11 Jun	19 Jun	19 Jun	12 Jun	07 Jun	19 Jun	12 Jun	11 Jun
Date of last capture	11 Sep	11 Sep	12 Sep	12 Sep	12 Sep	12 Sep	09 Sep	12 Sep	26 Aug

The average number of individuals per survey per month did not differ significantly throughout the sampling period (Table 30). However captures were quite low relative to the 2001 pilot study, where surveys at lower elevation sites on ENF captured nearly twice the average number of individuals per survey (3.67) than the basin. This corroborates our observations in 2001, and substantiates the generally held assumption that bat densities tend to be low at higher elevations.

Table 30. Number of surveys, individuals, and average number of individuals captured per survey per month of sampling period at bat sites (n=60) at 20 samples sites in 2002 at LTBMU.

Month	No. of Surveys	No. of Individuals	Average No. Individuals per Survey
May	3	0	0.00
June	28	49	1.75
July	31	37	1.19
August	60	146	2.43
September	28	59	2.11

**Introduction of juveniles into population**

Bat species occurring in the basin rear young that are generally able to fly within three weeks of birth (Zeiner et al. 1990), we therefore expected capture rates to peak in July and August with the introduction of juveniles into the volant population. And, although captures of juveniles totaled only 27 (Figure 29), the four most abundant species did reach peak numbers in August, including the little brown bat, which had 62% of its total captures in August. In June one juvenile each of two species were detected, silver-haired bat and California myotis; in July only a single juvenile California myotis was captured. Twenty juveniles of four species were detected in August, and by September juvenile captures dropped to four individuals of three species, including the only fringed myotis juvenile captured.

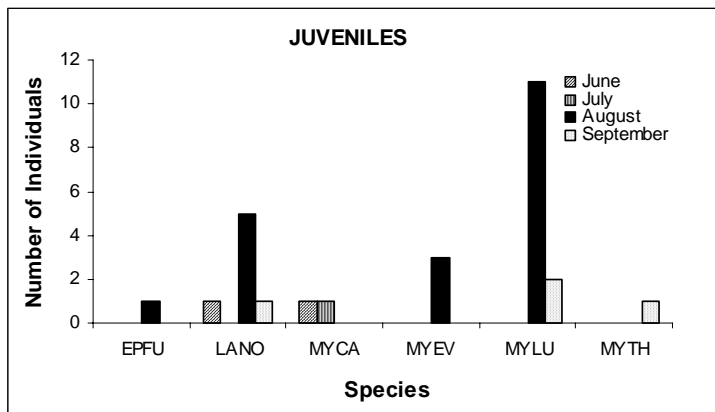


Figure 29. Captures of juveniles by species and month at bat sites (n=60) in 2002 in LTBMU.

**Proportion of Points Occupied and Detectability**

Each species was detected at an average of 36.1% of all monitoring points (range = 10.0 to 65.0% for hoary bat and long-eared myotis, respectively), with species being detected at a much lower proportion of sites (mean = 17.1%, range = 3.0 to 35.0% for hoary bat and long-eared myotis, respectively). This indicates that species were most often detected at a subset of sites (one or two) per point. The ratio of proportion of sites to proportion of points with detections averaged 44% (range = 30 to 55%), and this ratio serves as a rough guide to probability of detection across species. Probability of detection varied from 0.01 to 0.50 among species. One third of the species had detection probabilities of around 0.50, three others were between 0.25 and 0.36, and the remaining three species were below 0.10. Estimates of the proportion of points occupied were always higher than observed proportion of points occupied (Table 21), and ranged from 0.10 to 0.90 higher than observed. The estimated proportions of points occupied were only 0.10 to 0.15

higher than observed for 5 of the 9 species, two were 0.35 to 0.50 higher, and the remaining two were dramatically higher, 0.85 to 0.90.

### Sampling Efficiency

Surveys were conducted for 3.5 hours, starting at sunset. By examining the capture data in 30-minute intervals we found that bats were captured during all intervals, that most species were captured during every interval, and that most individuals were captured during the second 30-minute interval (Figure 30). Data from the 2001 pilot study also revealed peak captures during this second 30-minute interval. Similarly, data from both years show that approximately 40% of total captures occurred in the first hour of netting. However, while 2001 had 80% of species detected at a site occurring within the first two hours of the survey, 2002 had 67%. It took an average of 39.5 minutes (range 79-90) to detect the remaining species at sites past two hours/120 minutes, and included 5 species.

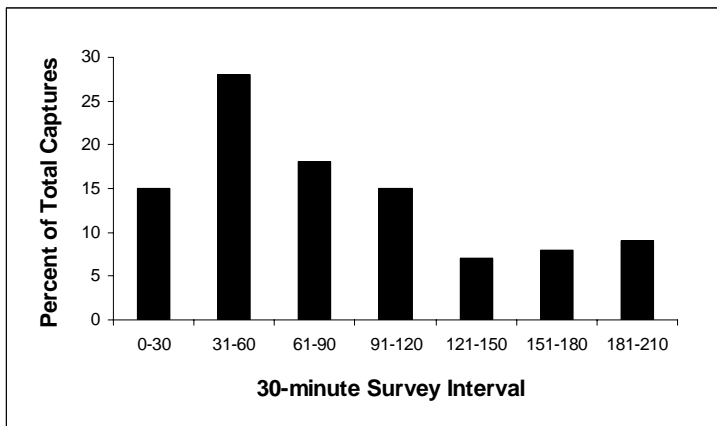


Figure 30. Percent of captures by 30-minute intervals of survey time at bat sites (n=60) in 2002, LTBMU.

Evaluation of the relationship between total meter net used per site and the number of captures showed that roughly 30% of the variation in capture rates was explained by the amount of meter net used ( $r=0.295$ ,  $P<0.0001$ ,  $n=60$ ).

The ability to predict sites that will be most productive for bat surveys in terms of either capture rates or species richness is difficult. Prior to netting bat biologists rated the potential productivity of the three sites, relative to each other, associated with the 20 monitoring points in the basin and two resample points. Not all biologists were able to rate all points, and four points had no captures. Evaluation of the ratings revealed that the most productive site was predicted as such 37% of the time, predicted as the second best site 50%, and predicted as the least productive of the three sites 14% of the time by any one biologist.

All three biologists correctly predicted the most productive site at only one point, at five points two biologists predicted the most productive site, and at four points at least one biologist predicted the most productive site. At the remaining eight points no biologist correctly predicted the most productive site. Because capture rates and species richness are related these evaluations were based only on capture rates, however, at one of these eight points, the site all biologists rated

as the most productive had the greatest species richness but captured three less individuals. Two other points had very low capture rates that occurred at only one of the three sites, and the remainder were points that had a stream site as the most productive, but biologists chose either another stream site associated with that point or a pond. Biologists were fairly equal in their distribution of ratings, that is, not all pond sites or all stream sites were consistently rated as potentially being the most productive.

The California Wildlife Habitat Relationship database analysis, used to compare the proportion of expected bat species to observed, across all 20 points surveyed for bats, resulted in a mean percent of 28.6% (s.d.=21.8) expected species detected; four points had no bat captures, resulting in a reduced mean and an increased standard deviation. These points had similar characteristics: in general, all four had a densely forested understory, making flight at net level difficult; three of the four with water had net sites on small, steep, channelized ephemeral streams; and one had net sites all located on trails.

Species expected, based on habitat, but not detected included the pallid bat (expected at 10 points) and the Mexican free-tailed bat (expected at 19 points). Mexican free-tailed bats are a high-flying species that typically forage 30 meters above ground (Zeiner et al. 1990) and are more often reported in studies as being detected acoustically rather than captured. Pallid bats are most common at lower elevations and in dry open habitats, such as oak woodlands in lower elevations of California, and Ponderosa pine in slightly higher elevations (Zeiner et al. 1990). Therefore, it is not surprising that neither of these species were captured in nets during surveys. Further, when pallid bats were captured during the 2001 pilot study (at elevations lower than the basin) they were captured consistently (each visit to a site), inferring that if this species were present at a point we would have detected it.

Seven of the nine species captured were expected at more points based on habitat than they were detected, including big brown bat (expected at 8 additional points), long-eared myotis (expected at 9 additional points), little brown bat and silver-haired bat (each expected at 10 additional points), fringed myotis (expected at 5 additional points), California myotis (expected at 15 additional points), and Yuma myotis (expected at 17 additional points). The first four species were the most frequently captured species, the latter three species we captured less than ten individuals of each. It is difficult to reconcile these differences between expected and observed species lists per point, except to say that although species may be associated with the vegetation types found in the basin they are often more numerous in them at lower elevations, something the CWHR database does not take into account. It is plausible that suitable habitat at higher elevations is not occupied or is used less consistently throughout the breeding season compared to lower elevation sites (as indicated by lower abundances per site).

In addition to expected bat species not being observed at a point the converse was true, species not expected to be present based on habitat relationships were observed; these species were the hoary bat (n=2 total captures) and the long-legged myotis (n=19 total captures). Because so few bat surveys have been conducted at higher elevations in California it is likely these species were not expected to occur simply because so little is known of their status and habitat use at the elevations present in the basin.

### *Acoustic Surveys*

In 2001, there were 52 acoustic surveys conducted simultaneously with mist net surveys at 32 of the 36 sites. A total of 625 call files were analyzed using the Sonobat call analysis program, resulting in 131 being eliminated due to poor recording quality. A good quality recording includes the harmonics associated with each call and often these harmonics are needed to make a species or species couplet determination. Of the remaining 494 files, 37% were identified to seven species and 63% to five species couplets. A couplet is comprised of two species that are difficult to

distinguish some or all of the time, such as some calls of the silver-haired and big brown bats, silver-haired and hoary bats, and hoary and Mexican free-tailed bats. There are two couplets of *Myotis* that are considered, in very conservative terms, to be indistinguishable from each other within the couplet, and are therefore always considered as the *Myotis* 40kHz group or California and Yuma *myotis*, and the *Myotis* 50kHz group or little brown and long-legged *myotis*.

The species detected more often acoustically than captured were the hoary and Mexican free-tailed bat (identified to both species and species couplet), and the western red bat. The latter, a Forest Service Sensitive species, was detected acoustically on three occasions at high elevation sites, but never captured. Although this species is typically associated with lowland valley riparian, it was detected at the upper Truckee river and Showers Lake sites, which are connected by the river and lined for much of this length with aspen trees, a likely roost tree species in the absence of their favored lowland riparian tree species (USDA 2001). The two former species are two of the three species potentially occurring in the study area with high aspect ratio to wing loading values, that is, species that are particularly inapt for foraging in cluttered environments. The hoary bat was detected acoustically on 13 occasions, captured on six, and was an acoustically detected addition to eight of the twelve pilot study points (Table 31). The Mexican free-tailed bat was detected on six occasions, captured once on the ENF, and was an acoustically detected addition to four points in the middle and high elevation clusters. The third species more suited for foraging in less cluttered environments was the western mastiff bat, which was not detected by either method, and is associated with more open and arid habitats.

Analysis of calls in Sonobat allowed for seven species to be confidently identified when a good quality recording was made. Species that were detected more or less equally by both methods were the fringed *myotis*, big brown bat, and silver-haired bat. The one species more often captured than detected acoustically was the long-eared *myotis*. The majority of calls identified to species were silver-haired bats, with nearly 60 files; 40 files were identified as big brown bats, and the remaining five species each had from three to 14 acoustic files attributed to them.

The species couplets most often detected acoustically were the *Myotis* 40kHz and 50kHz bats, making up more than 70% of the couplet identifications. An additional 23% were attributed equally to the hoary and silver-haired bat couplet and the hoary and Mexican free-tailed bat couplet. The remaining 4% were identified to the silver-haired and big brown bat couplet. The non-*Myotis* couplets include bats that are also identifiable to species using Sonobat when certain characteristics are present.

The contribution acoustic surveys can make towards a monitoring program are demonstrated by the fact that 26 of the 32 sites (>80%) with simultaneous acoustic and mist net surveys had from one to five species or species couplets added by acoustic surveys; most often additions at sites were the hoary and Mexican free-tailed bat couplet (Table 31).

All high and middle elevation points, and two of the four low elevation points had from one to three species or species couplet additions. This included the two *Myotis* couplets and four bat species: fringed *myotis*, hoary, free-tailed, and western red bat. In terms of captures, these four species were detected rarely if at all, with a combined total of 15 individuals out of a season total of 569, confirming the value of conducting acoustic surveys in a way that allows for some level of species identification.

Table 31. Common name and acronym of bat species and species couplets uniquely detected at sites and points during 2001 acoustic surveys at pilot study sites on LTBMU (n=12) and ENF (n=24).

Common Name	Acronym	Uniquely Detected by Acoustic Survey	
		No. of Sites	No. of Points
Big brown bat	EPFU	6	0
Western red bat	LABL	2	2
Hoary bat/Mexican free-tailed bat	LACI/TABR	13	8
Silver-haired bat	LANO	3	0
California myotis/Yuma myotis	MYCA/MYYU	5	1
Long-eared myotis	MYEV	2	0
Little brown bat/Long-legged myotis	MYLU/MYVO	8	3
Fringed myotis	MYTH	4	2

In 2002, there were 58 acoustic surveys conducted simultaneously with mist net surveys at 39 of the 60 monitoring sites. Although we had anticipated at least one simultaneous acoustic survey at each site, equipment failure prevented this from occurring. A total of 583 were analyzed in the Sonobat call analysis program, resulting in 192 being eliminated due to poor recording quality. Of the remaining 391 files, 32% were identified to five species and 68% to five species couplets, percentages similar to 2001 results above.

Only the Mexican free-tailed bat was detected more often acoustically than captured, with just two files being identified to this species and no captures. In 2001, western red bat and hoary bat were also detected more often acoustically, however, no red bat calls were detected this season and the hoary bat, along with silver-haired bat, were essentially detected equally by both methods. The species more often captured than detected acoustically in 2001 and 2002 was the long-eared myotis, with results being remarkably similar: 42 and 47 captures, and 14 and 15 acoustic detections, respectively. In 2002, big brown bat and fringed myotis were also captured more often than acoustically detected. As with 2001, the majority of calls identified to species were silver-haired bats (52 files), with the remaining five species each having from two to 15 files attributed to them.

The species couplet most often detected acoustically was the hoary and silver-haired bat couplet (44%), with an additional 40% of files attributed to Myotis 40kHz (28%) and Myotis 50kHz (12%). The remaining files were identified as silver-haired and big brown couplet and Mexican free-tailed and hoary couplet.

The contribution acoustic surveys made towards a more complete sampling of the bat community associated with a site or point are shown in Table 32. Nearly 50% of sites with simultaneous acoustic surveys, and 60% of points, had from one to four species or species couplet acoustic additions. Additionally, there were 16 sites (4 points) with no captures but that had from one to four species or species couplet detections.

Table 32. Common name and acronym of bat species and species couplets uniquely detected at sites and points during 2002 acoustic surveys at bat monitoring sites (n=60) on LTBMU.

Common Name	Acronym	Uniquely Detected by Acoustic Survey	
		No. of Sites	No. of Points
Big brown bat	EPFU	2	1
Hoary bat/Mexican free-tailed bat	LACI/TABR	5	4
Silver-haired bat	LANO	11	7
California myotis/Yuma myotis	MYCA/MYYU	9	3
Long-eared myotis	MYEV	4	1
Little brown bat/Long-legged myotis	MYLU/MYVO	13	7

Maximum likelihood estimations showed that it would be difficult to detect greater than 40% of all species associated with a given point no matter how many sites were sampled or surveys conducted (Figure 31). In addition, per unit effort, adding sites is more efficient than adding visits to sites. For example, 1 to 6 visits to a single site average a gain of 2.3% of the assemblage detected, whereas 1 to 6 sites with one visit average a gain of 4.8% of the assemblage detected. Similarly, the addition of a second site regardless of the number of visits to them increases the proportion of the assemblage detected by an average of over 10%, whereas the addition of a second visit to any number of sites increases the proportion of the assemblage detected by an average of almost 8%, but then quickly drops to 3.6%, 1.8% and < 1.0 for each additional visit. The most efficient combination of efforts appeared to be sampling two sites three times or three sites two times, for a total of 6 surveys per point. The third visit to two sites increases detections an estimated 6.5%, whereas a fourth visit to two sites is estimated to drop to an additional 2.1% of the assemblage detected. Similarly, the second visit to three sites increases detections an estimated 8.9%, whereas a third visit to three sites is estimated to drop to an additional 3.9% of the assemblage detected.

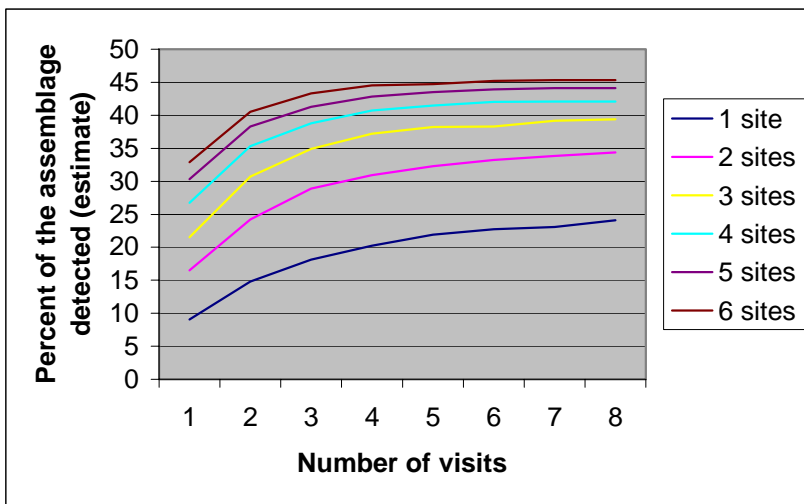


Figure 31. Percent of the bat assemblage at a given monitoring point that is estimated to be detected with various combinations of sites and visits to sites. Data collected in 2002 in LTBMU.

### Inter-year Variation

The eight resample points provided insights into the annual variability in point use and species detectability. This variability can be used to calibrate sample size estimates and inform the proportion of points that should be sampled every year (e.g., higher inter-year variability would suggest the need for a higher proportion of points sampled every year).

The same nine species were detected in each year (Table 33). Species composition at individual points varied little despite unequal sampling effort between the two years. In most instances two or three species, which were typically represented by one individual, were not captured in the second year of surveys (when only two visits were made as opposed to up to 6 visits in 2001). Most often these species were the fringed, long-eared, long-legged, and Yuma myotis. There were species gains at five of the points during the second year of surveys that included big brown bat and long-legged myotis at the high elevation points and little brown bat and fringed myotis at the low elevation points. The frequency of detection for species that were captured at the same point showed little to no difference between years.

The correlation between years for observed PPO was high but not significant ( $r = 0.606$ ,  $P = 0.063$ ), but was significant for observed PSO ( $r = 0.769$ ,  $P = 0.10$ ) (Table 33). Estimates for PPO were not closely correlated between years ( $r = 0.049$ ). For the seven species for which the probability of detection ( $p$ ) could be estimated, estimates among years were highly correlated ( $r = 0.967$ ,  $P < 0.001$ ). A high correlation in probability of detection among years and a similar pattern of correlation in the observed PPOs suggests that (1) differences observed in the proportion of points occupied may be an accurate index of the true proportion of points occupied, and (2) differences in the observed proportion of points occupied between years are likely to reflect population fluctuation and not measurement error. However, the lack of correlation between observed and estimated PPO presents a conundrum. The standard errors for estimates of PPO and  $p$  were often half as large as the numeric value of the estimate, suggesting that in cases such as this where sample size is small, it is probably wise to use the observed PPO as the monitoring metric. In cases where sample sizes are large enough to more precisely estimate PPO (e.g., when the s.e. is within 10 or 20% of the estimated value) then it is probably more reliable to use the estimated PPO as the monitoring metric. The observed PPO will always be relevant, and even when the sample sizes are large, there will be many species for which precise estimates of PPO will not be possible.

Table 33. Observed and estimated values for proportion of sites (PSO) and points (PPO) occupied by each species detected in 2001 or 2002, and estimated probability of detection ( $p$ ) for each year.

Species	2001				2002			
	Obs. PSO	Obs. PPO	Est. PPO	Est. $p$	Obs. PSO	Obs. PPO	Est. PPO	Est. $p$
EPFU	0.333	0.500	0.575	0.291	0.222	0.500	1.000	0.167
LACI	0.083	0.250	1.000	--	0.111	0.250	0.606	0.394
LANO	0.417	0.583	0.920	0.667	0.250	0.500	0.982	0.615
MYCA	0.250	0.333	0.655	0.667	0.139	0.333	0.967	0.750
MYEV	0.333	0.667	1.000	--	0.111	0.250	0.715	0.117
MYLU	0.306	0.500	0.573	0.291	0.333	0.583	1.000	0.292
MYTH	0.139	0.417	1.000	0.062	0.056	0.167	1.000	0.042
MYVO	0.167	0.417	0.715	0.117	0.111	0.250	0.715	0.117
MYYU	0.361	0.500	0.526	0.667	0.194	0.250	0.380	0.833
TABR	0.028	0.083	--	--	0	0	--	--

## Pitfall Trap and Coverboard Surveys

### Sample Effort

The use of pitfall traps and coverboards was exploratory in 2002 to determine their effectiveness in the higher elevation environment of the Lake Tahoe basin. Thus, only 9 of the 40 monitoring points were surveyed using pitfall traps and coverboards. Pitfall traps and coverboards were established between 21 June and 18 July 2002 at each of 9 monitoring points, and were checked periodically through 7 October 2002. Pitfall traps and cover boards were checked every 3 to 4 days at 8 points and once per week at 1 point in Desolation Wilderness (due to access difficulty). Two points were surveyed for a total of 34-36 days from July to August, 3 points for 41-47 days from July to August, and 4 points were surveyed for 53-60 days from late June to August. Traps were closed in early August and re-opened in late September (23 September) to compare early and late summer capture rates. All 9 monitoring points were then surveyed for a two-week period from 23 September to 7 October 2002.

### Species detections

No animals were found under the cover boards, therefore all data presented here represent species detected in pitfall traps. The lack of herpetofauna detections (snakes in particular) beneath coverboards was possibly due to the abundance of downed trees and litter at each of the survey points making the cover boards less attractive for herpetofauna. With reptiles being opportunistic shelter seekers, the chances of detecting an animal under a coverboard is decreased when the availability of such cover is high in the surrounding habitat (see Habitat Condition section below). Additionally, coverboards may have been ineffective because they were cut from plywood (Corn 1994) and were very thin; it is recommended that coverboards be approximately 5cm (2 in) thick for best moisture retaining abilities during the warmest times of the year (Fellers and Drost 1994).

A total of 12 small mammal, amphibian and reptile species were detected with pitfall traps at the 9 points surveyed during 2002, with a mean of 3 (s.d. = 1.6) species detected per point (Table 34). There appeared to be a slightly positive, but non-significant correlation between the length of the survey period and both the number of detections (Pearson's  $r = 0.58$ ,  $P = 0.051$ ), and the number of species detected (Pearson's  $r = 0.48$ ,  $P = 0.095$ ). Three species were detected uniquely with pitfall trap arrays and were not detected with any other survey protocol employed during 2002: northern alligator lizard (*Elgaria coeruleus*,  $n = 2$  ind.s), sagebrush lizard (*Sceloporus graciosus*;  $n = 3$  ind.s), and the mountain pocket gopher (*Thomomys monticola*,  $n = 12$  ind.s). In addition to the taxonomic groups mentioned above, both spiders and scorpions were detected in pitfall traps at one point each. No special status species were detected with pitfall trap arrays (MIS, TRPA SIS, T&E or SSC).

The most frequently detected small mammal was the mountain pocket gopher, detected at 5 of the 9 points surveyed (Table 34). Trowbridge's shrew (*Sorex trowbridgii*) was the next most frequently detected small mammal ( $n = 4$  points). Both long-toed salamanders and Pacific tree frogs were each detected at a single point, and were the only amphibian species detected with pitfall traps. Three reptiles were detected; the western fence lizard was detected most frequently ( $n = 3$  points), followed by the sagebrush lizard ( $n = 2$  points) and the northern alligator lizard ( $n = 1$  point; Table 34).

Table 34. Detections of vertebrate species in pitfall trap arrays at each of 9 monitoring points surveyed within LTBMU and within each of the two life zones (lower and upper montane conifer) sampled during 2002. Values listed per species are the sum of all captures per species. Detection rates per point represent the average number of captures of all species per month of survey time. Basin orientation (N, S, E and W) is indicated by the leading letter of the site name

Common Name	Lower Montane Conifer (n = 3)			Upper Montane Conifer (n = 6)					
	S23	E36	N01	E40	N14	S05	S27	W08	W29
<b>Amphibians</b>									
Long-toed salamander						1			
Pacific tree frog					1				
<b>Reptiles</b>									
Western fence lizard		12		2			1		
Sagebrush lizard		1		2					
Northern alligator lizard	1					1			
<b>Mammals</b>									
Mountain pocket gopher	4		1	2		4		1	
Trowbridge's shrew	2		2			1		4	
Vagrant or dusky shrew						3		1	
Golden-mantled ground squirrel							1		1
Deer mouse								1	1
Long-tailed vole	4					2			
Lodgepole chipmunk				1					
Unknown shrew	1		3			2		2	
Unknown chipmunk				1					
<b>Total # inds.</b>	12	13	6	8	1	14	2	9	2
<b>Detection rates (summer)</b>	6.0	1.1	4.3	4.0	0.7	7.5	1.3	5.0	1.8
<b>Detection rates (fall)</b>	0	22	0	2	0	0	0	6	0
<b>Species Richness</b>	4	2	1	4	1	6	2	4	2
<b>Mean Species Richness</b>	2.3			3.2					
<b>s.d.</b>	1.5			1.8					

Total species richness across all points and mean species richness per point was greater in upper montane conifer habitats than lower montane conifer (Table 34), although twice as many points were surveyed in upper montane conifer. Amphibian species (long-toed salamander and Pacific tree frog) were only detected in upper montane conifer habitat, while all reptile species were detected in both habitat types. Most mammal species were detected in both life zones, however, the vagrant and/or dusky shrew (indistinguishable species in the field), golden-mantled ground squirrel, deer mouse and lodgepole chipmunk were only detected with pitfall traps in upper montane conifer habitats. Vagrant/dusky shrews were similarly only detected in upper montane conifer and wet meadow habitat with Sherman live traps, while the latter three species were detected all habitat types with Sherman live traps (Appendix O).

Total and mean species richness per point was highest at points in the south, followed by points in the west, east and south orientations around Lake Tahoe (Table 34). Based on pitfall trap data, most species were detected at multiple orientations around Lake Tahoe, however, the northern alligator lizard and long-tailed vole were only detected in the south, deer mice were only detected in the west and lodgepole chipmunks only in the east. Long-tailed vole, deer mice and lodgepole chipmunk were each detected at all orientations around Lake Tahoe with Sherman live trapping (primary detection method; Appendix P). The northern alligator lizard was only detected with pitfall trapping methods during 2002, however, such patterns of occurrence should be viewed

with caution, since only 9 points were surveyed and detection rates were very low. Further sampling should be completed before drawing any conclusions about habitat or orientation associations for species detected with pitfall traps.

Detection rates per point for all species were very low; we observed a mean of 3.5 (s.d. = 2.4, min = 0.7, max = 7.5) individuals detected per month per point during summer months (June – August), and a highly variable average of 3.3 (s.d. = 7.3, min = 0, max = 22) individuals per month per point during fall (end September – early October; Table 34).

Similarly, the probability of detection (Pd) was low for most species captured (Table 35) and estimates of proportion of sites occupied were highly imprecise, indicating that these methods, as employed, were not effective population monitoring techniques for many species captured.

Table 35. Vertebrate species detected in pitfall trap arrays at 9 monitoring points surveyed within the Lake Tahoe Basin Management Unit (LTBMU), 2002. Number (Pts. Occ.) and percent (Pts. Occ. O%) of points at which each species was detected; and estimated point occupancy (E%), bootstrap standard error and probability of detection (Pd) per species as determined by PRESENCE (McKenzie et al. 2002). Species with standard error values of 0.0 were detected too infrequently to accurately estimate point occupancy (Pt. Occ. (E%)).

WHRid*	Scientific Name	Common Name	Pts. Occ.	Pt. Occ. (O%)	Pt. Occ. (E%)	Bootstrap S.E.	Pd
<b>Amphibians</b>							
A003	Ambystoma macrodactylum	Long-toed salamander	1	11.1	100	0	0.0068
A039	Hyla regilla	Pacific tree frog	1	11.1	100	0	0.0068
<b>Reptiles</b>							
R022	Sceloporus occidentalis	Western fence lizard	3	33.3	46.38	26.15	0.0841
R023	Sciurus graciosus	Sagebrush lizard	2	22.2	100	0	0.0136
R042	Elgaria coeruleus	Northern alligator lizard	2	22.2	100	0	0.0136
<b>Mammals</b>							
M085	Thomomys monticola	Mountain pocket gopher	5	55.6	83.02	19.38	0.0731
M012	Sorex trowbridgii	Trowbridge's shrew	4	44.4	59.18	23.45	0.0906
-	Sorex spp.	Shrews	4	44.4			
M003/M004	Sorex vagrans/monticolus	Vagrant or dusky shrew	2	22.2	36.64	34.51	0.0573
M075	Spermophilus lateralis	Golden-mantled ground squirrel	2	22.2	1	15.15	0.0136
M117	Peromyscus maniculatus	Deer mouse	2	22.2	1	31.37	0.0136
M136	Microtus longicaudus	Long-tailed vole	2	22.2	25.92	14.39	0.134
M063	Tamias speciosus	Lodgepole chipmunk	1	11.1	1	0	0.0068

\* California Wildlife Habitat Relationships (Mayer and Laudenslayer 1988)

### Sampling Efficiency and Bias

The following discussion about protocol efficiencies and bias are predominantly anecdotal as sample size for pitfall trapping in this effort was small. The presence of twine in pitfall traps (escape mechanism for small mammals) was associated with reduced detections of all taxonomic groups, not solely small mammals. Traps without twine had approximately 7 times the small mammal captures and nearly 5 times the captures of herpetofauna as traps with twine (Table 36). Hence, the use of twine is probably not an efficient way of reducing small mammal mortality (through escape), as escapes of other target taxonomic groups appear to occur as well, however, additional data are needed to corroborate these results.

The use of bait appeared to be associated with reduced mortality of small mammals in pitfall traps overall, but not for shrews in particular (Table 36). As expected, herpetofauna mortality was low in this effort (n = 0 individuals) and did not seem affected by the

presence/absence of bait in traps. The apparent ineffectiveness of bait at reducing shrew mortality may have been due to any of the following reasons: 1) bait is not effective at reducing shrew mortality in pitfall traps, 2) an insufficient amount of bait was provided and/or 3) insufficient types of bait were provided in this effort. Future efforts might experiment with additional types and amounts of bait to further test for this effect, or may also increase the visitation frequency of pitfall traps as another way to reduce mortality by reducing the total capture time.

Table 36. Total captures of vertebrates in pitfall traps with and without twine or bait. Vertebrate captures were separated into three species groups of interest: shrews (*Sorex* spp.), all mammals, and herpetofauna.

Species group	Twine		Bait	
	with	without	with	without
<i>Shrews (total)</i>	0	20		
alive			0	3
mortality			4	13
<i>Mammals (total)</i>	5	37		
alive			3	9
mortality			5	25
<i>Herpetofauna (total)</i>	3	13		
alive			3	12
mortality			0	0

#### Pitfall Trap and Coverboard Survey Cost Estimate

The approximate cost of pitfall trap and coverboard surveys during 2002 was \$1000 per point surveyed. This estimate included the cost of hiring and training field crews, site set up (very labor intensive), equipment, vehicle rental (one truck per crew of two) at \$800/mo for 3 months, and survey time.

Deleted: ¶

#### **Plant Species Composition and Habitat Conditions**

##### Sampling Effort

Plant composition and habitat variables were measured at the 40 monitoring points within the LTBMU from June 21 to September 28, 2002. Visits to each point were timed to maximize the probability of detecting all plant species at the site. Points at lower elevations were sampled earlier in the season and points at increasingly higher elevations were sampled as the season continued. Data from all sample locations were collected during a single visit with the exception of plant species composition at the center point. Center points were visited once or twice depending on the type of vegetation found at the site. Center points were visited a second time if: there would be new species emerging later in the season that would be missed with only one visit, or there were a significant number of species present during the first visit which had not flowered and flowers were needed for identification. Of the 40 center points, 20 were sampled twice.

##### General Description of Monitoring Points

Monitoring points were classified into CWHR vegetation types (Mayer and Laudenslayer 1988) based on field-collected data. The survey center points (n = 40) and peripheral habitat measurement plots (n = 3 additional stations per point coinciding with 3 of the point count

stations) represent a cross-section of the habitat types found in the Tahoe basin. Based on field visits the greatest number of these 160 plots fell in the red fir and white fir habitat types, 33 and 32 plots respectively. There were 28 plots in Jeffrey pine habitat, and 29 in the subalpine conifer type. Thirteen plots fell in the lodgepole pine habitat type. Ten were located in shrub-dominated habitat and 7 in wet meadow. The fewest plots were located in eastside pine and aspen habitat types; 2 each. The low number of plots located in the aspen habitat is representative of the rarity of this habitat type.

### Species Composition

Across all 40 points we detected a total of 13 tree species, 34 shrub species, 27 grass species and 224 species of herbs (Appendices S and T). Trees were detected at all 40 terrestrial monitoring points. The most common tree species found at these sites were white fir (*Abies concolor*) detected at 52% of monitoring points, followed by Jeffrey pine (*Pinus jeffreyi*) at 49% of points. Red fir (*Abies magnifica*) (48% of points), lodgepole pine (*Pinus contorta*) (43% of points) and western white pine (*Pinus monticola*) (34 % of points) were the next most frequently detected trees. The least frequently detected tree species was incense cedar (*Calocedrus decurrens ssp. australis*) and mountain hemlock (*Tsuga mertensiana*), which were each detected at only 1% of all points.

The most common shrub species, pinemat manzanita (*Arctostaphylos nevadensis*) was found at 15% of points. The next most commonly detected shrub, creeping snowberry (*Symphoricarpos mollis*), was found at 10.6% of points. Three shrub species were detected at only a single point, (*Ceanothus vanrensselaeri*), twin berry (*Lonicera involucrata var. involucrata*), and European red elderberry (*Sambucus racemosa var. microbotrys*).

The most frequently detected herbs were broad-seeded rock cress (*Arabis platysperma*), Kelloggia (*Kelloggia galioides*), and mountain pennyroyal (*Monardella odoratissima ssp. pallida*), found at 32.5%, 35% and 32.5% points, respectively. Of the 224 species of herbs that were detected, 50.8% were found at only a single point, 49.2% were found at 2 to 20 points (i.e., up to 50% of points), and no species occurred at > 50% of all points. Of the grasses and grass like herbs 65% were detected at a single point, 35% were found at 2 to 20 points and no species were detected at greater than 20 points.

Species richness by life form (tree, shrub, herb, grass) varied across habitat types. Mean tree species richness measured at all 160 points (Appendix S) was the highest in eastside pine habitat ( $\bar{x} = 4$ , s.d. = 1.41 species per point). The white fir habitat type had the next highest tree species richness ( $\bar{x} = 3.72$ , s.d. = 1. species per point) followed by red fir, subalpine conifer, Jeffrey pine and lodgepole pine. The aspen habitat type had the lowest per point species richness ( $\bar{x} = 1.5$ , s.d. = 0.71 species per point). Mean shrub species richness measured at 160 points was the highest in white fir habitat ( $\bar{x} = 2.50$ , s.d. = 2.81 species per point). The Jeffrey pine habitat type had the next highest shrub richness ( $\bar{x} = 1.79$ , s.d. = 2.74 species per point). The shrub habitat type had a shrub species richness of  $1.2 \pm 1.62$  species per point. No shrubs were recorded in aspen or eastside pine habitat.

Herb and grass species richness as measured at the central station of all 40 points (Appendix T) varied across habitat types. The subalpine conifer type had the highest mean herb species richness ( $\bar{x} = 20$ , s.d. = 12.3 species per point). The red fir habitat type had the lowest herb species richness ( $\bar{x} = 9.78$ , s.d. = 8.7 species per point). Mean grass species richness was low in all habitat types but the highest in montane riparian ( $\bar{x} = 6$ , s.d. = 0 species per point) and lodgepole pine habitat ( $\bar{x} = 4.3$ , s.d. = 2.5 species per point). White fir and red fir habitats had the

lowest grass species richness,  $\bar{x} = 1.2$ , s.d. = 2.1 and  $\bar{x} = 0.7$ , s.d. = 1.3 species per point respectively.

### Vegetation Structure

Vegetation structure varied among the 4 survey plots per point. Therefore, data were summarized in two ways: across all stations within each vegetation type, and across all vegetation types per point, to provide an overview of the vegetation conditions sampled (Tables 37 and 38). Vegetation structure is an important component of wildlife habitat condition and of forest health. Key elements of vegetation structure important to focal wildlife and to assessing forest condition in the Tahoe basin are: tree and snag age structure (i.e., dbh classes) and density, over-story and under-story canopy cover, and volume of coarse woody debris, organic litter depth and tree basal area.

The density of live trees in 3 diameter classes (medium: 28-60.5 cm, large; 60.5-76.2 cm, and extra-large > 76.2 cm dbh) varied among habitat types (Table 37). The red fir habitat type had the highest mean density of trees in the extra-large diameter class ( $\bar{x} = 23.24$ , s.d. = 11.57 stems/ha). White fir had the next highest density of the largest trees ( $\bar{x} = 17.47$ , s.d. = 9.45 stems/ha). Aspen and shrub habitat types had the lowest density of trees in the largest size class (Table 37). White fir habitat had the highest density of trees in the large diameter class ( $\bar{x} = 119.69$ , s.d. = 81.22 stems per acre) and wet meadow habitat had the lowest density of this diameter class.

Several monitoring points surveyed during 2002 met the large tree density criterion indicating late seral forest condition (> 5 trees per ha with dbh > 76.2 cm; Manley et al. 2000) (Table 37). All plots in white fir, red fir, montane riparian and eastside pine habitat types had > 5 trees/ha greater than 76.2 cm dbh. The other tree dominated habitat types, with the exception of the aspen type, all had over 50% of plots that met this criterion for old growth habitat. It is important to recognize that there are additional stand characteristics that characterize old growth forest (e.g., overstory canopy cover, etc.), and those characteristics vary by habitat type and orientation (Manley et al. 2000). These data represent one of a suite of criterion used to indicate late seral/old growth forest.

The mean density of snags in 4 diameter and hardness class combinations varied little across most of the habitat types surveyed (Table 37). White fir habitat had the highest overall mean snag density followed by the Jeffrey pine, lodgepole pine and red fir habitat types. The lowest overall mean snag density was found in shrub and wet meadow habitat (Table 37). Overall, mean snag densities of the largest sized snags (> 60.5 cm dbh) were low relative to large tree densities. White fir habitat had the greatest mean large snag densities in both hardness classes (2.3 hard snags/ha and 9.0 soft snags/ha). White fir habitat also had the highest mean density recorded for soft snags of both size classes (large/soft  $\bar{x} = 8.97$ , s.d. = 5.89; small/soft  $\bar{x} = 8.63$ , s.d. = 7.18).

Snag densities were highly variable at the 40 center points surveyed ( $\bar{x} = 106.03$ , s.d. = 100.26 stems/ha). The highest snag density was 450 stems/ha (point N14); 91% of snags were red fir and the remainder white fir. This percentage is significantly different from the tree densities found at the same point where 52% of trees recorded were red fir and 48% were white fir ( $\chi^2 = 37.3$ ,  $P < 0.001$ ,  $df = 1$ ). At nearly half (19 out of 40) of the points surveyed *Abies spp.* accounted for at least 50% of the standing dead trees recorded. This includes points at which firs were not the dominant vegetation as described by CWHR type.

Each CWHR habitat type encountered during this survey effort varied in overstory canopy cover (Table 38). The white fir habitat type had the highest mean overstory canopy cover of 69.56

% (s.e. = 3.44). Eastside pine habitat type had the next highest mean overstory canopy cover at 65.59% (s.e. = 7.09). The habitat with the lowest overstory cover was found in shrub dominated habitat types ( $\bar{x} = 2.71$  s.d. = 2.13%). The mean overstory canopy cover was higher in wet meadow dominated habitat ( $\bar{x} = 14.7$  s.d. = 10.0%) than in shrub dominated habitat, however very few monitoring points were in either meadow (n = 2 points) or shrub (n = 1 point) dominated habitat. Mean overstory cover in wet meadow habitat was greater than the minimum percent cover established by CWHR as tree dominated, 10 %, however, the large standard error shows the highly variable (i.e., patchy) nature of overstory canopy within wet meadow habitat. This also probably indicates that meadow dominated habitat in our sample was found in patch sizes of a smaller scale than surveys conducted at each monitoring point, such that portions of tree dominated habitat were sampled at points dominated by wet meadow vegetation.

Shrub and herbaceous cover were also highly variable within and among habitat types.

Aspen ( $\bar{x} = 27.00$ , s.d. = 31.82%) and montane riparian ( $\bar{x} = 25.69$ , s.d. = 37.36%) habitat types had the highest mean percentage of shrub cover, although cover was highly variable (Table 38). Shrub dominated habitats had lower, but similarly variable shrub cover ( $\bar{x} = 12.93$ , s.d. = 23.85 %), which was comparable to that found in Jeffrey pine ( $\bar{x} = 9.47$ , s.d. = 22.13%), red fir ( $\bar{x} = 13.71$ , s.d. = 26.82%) and white fir ( $\bar{x} = 11.28$ , s.d. = 22.19%) habitat types. Lodgepole pine ( $\bar{x} = 4.93$ , s.d. = 17.6%) and eastside pine ( $\bar{x} = 3.61$ , s.d. = 14.89%) habitat had the lowest shrub cover.

Herbaceous cover also varied within and among habitat types. Aspen and wet meadow habitats had the highest percentage of herbaceous cover, ( $\bar{x} = 25.33$ , s.d. = 37.03%) and ( $\bar{x} = 24.35$  s.d. = 29.95%), respectively. No herbaceous cover was detected in eastside pine habitat. The high variability observed in these cover data are likely the result of the patchy nature of understory cover and the small sample sizes within each habitat type (2 to 33 plots per habitat type).

Table 37. Mean tree and snag densities per point in each of the 10 CWHR habitat types at 40 monitoring points in the Snags were separated into 2 size classes; large (>60.5 cm dbh) and medium (60-30.5 cm dbh) and 2 hardness classes; intact) and soft (lacking structural integrity). Trees were separated into 3 size classes; extra large (>76.2cm dbh), large medium (60.5-28.0 cm dbh). The percent of monitoring points (n = 40) within each habitat type at which we observe comparable to that in old growth stands (> 5 extra large stems per acre; Manley et al. 2000) was recorded.

Category	Aspen (n = 2)		Eastside Pine (n = 2)		Jeffrey Pine (n= 28)		Lodgepole Pine (n = 13)		Montane Riparian (n = 4)		Red Fir (n = 33)		Shrub (n = 10)		M
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	
<u>Snags/ha (&gt;60.5 cm dbh)</u>															
hard	0.0	0.0	2.0	0.3	2.4	2.2	1.6	0.9	1.0	0.3	2.1	1.5	0.0	0.0	
soft	0.0	0.0	1.0	0.2	2.3	1.8	2.7	1.2	5.8	1.2	4.9	3.1	0.4	0.2	:
<u>Snags/ha (60.5-30.5 cm dbh)</u>															
hard	0.0	0.0	2.0	0.3	3.5	3.4	5.4	4.0	1.5	0.5	1.3	1.2	0.3	0.3	
soft	0.5	0.1	3.0	0.4	5.2	5.2	5.0	3.0	2.8	0.8	3.8	2.8	0.2	0.2	:
Snags/ha (all snags)	5.4	7.7	8.0	5.7	27.2	43.0	22.3	31.1	13.5	12.0	18.1	16.9	0.9	2.2	1
Trees/ha (>76.2 cm dbh)	0.5	0.7	13.5	1.6	12.1	6.8	7.9	2.8	12.0	2.4	23.2	11.6	0.5	0.2	'
Trees/ha (76.2-60.5 cm dbh)	1.0	0.2	19.5	2.4	9.0	4.7	9.2	4.0	10.3	2.1	14.2	7.3	0.4	0.2	;
Trees/ha (60-28 cm dbh)	60.0	14.1	45.0	7.1	106.1	91.2	100.8	81.3	25.0	12.9	67.6	51.6	6.0	10.0	5
Trees/ha (< 28 cm dbh)	120.0	56.6	180.0	198.0	110.0	142.7	95.4	181.6	100.0	100.7	47.3	110.2	4.0	0.0	5
Old growth (%)	0.0		100.0		85.7		84.6		100.0		100.0		20.0		7

Mean litter depth and mean volume of coarse woody debris varied across habitat types (Table 38). Montane riparian and red fir habitat types had the thickest litter layer (i.e., O horizon) recorded; ( $\bar{x} = 7.5$ , s.d. = 2.54 cm) and ( $\bar{x} = 5.38 \pm 1.76$  cm), respectively. The thinnest litter layer was found in the shrub dominated ( $\bar{x} = 0.42$ , s.d. = 0.20cm) and eastside pine ( $\bar{x} = 0.6$ , s.d. = 0.56cm) habitat types. The volume of large logs (> 30.5 cm)/ha was highest in the red fir ( $\bar{x} = 266.31$  m<sup>3</sup>/ha, s.d. = 153.66) and white fir ( $\bar{x} = 209.97$  m<sup>3</sup>/ha, s.d. = 74.20) habitat types. Habitat types with the lowest volume of large logs were eastside pine, ( $\bar{x} = 56.08$  m<sup>3</sup>/ha, s.d. = 0.00) and shrub dominated habitats, which had no large logs. Similarly, volume of small logs(10-30.5 cm)/ha was greatest in aspen, red fir and subalpine conifer habitat types (Table 38), and lowest in eastside pine, montane riparian and shrub habitat types. When viewed in combination, the three above variables (litter depth, small and large log volume/ha) indicate that plots in red fir habitat contain the highest levels of fuel loading (litter accumulation and coarse woody debris) followed by white fir habitat, then subalpine conifer habitat; and plots in shrub habitat had the least fuel loading, followed by eastside pine and wet meadow habitat (Table 38).

Volume of hard logs was low across all habitat types varying from a high in aspen habitat of 41.22 m<sup>3</sup>/ha (s.d. = 11.65) to eastside pine, wet meadow and shrub dominated habitat types which all contained no hard logs. Volume of soft logs was generally much higher, with red fir habitat having the highest at 300.38 m<sup>3</sup>/ha (s.d. = 150.79) and white fir to follow ( $\bar{x} = 233.86$  m<sup>3</sup>/ha, s.d. = 89.29). Wet meadow ( $\bar{x} = 73.18$  m<sup>3</sup>/ha, s.d. = 47.75) and shrub dominated ( $\bar{x} = 1.44$  m<sup>3</sup>/ha, s.d. = 0.00) habitat types had the lowest soft log volume.

Mean basal area per hectare of live trees varied between habitat types (Table 38). White fir habitat had the highest basal area, ( $\bar{x} = 203.36$ , s.d. = 6.79 m<sup>2</sup>/ha), followed by Jeffrey pine ( $\bar{x} = 163.49$ , s.d. = 6.56 m<sup>2</sup>/ha), lodgepole pine, red fir, eastside pine, subalpine conifer, aspen and montane riparian. Shrub dominated habitat had a slightly higher mean basal area than wet meadow, ( $\bar{x} = 7.89$ , s.d. = 6.42 m<sup>2</sup>/ha) and ( $\bar{x} = 7.63$ , s.d. = 5.52 m<sup>2</sup>/ha) respectively.

Table 38. Mean values (and s.d.) of vegetation structure variables measured across 160 plots at 40 points within each habitat types (Mayer and Laudenslayer 1988) within the LTBMU 2002.

Structure Category	Aspen (n = 2)		Eastside Pine (n = 2)		Jeffrey Pine (n = 28)		Lodgepole Pine (n = 13)		Montane Riparian (n = 4)		Red Fir (n = 33)		Shrub (n = 10)		Subalpine Conifer (n = 29)		Mean (s.d.)
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	
Basal area (m <sup>2</sup> /ha)	71.9	5.8	223.5	6.0	162.7	6.7	164.0	7.1	81.3	4.8	130.9	5.8	6.8	5.5	91.1	6.8	8.1
Overstory Canopy Cover (%)	62.3	19.2	65.6	7.1	55.0	4.9	52.0	8.6	52.7	17.9	53.9	4.1	3.5	2.8	21.8	4.4	14.1
Litter Depth (cm)	1.2	0.6	1.8	1.2	3.1	0.3	2.2	0.4	8.1	0.9	5.1	1.2	0.4	0.2	3.0	1.1	2.4
Vol Large Log (m <sup>3</sup> /ha)	134.4	26.1	56.1	0.0	86.1	63.1	184.5	216.0	91.8	137.9	266.3	153.7	0.0	0.0	118.4	62.1	73.1
Vol Small Log (m <sup>3</sup> /ha)	156.1	54.6	21.5	30.4	60.6	96.4	58.9	125.5	10.7	13.6	111.7	196.1	1.3	4.1	93.3	194.0	48.1
Vol Hard logs (m <sup>3</sup> /ha)	41.2	11.7	0.0	0.0	22.3	18.9	37.0	182.1	0.9	0.0	18.5	58.4	0.0	0.0	0.3	0.0	0.0
Vol Soft logs (m <sup>3</sup> /ha)	114.9	21.5	104.1	23.8	76.3	65.9	227.8	255.7	141.9	211.3	300.4	150.8	1.4	0.0	130.4	62.2	73.1
Grass Cover (%)	0.0	0.0	0.0	0.0	0.6	3.0	3.1	11.8	0.3	1.7	0.4	5.3	0.0	0.4	0.2	1.5	12.1
Herbaceous Cover (%)	31.7	40.6	0.0	0.0	2.5	9.5	14.4	27.0	20.3	30.1	2.2	10.1	2.4	8.6	2.1	7.1	36.1
Shrub Cover (%)	27.0	32.9	3.6	15.3	9.5	22.2	5.3	18.4	25.7	37.9	13.7	26.9	12.0	24.0	9.2	21.4	6.1

## Sampling Efficiencies and Bias

The 4 survey techniques used for measuring plant species composition at monitoring points in 2002 (15 minute search, quadrats, line transects and 1/16 acre subplots) each differed in their relative effectiveness at detecting species assemblages per point. The single most effective method of detecting plant species composition was the quadrat method, which detected 67.2% of all species encountered (Appendix U). The 15 min search detected 46.4% of species, while the subplot method detected 35.6% of species. The least effective method used was the line intercept transect method, which detected only 27.8% of all species encountered. However, no single method was effective at detecting the complete species assemblage detected by all survey methods combined (Appendix U). Therefore, the combination of multiple survey techniques is most effective.

## **I. Aquatic Monitoring Network Results**

### **Aquatic Site Characteristics**

The majority of aquatic sites surveyed in 2002 ( $n = 22$ , 48 %) were lakes ( $> 1$  ha), followed by 16 ponds ( $\leq 1$  ha) and 8 wet meadows (Appendix D).

Abiotic characteristics varied considerably across monitoring points. Points ranged from 1900 m in elevation near the shores of Lake Tahoe up to 2829 m near the Tahoe Basin rim, and represented locations in all 4 basin orientations around Lake Tahoe (Figure 32). Eighteen sites were located in the south, where the majority of national forest system land exists in the basin, 15, 6 and 7 sites were located on the west, north and east portions of the basin, respectively.

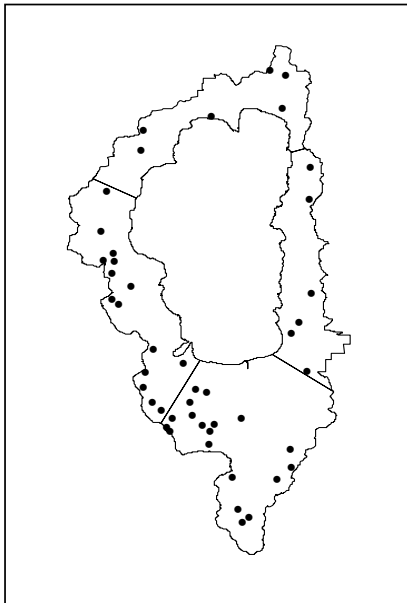


Figure 32. Locations and orientation of 46 lentic monitoring network sites surveyed during 2002.

## Aquatic Amphibian and Reptile Surveys

### Survey Effort

Forty-six lentic sites (38 lakes/ponds and 8 meadows) were surveyed for aquatic associated reptiles and amphibians during 2002 (Appendix D). These sites represented a random subset of 88 lentic sites (stratified by elevation and orientation around Lake Tahoe) that were previously surveyed during the 1997-1998 field seasons (Manley and Schlesinger 2001) and followed the same protocols. Eleven of these 46 sites were visited twice during the 2002 field season to detect seasonal changes in physical and biotic characteristics (Appendix D). Amphibian and reptile surveys were conducted between 13 June and 29 August 2002 between the hours of 0800 and 1700. Two sites that were dry at the first survey visit (i.e., unsuitable for amphibian breeding) were replaced with 2 additional randomly selected sites from the 88 lentic sites surveyed in 1997-1998 (Manley and Schlesinger 2001). Only final survey sites (n = 46) were reported here. None of the 11 lentic units with two survey visits were dry on the second visit.

More extensive aquatic surveys were conducted in the basin during 2003; 97 lentic sites were each surveyed twice for aquatic amphibians, reptiles and once for birds. These 97 sites comprised the same 88 sites surveyed by Manley and Schlesinger (2001), with an additional 9 sites randomly chosen from all remaining USGS mapped wet meadows, lakes and ponds (selected in a similar fashion to the original 88 sites). Survey protocols were the same for aquatic herpetofauna and birds during 2003 as during 1997/1998. These data are only referenced here, but will be presented with more detailed analyses in a separate document (Manley and Lind, in prep).

### Species Occurrence and Abundance

A total of 4 amphibian and 6 reptile species were detected across the 46 lentic sites surveyed during 2002, with 33 (73%) of the lentic sites having one or more species (Appendix V). Average amphibian and reptile species richness across all sites was 1.0 species (s.d. = 0.7, range= 0-3) and 0.6 species (s.d. = 0.7, range = 0-2) per site, respectively, based on first survey visits only.

The most commonly detected amphibian was the pacific tree frog (*Hyla regilla*), detected at 25 (56%) sites surveyed, followed by the southern long-toed salamander (*Ambystoma macrodactylum sigillatum*) and western toad (*Bufo boreas*) detected at 6 and 4 sites, respectively. The least frequently detected amphibian was the bullfrog (*Rana catesbeiana*), an exotic species, detected at only 3 (7%) sites (Appendix V). Pacific tree frogs were detected at all 4 sites at which western toad was detected and at 5 of 6 sites with long toed salamander detections. The western toad and long-toed salamander, however, were never detected at the same sites during 2002. During aquatic surveys in 2003, *A. macrodactylum* and *B. boreas* were found to co-occur at 2 of 100 sites visited (Homey meadow and Grass lake at Luther pass). In 2002, the bullfrog was detected at sites with both pacific tree frog (n = 2) and long-toed salamander (n = 1), but not at sites with detections of western toad. During 2003, however, the bullfrog was found to co-occur at one or more sites with each of these three species: long-toed salamander, western toad and pacific tree frog (Manley and Lind, in prep).

The common garter snake (*Thamnophis sirtalis*) was the most frequently detected reptile, detected at 10 (22%) sites, followed by the western terrestrial garter snake (*Thamnophis elegans*), the western aquatic garter snake (*Thamnophis couchii*; Appendix V). The least frequently detected

reptiles were the alligator lizard (*Elgaria spp.*), western skink (*Eumeces skiltonianus*) and western fence lizard (*Sceloporus occidentalis*), all detected at only a single site (Appendix V). We observed co-occurrence between *T. elegans* and *T. sirtalis* at 3 sites surveyed, however, at sites where *T. couchii* was detected (n = 2), no other *Thamnophis* species were detected during 2002. In 2003, however, *T. couchii* was detected at a total of 3 sites, one at which it co-occurred with *T. elegans* (Manley and Lind, in prep). The western skink, western fence lizard, and alligator lizard are more commonly associated with terrestrial habitats rather than aquatic habitats, probably explaining their infrequent detections at the 45 aquatic sites surveyed.

No special status amphibians or reptiles were detected at lentic sites surveyed in 2002. Currently no amphibians or reptiles that occur in the Lake Tahoe basin are listed at the federal or state level as threatened or endangered, and none are listed as Forest Service Management Indicator Species (MIS) or as TRPA indicator species. Only one amphibian in the basin, *Rana muscosa* (mountain yellow-legged frog), is listed as a California species of special concern. This species was not detected during 2002, but was detected with surveys in 2003 at a single location; the only location that this species is known to occur in the basin. The general rarity and decline in populations of the mountain yellow-legged frog have been noted across the Sierra Nevada. No reptiles in the Tahoe basin are listed as California species of special concern.

Mean amphibian species richness was greatest in wet meadows ( $\bar{x} = 1.0$ , s.d. = 0.8), followed by medium, then small, and lastly large lakes/ponds (Appendix W). Average reptile species richness was greatest in medium and large sized lakes/ponds ( $\bar{x} = 0.8$ , s.d. = 0.8), and was least in small lakes/ponds and wet meadows ( $\bar{x} = 0.3$ , s.d. = 0.7) (Appendix W).

Mean species richness was greatest for both amphibians and reptiles at sites in the west ( $\bar{x} = 1.1$ , s.d. = 0.9 and  $\bar{x} = 0.7$ , s.d. = 0.6, respectively), relative to sites in other orientations around Lake Tahoe, with lowest richness values observed in the eastern portion of the basin (Appendix X). Overall variation in species richness across sites was high relative to differences in mean richness values between size/habitat and orientation classes, therefore, reported differences between these classes are probably not significant.

#### Detections of non-target species

Four mammal species were detected during aquatic perimeter surveys; pika at 2 sites, and broad-footed mole (*Scapanus latimanus*), white-footed mouse (*Peromyscus sp.*) and long-tailed weasel each at one site. Broad-footed moles were not detected with any other protocol implemented as part of this multi-species inventory and monitoring effort, however only a single dead mole was found along the shoreline of Lily lake. Despite being the only protocol to detect broad-footed moles, aquatic herpetofauna surveys are not an efficient method of detection for this species.

#### Sampling Efficiency and Biases

These 10 herpetofaunal species detected at lentic sites during 2002 represented 80% of all amphibians and 63% of all reptile species expected to occur in the Tahoe basin (Murphy and Knopp 2000). The only amphibian that missed detection was the mountain yellow-legged frog, which is only known to occur in a single location in the Tahoe basin, and was detected with surveys in 2003. Reptiles occurring in the basin that missed detection include: Rubber boa

(*Charina bottae*), definitive detections of northern and southern alligator lizards (*Elgaria coerulea* or *E. multicarinata*) and the sagebrush lizard (*Sceloporus graciosus*). Alligator lizards and the sagebrush lizard predominantly inhabit forested, shrubby or more upland habitats than are represented by the lentic sites surveyed in this effort and are not associated with permanent water. Therefore, detection of these species might be more likely with alternative survey methods (e.g., pitfall trapping and terrestrial visual encounter surveys). The rubber boa is the only one of these 4 species consistently associated with riparian areas throughout its range (Stebbins 1985), and therefore was expected at lentic sites. However, the only sighting of rubber boa during 2002 was an incidental sighting a few hundred meters upslope from the northern shore of Echo Lake in shrub dominated habitat. Most likely a combination of aquatic vertebrate searches, terrestrial visual encounter surveys (Manley et al. 2002) and/or pitfall and coverboard surveys at terrestrial sites would adequately detect all reptile species occurring within the basin.

With the exception of the rubber boa, aquatic based visual encounter surveys provide a highly representative sample of the aquatic associated herpetofauna in the Tahoe basin.

### Seasonal Patterns in Species Detection

Overall, amphibians were detected more frequently during first survey visits (n = 6 of 11 sites), than during second visits (n = 2 of 11 sites), suggesting perhaps a greater chance at detecting amphibians early in the summer. Reptiles showed a similar, but less dramatic pattern of detection rates per visit; reptiles were detected more frequently during first visits at 4 sites and more frequently during second visits at only 2 sites.

Temporal variation in detection probabilities of individual species were not apparent for most species, but may exist for the long-toed salamander and western toad. These species had a greater number of larval detections early in the season followed by fewer individuals detected later in the season (Figure 33), however this is based on a small sample size. Additionally, see discussion below regarding a contradictory pattern suggested for long-toed salamander detections over time at individual sites. A more complete dataset for investigating such patterns is available from surveys conducted by USFS and TRPA during 2003, which should be referenced for further information (Manley and Lind, in prep). All remaining amphibian and reptile species were detected with consistent frequencies throughout the summer, 2002, except for the western fence lizard, alligator lizard and western skink, detected too infrequently to assess any seasonal patterns of detection.

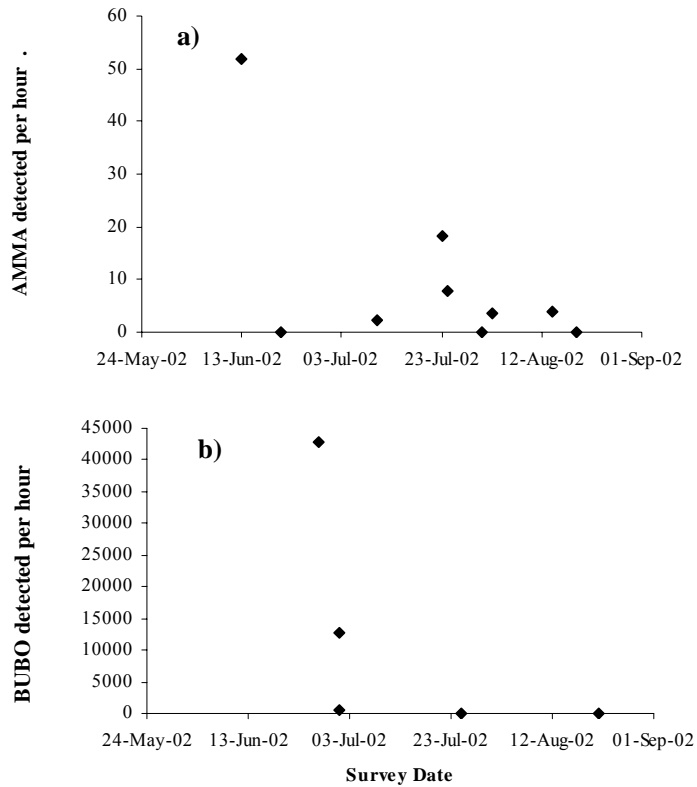


Figure 33. Seasonal pattern of detections of a) long-toed salamanders (*Ambystoma macrodactylum* - AMMA) and b) westerntoads (*Bufo boreas* – BUBO) at sites where detected of the 46 sites surveyed within the Lake Tahoe basin during 2002. Values represent the mean number of individuals detected per hour of survey time at each location during a single survey visit to a site.

### Species accumulation with effort

Conducting 2 survey visits per site was more effective than a single visit for detecting species assemblages at a given site during 2002. At sites with two survey visits (n = 11 sites), second visits resulted in the detection one additional species not detected during first visits at 55 % of sites (n = 6); the remaining 5 sites had no additional species detected on the second survey. Multiple survey visits (at least 2) are recommended in future efforts to increase the probability of detecting and monitoring a wider array of species that exist at aquatic sites throughout the Tahoe basin. Two survey visits were conducted to all 100 lentic sites surveyed in the Tahoe basin during

2003 as recommended and also demonstrated that additional species were detected at 22% of points after second visits (Manley and Lind, in prep). Multiple visits increase the likelihood that species with different seasonal phenologies will be detected at each site.

No apparent biases were observed with regard to additional species detected during second visits during 2002 (i.e., species missed during first visits) (Table 39). Additional species detected during second visits included the pacific tree frog (n = 1 site), long-toed salamander (n = 2 sites), garter snakes (n = 2 sites), and western toad (n = 1 site). During 2003, we observed a potential bias in that one species showed a disproportionate number of first time detections during second visits compared to other species (e.g., *Ambystoma macrodactylum*; see Manley and Lind, in prep). Therefore, conducting only single survey visits to sites early in the breeding season may be biased against the detection of *A. macrodactylum*, further supporting the recommendation of 2 survey visits per site per season.

Changes in per species abundances between first and second survey visits were suggestive of possible seasonality of detection for some species, however, detection frequencies were overall low for most species (Table 39). Despite only being detected at 2 of the 11 sites with multiple visits, *A. macrodactylum* showed increases in detection frequency from first to second visits per site, suggesting that this species may be more detectable later in the season due to life history characteristics. First year *A. macrodactylum* larvae are very small early in the season and do tend to reach more detectable size later in the season, which may explain the increased detections later in the season. Only *Hyla regilla* was detected in much lower frequencies during the second visits at three of seven multi-visit sites with detections (Table 39). This may suggest that a large number of *H. regilla* larvae metamorphosed into adults and dispersed away from the aquatic unit surveyed between the first and second visit. Second visits at these 3 sites were conducted in late July, mid August and late August. Therefore, survey timing should not extend beyond late August if detections or lack of detections of *H. regilla* are to be reliable.

Table 39. Difference in abundances per species from first to second survey visits at 11 lentic units surveyed on 2 occasions during summer 2002 within LTBMU.

Survey Location	Scientific Name													
	<i>Ambystoma macrodactylum</i>		<i>Bufo boreas</i>		<i>Hyla regilla</i>		<i>Rana catesbeiana</i>		<i>Thamnophis sirtalis</i>		<i>Thamnophis elegans</i>		<i>Thamnophis spp.</i>	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
BIR	0	0	0	0	0	0	34	33	0	0	0	0	0	0
FAL	0	0	0	0	0	1	13	5	1	0	1	1	0	0
SUM	0	5	0	0	295	291	0	0	0	0	3	1	1	2
CAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DAR	0	0	0	0	1	0	0	0	0	0	0	0	0	0
GRO	0	0	0	0	14	2	0	0	0	0	0	0	0	1
BUC	0	0	0	2	3	13	0	0	0	0	4	5	0	0
BLA	0	17	0	0	1000	203	0	0	9	11	0	0	0	0
MUD	0	0	0	0	1540	110	0	0	0	0	0	0	0	0
DIV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAR	0	0	0	0	0	0	0	0	0	1	0	0	0	0

## Aquatic Amphibian and Reptile Survey Cost Estimate

Aquatic amphibian and reptile surveys cost approximately \$450 per site surveyed. This cost reflects two survey visits per lentic aquatic unit, and includes the cost of hiring and training field crews, equipment, site set up, survey time and habitat data collection.

## **Aquatic Bird Surveys**

### Survey Effort and Species Richness

Time constrained surveys for aquatic associated bird species were conducted from 13 June to 29 August 2002. Forty-five lentic habitat sites were surveyed for aquatic birds; the same sites that were surveyed for aquatic reptiles and amphibians (see Aquatic Amphibian and Reptile Surveys section above). Eleven of the 46 sites were surveyed twice, coinciding with the two visits for amphibian and reptile surveys. Most sites required only a single observer to survey, however three sites over 10 ha in size (Fallen Leaf, Cascade and Susie lakes) required multiple observers to survey 100% of the area. More extensive lentic site point counts were conducted at 100 sites during 2003 (see Manley and Lind, in prep)

### Species Composition and Abundances

A total of 20 bird species within the basin were detected during the time-constrained bird surveys across all 46 lentic sites, 14 of which are aquatic-associated species (USDA 1999, Appendix B). These 14 species represent 22% of all aquatic associated species expected to occur in the Tahoe basin ( $n = 63$ ) according to the Sierran All Species database (USDA 1999) and the Watershed Assessment (Murphy and Knopp 2000; Appendix B). Of these, 6 were unique to the aquatic surveys and not detected with point counts conducted at the 40 monitoring points; Black-crowned Night Heron (*Nycticorax nycticorax*), Bufflehead (*Bucephala albeola*), California Gull (*Larus californicus*) Great Blue Heron (*Ardea herodias*), Greater Scaup (*Aythya marila*) and Ring-necked Duck (*Aythya collaris*). The most frequently detected aquatic-associated species were the Mallard, Brewer's Blackbird and Red-winged Blackbird detected at 14, 8 and 7 of the 46 lentic sites, respectively. All remaining species were detected at 5 or fewer points. The Mallard and Canada Goose were the most abundantly detected species at individual sites (Appendix Y). At sites where Mallard was present, we detected an average of 8.4 Mallard per site; and at sites where Canada Goose was present, we detected an average of 36.4 Canada Geese per site. Overall, detection rates of aquatic species were fairly low in this effort. Despite low frequency of detection, sixteen of the 20 species detected had sufficient data to estimate point occupancy across all sites, however, error estimates for some species were fairly high (Appendix Z; MacKenzie et al. 2002).

Mallard is the only lentic associated bird species listed as a Forest Service MIS species, and was detected frequently in this effort. All water-associated species such as ducks, geese, shorebirds, loons, grebes, mergansers, herons, rails, gulls, and terns are considered TRPA special interest species (SIS) in the basin ( $n = 63$  species). We detected 12 (19%) of the TRPA SIS in this effort. No federal or state listed T&E species or species of special concern were detected. We detected one aquatic-associated California state species of special concern, California Gull.

Mean aquatic bird species richness across all 46 sites was 1.2 species (s.d. = 1.7) per site and was 2.5 species (s.d. = 1.7) per site across the 22 sites with one or more detections. When sites were grouped into habitat/size classes, mean aquatic-associated bird species richness per site

was greatest at large lakes, followed by medium lakes/ponds, wet meadows and small lakes/ponds (Appendix Y). When summarizing species richness per site based on orientation around Lake Tahoe, mean species richness was greatest per site on the east shore, followed by the south, north and west portions of the Tahoe basin (Appendix AA).

In summary, targeting aquatic sites in addition to forest wide monitoring point locations for bird surveys increases the array of bird species within the Tahoe basin that we can effectively detect and monitor. However, surveying greater than the 45 sites surveyed in 2002, and surveying for all bird species (e.g., similar to surveys in 1997-1998 (Manley and Schlesinger 2001), and in 2003) is recommended to detect and effectively monitor a greater array of aquatic associated bird species.

### Sampling Efficiencies and Biases

Aquatic-associated birds were overall detected infrequently in this effort. We detected one or more species at only 54% of sites (none at 46% of sites), and individual species point occupancy was < 35% for all species (Appendix Z). Bird species detected at >5 - ≤ 50% of the lentic sites (n = 6 species) were fairly representative of the 63 aquatic-associated species expected to occur in the basin with regard to habitat specialists, late seral/old growth dependency, trophic level (although omnivores were not represented) and home range size (although species with the smallest home ranges were absent). However, they were not very representative with regard to riparian association, aquatic-association and listing status (Appendix AB). Aquatic-based searches in this effort appeared biased towards detection of species using riparian habitat, and against detection of strictly aquatic species, and species of special concern status. Aquatic and riparian species were the target in this effort and their lack of frequent detection in the dataset may suggest more extensive surveys need to be conducted at lentic sites in order for a wider array of species to be detected, and to be detected well (i.e., high frequency of occurrence). It is recommended that complete bird census surveys be conducted during each survey visit to each lentic site (e.g., point counts be conducted for all bird species seen/heard, not just a subset which was done in this effort), and multiple surveys be conducted to each lentic unit during each breeding season, similar to what was done with terrestrial point counts.

### Seasonal Patterns in Species Detection

There did not appear to be any biases with regard to the species detected during first or second visits. Of all species detected during more than one survey (n = 6), only one species (Bufflehead) was detected during a single visit alone (first visit), and this species was detected with low frequency overall (n = 7 individuals across all surveys).

Total bird detections per site also did not appear to differ markedly between visits at the 11 sites surveyed twice. Most sites (n = 10) detected a similar number of individuals during first and second visits (within 6 detections of each other). Only one site in the southeast corner of the Tahoe basin, Birdie pond, had 160 more bird detections during the second visit than during the first visit. This difference was due to the presence of a large flock of Canada Geese at the site during the second visit. The second visit to this site was in late August and the survey may have detected a group of migratory geese. Otherwise detection rates were comparably low at all sites across both visits. Due to potential for migration of some species during late summer/early fall,

lentic based bird surveys should be completed by early August to avoid biases against migratory species.

### Species Accumulation with Effort

Bird species were detected during second surveys at 7 of 11 lentic sites that were revisited during 2002. At five sites with 2 survey visits (45%) we detected at least one additional species not detected during the first visit (Figure 34). The increase in mean cumulative species richness from one to two visits at these 11 sites was small and highly variable, 1.4 (s.d. = 1.5) species were detected per site after one visit and 2.2 (s.d. = 2.2) species per site after 2 visits. Multiple visits to lentic habitat sites appear to increase the probability of detection for aquatic associated birds, however, a larger dataset is necessary to better evaluate whether there is a significant increase in species richness with multiple visits to lentic sites. Due to the apparent effectiveness of multiple visits at increasing species detections at terrestrial monitoring points (see Point Count Results section above; Table 12), it is recommended that multiple bird survey visits also be conducted to lentic sites during each breeding season.

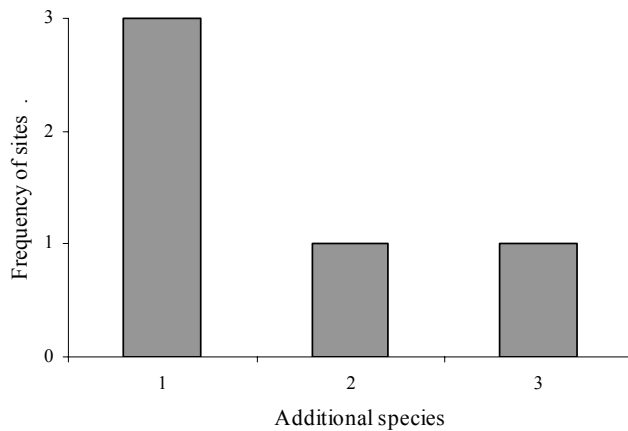


Figure 34. Number of lentic sites surveyed twice during 2002 (n = 11) with 1, 2 and 3 additional aquatic associated bird species detected during the second survey relative to the first visit to each site. All surveys were conducted from June-August 2002 within the Lake Tahoe basin.

### Aquatic Bird Survey Cost Estimate

Thirty minute aquatic bird searches cost approximately \$200 per site surveyed. This cost reflects two survey visits per aquatic unit. This estimate includes the cost of hiring and training previously experienced field crews, equipment to conduct point counts, survey and travel time.

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## K. Appendices

**Appendix A.** The allocation of the 10 vertebrate, plant and habitat survey protocols to points during 2002. An “X” indicates the particular protocol was conducted at the given point during 2002.

Monitoring Point	Point Counts	Live-trapping	Covered track plates and cameras	Bat mist-netting	Bat acoustic surveys	Pitfalls	Cover-boards	Plant surveys	Habitat
1	X	X	X	X	X	X	X	X	X
2	X	X						X	X
3	X	X						X	X
4	X	X		X	X			X	X
5	X	X	X	X	X	X	X	X	X
6	X	X		X	X			X	X
7	X	X		X	X			X	X
8	X	X	X	X	X	X	X	X	X
9	X	X	X	X	X			X	X
10	X	X						X	X
11	X	X	X	X	X			X	X
12	X	X		X	X			X	X
13	X	X	X					X	X
14	X	X	X			X	X	X	X
15	X	X	X	X	X			X	X
16	X	X						X	X
17	X	X						X	X
18	X	X	X					X	X
19	X	X	X	X	X			X	X
20	X	X	X	X	X			X	X
22	X	X						X	X
23	X	X	X	X	X	X	X	X	X
24	X	X	X					X	X
25	X	X						X	X
26	X	X	X	X	X			X	X
27	X	X	X			X	X	X	X
28	X	X	X	X	X			X	X
29	X	X	X			X	X	X	X
30	X	X						X	X
31	X	X		X	X			X	X
32	X	X						X	X
33	X	X	X	X	X			X	X
34	X	X						X	X
35	X	X	X	X	X			X	X
36	X	X	X	X	X	X	X	X	X
37	X	X						X	X
38	X	X	X	X	X			X	X
39	X	X						X	X
40	X	X	X			X	X	X	X
88	X	X		X	X			X	X

**Appendix B.** Aquatic-associated bird species occurring in the Tahoe basin (USDA 1999, Murphy and Knopp 2000) and their status as Forest Service Management indicator species (MIS), Forest Service sensitive species (FSS), TRPA special interest species (SIS), or California state species of concern (SSC).

WHR Id	Scientific Name	Common Name	MIS	FSS	TRPA SIS	SSC
B164	<i>Recurvirostra americana</i>	American Avocet			x	
B049	<i>Botaurus lentiginosus</i>	American Bittern			x	
B149	<i>Fulica americana</i>	American Coot			x	
B373	<i>Cinclus mexicanus</i>	American Dipper			x	
B042	<i>Pelecanus erythrorhynchos</i>	American White Pelican			x	x
B087	<i>Anas americana</i>	American Wigeon			x	
B113	<i>Haliaeetus leucocephalus</i>	Bald Eagle			x	
B102	<i>Bucephala islandica</i>	Barrow's Goldeneye			x	x
B293	<i>Ceryle alcyon</i>	Belted Kingfisher			x	
B235	<i>Chlidonias niger</i>	Black Tern			x	x
B059	<i>Nycticorax nycticorax</i>	Black-crowned Night Heron			x	
B163	<i>Himantopus mexicanus</i>	Black-necked Stilt			x	
B211	<i>Larus philadelphia</i>	Bonaparte's Gull			x	
B103	<i>Bucephala albeola</i>	Bufflehead			x	
B215	<i>Larus californicus</i>	California Gull			x	x
B075	<i>Branta canadensis</i>	Canada Goose			x	
B089	<i>Aythya valisineria</i>	Canvasback			x	
B227	<i>Sterna caspia</i>	Caspian Tern			x	
B083	<i>Anas cyanoptera</i>	Cinnamon Teal			x	
B101	<i>Bucephala clangula</i>	Common Goldeneye			x	
B003	<i>Gavia immer</i>	Common Loon			x	x
B105	<i>Mergus merganser</i>	Common Merganser			x	
B199	<i>Gallinago gallinago</i>	Common Snipe			x	
B044	<i>Phalacrocorax auritus</i>	Double-crested Cormorant			x	x
B009	<i>Podiceps nigricollis</i>	Eared Grebe			x	
B233	<i>Sterna forsteri</i>	Forster's Tern			x	
B085	<i>Anas strepera</i>	Gadwall			x	
B051	<i>Ardea herodias</i>	Great Blue Heron			x	
B052	<i>Ardea alba</i>	Great Egret			x	
B093	<i>Aythya marila</i>	Greater Scaup			x	
B070	<i>Anser albifrons</i>	Greater White-fronted Goose			x	
B165	<i>Tringa melanoleuca</i>	Greater Yellowlegs			x	
B058	<i>Butorides virescens</i>	Green Heron			x	
B077	<i>Anas crecca</i>	Green-winged Teal			x	
B216	<i>Larus argentatus</i>	Herring Gull			x	
B104	<i>Lophodytes cucullatus</i>	Hooded Merganser			x	
B007	<i>Podiceps auritus</i>	Horned Grebe			x	
B158	<i>Charadrius vociferus</i>	Killdeer			x	
B050	<i>Ixobrychus exilis</i>	Least Bittern			x	x
B185	<i>Calidris minutilla</i>	Least Sandpiper			x	
B094	<i>Aythya affinis</i>	Lesser Scaup			x	

WHR Id	Scientific Name	Common Name	MIS	FSS	TRPA SIS	SSC
B173	Numenius americanus	Long-billed Curlew			x	x
B197	Limnodromus scolopaceus	Long-billed Dowitcher			x	
B079	Anas platyrhynchos	Mallard	x		x	
B080	Anas acuta	Northern Pintail			x	
B084	Anas clypeata	Northern Shoveler			x	
B110	Pandion haliaetus	Osprey			x	x
B006	Podilymbus podiceps	Pied-billed Grebe			x	
B090	Aythya americana	Redhead			x	
B214	Larus delawarensis	Ring-billed Gull			x	
B091	Aythya collaris	Ring-necked Duck			x	
B107	Oxyura jamaicensis	Ruddy Duck			x	
B150	Grus canadensis	Sandhill Crane			x	x
B071	Chen caerulescens	Snow Goose			x	
B053	Egretta thula	Snowy Egret			x	
B146	Porzana carolina	Sora			x	
B170	Actitis macularia	Spotted Sandpiper			x	
B067	Cygnus columbianus	Tundra Swan			x	
B145	Rallus limicola	Virginia Rail			x	
B010	Aechmophorus occidentalis/clarkii	Western/Clark's Grebe			x	
B168	Catoptrophorus semipalmatus	Willet			x	
B200	Phalaropus tricolor	Wilson's Phalarope			x	
B076	Aix sponsa	Wood Duck			x	
<b>Total Species</b>			<b>1</b>	<b>0</b>	<b>63</b>	<b>10</b>

**Appendix C.** Values for environmental variables at each of the 40 terrestrial monitoring points surveyed during 2002. derived from USGS quad maps and annual precipitation from GIS data available for the Tahoe Basin (TRPA 1971). C point was determined based on boundaries shown in Figure 8. Habitat type, slope and aspect were derived from both fi generated data. Canopy cover estimates were derived from field collected data only and estimates of disturbance were only as a measure of the percent of area surrounding the monitoring point covered by permanent human development ( courses, campgrounds, etc.).

GIS Generated Values										
										Field C
Point	Elevation (m)	Orientation	Precipitation (cm/yr)	Mean Slope (%)	Dominant Aspect	Dominant Habitat Type (CWHR)	Disturbance (%)	Mean Slope	Mean Aspect	Dominant Hab: Type (CWHR)
1	2146	north	102	18	270	Sierran Mixed Conifer	1.5*	2	53	White fir
2	2170	north	91	114	45	Sierran Mixed Conifer	0.8	41	112	White fir
3	1935	south	73	60	90	Montane Chaparral	15.1	25	94	Jeffrey Pine
4	2573	south	91	98	270	Lodgepole Pine	0.0	38	275	Red Fir
5	2396	south	98	63	225	Red Fir/ Aspen	0.0*	12	165	Lodgepole Pin
6	2585	south	160	74	45	Annual Grassland	0.0*	32	204	Subalpine Con
7	2707	west	150	135	225	Annual Grassland	0.0*	42	190	Alpine Dwarf-S
8	2073	west	98	107	45	Red Fir	0.0*	28	65	Red Fir
9	1963	east	53	87	315	Jeffrey Pine	4.4	22	247	Jeffrey Pine
10	2085	east	57	116	270	Jeffrey Pine	0.3	38	198	Jeffrey Pine/W
11	2329	north	101	61	180	Sierran Mixed Conifer	4.5	15	231	Red Fir
12	2304	north	102	58	135	Aspen/Red Fir	2.5	13	164	Lodgepole Pin
13	2426	north	100	67	135	Lodgepole Pine	4.3	20	155	Red Fir
14	2185	north	88	74	90	Sierran Mixed Conifer	3.5	24	108	White fir
15	2987	north	91	103	90	Subalpine Conifer	1.9	44	101	Subalpine Con
16	2816	south	84	48	315	Lodgepole Pine	0.0*	14	96	Subalpine Con
17	2219	south	104	70	45	Lodgepole Pine	1.4	23	122	Red Fir
18	2853	south	88	100	315	Lodgepole Pine	2.2	27	251	Subalpine Con
19	2352	south	95	21	1	Wet Meadow	0.9	0	0	Wet Meadow
20	2621	south	115	88	225	Montane Chaparral	0.0	30	249	Subalpine Con
22	1926	south	77	22	45	Jeffrey Pine	17.4	6	206	Eastside Pine
23	1969	south	82	31	270	Jeffrey Pine	1.7	5	182	Jeffrey Pine
24	2134	south	92	106	315	Sierran Mixed Conifer	1.1*	34	249	Red Fir

## GIS Generated Values

Field C

Point	Elevation (m)	Orientation	Precipitation (cm/yr)	Mean Slope (%)	Dominant Aspect	Dominant Habitat Type (CWHR)	Disturbance (%)	Mean Slope	Mean Aspect	Dominant Habitat Type (CWHR)
25	2207	south	88	141	315	Sierran Mixed Conifer	0.0	40	318	White fir
26	2585	south	166	76	90	Lodgepole Pine	0.0*	37	104	Subalpine Con
27	2536	south	78	124	45	Red Fir	0.0	44	29	Red Fir
28	2487	west	161	48	45	Annual Grassland	0.0*	10	112	Subalpine Con
29	2505	west	157	47	315	Red Fir	0.0	12	303	Subalpine Con
30	2414	west	131	116	270	Red Fir	0.0*	37	250	Red Fir
31	2036	west	119	102	360	Lodgepole Pine/Sierran Mixed Conifer	0.0	13	106	White fir
32	2195	west	165	108	360	Red Fir	0.9*	26	195	Subalpine Con
33	1920	west	93	51	315	Lodgepole Pine/Sierran Mixed Conifer	1.0	15	220	White fir
34	2201	west	116	131	315	Sierran Mixed Conifer	0.0	42	314	Red Fir
35	2426	west	172	147	180	Montane Chaparral	0.0	51	175	White fir
36	1914	east	45	21	225	Montane Chaparral	4.6	8	197	Jeffrey Pine
37	2329	east	74	91	315	Sierran Mixed Conifer	0.0	32	272	White fir
38	2146	east	53	59	45	Sierran Mixed Conifer	2.6	26	82	Jeffrey Pine
39	2329	east	64	135	270	Sierran Mixed Conifer	0.0	45	268	Jeffrey Pine/W
40	2377	east	76	51	270	Montane Chaparral	2.7	12	195	Jeffrey Pine
88	2707	south	116	104	45	Montane Chaparral	0.0*	29	82	Wet Meadow

\* indicates points with human use trails present within 100 m of habitat survey plots

**Appendix D.** Names and characteristics of the forty-six lentic sites (20 lakes, 16 ponds, and 8 meadows) surveyed for reptiles and amphibians within the Lake Tahoe Basin Management Unit from 13 June-29 August 2002. The following site characteristics are listed: site code, number of survey visits, elevation class (l <2290 m, h ≥ 2290 m), orientation around Lake Tahoe (n = north, s = south, e = east and w = west; see Figure 32), size class (s ≤ 1 acre, m >1 – 10 acres, l >10acres), and disturbance class (l = low, m = moderate and h = high; see Manley and Schlesinger 2001 for description). Size and disturbance class were not determined for meadows (n = 8 sites).

Site Name	Site Code	Survey Visits	Orientation	Elevation	Habitat Type	Size	Disturbance
Benwood Pond	BEN	1	s	h	pond	s	m
Birdie Pond	BIR	2	s	l	lake	m	h
Blackwood Pond	BLA	2	w	l	pond	s	m
Blob lookin at ya Lake	BLO	1	w	h	lake	m	l
Buck Lake	BUC	2	w	l	lake	m	m
Burton Pond	BUR	1	n	l	pond	s	m
Cascade Lake	CAS	2	w	l	lake	l	m
Dardanelles Lake	DAR	2	s	h	lake	l	l
Divot Pond	DIV	2	n	l	pond	s	h
Ellis Lake	ELL	1	w	h	lake	m	m
Fallen Leaf Lake	FAL	2	s	l	lake	l	h
Folsom Spring Pond	FOL	1	e	l	pond	s	h
Found Pond	FND	1	w	l	pond	s	m
Four Lakes # 2	FOU	1	s	h	lake	m	l
Freel Meadows	FRE	1	s	h	meadow	-	-
Grass Lake at Glen Alpine	GRS	1	s	l	lake	l	l
Grass Lake at Luther Pass	GRA	1	s	h	lake	l	m
Hardlia Meadow	HAR	1	w	h	meadow	-	-
Honey Meadow	HOM	1	w	h	meadow	-	-
Lake Louise	LOU	1	w	h	lake	m	h
Lily Lake	LIL	1	s	l	lake	m	m
Lily Pond Meadow	LPM	1	w	l	meadow	-	-
Limbo Pond	LIM	1	s	h	pond	s	l
Lost Lake	LOS	1	w	h	lake	l	l
Lower Echo Lake	ECH	1	s	l	lake	l	h
Lower Grouse Lake	GRO	2	w	h	pond	s	l
Marlette Lake	MAR	2	e	h	lake	l	l
Mud Lake	MUD	2	n	h	pond	s	l
North Canyon Meadow	NCM	1	e	l	meadow	-	-
Oleo Pond	OLE	1	s	h	pond	s	h
Overlook Meadow	OVE	1	s	h	meadow	-	-
Page Meadows Pond	PAG	1	w	l	pond	s	m
Pew Pond	PEW	1	s	h	pond	s	l
Pond of the Woods	POW	1	s	h	pond	s	m
Recline Pond	REC	1	n	h	pond	s	m
Round Hill Sewage Pond	ROU	1	e	l	lake	m	h
Round Lake	RND	1	e	h	lake	l	l
Seneca Pond	SEN	1	s	l	pond	s	h
Sky Meadows Pond	SKY	1	e	h	pond	s	h
Snow Creek Meadow	SCM	1	n	l	meadow	-	-
Summit View Lake	SUM	2	s	l	lake	m	m
Susie Lake	SUS	1	w	h	lake	l	l

<b>Site Name</b>	<b>Site Code</b>	<b>Survey Visits</b>	<b>Orientation</b>	<b>Elevation</b>	<b>Habitat Type</b>	<b>Size</b>	<b>Disturbance</b>
Upper Angora Lake	ANG	1	s	h	lake	l	m
Van Gogh Lake	VAN	1	w	h	lake	m	l
Watson Lake	WAT	1	n	h	lake	m	m
Zephyr Meadow	ZEP	1	e	h	meadow	-	-

**Appendix E.** Species detected with multiple survey protocols at monitoring points during 2002.

Values represent the number of points at which respective species were detected with each protocol type, and with all protocols combined (ALL). The most effective protocol was determined as the protocol with the greatest proportion of points with detections per species. Species detected at an equal number of points across protocols were determined to be most efficiently detected with both protocols. Protocols are referred to as follows: Sherman = Sherman live trapping, PC = point counts, TP = Track plates, Camera = Trail Master camera surveys, VES = Aquatic visual encounter surveys, PF = Pitfall Trapping. Sample sizes refer to the number of points surveyed per protocol and are all subsets of the 40 total monitoring points, with the exception of VES. Forty-six separate aquatic sites were surveyed using VES, 4 of which nearly overlapped with 4 of the monitoring points.

Scientific Name	Common Name	Trap (n = 40)	PC (n = 40)	TP (n = 22)	Cam (n = 22)	PF (n = 9)	VES (n = 46)	ALL	Most Effective Protocol
<i>Sorex vagrans/monticolus</i>	Vagrant Or Montane Shrew	3	0	0	0	2	0	5	PF
<i>Sorex trowbridgii</i>	Trowbridge's Shrew	3	0	0	0	4	0	7	PF
<i>Peromyscus maniculatus</i>	Deer Mouse	40	0	0	6	2	0	40	Trap
<i>Microtus longicaudus</i>	Long-Tailed Vole	13	0	0	0	2	0	13	Trap
<i>Spermophilus beecheyi</i>	California Ground Squirrel	11	0	0	4	0	0	14	Trap
<i>Neotoma</i> spp.	Woodrat species	2	0	1	0	0	0	3	Trap
<i>Spermophilus lateralis</i>	Golden-Mantled Ground Squirrel	34	0	2	16	3	0	35	Trap
<i>Tamiasciurus douglasii</i>	Douglas' Squirrel	6	40	0	2	0	0	40	PC
<i>Ocotona princeps</i>	American Pika	2	9	0	0	0	0	9	PC
<i>Corvus corax</i>	Common Raven	0	13	0	1	0	0	14	PC
<i>Cyanocitta stelleri</i>	Steller's Jay	0	39	0	10	0	0	40	PC
<i>Cathartes aura</i>	Turkey Vulture	0	1	0	1	0	0	2	TP and Cam
<i>Branta canadensis</i>	Canada Goose	0	1	0	0	0	5	6	VES
<i>Mergus merganser</i>	Common Merganser	0	3	0	0	0	5	8	VES
<i>Buteo jamaicensis</i>	Red-tailed Hawk	0	7	0	0	0	4	11	PC
<i>Fulica americana</i>	American Coot	0	1	0	0	0	1	2	VES
<i>Charadrius vociferus</i>	Killdeer	0	3	0	0	0	4	6	VES
<i>Actitis macularia</i>	Spotted Sandpiper	0	3	0	0	0	6	9	VES
<i>Zenaida macroura</i>	Mourning Dove	0	24	0	0	0	1	25	PC
<i>Tachycineta bicolor</i>	Tree Swallow	0	3	0	0	0	2	5	PC
<i>Tachycineta thalassina</i>	Violet-green Swallow	0	4	0	0	0	2	6	PC
<i>Hirundo rustica</i>	Barn Swallow	0	1	0	0	0	2	3	VES
<i>Agelaius phoeniceus</i>	Red-winged Blackbird	0	9	0	0	0	7	14	PC
<i>Xanthocephalus xanthocephalus</i>	Yellow-headed Blackbird	0	1	0	0	0	2	3	VES
<i>Euphagus cyanocephalus</i>	Brewer's Blackbird	0	5	0	0	0	8	13	VES
<i>Sceloporus occidentalis</i>	Western fence lizard	0	0	0	0	3	1	4	PF
<i>Canis</i> spp.	Canid species	0	0	4	4	0	0	7	TP and Cam
<i>Martes americana</i>	American marten	0	0	8	5	0	0	9	TP
<i>Spilogale gracillis</i>	Western spotted skunk	0	0	1	1	0	0	2	TP and Cam
<i>Uram americanus</i>	Black bear	0	0	1	4	0	0	5	Cam

**Appendix F.** List of medium/large mammal species occurring in the Lake Tahoe basin (Murphy and Knopp 2000) and expected to be detected with trackplate (tp) and camera (cam) surveys conducted in LTBMU during 2002. Most likely detection method for each species is listed.

<b>Scientific Name</b>	<b>Common Name</b>	<b>Detection Method</b>
Canis latrans	Coyote	cam
Felis concolor	Mountain lion	cam
Felis rufus	Bobcat	cam
Martes americana	Marten	tp, cam
Martes pennanti	Fisher	tp, cam
Mephitis mephitis	Striped skunk	cam
Mustela frenata	Long-tailed weasel	tp, cam
Mustela vison	Mink	tp, cam
Procyon lotor	Raccoon	tp, cam
Spilogale gracilis	Western spotted skunk	tp, cam
Taxidea taxus	Badger	tp, cam
Ursus americanus	Black bear	cam

**Appendix G.** Bird species detected during point count surveys conducted at 40 monitoring point locations throughout the Lake Tahoe Basin Management Unit from 13 June to 5 August 2002. The observed (O%) and estimated (E%) proportion of points occupied by each species, the associated bootstrapped standard error and probability of detection (Pd) for each species. The estimated proportion of points occupied, associated bootstrap s.e. and Pd were calculated by the program PRESENCE (McKenzie et al. 2002) using data from all visits to all points and detections at all distances from the point count station. Species with a value of 0.0 for bootstrap s.e. and that were detected at < 100% of points (n = 31 species) were not detected frequently enough at the 40 monitoring points for Pd and E% to be accurately estimated. Species are listed in order of decreasing observed point occupancy values. Management indicator species, Forest Service sensitive species, California species of special concern and Tahoe Regional Planning Agency indicator species are indicated. No US FWS federal or state listed threatened or endangered species were detected with point count surveys.

Taxa Code	WHRid	Scientific Name	Common Name	Point Occupancy (O%)	Point Occupancy (E%)	Bootstrap S.E.	Pd
AMRO	B389	<i>Turdus migratorius</i>	American Robin	100.0	100.0	0.0	0.9417
MOCH	B356	<i>Poecile gambeli</i>	Mountain Chickadee	100.0	100.0	0.0	0.9903
ORJU	B512	<i>Junco hyemalis</i>	Dark-eyed Junco	100.0	100.0	0.0	0.9612
STJA	B346	<i>Cyanocitta stelleri</i>	Steller's Jay	100.0	100.0	0.0	0.9223
YRWA	B435	<i>Dendroica coronata</i>	Yellow-rumped Warbler	100.0	100.0	0.0	0.8155
NOFL	B307	<i>Colaptes auratus</i>	Northern Flicker	97.5	100.0	1.0	0.7767
PISI	B542	<i>Carduelis pinus</i>	Pine Siskin	95.0	100.0	1.3	0.6214
DUFL	B318	<i>Empidonax oberholseri</i>	Dusky Flycatcher	92.5	94.6	4.2	0.8185
RBNU	B361	<i>Sitta canadensis</i>	Red-breasted Nuthatch	90.0	90.7	4.7	0.8530
WBNU	B362	<i>Sitta carolinensis</i>	White-breasted Nuthatch	90.0	100.0	0.6	0.5534
BRCR	B364	<i>Certhia americana</i>	Brown Creeper	85.0	88.4	6.2	0.7869
TOSO	B382	<i>Myadestes townsendi</i>	Townsend's Solitaire	85.0	91.9	6.0	0.6731
WETA	B471	<i>Piranga ludoviciana</i>	Western Tanager	85.0	86.8	5.8	0.8415
CLNU	B350	<i>Nucifraga columbiana</i>	Clark's Nutcracker	82.5	85.6	6.3	0.7398
FOSP	B504	<i>Passerella iliaca</i>	Fox Sparrow	82.5	84.0	6.2	0.8105
BHCO	B528	<i>Molothrus ater</i>	Brown-headed Cowbird	80.0	88.1	7.7	0.5993
OSFL	B309	<i>Contopus cooperi</i>	Olive-sided Flycatcher	80.0	83.3	6.7	0.7604
GCKI	B375	<i>Regulus satrapa</i>	Golden-crowned Kinglet	77.5	79.5	7.0	0.7976
MOQU	B141	<i>Oreortyx pictus</i>	Mountain Quail	77.5	100.0	3.8	0.4272
HAWO	B304	<i>Picoides villosus</i>	Hairy Woodpecker	75.0	100.0	6.1	0.4369
WEWP	B311	<i>Contopus sordidulus</i>	Western Wood-pewee	75.0	78.5	7.5	0.7438
HETH	B386	<i>Catharus guttatus</i>	Hermit Thrush	67.5	81.9	10.0	0.5083
WAVI	B418	<i>Vireo gilvus</i>	Warbling Vireo	67.5	76.1	9.1	0.5954
NAWA	B426	<i>Vermivora ruficapilla</i>	Nashville Warbler	65.0	73.8	9.9	0.5692
CAFI	B537	<i>Carpodacus cassinii</i>	Cassin's Finch	62.5	100.0	6.5	0.3010
CAVI	B415	<i>Vireo cassinii</i>	Cassin's Vireo	62.5	100.0	8.7	0.3301
MOD0	B255	<i>Zenaida macroura</i>	Mourning Dove	60.0	68.4	9.7	0.5860
PYNU	B363	<i>Sitta pygmaea</i>	Pygmy Nuthatch	60.0	83.3	12.0	0.4062
WISA	B300	<i>Sphyrapicus thyroideus</i>	Williamson's Sapsucker	60.0	74.9	12.5	0.4878
MGWA	B460	<i>Oporornis tolmiei</i>	MacGillivray's Warbler	55.0	89.4	13.9	0.3148
HEWA	B438	<i>Dendroica occidentalis</i>	Hermit Warbler	52.5	100.0	5.1	0.2330
EVGR	B546	<i>Coccothraustes vespertinus</i>	Evening Grosbeak	45.0	63.6	16.8	0.3746
WHWO	B305	<i>Picoides albolarvatus</i>	White-headed Woodpecker	42.5	79.0	19.2	0.2591
WIWA	B463	<i>Wilsonia pusilla</i>	Wilson's Warbler	42.5	100.0	15.5	0.1942
CHSP	B489	<i>Spizella passerina</i>	Chipping Sparrow	40.0	83.9	18.9	0.2208

Taxa Code	WHRid	Scientific Name	Common Name	Point	Point	S.E.	Pd
				Occupancy	Occupancy		
				(O%)	(E%)		
CORA	B354	Corvus corax	Common Raven	37.5	64.1	21.1	0.2990
BTPI	B251	Columba fasciata	Band-tailed Pigeon	35.0	57.4	19.7	0.3077
PIGR	B535	Pinicola enucleator	Pine Grosbeak	32.5	100.0	17.4	0.1359
RUHU	B291	Selasphorus rufus	Rufous Hummingbird	32.5	36.7	8.8	0.5914
BLGR <sup>a</sup>	B134	Dendragapus obscurus	Blue Grouse	30.0	66.9	22.7	0.2146
CAHU	B289	Stellula calliope	Calliope Hummingbird	30.0	64.4	23.7	0.2140
GTTO	B482	Pipilo chlorurus	Green-tailed Towhee	30.0	64.4	26.5	0.2140
SOSP	B505	Melospiza melodia	Song Sparrow	30.0	45.7	19.8	0.3430
WEBL	B380	Sialia mexicana	Western Bluebird	27.5	100.0	17.2	0.1165
DOWO	B303	Picoides pubescens	Downy Woodpecker	25.0	68.5	26.6	0.1583
RBSA	B299	Sphyrapicus ruber	Red-breasted Sapsucker	25.0	100.0	23.6	0.1068
RWBL	B519	Agelaius phoeniceus	Red-winged Blackbird	22.5	25.1	9.7	0.6059
SPTO	B483	Pipilo maculatus	Spotted Towhee	22.5	36.3	27.3	0.3187
HOWR	B369	Troglodytes aedon	House Wren	20.0	31.8	21.9	0.3281
RECR	B539	Loxia curvirostra	Red Crossbill	20.0	61.3	29.1	0.1428
BHGR	B475	Pheucticus melanocephalus	Black-headed Grosbeak	17.5	52.8	31.7	0.1465
MALL <sup>a,d</sup>	B079	Anas platyrhynchos	Mallard	17.5	20.6	25.8	0.5262
RTHA	B123	Buteo jamaicensis	Red-tailed Hawk	17.5	100.0	0.0	0.0680
WCSP	B510	Zonotrichia leucophrys	White-crowned Sparrow	17.5	25.3	27.3	0.3760
YEWA <sup>c</sup>	B430	Dendroica petechia	Yellow Warbler	17.5	52.8	31.9	0.1465
BBWO	B306	Picoides arcticus	Black-backed Woodpecker	15.0	100.0	0.0	0.0583
WIWR	B370	Troglodytes troglodytes	Winter Wren	15.0	19.7	17.5	0.4390
BRBL	B524	Euphagus cyanocephalus	Brewer's Blackbird	12.5	14.3	17.9	0.5750
BTGW	B436	Dendroica nigrescens	Black-throated Gray Warbler	12.5	100.0	0.0	0.0485
BUSH	B360	Psaltiriparus minimus	Bushtit	12.5	100.0	0.0	0.0485
CLSW	B343	Petrochelidon pyrrhonota	Cliff Swallow	12.5	15.9	29.3	0.4563
LISP	B506	Melospiza lincolni	Lincoln's Sparrow	12.5	100.0	0.0	0.0485
ROWR	B366	Salpinctes obsoletus	Rock Wren	12.5	15.9	29.7	0.4563
OCWA	B425	Vermivora celata	Orange-crowned Warbler	10.0	100.0	0.0	0.0388
VGSW	B340	Tachycineta thalassina	Violet-green Swallow	10.0	100.0	0.0	0.0388
COME <sup>d</sup>	B105	Mergus merganser	Common Merganser	7.5	8.5	42.3	0.5764
KILL	B158	Charadrius vociferus	Killdeer	7.5	10.0	40.9	0.4244
LABU	B477	Passerina amoena	Lazuli Bunting	7.5	100.0	0.0	0.0291
MOBL	B381	Sialia currucoides	Mountain Bluebird	7.5	14.6	40.2	0.2494
PIWO <sup>a</sup>	B308	Dryocopus pileatus	Pileated Woodpecker	7.5	100.0	0.0	0.0291
SPSA	B170	Actitis macularia	Spotted Sandpiper	7.5	7.9	23.2	0.7203
TRES	B339	Tachycineta bicolor	Tree Swallow	7.5	100.0	0.0	0.0291
WTSW	B282	Aeronautes saxatalis	White-throated Swift	7.5	100.0	0.0	0.0291
CAGO <sup>d</sup>	B075	Branta canadensis	Canada Goose	5.0	100.0	0.0	0.0194
COPO	B277	Phalaenoptilus nuttallii	Common Poorwill	5.0	6.1	39.5	0.4932
COSN	B199	Gallinago gallinago	Common Snipe	5.0	6.1	40.2	0.4932
SSHA <sup>c</sup>	B115	Accipiter striatus	Sharp-shinned Hawk	5.0	100.0	0.0	0.0194
AMCO <sup>d</sup>	B149	Fulica americana	American Coot	2.5	100.0	0.0	0.0097
ANHU	B287	Calypte anna	Anna's Hummingbird	2.5	100.0	0.0	0.0097
BARS	B344	Hirundo rustica	Barn Swallow	2.5	2.8	2.7	0.6156
BGGN	B377	Polioptila caerulea	Blue-gray Gnatcatcher	2.5	100.0	0.0	0.0097
COHA <sup>c</sup>	B116	Accipiter cooperii	Cooper's Hawk	2.5	100.0	0.0	0.0097

Taxa Code	WHRid	Scientific Name	Common Name	Point	Point	S.E.	Pd
				Occupancy	Occupancy Bootstrap		
				(O%)	(E%)		
CONI	B276	Chordeiles minor	Common Nighthawk	2.5	2.5	2.4	1.0000
HOFI	B538	Carpodacus mexicanus	House Finch	2.5	100.0	0.0	0.0097
LASP	B495	Chondestes grammacus	Lark Sparrow	2.5	100.0	0.0	0.0097
NOGO <sup>a,b,c,d</sup>	B117	Accipiter gentilis	Northern Goshawk	2.5	100.0	0.0	0.0097
OSPR <sup>c,d</sup>	B110	Pandion haliaetus	Osprey	2.5	2.8	2.8	0.6156
PSFL	B320	Empidonax difficilis	Pacific Slope Flycatcher	2.5	100.0	0.0	0.0097
RCKI	B376	Regulus calendula	Ruby-crowned Kinglet	2.5	100.0	0.0	0.0097
RODO	B250	Columba livia	Rock Dove	2.5	100.0	0.0	0.0097
RUDU <sup>d</sup>	B107	Oxyura jamaicensis	Ruddy Duck	2.5	100.0	0.0	0.0097
SASP	B499	Passerculus sandwichensis	Savannah Sparrow	2.5	100.0	0.0	0.0097
SWTH	B385	Catharus ustulatus	Swainson's Thrush	2.5	100.0	0.0	0.0097
TOWA	B437	Dendroica townsendi	Townsend's Warbler	2.5	100.0	0.0	0.0097
TUVU	B108	Cathartes aura	Turkey Vulture	2.5	100.0	0.0	0.0097
WIPH	B200	Phalaropus tricolor	Wilson's Phalarope	2.5	100.0	0.0	0.0097
WREN	B391	Chamaea fasciata	Wrentit	2.5	100.0	0.0	0.0097
YHBL	B522	Xanthocephalus xanthocephalus	Yellow-headed Blackbird	2.5	100.0	0.0	0.0097

<sup>a</sup> Management Indicator Species (MIS)

<sup>b</sup> Forest Service Sensitive Species (FSS)

<sup>c</sup> California Species of Special Concern (SSC)

<sup>d</sup> Tahoe Regional Planning Agency Special Interest Species

**Appendix H.** Average abundances per count station for bird species detected with point count surveys at 40 monitoring points during summer 2002. Values reported per species are: average abundance across points at which each species was detected (Average Abundance and associated standard error across all 40 points (Ave. Abund. Overall and Overall s.e.), and mean abundance and associated standard error across points within each of 5 elevation/habitat classes (lower montane conifer, upper montane conifer and wet meadow habitats). Abundance and point occupancy values were calculated using bird detections from all survey points at the count station.

Common Name	Pts. Occ.	Ave. where present	Ave. Abund. Overall	Overall s.e.	Lower Montane Conifer (n = 10)			Upper Montane Conifer (n = 22)			Sub-Alpine Conifer (n = 5)			Shrubland (n = 5)	
					Mean	s.e.	Pts. Occ. (%)	Mean	s.e.	Pts. Occ. (%)	Mean	s.e.	Pts. Occ. (%)	Mean	s.e.
Dark-eyed Junco	40	2.02	2.02	0.11	1.40	0.21	100.0	2.37	0.12	100.0	1.74	0.30	100.0	1.86	
Mountain Chickadee	40	1.87	1.87	0.09	2.29	0.19	100.0	1.75	0.10	100.0	1.91	0.26	100.0	1.14	
Steller's Jay	40	1.65	1.65	0.17	2.49	0.39	100.0	1.60	0.19	100.0	0.96	0.36	100.0	0.43	
Fox Sparrow	33	1.24	1.02	0.17	0.55	0.09	100.0	1.42	0.28	86.4	0.33	0.21	40.0	1.07	
American Robin	40	1.00	1.00	0.07	1.03	0.08	100.0	1.03	0.11	100.0	0.95	0.25	100.0	0.50	
Yellow-rumped Warbler	40	0.81	0.81	0.07	0.62	0.14	100.0	0.98	0.09	100.0	0.61	0.24	100.0	0.29	
Western Tanager	34	0.89	0.76	0.10	1.04	0.15	100.0	0.83	0.14	86.4	0.19	0.06	80.0	0.00	
Clark's Nutcracker	33	0.91	0.75	0.21	0.04	0.02	40.0	0.37	0.06	95.5	3.08	1.01	100.0	1.36	
Red-breasted Nuthatch	36	0.75	0.67	0.07	0.68	0.17	80.0	0.77	0.08	95.5	0.49	0.21	80.0	0.14	
Dusky Flycatcher	37	0.72	0.66	0.09	0.53	0.22	90.0	0.77	0.12	90.9	0.40	0.23	100.0	0.71	
Brown-headed Cowbird	32	0.71	0.57	0.12	1.19	0.29	100.0	0.47	0.15	81.8	0.04	0.03	40.0	0.00	
Western Wood-pewee	30	0.62	0.46	0.09	0.65	0.16	100.0	0.42	0.11	72.7	0.09	0.06	40.0	0.14	
Olive-sided Flycatcher	32	0.58	0.46	0.08	0.48	0.21	70.0	0.55	0.10	86.4	0.12	0.08	60.0	0.64	
Golden-crowned Kinglet	31	0.59	0.46	0.08	0.56	0.12	90.0	0.52	0.12	86.4	0.12	0.10	40.0	0.00	

Common Name	Ave. Abund.				Lower Montane Conifer (n = 10)			Upper Montane Conifer (n = 22)			Sub-Alpine Conifer (n = 5)			Sh (n = )	
	Pts. Occ.	where present	Abund. Overall	s.e.	Pts. Occ.			Pts. Occ.			Pts. Occ.			Mean	s.e.
					Mean	s.e.	(%)	Mean	s.e.	(%)	Mean	s.e.	(%)		
Northern Flicker	39	0.46	0.45	0.05	0.58	0.13	100.0	0.45	0.07	95.5	0.37	0.14	100.0	0.14	
Brown Creeper	34	0.49	0.42	0.06	0.58	0.13	100.0	0.44	0.07	86.4	0.21	0.09	80.0	0.00	
Pine Siskin	38	0.37	0.35	0.06	0.47	0.20	90.0	0.29	0.05	95.5	0.33	0.08	100.0	0.36	
Hermit Thrush	27	0.50	0.34	0.08	0.20	0.11	40.0	0.45	0.12	81.8	0.24	0.13	60.0	0.07	
Red-winged Blackbird	9	1.42	0.32	0.19	0.46	0.32	60.0	0.06	0.05	9.1	0.00	0.00	0.0	0.00	
Townsend's Solitaire	34	0.36	0.31	0.04	0.25	0.07	80.0	0.40	0.07	95.5	0.16	0.10	60.0	0.07	
Nashville Warbler	26	0.43	0.28	0.06	0.51	0.19	80.0	0.24	0.05	77.3	0.00	0.00	0.0	0.00	
White-breasted Nuthatch	36	0.30	0.27	0.03	0.33	0.08	80.0	0.26	0.04	100.0	0.36	0.11	100.0	0.14	
Warbling Vireo	27	0.39	0.26	0.06	0.34	0.10	100.0	0.26	0.09	63.6	0.12	0.08	40.0	0.00	
Rufous Hummingbird	13	0.71	0.23	0.10	<0.01	<0.01	10.0	0.19	0.06	40.9	0.23	0.18	40.0	0.00	
Cassin's Finch	25	0.35	0.22	0.06	0.03	0.01	40.0	0.13	0.05	59.1	0.67	0.24	100.0	0.29	
Mountain Quail	31	0.23	0.18	0.04	0.19	0.08	60.0	0.22	0.05	90.9	0.05	0.03	60.0	0.14	
White-crowned Sparrow	7	0.97	0.17	0.11	0.01	0.01	10.0	0.14	0.13	13.6	0.04	0.02	40.0	0.00	
Williamson's Sapsucker	24	0.24	0.15	0.03	0.10	0.04	60.0	0.17	0.04	63.6	0.21	0.14	60.0	0.07	
Mourning Dove	24	0.23	0.14	0.03	0.23	0.05	90.0	0.12	0.04	54.5	0.13	0.07	60.0	0.00	
Hermit Warbler	21	0.24	0.13	0.03	0.18	0.09	60.0	0.14	0.04	59.1	0.04	0.03	40.0	0.00	
Hairy Woodpecker	30	0.16	0.12	0.02	0.20	0.05	90.0	0.10	0.02	81.8	0.14	0.08	60.0	0.00	
Pygmy Nuthatch	24	0.20	0.12	0.03	0.22	0.11	60.0	0.08	0.02	63.6	0.10	0.05	60.0	0.00	
Cassin's Vireo	25	0.16	0.10	0.02	0.17	0.05	90.0	0.10	0.03	63.6	0.05	0.04	40.0	0.00	
MacGillivray's Warbler	22	0.18	0.10	0.02	0.16	0.05	70.0	0.10	0.03	54.5	0.01	0.01	20.0	0.00	
Evening Grosbeak	18	0.21	0.10	0.03	0.18	0.06	50.0	0.08	0.04	50.0	0.03	0.03	20.0	0.00	

Common Name	Pts. Occ.	Ave. Abund. where present	Ave. Abund. Overall	Overall s.e.	Lower Montane Conifer (n = 10)			Upper Montane Conifer (n = 22)			Sub-Alpine Conifer (n = 5)			Shu (n = )
					Pts. Occ.			Pts. Occ.			Pts. Occ.			
					Mean	s.e.	(%)	Mean	s.e.	(%)	Mean	s.e.	(%)	
Brewer's Blackbird	5	0.71	0.09	0.06	0.30	0.21	40.0	0.02	0.02	4.5	0.00	0.00	0.0	0.00
Song Sparrow	12	0.27	0.08	0.03	0.02	0.01	20.0	0.07	0.03	31.8	0.06	0.06	20.0	0.00
Cliff Swallow	5	0.57	0.07	0.04	0.17	0.17	10.0	0.02	0.02	9.1	0.00	0.00	0.0	0.00
Wilson's Warbler	17	0.17	0.07	0.02	0.11	0.07	40.0	0.06	0.02	50.0	0.00	0.00	0.0	0.00
White-headed Woodpecker	17	0.15	0.06	0.02	0.11	0.05	50.0	0.05	0.01	45.5	0.01	0.01	20.0	0.00
Band-tailed Pigeon	14	0.18	0.06	0.02	0.05	0.03	20.0	0.09	0.03	50.0	0.00	0.00	0.0	0.07
Chipping Sparrow	16	0.15	0.06	0.02	0.10	0.06	40.0	0.05	0.01	45.5	0.04	0.04	20.0	0.00
Mallard	7	0.35	0.06	0.03	0.03	0.02	20.0	0.06	0.05	13.6	0.00	0.00	0.0	0.21
House Wren	8	0.28	0.06	0.02	0.10	0.07	30.0	0.03	0.02	13.6	0.05	0.05	20.0	0.00
Common Raven	15	0.14	0.05	0.02	0.11	0.04	70.0	0.05	0.02	31.8	0.01	0.01	20.0	0.00
Green-tailed Towhee	12	0.15	0.05	0.02	0.03	0.02	30.0	0.04	0.01	27.3	0.13	0.10	40.0	0.00
Spotted Towhee	9	0.17	0.04	0.02	0.12	0.07	70.0	0.02	0.01	9.1	0.00	0.00	0.0	0.00
Calliope Hummingbird	12	0.13	0.04	0.01	<0.01	<0.01	10.0	0.05	0.02	45.5	0.00	0.00	0.0	0.36
Western Bluebird	11	0.14	0.04	0.01	0.06	0.04	30.0	0.03	0.01	22.7	0.04	0.02	40.0	0.00
Winter Wren	6	0.25	0.04	0.02	0.06	0.03	30.0	0.04	0.03	13.6	0.00	0.00	0.0	0.00
Pine Grosbeak	13	0.11	0.04	0.01	0.00	0.00	0.0	0.04	0.01	36.4	0.02	0.01	40.0	0.14
Blue Grouse	12	0.12	0.04	0.01	0.00	0.00	0.0	0.05	0.02	45.5	0.05	0.03	40.0	0.00
Lincoln's Sparrow	5	0.29	0.04	0.02	0.03	0.03	10.0	0.02	0.01	9.1	0.00	0.00	0.0	0.00
Downy Woodpecker	10	0.11	0.03	0.01	0.02	0.01	20.0	0.04	0.02	31.8	0.00	0.00	0.0	0.00
Red Crossbill	8	0.14	0.03	0.01	0.05	0.04	30.0	0.03	0.01	22.7	0.00	0.00	0.0	0.00
Spotted Sandpiper	3	0.37	0.03	0.02	<0.01	<0.01	10.0	0.03	0.03	4.5	0.00	0.00	0.0	0.00

Common Name	Pts. Occ.	Ave. Abund. where present	Ave. Abund. Overall	Overall s.e.	Lower Montane Conifer (n = 10)			Upper Montane Conifer (n = 22)			Sub-Alpine Conifer (n = 5)			Sh (n = )
					Pts. Occ.			Pts. Occ.			Pts. Occ.			
					Mean	s.e.	(%)	Mean	s.e.	(%)	Mean	s.e.	(%)	
Rock Wren	5	0.22	0.03	0.01	0.00	0.00	0.0	0.02	0.01	9.1	0.09	0.09	20.0	0.21
Violet-green Swallow	4	0.27	0.03	0.01	0.05	0.05	10.0	0.02	0.01	9.1	0.06	0.06	20.0	0.00
Red-breasted Sapsucker	10	0.11	0.03	0.01	0.01	0.01	10.0	0.04	0.02	36.4	0.01	0.01	20.0	0.00
Barn Swallow	1	0.90	0.02	0.02	0.09	0.09	10.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Bushtit	5	0.17	0.02	0.01	0.01	0.01	20.0	<0.01	<0.01	4.5	0.12	0.10	40.0	0.00
Yellow Warbler	7	0.11	0.02	0.01	0.02	0.02	20.0	0.02	0.01	22.7	0.00	0.00	0.0	0.00
Black-headed Grosbeak	7	0.11	0.02	0.01	0.02	0.01	20.0	0.02	0.01	18.2	0.04	0.04	20.0	0.00
Common Snipe	2	0.37	0.02	0.01	0.02	0.02	10.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Tree Swallow	3	0.22	0.02	0.01	0.00	0.00	0.0	0.03	0.02	9.1	0.00	0.00	0.0	0.00
Mountain Bluebird	3	0.17	0.01	0.01	0.00	0.00	0.0	0.02	0.01	9.1	0.04	0.04	20.0	0.00
Black-throated Gray Warbler	5	0.10	0.01	0.01	0.01	0.01	20.0	0.02	0.01	13.6	0.00	0.00	0.0	0.00
White-throated Swift	3	0.15	0.01	0.01	<0.01	<0.01	10.0	0.00	0.00	0.0	0.04	0.04	20.0	0.21
Common Merganser	3	0.14	0.01	0.01	0.00	0.00	0.0	0.02	0.01	9.1	0.00	0.00	0.0	0.07
Orange-crowned Warbler	4	0.11	0.01	0.01	0.01	0.01	10.0	0.01	0.01	9.1	0.00	0.00	0.0	0.00
Red-tailed Hawk	7	0.06	0.01	<0.01	0.02	0.01	30.0	<0.01	<0.01	4.5	0.03	0.01	60.0	0.00
Savannah Sparrow	1	0.43	0.01	0.01	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Black-backed Woodpecker	6	0.07	0.01	<0.01	<0.01	<0.01	10.0	0.01	0.01	13.6	0.01	0.01	20.0	0.07
Killdeer	3	0.11	0.01	0.01	0.01	0.01	10.0	<0.01	<0.01	4.5	0.00	0.00	0.0	0.00

Common Name	Pts. Occ.	Ave. Abund.			Lower Montane Conifer (n = 10)			Upper Montane Conifer (n = 22)			Sub-Alpine Conifer (n = 5)			Sh
		where present	Abund. Overall	s.e.	Pts. Occ.			Pts. Occ.			Pts. Occ.			(n =
					Mean	s.e.	(%)	Mean	s.e.	(%)	Mean	s.e.	(%)	Mean
Common Poorwill	2	0.15	0.01	0.01	0.00	0.00	0.0	<0.01	<0.01	4.5	0.00	0.00	0.0	0.00
Lazuli Bunting	3	0.10	0.01	<0.01	0.01	0.01	10.0	<0.01	<0.01	4.5	0.00	0.00	0.0	0.00
Common Nighthawk	1	0.29	0.01	0.01	0.00	0.00	0.0	0.01	0.01	4.5	0.00	0.00	0.0	0.00
Canada Goose	2	0.12	0.01	<0.01	0.02	0.02	20.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Pileated Woodpecker	3	0.08	0.01	<0.01	0.01	0.01	10.0	0.01	<0.01	9.1	0.00	0.00	0.0	0.00
Yellow-headed Blackbird	1	0.24	0.01	0.01	0.02	0.02	10.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Sharp-shinned Hawk	2	0.10	<0.01	<0.01	<0.01	<0.01	10.0	0.01	0.01	4.5	0.00	0.00	0.0	0.00
Wrentit	1	0.19	<0.01	<0.01	0.00	0.00	0.0	0.01	0.01	4.5	0.00	0.00	0.0	0.00
American Coot	1	0.14	<0.01	<0.01	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Blue-gray Gnatcatcher	1	0.14	<0.01	<0.01	0.00	0.00	0.0	0.01	0.01	4.5	0.00	0.00	0.0	0.00
House Finch	1	0.14	<0.01	<0.01	0.00	0.00	0.0	0.01	0.01	4.5	0.00	0.00	0.0	0.00
Ruby-crowned Kinglet	1	0.14	<0.01	<0.01	0.00	0.00	0.0	0.01	0.01	4.5	0.00	0.00	0.0	0.00
Rock Dove	1	0.14	<0.01	<0.01	0.01	0.01	10.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Ruddy Duck	1	0.14	<0.01	<0.01	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Townsend's Warbler	1	0.14	<0.01	<0.01	0.01	0.01	10.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Wilson's Phalarope	1	0.14	<0.01	<0.01	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Osprey	1	0.10	<0.01	<0.01	0.01	0.01	10.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00
Pacific Slope Flycatcher	1	0.10	<0.01	<0.01	0.00	0.00	0.0	<0.01	<0.01	4.5	0.00	0.00	0.0	0.00

Common Name	Pts. Occ.	Ave. Abund. where present	Ave. Abund. Overall	Overall s.e.	Lower Montane Conifer (n = 10)			Upper Montane Conifer (n = 22)			Sub-Alpine Conifer (n = 5)			Shrub (n = 5)	
					Pts. Occ.		Pts. Occ.		Pts. Occ.		Pts. Occ.				
					Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	
Turkey Vulture	1	0.07	<0.01	<0.01	0.00	0.00	0.0	<0.01	<0.01	4.5	0.00	0.00	0.0	0.00	
Anna's Hummingbird	1	0.05	<0.01	<0.01	<0.01	<0.01	10.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	
Cooper's Hawk	1	0.05	<0.01	<0.01	0.00	0.00	0.0	<0.01	<0.01	4.5	0.00	0.00	0.0	0.00	
Lark Sparrow	1	0.05	<0.01	<0.01	0.00	0.00	0.0	0.00	0.00	0.0	0.01	0.01	20.0	0.00	
Northern Goshawk	1	0.05	<0.01	<0.01	0.00	0.00	0.0	<0.01	<0.01	4.5	0.00	0.00	0.0	0.00	
Swainson's Thrush	1	0.05	<0.01	<0.01	0.00	0.00	0.0	<0.01	<0.01	4.5	0.00	0.00	0.0	0.00	
<b>Species Richness</b>					<b>33.40</b>	<b>4.79</b>		<b>32.27</b>	<b>5.15</b>		<b>25.00</b>	<b>6.32</b>		<b>27.00</b>	
<b>Total Richness</b>					<b>69</b>			<b>74</b>			<b>52</b>			<b>27</b>	

<sup>a</sup> Only one point was classified as Shrub habitat, therefore mean detection rates for shrub habitat do not have a standard error.

**Appendix I.** Species detected, mean abundances per point count station and the proportion of points occupied (Pts. Occup. orientation within the Lake Tahoe Basin Management Unit. Orientations were defined the same as in Manley and Schlesi point occupancy values were calculated using bird detections from all survey visits and at any distance from the count station values were calculated per orientation based on data collected during the first 2 visits to each point only. Three survey visits: 50%, 71 and 60% of points in each orientation, north, south, east and west respectively.

Common Name	North (n = 7 pts)			South (n = 16 pts)			East (n = 7 pts)			West (n = 10 pts)		
	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)
American Coot	0.00	0.00	0.0	0.01	0.01	6.3	0.00	0.00	0.0	0.00	0.00	0.0
American Robin	1.04	0.17	100.0	1.00	0.13	100.0	0.96	0.13	100.0	0.98	0.15	100.0
Anna's Hummingbird	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	10.0
Barn Swallow	0.00	0.00	0.0	0.00	0.00	0.0	0.13	0.13	14.3	0.00	0.00	0.0
Black-backed Woodpecker	0.00	0.00	0.0	0.01	0.01	12.5	0.01	0.01	14.3	0.02	0.01	30.0
Blue-gray Gnatcatcher	0.00	0.00	0.0	0.00	0.00	0.0	0.02	0.02	14.3	0.00	0.00	0.0
Brown-headed Cowbird	0.42	0.19	85.7	0.55	0.18	81.3	1.20	0.39	100.0	0.26	0.21	60.0
Black-headed Grosbeak	0.02	0.02	14.3	0.03	0.02	18.8	0.02	0.01	28.6	0.00	0.00	10.0
Blue Grouse	0.03	0.02	28.6	0.02	0.01	25.0	0.03	0.03	14.3	0.06	0.03	50.0
Brewer's Blackbird	0.00	0.00	0.0	0.05	0.04	12.5	0.37	0.30	28.6	0.02	0.02	10.0
Brown Creeper	0.53	0.12	85.7	0.30	0.09	81.3	0.48	0.10	100.0	0.48	0.14	80.0
Black-throated Gray Warbler	0.01	0.01	14.3	0.02	0.02	12.5	0.00	0.00	0.0	0.01	0.01	20.0
Band-tailed Pigeon	0.04	0.04	14.3	0.05	0.03	25.0	0.12	0.05	57.1	0.06	0.02	50.0
Bushtit	0.00	0.00	0.0	0.04	0.03	18.8	0.01	0.01	14.3	0.01	0.01	10.0
Cassin's Finch	0.15	0.09	42.9	0.36	0.14	62.5	0.06	0.02	71.4	0.15	0.07	70.0
Canada Goose	0.00	0.00	0.0	0.00	0.00	0.0	0.01	0.01	14.3	0.01	0.01	10.0
Calliope Hummingbird	0.04	0.03	28.6	0.04	0.02	31.3	0.00	0.00	0.0	0.07	0.04	50.0
Cassin's Vireo	0.12	0.06	71.4	0.04	0.02	37.5	0.09	0.03	85.7	0.20	0.07	80.0
Chipping Sparrow	0.20	0.06	100.0	0.03	0.01	18.8	0.06	0.02	57.1	0.02	0.01	20.0
Clark's Nutcracker	0.63	0.47	85.7	1.24	0.44	87.5	0.17	0.08	71.4	0.45	0.14	80.0
Cliff Swallow	0.00	0.00	0.0	0.07	0.04	18.8	0.25	0.24	28.6	0.00	0.00	0.0
Cooper's Hawk	0.01	0.01	14.3	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
Common Merganser	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.04	0.03	30.0
Common Nighthawk	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.03	0.03	10.0
Common Poorwill	0.01	0.01	14.3	0.01	0.01	6.3	0.00	0.00	0.0	0.00	0.00	0.0
Common Raven	0.05	0.03	42.9	0.06	0.03	25.0	0.11	0.05	85.7	0.01	0.01	20.0

Common Name	North (n = 7 pts)			South (n = 16 pts)			East (n = 7 pts)			West (n = 10 pts)		
	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)
Common Snipe	0.00	0.00	0.0	0.03	0.03	6.3	0.00	0.00	0.0	0.02	0.02	10.0
Downy Woodpecker	0.07	0.04	42.9	0.02	0.01	18.8	0.01	0.01	14.3	0.02	0.01	30.0
Dusky Flycatcher	1.10	0.30	100.0	0.55	0.12	87.5	0.49	0.13	100.0	0.66	0.19	90.0
Evening Grosbeak	0.18	0.08	71.4	0.08	0.03	43.8	0.04	0.02	42.9	0.11	0.09	30.0
Fox Sparrow	2.12	0.70	85.7	0.68	0.19	68.8	0.75	0.23	85.7	1.00	0.21	100.0
Golden-crowned Kinglet	0.75	0.30	85.7	0.41	0.10	75.0	0.44	0.10	100.0	0.34	0.14	60.0
Green-tailed Towhee	0.04	0.02	42.9	0.05	0.03	18.8	0.06	0.03	57.1	0.03	0.02	20.0
Hairy Woodpecker	0.14	0.05	85.7	0.09	0.03	56.3	0.18	0.06	100.0	0.12	0.04	80.0
Hermit Thrush	0.63	0.33	71.4	0.31	0.09	62.5	0.12	0.07	42.9	0.34	0.10	90.0
Hermit Warbler	0.07	0.05	42.9	0.11	0.04	56.3	0.03	0.03	14.3	0.26	0.09	80.0
House Finch	0.00	0.00	0.0	0.00	0.00	0.0	0.02	0.02	14.3	0.00	0.00	0.0
House Wren	0.10	0.07	28.6	0.08	0.04	25.0	0.03	0.02	28.6	0.00	0.00	0.0
Killdeer	0.00	0.00	0.0	0.02	0.01	12.5	0.01	0.01	14.3	0.00	0.00	0.0
Lazuli Bunting	0.01	0.01	14.3	0.01	0.01	12.5	0.00	0.00	0.0	0.00	0.00	0.0
Lark Sparrow	0.00	0.00	0.0	0.00	0.00	6.3	0.00	0.00	0.0	0.00	0.00	0.0
Lincoln's Sparrow	0.00	0.00	0.0	0.07	0.04	18.8	0.00	0.00	0.0	0.04	0.02	20.0
Mallard	0.02	0.02	14.3	0.05	0.04	12.5	0.00	0.00	0.0	0.15	0.10	40.0
MacGillivray's Warbler	0.14	0.07	42.9	0.08	0.04	43.8	0.12	0.05	71.4	0.09	0.03	70.0
Mountain Bluebird	0.03	0.03	14.3	0.00	0.00	0.0	0.00	0.00	0.0	0.03	0.02	20.0
Mountain Chickadee	1.90	0.26	100.0	1.89	0.16	100.0	1.97	0.18	100.0	1.72	0.15	100.0
Mourning Dove	0.08	0.04	57.1	0.22	0.06	68.8	0.11	0.04	71.4	0.08	0.04	40.0
Mountain Quail	0.25	0.10	100.0	0.07	0.03	50.0	0.14	0.05	85.7	0.34	0.09	100.0
Nashville Warbler	0.51	0.21	71.4	0.17	0.06	56.3	0.15	0.05	85.7	0.39	0.15	60.0
Northern Flicker	0.59	0.18	100.0	0.42	0.09	100.0	0.43	0.05	100.0	0.42	0.12	90.0
Northern Goshawk	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	10.0
Orange-crowned Warbler	0.00	0.00	0.0	0.00	0.00	6.3	0.00	0.00	0.0	0.04	0.02	30.0
Oregon Junco	2.23	0.33	100.0	2.00	0.16	100.0	1.66	0.24	100.0	2.15	0.24	100.0
Olive-sided Flycatcher	0.39	0.16	71.4	0.23	0.07	68.8	0.42	0.14	85.7	0.91	0.20	100.0
Osprey	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.01	0.01	10.0
Pine Grosbeak	0.01	0.01	14.3	0.05	0.02	43.8	0.00	0.00	0.0	0.06	0.02	50.0
Pine Siskin	0.25	0.06	100.0	0.46	0.10	100.0	0.44	0.21	85.7	0.17	0.03	90.0
Pileated Woodpecker	0.00	0.00	0.0	0.01	0.01	12.5	0.00	0.00	0.0	0.00	0.00	10.0

Common Name	North (n = 7 pts)			South (n = 16 pts)			East (n = 7 pts)			West (n = 10 pts)		
	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)
Pacific Slope Flycatcher	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.01	0.01	10.0
Pygmy Nuthatch	0.08	0.03	57.1	0.12	0.03	62.5	0.20	0.16	57.1	0.09	0.03	60.0
Red-breasted Nuthatch	0.85	0.20	100.0	0.69	0.11	87.5	0.60	0.16	85.7	0.58	0.12	90.0
Red-breasted Sapsucker	0.02	0.02	14.3	0.03	0.02	25.0	0.06	0.03	42.9	0.01	0.01	20.0
Ruby-crowned Kinglet	0.00	0.00	0.0	0.01	0.01	6.3	0.00	0.00	0.0	0.00	0.00	0.0
Red Crossbill	0.01	0.01	14.3	0.03	0.02	12.5	0.03	0.02	28.6	0.04	0.02	30.0
Rock Dove	0.00	0.00	0.0	0.00	0.00	0.0	0.02	0.02	14.3	0.00	0.00	0.0
Rock Wren	0.06	0.06	14.3	0.03	0.02	12.5	0.00	0.00	0.0	0.03	0.02	20.0
Red-tailed Hawk	0.02	0.01	42.9	0.01	0.00	12.5	0.02	0.02	14.3	0.00	0.00	10.0
Ruddy Duck	0.00	0.00	0.0	0.01	0.01	6.3	0.00	0.00	0.0	0.00	0.00	0.0
Rufous Hummingbird	0.05	0.05	14.3	0.42	0.24	43.8	0.00	0.00	0.0	0.22	0.11	50.0
Red-winged Blackbird	0.04	0.03	28.6	0.49	0.42	25.0	0.62	0.46	28.6	0.03	0.03	10.0
Savannah Sparrow	0.00	0.00	0.0	0.03	0.03	6.3	0.00	0.00	0.0	0.00	0.00	0.0
Song Sparrow	0.03	0.02	28.6	0.12	0.07	31.3	0.11	0.08	28.6	0.04	0.02	30.0
Spotted Sandpiper	0.00	0.00	0.0	0.02	0.02	6.3	0.01	0.01	14.3	0.07	0.07	10.0
Spotted Towhee	0.05	0.03	42.9	0.01	0.01	12.5	0.14	0.10	57.1	0.00	0.00	0.0
Sharp-shinned Hawk	0.00	0.00	0.0	0.00	0.00	0.0	0.01	0.01	14.3	0.01	0.01	10.0
Steller's Jay	1.07	0.41	100.0	1.63	0.31	100.0	2.02	0.29	100.0	1.82	0.33	100.0
Swainson's Thrush	0.00	0.00	0.0	0.00	0.00	6.3	0.00	0.00	0.0	0.00	0.00	0.0
Townsend's Solitaire	0.31	0.09	85.7	0.27	0.09	75.0	0.41	0.07	100.0	0.29	0.07	90.0
Townsend's Warbler	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.01	0.01	10.0
Tree Swallow	0.00	0.00	0.0	0.01	0.01	12.5	0.00	0.00	0.0	0.05	0.05	10.0
Turkey Vulture	0.00	0.00	0.0	0.00	0.00	0.0	0.01	0.01	14.3	0.00	0.00	0.0
Violet-green Swallow	0.00	0.00	0.0	0.03	0.02	12.5	0.07	0.07	14.3	0.01	0.01	10.0
Warbling Vireo	0.26	0.17	42.9	0.29	0.11	62.5	0.33	0.12	100.0	0.16	0.06	70.0
White-breasted Nuthatch	0.36	0.12	85.7	0.26	0.06	81.3	0.29	0.05	100.0	0.22	0.04	100.0
White-crowned Sparrow	0.03	0.02	28.6	0.22	0.21	25.0	0.00	0.00	0.0	0.30	0.30	10.0
Western Bluebird	0.01	0.01	14.3	0.04	0.02	31.3	0.08	0.05	42.9	0.03	0.02	20.0
Western Tanager	0.91	0.25	85.7	0.61	0.14	87.5	1.12	0.17	100.0	0.64	0.25	70.0
Western Wood-pewee	0.30	0.17	71.4	0.41	0.16	50.0	0.90	0.24	100.0	0.35	0.08	100.0
White-headed Woodpecker	0.04	0.02	42.9	0.10	0.04	50.0	0.04	0.03	28.6	0.04	0.02	40.0
Wilson's Phalarope	0.00	0.00	0.0	0.01	0.01	6.3	0.00	0.00	0.0	0.00	0.00	0.0

Common Name	North (n = 7 pts)			South (n = 16 pts)			East (n = 7 pts)			West (n = 10 pts)		
	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)	Mean Abund.	s.e.	Pts. Occup. (%)
Williamson's Sapsucker	0.24	0.07	85.7	0.09	0.05	37.5	0.18	0.07	71.4	0.14	0.04	70.0
Wilson's Warbler	0.09	0.05	42.9	0.04	0.02	25.0	0.03	0.02	42.9	0.14	0.06	70.0
Winter Wren	0.00	0.00	0.0	0.00	0.00	0.0	0.02	0.02	14.3	0.14	0.07	50.0
Wrentit	0.00	0.00	0.0	0.01	0.01	6.3	0.00	0.00	0.0	0.00	0.00	0.0
White-throated Swift	0.00	0.00	0.0	0.01	0.01	6.3	0.00	0.00	0.0	0.03	0.02	20.0
Yellow Warbler	0.01	0.01	14.3	0.01	0.01	6.3	0.03	0.02	28.6	0.03	0.02	30.0
Yellow-headed Blackbird	0.00	0.00	0.0	0.00	0.00	0.0	0.03	0.03	14.3	0.00	0.00	0.0
Yellow-rumped Warbler	0.76	0.17	100.0	0.89	0.11	100.0	0.60	0.14	100.0	0.84	0.17	100.0
<b>Species Richness</b>	<b>31.29</b>	<b>6.37</b>		<b>29.75</b>	<b>7.09</b>		<b>33.86</b>	<b>3.29</b>		<b>33.80</b>	<b>4.96</b>	
<b>Total Species Richness</b>	<b>61</b>			<b>80</b>			<b>66</b>			<b>77</b>		

**Appendix J.** Number of detections of special status bird species at the 40 terrestrial monitoring points and 46 lentic (aquatic) habitat units surveyed in LTBMU during 2002. MIS = USFS Management Indicator species, FSS = USDA Forest Service Sensitive Species, CA SCC = DFG Species of Special Concern, and TRPA = TRPA Special Interest Species.

Common Name	MIS	FSS	CA_SSC	TRPA	Terrestrial Detections	Aquatic Detections
Canada Goose				x	5	182
Mallard	x			x	42	117
California Gull			x	x	0	26
Common Merganser				x	6	20
American Coot				x	2	17
Bufflehead				x	0	7
Greater Scaup						
Blue Grouse	x			x	0	6
Yellow Warbler			x		27	0
Pileated Woodpecker	x				15	0
Sharp shinned hawk			x		5	0
Osprey			x	x	3	0
Ruddy Duck				x	2	0
Cooper's hawk			x		1	0
Northern Goshawk	x	x	x	x	1	0
American White Pelican			x		0	0
Arctic Loon				x	0	0
Bald Eagle	x			x	0	0
Bank swallow					0	0
Barrow's Goldeneye			x	x	0	0
Black swift			x		0	0
Black Tern			x	x	0	0
Bonaparte's Gull				x	0	0
California Spotted Owl	x	x	x		0	0
Canvasback						
Caspian Tern				x	0	0
Cinnamon Teal				x	0	0
Common Goldeneye				x	0	0
Common Loon			x	x	0	0
Common Tern				x	0	0
Double crested cormorant			x	x	0	0
Eared Grebe				x	0	0
Forster's Tern				x	0	0
Gadwall				x	0	0
Golden Eagle			x	x	0	0
Greater Sandhill Crane			x		0	0

<b>Common Name</b>	<b>MIS</b>	<b>FSS</b>	<b>CA_SSC</b>	<b>TRPA</b>	<b>Terrestrial Detections</b>	<b>Aquatic Detections</b>
Great-Grey owl		x			0	0
Greater White-fronted Goose				x	0	0
Green-winged Teal				x	0	0
Herring Gull				x	0	0
Hooded Merganser				x	0	0
Horned Grebe				x	0	0
Least Bittern					0	0
Least Grebe				x	0	0
Lesser Scaup				x	0	0
Loggerhead shrike			x		0	0
Long billed curlew			x		0	0
Long-billed Curlew			x		0	0
Long-eared owl			x		0	0
Merlin			x		0	0
Northern Harrier					0	0
Northern Pintail				x	0	0
Northern Shoveler				x	0	0
Peregrine Falcon	x			x	0	0
Pied-billed Grebe					0	0
Prairie Falcon			x		0	0
Purple Martin			x		0	0
Red-breasted Merganser				x	0	0
Redhead				x	0	0
Red-necked Grebe				x	0	0
Ring-billed Gull				x	0	0
Snow Goose				x	0	0
Thayer's Gull				x	0	0
Tri-colored Black bird			x		0	0
Tundra Swan				x	0	0
Vaux's swift			x		0	0
Western/Clark's Grebe				x	0	0
Willow Flycatcher	x	x	x		0	0
Wood Duck				x	0	0
Yellow-billed Loon				x	0	0
<b>Totals</b>	<b>8</b>	<b>4</b>	<b>25</b>	<b>46</b>		

**Appendix K.** Bird species expected to occur within the Lake Tahoe Basin Management Unit (Murphy and Knopp 2000) that were not detected during point count surveys at monitoring points within LTBMU during summer 2002. Associated character traits of missed species (based on SASI database (USDA 1999), and CWHR range data) indicating survey biases.

Common Name	Aquatic	Shrub	Raptor	Fed/State/FS CWHR	
				Listed	Rare
American Avocet	X				
American Bittern	X				
American Crow					X
American Dipper	X				
American Goldfinch					X
American Kestrel			X		
American Pipit					
American White Pelican	X			X	
American Wigeon	X				
Arctic Loon					X
Ash-throated Flycatcher					X
Bald Eagle	X		X	X	
Bank Swallow	X			X	
Barrow's Goldeneye	X				
Belted Kingfisher	X				
Bewick's Wren		X			
Black Swift				X	
Black Tern	X				
Black-billed Magpie	X				
Black-capped Chickadee					X
Black-chinned Hummingbird					X
Black-crowned Night Heron	X				
Black-necked Stilt	X				
Bonaparte's Gull	X				
Brewer's Sparrow		X			
Broad-tailed Hummingbird					X
Bufflehead	X				
Bullock's Oriole					
California Gull	X				
California Quail					X
California Towhee					X
Canvasback	X				
Caspian Tern	X			X	
Cedar Waxwing					X
Cinnamon Teal	X				

Common Name	Aquatic	Shrub	Raptor	Fed/State/FS CWHR	
				Listed	Rare
Common Goldeneye	X				
Common Loon	X			X	
Common Tern					X
Common Yellowthroat	X				
Double-crested Cormorant	X			X	
Dunlin					X
Eared Grebe	X				
European Starling					
Flammulated Owl			X		
Forster's Tern	X			X	
Gadwall	X				
Golden Eagle			X	X	
Golden-crowned Sparrow					X
Gray-crowned Rosy Finch		X			
Great Blue Heron	X				
Great Egret	X				
Great Horned Owl			X		
Greater Scaup	X			X	
Greater White-fronted Goose	X				
Greater Yellowlegs	X				
Green Heron	X				
Green-winged Teal	X				
Hammond's Flycatcher					
Herring Gull	X				
Hooded Merganser	X				
Horned Grebe	X				
Horned Lark		X			
House Sparrow					
Least Bittern	X				
Least Grebe					X
Least Sandpiper	X				
Lesser Goldfinch	X				
Lesser Scaup	X				
Loggerhead Shrike					X
Long-billed Curlew	X				
Long-billed Dowitcher	X			X	
Long-eared Owl			X		
Marbled Godwit					X
Marsh Wren	X				
Merlin			X	X	
Northern Harrier			X		

Common Name	Fed/State/FS CWHR				
	Aquatic	Shrub	Raptor	Listed	Rare
Northern Mockingbird					X
Northern Pintail	X				
Northern Pygmy-owl			X		
Northern Rough-winged Swallow					X
Northern Saw-whet Owl			X	X	
Northern Shoveler	X				
Northern Shrike				X	
Pied-billed Grebe	X				
Pinyon Jay		X			
Prairie Falcon			X	X	
Purple Finch					X
Purple Martin				X	
Red-breasted Merganser					X
Redhead	X				
Red-necked Grebe					X
Red-necked Phalarope					X
Ring-billed Gull	X				
Ring-necked Duck	X				
Rough-legged Hawk			X	X	
Sandhill Crane	X				
Semipalmated Plover					X
Snow Goose	X				
Snowy Egret	X			X	
Sora	X				
Spotted Owl			X		
Thayer's Gull					X
Tricolored Blackbird	X			X	
Tundra Swan	X				
Varied Thrush					X
Vaux's Swift				X	
Vesper Sparrow		X			
Virginia Rail	X				
Western Kingbird				X	
Western Meadowlark		X			
Western Sandpiper					X
Western Screech-owl			X		
Western Scrub Jay		X			

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<b>Common Name</b>	<b>Fed/State/FS CWHR</b>				
	<b>Aquatic</b>	<b>Shrub</b>	<b>Raptor</b>	<b>Listed</b>	<b>Rare</b>
Western/Clark's Grebe	X				
White-throated Sparrow					X
Wild Turkey					X
Willet	X				
Willow Flycatcher	X				
Wood Duck	X				
Yellow-billed Loon					X
Yellow-billed Magpie					X
<b>Species Tally</b>	<b>60</b>	<b>8</b>	<b>14</b>	<b>21</b>	<b>30</b>

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**Appendix L.** Comparison of life history traits represented by bird species detected frequently (< 50% point occupancy) during 2002 and all species occurring in the Tahoe basin. Number and percent of species within each life history category are shown to highlight similarities/differences in respective distributions.

Variable	Category Level	No. species		% species	
		Freq. > 50%	Expected species	Freq. > 50%	Expected species
Habitat specificity	Habitat specialists	9	137	31.0	66.8
	Moderate specialists	17	51	58.6	24.9
	Habitat generalist	3	17	10.3	8.3
Late seral/ old growth dependency	Old growth dependent	3	14	10.3	6.8
	utilizes old growth	8	23	27.6	11.2
	doesn't use old growth	18	168	62.1	82.0
Riparian Dependent	Riparian dependent	1	57	3.4	27.8
	utilizes riparian habitat	8	48	27.6	23.4
	doesn't use riparian habitat	20	100	69.0	48.8
Aquatic Association	Terrestrial species	29	142	100.0	69.3
	Semi-aquatic		46	0.0	22.4
	Aquatic		17	0.0	8.3
Trophic Level	Carnivore	20	128	69.0	62.4
	Scavenger		1	0.0	0.5
	Omnivore	6	42	20.7	20.5
	Herbivore	3	34	10.3	16.6
Home Range Size	1-1000 m <sup>2</sup>		10	0.0	4.9
	1,001 - 400,000 m <sup>2</sup>	26	138	89.7	67.3
	> 400,001 m <sup>2</sup>	3	57	10.3	27.8
Listing Status	Federal, State listed Threatened or Endangered or California species of concern		25	0.0	12.2
	Not Federal or State listed	29	180	100.0	87.8

**Appendix M.** Bird species uniquely detected and species uniquely missed species by each of the three primary observers across all point count surveys conducted in LTBMU during summer 2002. Observer codes are listed in Appendix AC.

Common Name	Uniquely Detected			Uniquely Missed		
	CLC	MDS	JRM	CLC	MDS	JRM
White-throated Swift	X					
Yellow-headed Blackbird	X					
Anna's Hummingbird	X					
Blue-gray Gnatcatcher	X					
Cooper's Hawk	X					
Common Poorwill	X					
Northern Goshawk	X					
Pacific-slope Flycatcher	X					
Townsend's Warbler	X					
American Coot		X				
House Finch		X				
Lazuli Bunting		X				
Lincoln Sparrow		X				
Ruby-crowned Kinglet		X				
Rock Dove		X				
Ruddy Duck		X				
Savannah Sparrow		X				
Swainson's Thrush		X				
Tree Swallow		X				
Turkey Vulture		X				
Wilson's Phalarope		X				
Wrentit			X			
Lark Sparrow			X			
Barn Swallow				X		
Black-throated Gray Warbler				X		
Common Merganser				X		
Common Nighthawk				X		
Black-backed Woodpecker					X	
Sharp-shinned Hawk					X	
Violet-green Swallow					X	
Canada Goose					X	
Bushtit						X
Cliff Swallow						X
Pine Grosbeak						X
Red Crossbill						X
Rock Wren						X

**Appendix N.** Small mammal species detected during Sherman live trapping surveys conducted at 40 monitoring points in the Basin Management Unit from 18 June to 13 September 2002. The observed (O%) and estimated (E%) proportion of point occupancy and the associated bootstrapped standard error and probability of detection (Pd) for each species, as calculated by the program PRESENCE (2002). Each survey day (1-3) was considered a sampling occasion in PRESENCE. Species are listed in order of decreasing observed values. No small mammal species are considered Forest Service Management indicator species (MIS). No special status species (Federal or State T&E, California species of special concern, TRPA indicator species etc.).

Taxa Code	WHRid	Scientific Name	Common Name	Point Occupancy (O%)	Point Occupancy (E%)	Bootstrap S.E.	Pd
PEMA	M117	Peromyscus maniculatus	Deer Mouse	100.0	100.0	0.0	1.0
SPLA	M075	Spermophilus lateralis	Golden-mantled ground squirrel	85.0	85.1	5.5	0.9
TAAM	M055	Tamias amoenus	Yellow-pine chipmunk	82.5	82.7	5.9	0.8
TASE	M057	Tamias senex	Allen's chipmunk	75.0	75.6	6.7	0.8
TAQU	M062	Tamias quadrimaculatus	Long-eared chipmunk	70.0	71.8	7.5	0.7
TASP	M063	Tamias speciosus	Lodgepole chipmunk	70.0	70.0	7.2	0.9
MILO	M136	Microtus longicaudus	Long-tailed vole	32.5	34.2	7.8	0.6
SPBE	M072	Spermophilus beecheyi	California ground squirrel	27.5	28.5	7.7	0.6
PEBO	M119	Peromyscus boylii	Brush Mouse	20.0	30.2	27.0	0.2
GLSA	M080	Glaucomys sabrinus	Northern flying squirrel	15.0	38.8	34.3	0.1
MIMO	M133	Microtus montanus	Montane vole	15.0	15.8	11.4	0.6
TADO	M079	Tamiasciurus douglasii	Douglas' squirrel	15.0	1.0	0.0	0.0
MUER	M156	Mustela erminea	Ermine	7.5	1.0	0.0	0.0
MUFR	M157	Mustela frenata	Long-tailed weasel	7.5	1.0	0.0	0.0
SOTR	M012	Sorex trowbridgii	Trowbridge's shrew	7.5	12.1	42.1	0.2
SOVM	-	Sorex vagrans/monticolus	Vagrant or montane shrew	7.5	1.0	0.0	0.0
OCPR	M043	Ochotona princeps	American Pika	5.0	5.3	39.1	0.6
PEPA	M088	Perognathus parvus	Great Basin pocket mouse	5.0	1.0	0.0	0.0
ZAPR	M143	Zapus princeps	Western jumping mouse	5.0	1.0	0.0	0.0
NECI	M128	Neotoma cinerea	Bushy-tailed woodrat	2.5	2.5	2.5	1.0
NELE	M126	Neotoma lepida	Desert woodrat	2.5	2.6	2.7	0.6
PETR	M120	Peromyscus truei	Pinon mouse	2.5	1.0	0.0	0.0
SPBL	M070	Spermophilus beldingi	Belding's ground squirrel	2.5	2.5	2.5	1.0

**Appendix O.** Average small mammal abundances per point (# first time captures per 100 trap days) for species detected 40 monitoring points within LTBMU during summer 2002. Values reported per species are: average abundance across p was detected (Ave. Abund. where present), average abundance and associated standard error across all 40 points (Ave. Al and mean abundance with associated standard error (s.e.) across points within each of 5 elevation/habitat classes (lower n conifer, sub alpine conifer, shrub and wet meadow habitats).

Scientific Name	Pts. Occ.	Ave. Abund. where present	Ave. Abund. Overall	Overall s.d.	Lower Montane Conifer (n = 10)			Upper Montane Conifer (n = 22)			Sub Alpine Conifer (n = 5)			Mea
					Mean	s.d.	Pts. Occ. %	Mean	s.d.	Pts. Occ. %	Mean	s.d.	Pts. Occ. %	
Peromyscus maniculatus	40	17.01	17.01	7.89	16.88	8.48	100.00	16.05	7.08	100.00	20.68	10.27	100.00	12.8
Tamias amoenus	33	8.74	7.21	9.24	8.80	11.16	100.00	7.36	9.69	77.27	5.93	5.12	80.00	8.54
Tamias speciosus	28	9.17	6.42	9.15	0.36	1.04	20.00	6.97	7.77	81.82	17.60	15.59	100.00	3.94
Spermophilus lateralis	34	5.53	4.70	4.82	3.53	4.04	80.00	5.21	4.72	90.91	7.01	7.12	80.00	2.30
Tamias senex	30	3.83	2.87	3.52	4.41	3.98	80.00	3.03	3.57	81.82	0.20	0.46	20.00	2.30
Tamias quadrimaculatus	28	3.34	2.34	3.90	4.30	6.51	60.00	2.11	2.62	72.73	0.59	0.49	80.00	0.33
Spermophilus beecheyi	11	3.22	0.89	2.70	3.07	4.90	60.00	0.18	0.46	18.18	0.14	0.30	20.00	0.00
Microtus longicaudus	13	0.70	0.23	0.40	0.21	0.38	30.00	0.23	0.43	31.82	0.26	0.42	40.00	0.00
Microtus montanus	6	0.95	0.14	0.40	0.27	0.47	30.00	0.05	0.16	9.09	0.00	0.00	0.00	0.00
Peromyscus boylii	8	0.46	0.09	0.24	0.03	0.10	10.00	0.12	0.30	22.73	0.07	0.15	20.00	0.00
Spermophilus beldingi	1	3.40	0.09	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.68	1.52	20.00	0.00
Glaucomys sabrinus	6	0.44	0.07	0.17	0.07	0.14	20.00	0.09	0.21	18.18	0.00	0.00	0.00	0.00
Neotoma cinerea	1	2.63	0.07	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Tamiasciurus douglasii	6	0.39	0.06	0.15	0.10	0.23	20.00	0.06	0.13	18.18	0.00	0.00	0.00	0.00
Ochotona princeps	2	0.83	0.04	0.22	0.00	0.00	0.00	0.08	0.29	9.09	0.00	0.00	0.00	0.00
Sorex vagrans/monticolus	3	0.45	0.03	0.13	0.00	0.00	0.00	0.05	0.16	9.09	0.00	0.00	0.00	0.00
Sorex trowbridgii	3	0.44	0.03	0.13	0.03	0.10	10.00	0.03	0.14	4.55	0.00	0.00	0.00	0.00
Mustela erminea	3	0.33	0.02	0.09	0.00	0.00	0.00	0.05	0.12	13.64	0.00	0.00	0.00	0.00
Mustela frenata	3	0.32	0.02	0.09	0.03	0.10	10.00	0.03	0.10	9.09	0.00	0.00	0.00	0.00
Neotoma lepida	1	0.68	0.02	0.11	0.07	0.21	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zapus princeps	2	0.33	0.02	0.07	0.00	0.00	0.00	0.03	0.10	9.09	0.00	0.00	0.00	0.00
Perognathus parvus	2	0.33	0.02	0.07	0.00	0.00	0.00	0.02	0.07	4.55	0.06	0.15	20.00	0.00

Scientific Name	Pts. Occ.	Ave. Abund. where present	Ave. Abund. Overall	Overall s.d.	Lower Montane Conifer (n = 10)			Upper Montane Conifer (n = 22)			Sub Alpine Conifer (n = 5)			Mea
					Mean	s.d.	Pts. Occ. %	Mean	s.d.	Pts. Occ. %	Mean	s.d.	Pts. Occ. %	
Peromyscus truei	1	0.34	0.01	0.05	0.03	0.11	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microtus spp.	14	0.50	0.03	0.12	0.04	0.11	10.00	0.00	0.00	0.00	0.13	0.29	20.00	0.00
Sorex spp.	6	0.41	0.04	0.13	0.00	0.00	0.00	0.06	0.17	13.64	0.00	0.00	0.00	0.00
<b>Species Richness</b>			<b>6.68</b>	<b>1.69</b>	<b>6.50</b>	<b>1.35</b>		<b>6.91</b>	<b>1.87</b>		<b>5.80</b>	<b>1.30</b>		<b>7.00</b>
<b>Total Species Richness</b>					<b>15.00</b>			<b>19.00</b>			<b>11.00</b>			<b>7.00</b>

**Appendix P.** Species detected, mean abundances per point (number of first captures per 100 trap days) and the proportion Occupied (%) for each spatial orientation within the Lake Tahoe Basin Management Unit. Orientations were defined by Man

Scientific Name	North (n = 7 points)			South (n = 16 points)			East (n = 7 points)			West (n = 10 points)	
	Mean		Pts.	Mean		Pts.	Mean		Pts.	Mean	
	Abund.	s.d.	Occup. (%)	Abund.	s.d.	Occup. (%)	Abund.	s.d.	Occup. (%)	Abund.	s.d.
<i>Glaucomys sabrinus</i>	0.05	0.12	14.29	0.08	0.19	18.75	0.00	0.00	0.00	0.10	0.22
<i>Microtus longicaudus</i>	0.38	0.41	57.14	0.33	0.51	43.75	0.09	0.25	14.29	0.03	0.11
<i>Microtus montanus</i>	0.14	0.26	28.57	0.29	0.59	25.00	0.00	0.00	0.00	0.00	0.00
<i>Mustela erminea</i>	0.05	0.13	14.29	0.02	0.08	6.25	0.05	0.12	14.29	0.00	0.00
<i>Mustela frenata</i>	0.00	0.00	0.00	0.02	0.08	6.25	0.00	0.00	0.00	0.06	0.14
<i>Neotoma cinerea</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.83
<i>Neotoma lepida</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.26	14.29	0.00	0.00
<i>Ochotona princeps</i>	0.00	0.00	0.00	0.02	0.08	6.25	0.00	0.00	0.00	0.13	0.42
<i>Peromyscus boylii</i>	0.05	0.13	14.29	0.08	0.15	25.00	0.00	0.00	0.00	0.20	0.42
<i>Peromyscus maniculatus</i>	19.32	8.67	100.00	18.40	8.37	100.00	11.17	6.44	100.00	17.27	6.43
<i>Perognathus parvus</i>	0.00	0.00	0.00	0.02	0.08	6.25	0.00	0.00	0.00	0.03	0.11
<i>Peromyscus truei</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.13	14.29	0.00	0.00
<i>Sorex trowbridgii</i>	0.00	0.00	0.00	0.02	0.08	6.25	0.00	0.00	0.00	0.10	0.22
<i>Sorex vagrans/monticolus</i>	0.14	0.27	28.57	0.02	0.08	6.25	0.00	0.00	0.00	0.00	0.00
<i>Spermophilus beecheyi</i>	0.29	0.53	28.57	1.50	3.97	25.00	1.01	2.25	42.86	0.24	0.55
<i>Spermophilus beldingi</i>	0.49	1.29	14.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Spermophilus lateralis</i>	7.04	5.96	85.71	4.05	5.26	75.00	4.33	2.86	100.00	4.37	4.51
<i>Tamias amoenus</i>	11.92	11.22	100.00	5.98	9.17	75.00	12.35	10.39	85.71	2.29	2.61
<i>Tamiasciurus douglasii</i>	0.05	0.13	14.29	0.06	0.18	12.50	0.00	0.00	0.00	0.10	0.16
<i>Tamias quadrimaculatus</i>	1.19	1.26	71.43	1.76	4.62	56.25	4.36	5.47	71.43	2.64	2.15
<i>Tamias senex</i>	2.84	3.64	100.00	1.93	2.84	56.25	1.27	2.17	57.14	5.52	4.13
<i>Tamias speciosus</i>	2.51	2.46	57.14	9.13	11.38	81.25	4.48	8.78	57.14	6.16	7.98
<i>Zapus princeps</i>	0.05	0.13	14.29	0.00	0.00	0.00	0.05	0.12	14.29	0.00	0.00
<i>Microtus spp.</i>	0.00	0.00	0.00	0.06	0.18	12.50	0.00	0.00	0.00	0.00	0.00
<i>Sorex spp.</i>	0.00	0.00	0.00	0.02	0.08	6.25	0.05	0.12	14.29	0.10	0.22
<b>Species Richness</b>	<b>7.43</b>	<b>2.07</b>		<b>6.31</b>	<b>1.82</b>		<b>6.00</b>	<b>0.82</b>		<b>7.20</b>	<b>1.48</b>
<b>Total Species Richness</b>	<b>16</b>			<b>18</b>			<b>12</b>			<b>16</b>	

**Appendix Q.** Small mammal species occurring in the Lake Tahoe Basin (Murphy and Knopp 2000), and expected to be trappable with Sherman long traps (3"x 3.75"x 12") based on typical adult size.

<b>WHR id</b>	<b>Scientific name</b>	<b>Common name</b>
M080	<i>Glaucomys sabrinus</i>	Northern flying squirrel
M136	<i>Microtus longicaudus</i>	Long-tailed vole
M133	<i>Microtus montanus</i>	Montane vole
M156	<i>Mustela erminea</i>	Ermine
M157	<i>Mustela frenata</i>	Long-tailed weasel
M128	<i>Neotoma cinerea</i>	Bushy-tailed woodrat
M126	<i>Neotoma lepida</i>	Desert woodrat
M043	<i>Ochotona princeps</i>	Pika
M119	<i>Peromyscus boylii</i>	Brush mouse
M117	<i>Peromyscus maniculatus</i>	Deer mouse
M120	<i>Peromyscus truei</i>	Pinyon mouse
M018	<i>Scapanus latimanus</i>	Broad-footed mole
M077	<i>Sciurus griseus</i>	Western gray squirrel
M004	<i>Sorex monticolus</i>	Dusky shrew
M010	<i>Sorex palustris</i>	Water shrew
M012	<i>Sorex trowbridgii</i>	Trowbridge's shrew
M003	<i>Sorex vagrans</i>	Vagrant shrew
M072	<i>Spermophilus beecheyi</i>	California ground squirrel
M070	<i>Spermophilus beldingi</i>	Belding's ground squirrel
M075	<i>Spermophilus lateralis</i>	Golden-mantled ground squirrel
M055	<i>Tamias amoenus</i>	Yellow-pine chipmunk
M054	<i>Tamias minimus</i>	Least chipmunk
M062	<i>Tamias quadrimaculatus</i>	Long-eared chipmunk
M057	<i>Tamias senex</i>	Allen's chipmunk
M063	<i>Tamias speciosus</i>	Lodgepole chipmunk
M079	<i>Tamiasciurus douglasii</i>	Douglas' squirrel
M085	<i>Thomomys monticola</i>	Mountain pocket gopher
M143	<i>Zapus princeps</i>	Western jumping mouse

**Appendix R.** Comparison of life history traits represented by small mammal species detected frequently (< 50% point occupancy) during 2002 and all species expected to be detected with Sherman trapping in the Tahoe basin. Number and percent of species within each life history category are shown to highlight similarities/differences in respective distributions.

Variable	Category Level	No. species		% species	
		Freq. > 50%	Expected species	Freq. > 50%	Expected species
Habitat specificity	Habitat specialists	2	17	33.3	60.7
	Moderate specialists	3	9	50.0	32.1
	Habitat generalist	1	2	16.7	7.1
Late seral/ old growth dependency	Old growth dependent	0	1	0.0	3.6
	utilizes old growth	0	8	0.0	28.6
	doesn't use old growth	6	19	100.0	67.9
Riparian Dependent	Riparian dependent	0	4	0.0	14.3
	utilizes riparian habitat	1	7	16.7	25.0
	doesn't use riparian habitat	5	17	83.3	60.7
Aquatic Association	Terrestrial species	6	27	100.0	96.4
	Semi-aquatic	0	1	0.0	3.6
	Aquatic	0	0	0.0	0.0
Trophic Level	Carnivore	0	7	0.0	25.0
	Scavenger	0	0	0.0	0.0
	Omnivore	1	6	16.7	21.4
	Herbivore	5	15	83.3	53.6
Home Range Size	1-1000 m <sup>2</sup>	0	4	0.0	14.3
	1,001 - 400,000 m <sup>2</sup>	6	24	100.0	85.7
	> 400,001 m <sup>2</sup>	0	0	0.0	0.0
Listing Status	Federal, State listed Threatened or Endangered or California species of concern	0	0	0.0	0.0
	Not Federal or State listed	6	28	100.0	100.0

**Appendix S.** Tree and shrub species detections and total species richness by life form (e.g., trees, shrubs) at all 40 monitored CWHR defined habitat types. Detections of each species within each habitat type are denoted with an "X". The number with detections of each species are listed. Habitat types were assigned to each of the 40 points based on CWHR habitat type field collected data. Detections were based on data collected from subplot, quadrat and line transect sampling methods at around 40 monitoring points surveyed during 2002.

Scientific Name	Plot Occ. (O%)	Plots Occ. (#)	Jeffrey Pine (n=28)	Lodgepole Pine (n=12)	Red Fir (n=33)	Subalpine Conifer (n=28)	White Fir (n=32)	Shrub (n=9)	We Mead (n=)
<b>Shrubs</b>									
<i>Acer glabrum</i>	1.88	3		X			X		
<i>Amelanchier utahensis</i>	3.13	5					X		
<i>Apocynum androsaemifolium</i>	6.25	10	X	X	X	X	X		
<i>Arctostaphylos nevadensis</i>	15.00	24	X						
<i>Arctostaphylos patula</i>	4.38	7	X			X		X	
<i>Artemisia tridentata</i>	5.00	8	X		X		X		
<i>Ceanothus cordulatus</i>	6.25	10	X		X		X		
<i>Ceanothus prostratus</i>	3.75	6					X		
<i>Ceanothus vanrensselaeri</i>	0.63	1	X		X		X		
<i>Ceanothus velutinus</i>	5.00	8	X		X	X	X		
<i>Chrysolepis sempervirens</i>	9.38	15					X		
<i>Cornus sericea</i>	1.25	2	X		X	X		X	
<i>Holodiscus discolor</i>	3.13	5			X	X	X		
<i>Lonicera conjugialis</i>	2.50	4		X					
<i>Lonicera involucrata</i> var. <i>involucrata</i>	0.63	1	X		X	X	X		
<i>Penstemon newberryi</i> ssp. <i>newberryi</i>	6.88	11		X		X			
<i>Phyllodoce breweri</i>	3.13	5				X			
<i>Prunus emarginata</i>	1.25	2	X						
<i>Purshia tridentata</i>	4.38	7	X		X	X	X	X	
<i>Quercus vaccinifolia</i>	7.50	12		X	X		X		
<i>Ribes</i> spp.	3.13	5	X		X		X	X	
<i>Ribes cereum</i>	7.50	12		X	X		X	X	X
<i>Ribes montigenum</i>	5.00	8			X	X	X		
<i>Ribes nevadense</i>	3.75	6	X				X		
<i>Ribes roezlii</i>	1.25	2			X	X	X		
<i>Ribes roezlii</i> var. <i>roezlii</i>	2.50	4			X				

Scientific Name	Plot Occ. (O%)	Plots Occ. (#)	Jeffrey Pine (n=28)	Lodgepole Pine (n=12)	Red Fir (n=33)	Subalpine Conifer (n=28)	White Fir (n=32)	Shrub (n=9)	We Meac (n=)
<i>Ribes viscosissimum</i>	1.88	3	X				X		
<i>Rosa woodsii</i>	2.50	4			X	X	X		
<i>Rubus parviflorus</i>	3.13	5		X					
<i>Salix</i>	1.25	2				X			X
<i>Salix lemmonii</i>	2.50	4	X	X			X		
<i>Salix orestera</i>	2.50	4			X			X	
<i>Sambucus racemosa ssp. pubens var. microbotrys</i>	1.88	3			X				
<i>Sambucus racemosa var. microbotrys</i>	0.63	1					X		
<i>Salix scouleriana</i>	1.88	3		X		X		X	
<i>Spiraea densiflora</i>	2.50	4	X				X		
<i>Symphoricarpos acutus</i>	3.13	5	X	X	X		X		
<i>Symphoricarpos mollis</i>	10.63	17	X		X	X	X	X	
<i>Symphoricarpos rotundifolius</i>	3.75	6				X			
<i>Vaccinium cespitosum</i>	1.25	2	X	X	X	X	X	X	X
<b>Shrub Species Richness</b>			19	11	22	17	27	9	3
<b>Trees</b>									
<i>Abies concolor</i>	51.88	83	X	X	X	X	X	X	X
<i>Abies magnifica</i>	48.13	77		X	X	X	X		
<i>Alnus incana</i>	5.63	9	X	X			X		
<i>Calocedrus decurrens</i>	7.50	12	X	X	X	X	X	X	
<i>Juniperus occidentalis</i>	6.25	10						X	
<i>Juniperus occidentalis var. australis</i>	0.63	1		X	X	X			
<i>Pinus albicaulis</i>	6.88	11	X	X	X	X	X	X	X
<i>Pinus contorta</i>	42.50	68	X		X	X	X	X	
<i>Pinus jeffreyi</i>	48.75	78	X		X		X		
<i>Pinus lambertiana</i>	8.75	14		X	X	X	X		X
<i>Pinus monticola</i>	34.38	55	X	X	X	X	X	X	X
<i>Populus tremuloides</i>	4.38	7					X		
<i>Tsuga mertensiana</i>	0.63	1		X	X		X		
<b>Tree Species Richness</b>			7	9	10	8	11	6	4

**Appendix T.** Herb and grass species detections and total species richness by life form (e.g., herbs, grasses) at monitoring defined habitat types. Species detections within each habitat type are denoted by an “X”. The number and percent of monitoring detections of each species are listed. Habitat types were assigned to each of the 40 points based on CWHR habitat type criteria collected data. Detections were based on data collected from subplot, quadrat and line transect sampling methods conducted at center point plots only).

Scientific Name	Pt. Occ. (O%)	Pts. Occ (#)	Jeffrey Pine (n = 7)	Lodgepole Pine (n = 3)	Red Fir (n = 9)	Sub Alpine Conifer (n = 7)	White Fir (n = 10)	Shrub (n = 2)	Wet Meadow (n = 1)
<u>Herbs</u>									
<i>Achillea millefolium</i>	12.5	5	X	X	X				
<i>Aconitum columbianum</i>	2.5	1		X					
<i>Adenocaulon bicolor</i>	2.5	1					X		
<i>Agastache urticifolia</i>	2.5	1			X				
<i>Allionia incarnata</i>	2.5	1					X		
<i>Allium</i>	5	2	X				X		
<i>Allium campanulatum</i>	15	6	X			X		X	
<i>Allium validum</i>	2.5	1			X				
<i>Allophyllum integrifolium</i>	2.5	1	X						
<i>Allotropa virgata</i>	5	2			X		X		
<i>Anaphalis</i>	2.5	1				X			
<i>Angelica breweri</i>	10	4		X	X		X	X	
<i>Antennaria</i>	2.5	1				X			
<i>Antennaria brevistyla</i>	2.5	1					X		
<i>Antennaria media</i>	2.5	1				X			
<i>Apiastrum angustifolium</i>	2.5	1					X		
<i>Aquilegia formosa</i>	22.5	9			X	X	X	X	
<i>Arabidopsis</i>	7.5	3	X			X	X		
<i>Arabis</i>	12.5	5	X		X	X			
<i>Arabis parishii</i>	5	2	X				X		
<i>Arabis platysperma</i>	32.5	13	X	X	X	X	X	X	
<i>Arenaria</i>	2.5	1				X			
<i>Arenaria aculeata</i> S. Wats.	5	2				X			
<i>Arnica</i>	2.5	1				X			
<i>Arnica mollis</i>	2.5	1				X			

Scientific Name	Pt. Occ. (O%)	Pts. Occ (#)	Jeffrey			Sub	Wet	
			Pine (n = 7)	Lodgepole Pine (n = 3)	Red Fir (n = 9)	Alpine Conifer (n = 7)	White Fir (n = 10)	Shrub (n = 2)
<i>Arnica parryi</i>	2.5	1		X				
<i>Artemisia douglasiana</i>	2.5	1					X	
<i>Aster</i>	7.5	3	X			X	X	
<i>Aster ascendens</i>	5	2		X			X	
<i>Aster breweri</i>	22.5	9			X	X	X	
<i>Aster integrifolius</i>	5	2	X					
<i>Aster occidentalis</i>	5	2				X	X	
<i>Astragalus bolanderi</i>	2.5	1			X			
<i>Athyrium alpestre</i>	2.5	1						X
<i>Calochortus leichtlinii</i>	10	4	X		X	X		
<i>Caltha leptosepala</i>	2.5	1				X		
<i>Calycademia spicata</i>	2.5	1			X			
<i>Calyptridium umbellatum</i>	15	6	X	X	X	X	X	
<i>Cardamine cordifolia</i> var. <i>lyallii</i>	2.5	1		X				
<i>Castilleja applegatei</i>	10	4	X			X	X	X
<i>Castilleja miniata</i> ssp. <i>miniata</i>	15	6		X	X	X	X	
<i>Castilleja nana</i>	5	2				X		
<i>Castilleja stenantha</i>	5	2				X	X	
<i>Chaenactis douglasii</i>	2.5	1				X		
<i>Chaenactis douglasii</i> var. <i>achilleifolia</i>	2.5	1				X		
<i>Cheilanthes gracillima</i>	5	2				X		X
<i>Cheilanthes gracillima</i>	10	4			X		X	
<i>Chimaphila umbellata</i>	5	2					X	
<i>Circaea alpina</i> ssp. <i>pacifica</i>	7.5	3				X	X	
<i>Cirsium andersonii</i>	5	2			X			
<i>Collinsia grandiflora</i>	2.5	1	X					
<i>Collinsia linearis</i>	2.5	1						
<i>Collinsia torreyi</i>	2.5	1				X		
<i>Corallorrhiza maculata</i>	5	2					X	
<i>Crepis</i>	2.5	1				X		
<i>Cryptantha</i>	10	4	X				X	

Scientific Name	Pt. Occ. (O%)	Pts. Occ (#)	Jeffrey			Sub	White Fir (n = 10)	Shrub (n = 2)	Wet Meadov (n = 1)
			Pine (n = 7)	Lodgepole Pine (n = 3)	Red Fir (n = 9)	Alpine Conifer (n = 7)			
<i>Cryptogramma acrostichoides</i>	10	4				X	X		
<i>Cystopteris fragilis</i>	2.5	1					X		
<i>Delphinium glaucum</i>	2.5	1				X			
<i>Delphinium nudicaule</i>	2.5	1			X				
<i>Dodecatheon alpinum</i>	7.5	3		X		X		X	
<i>Dodecatheon jeffreyi</i>	2.5	1				X			
<i>Drosera rotundifolia</i>	2.5	1						X	
<i>Epilobium</i>	2.5	1			X				
<i>Epilobium angustifolium</i>	12.5	5			X	X	X		
<i>Epilobium angustifolium ssp. circumvagum</i>	5	2		X			X		
<i>Epilobium ciliatum ssp. glandulosum</i>	2.5	1		X					
<i>Equisetum arvense</i>	5	2	X				X		
<i>Ericameria discoidea</i>	2.5	1				X			
<i>Ericameria suffruticosa</i>	2.5	1				X			
<i>Erigeron</i>	5	2				X	X		
<i>Erigeron breweri</i>	10	4	X					X	
<i>Erigeron coulteri</i>	2.5	1		X					
<i>Erigeron peregrinus</i>	10	4		X		X			
<i>Eriogonum</i>	2.5	1				X			
<i>Eriogonum incanum</i>	12.5	5			X	X			
<i>Eriogonum nudum</i>	15	6				X	X		
<i>Eriogonum umbellatum</i>	5	2				X			
<i>Eriogonum wrightii</i>	2.5	1	X						
<i>Eriophyllum lanatum var. integrifolium</i>	5	2				X			
<i>Erysimum capitatum</i>	2.5	1	X						
<i>Fragaria virginiana</i>	10	4		X			X		
<i>Galium</i>	7.5	3	X		X		X		
<i>Galium triflorum</i>	2.5	1					X		
<i>Gayophytum</i>	5	2	X					X	
<i>Gayophytum diffusum</i>	7.5	3	X		X				
<i>Gayophytum diffusum ssp. parviflorum</i>	20	8	X	X	X	X			

Scientific Name	Pt. Occ. (O%)	Pts. Occ (#)	Jeffrey			Sub	White Fir (n = 10)	Shrub (n = 2)	Wet Meadov (n = 1)
			Pine (n = 7)	Lodgepole Pine (n = 3)	Red Fir (n = 9)	Alpine Conifer (n = 7)			
<i>Gentianella simplex</i>	2.5	1		X					
<i>Geranium richardsonii</i>	2.5	1				X			
<i>Gilia capillaris</i>	2.5	1				X			
<i>Gilia latiflora</i>	5	2	X						
<i>Goodyera oblongifolia</i>	2.5	1				X			
<i>Hackelia micrantha</i>	2.5	1			X				
<i>Hackelia nervosa</i>	20	8	X	X	X	X	X		
<i>Heracleum lanatum</i>	12.5	5		X	X	X	X		
<i>Hieracium albiflorum</i>	17.5	7			X	X	X		
<i>Hieracium horridum</i>	2.5	1						X	
<i>Horkelia fusca</i>	2.5	1					X		
<i>Horkelia fusca ssp. capitata</i>	2.5	1	X						
<i>Ipomopsis aggregata</i>	2.5	1						X	
<i>Kelloggia galioides</i>	32.5	13	X		X	X	X		
<i>Lathyrus</i>	5	2	X						
<i>Ligusticum</i>	2.5	1							
<i>Ligusticum grayi</i>	5	2				X			
<i>Lilium parvum</i>	2.5	1					X		
<i>Linanthus ciliatus</i>	5	2				X		X	
<i>Linanthus liniflorus ssp. liniflorus</i>	2.5	1		X					
<i>Linanthus nuttallii</i>	2.5	1				X			
<i>Linanthus nuttallii ssp. pubescens</i>	2.5	1					X		
<i>Linum lewisii</i>	2.5	1				X			
<i>Lotus</i>	2.5	1	X						
<i>Lotus nevadensis</i>	2.5	1			X				
<i>Lotus purshianus</i>	2.5	1					X		
<i>Lupinus</i>	7.5	3	X	X		X			
<i>Lupinus arbustus</i>	17.5	7			X	X	X	X	
<i>Lupinus breweri</i>	7.5	3			X	X			
<i>Lupinus fulcratus</i>	5	2	X		X				
<i>Lupinus latifolius var. columbianus</i>	2.5	1							

Scientific Name	Pt. Occ. (O%)	Pts. Occ (#)	Jeffrey			Sub	White Fir (n = 10)	Shrub (n = 2)	Wet Meadov (n = 1)
			Pine (n = 7)	Lodgepole Pine (n = 3)	Red Fir (n = 9)	Alpine Conifer (n = 7)			
<i>Lupinus polyphyllus</i>	5	2		X		X			
<i>Menyanthes trifoliata</i>	2.5	1						X	
<i>Mertensia ciliata</i>	5	2				X			
<i>Mimulus</i>	2.5	1			X				
<i>Mimulus guttatus</i>	10	4		X		X	X		
<i>Mimulus lewisii</i>	2.5	1			X				
<i>Mimulus primuloides</i>	5	2				X		X	
<i>Mimulus tilingii</i>	2.5	1				X			
<i>Mitella breweri</i>	5	2			X	X			
<i>Monardella odoratissima ssp. pallida</i>	32.5	13	X		X	X	X	X	
<i>Nemophila spatulata</i>	2.5	1					X		
<i>Orobancha corymbosa</i>	2.5	1					X		
<i>Orthilia secunda</i>	2.5	1					X		
<i>Orthocarpus cuspidatus ssp. cryptanthus</i>	2.5	1						X	
<i>Osmorhiza chilensis</i>	20	8	X	X	X	X	X	X	
<i>Osmorhiza occidentalis</i>	22.5	9		X	X	X	X	X	
<i>Paeonia brownii</i>	5	2	X						
<i>Pedicularis attollens</i>	2.5	1				X			
<i>Pedicularis groenlandica</i>	5	2				X			
<i>Pedicularis semibarbata</i>	20	8	X		X	X	X		
<i>Pellaea bridgesii</i>	2.5	1				X			
<i>Penstemon</i>	5	2			X		X		
<i>Penstemon heterodoxus</i>	10	4		X	X	X			
<i>Penstemon rydbergii</i>	2.5	1					X		
<i>Penstemon rydbergii var. oreocharis</i>	2.5	1	X						
<i>Perideridia</i>	7.5	3		X	X	X			
<i>Perideridia lemmonii</i>	7.5	3				X		X	
<i>Perideridia parishii ssp. latifolia</i>	5	2					X		
<i>Phacelia hastata ssp. compacta</i>	2.5	1					X		
<i>Phacelia hastata var. hastata</i>	2.5	1				X			
<i>Phacelia hydrophylloides</i>	22.5	9			X		X	X	

Scientific Name	Pt. Occ. (O%)	Pts. Occ (#)	Jeffrey			Sub	White Fir (n = 10)	Shrub (n = 2)	Wet Meadov (n = 1)
			Pine (n = 7)	Lodgepole Pine (n = 3)	Red Fir (n = 9)	Alpine Conifer (n = 7)			
<i>Phacelia ramosissima</i> var. <i>eremophila</i>	2.5	1	X						
<i>Phlox diffusa</i>	17.5	7				X	X		
<i>Platanthera leucostachys</i>	5	2		X			X		
<i>Polemonium californicum</i>	5	2		X		X			
<i>Polygonum bistortoides</i>	2.5	1						X	
<i>Polygonum polygaloides</i> ssp. <i>kelloggii</i>	2.5	1					X		
<i>Polygonum shastense</i>	2.5	1				X			
<i>Potentilla drummondii</i> ssp. <i>breweri</i>	2.5	1				X			
<i>Potentilla drummondii</i> ssp. <i>drummondii</i>	2.5	1	X						
<i>Potentilla glandulosa</i>	15	6	X				X		
<i>Potentilla glandulosa</i> ssp. <i>Ashlandica</i>	2.5	1				X			
<i>Potentilla glandulosa</i> ssp. <i>globosa</i>	5	2	X				X		
<i>Potentilla gracilis</i>	12.5	5	X	X	X		X		
<i>Potentilla gracilis</i> var. <i>fastigiata</i>	2.5	1	X						
<i>Potentilla palustris</i>	2.5	1						X	
<i>Pteridium aquilinum</i>	12.5	5			X	X	X		
<i>Pterospora andromedea</i>	5	2			X	X			
<i>Pyrola picta</i>	20	8			X		X		
<i>Raillardella argentea</i>	2.5	1				X			
<i>Raillardella scabrida</i>	2.5	1				X			
<i>Raillardella scaposa</i>	2.5	1				X			
<i>Ranunculus alismifolius</i>	2.5	1		X					
<i>Ranunculus occidentalis</i>	5	2	X				X		
<i>Rumex acetosella</i>	2.5	1	X						
<i>Sambucus racemosa</i>	2.5	1				X			
<i>Saxifraga bryophora</i>	2.5	1				X			
<i>Saxifraga odontoloma</i>	5	2		X			X		
<i>Saxifraga oregana</i>	2.5	1		X					
<i>Scirpus microcarpus</i>	2.5	1					X		
<i>Sedum obtusatum</i> ssp. <i>obtusatum</i>	5	2				X			
<i>Senecio triangularis</i>	17.5	7		X	X	X	X		

Scientific Name	Pt. Occ. (O%)	Pts. Occ (#)	Jeffrey			Sub	White Fir (n = 10)	Shrub (n = 2)	Wet Meadov (n = 1)
			Pine (n = 7)	Lodgepole Pine (n = 3)	Red Fir (n = 9)	Alpine Conifer (n = 7)			
<i>Sidalcea glaucescens</i>	10	4			X	X	X		
<i>Sidalcea oregana ssp. spicata</i>	5	2		X			X		
<i>Silene douglasii</i>	5	2				X			
<i>Silene lemmonii</i>	2.5	1	X						
<i>Smilacina racemosa var. amplexicaulis</i>	12.5	5		X	X	X	X		
<i>Smilacina stellata</i>	5	2				X	X		
<i>Sphenosciadium capitellatum</i>	7.5	3		X		X		X	
<i>Spiranthes romanzoffiana</i>	2.5	1						X	
<i>Stachys ajugoides var. rigida</i>	5	2		X			X		
<i>Stellaria</i>	2.5	1				X			
<i>Streptanthus tortuosus var. orbiculatus</i>	7.5	3				X		X	
<i>Swertia radiata</i>	5	2					X		
<i>Thalictrum fendleri var. fendleri</i>	25	10	X		X	X	X		
<i>Trifolium</i>	7.5	3	X				X		
<i>Trifolium longipes</i>	2.5	1					X		
<i>Trifolium longipes var. nevadense</i>	2.5	1		X					
<i>Trifolium variegatum</i>	2.5	1		X					
<i>Triteleia ixiooides</i>	2.5	1				X			
<i>Triteleia ixiooides ssp. anilina</i>	2.5	1				X			
<i>Valeriana californica</i>	7.5	3			X	X		X	
<i>Veratrum californicum</i>	15	6		X	X	X			
<i>Verbena californica</i>	7.5	3		X	X				
<i>Vicia</i>	2.5	1					X		
<i>Viola glabella</i>	5	2					X		
<i>Viola purpurea</i>	15	6	X		X	X	X		
<i>Viola purpurea ssp. integrifolia</i>	2.5	1	X						
<i>Wyethia mollis</i>	10	4			X		X		
<b>Herb Species Richness</b>			<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	
<u>Grasses</u>									
<i>Achnatherum latiglume</i>	2.5	1					X		

Scientific Name	Pt. Occ. (O%)	Pts. Occ (#)	Jeffrey		Red Fir (n = 9)	Sub Alpine Conifer (n = 7)	White Fir (n = 10)	Shrub (n = 2)	Wet Meadow (n = 1)
			Pine (n = 7)	Lodgepole Pine (n = 3)					
<i>Achnatherum occidentale</i>	5	2			X			X	
<i>Agrostis thurberiana</i>	2.5	1				X			
<i>Agrostis variabilis</i>	2.5	1				X			
<i>Bromus</i>	2.5	1		X					
<i>Bromus carinatus</i>	7.5	3				X	X		
<i>Bromus suksdorfii</i>	5	2				X	X		
<i>Bromus tectorum</i>	2.5	1	X						
<i>Carex</i>	17.5	7	X	X		X	X		X
<i>Carex amplifolia</i>	7.5	3			X	X	X		
<i>Carex hassei</i>	2.5	1					X		
<i>Carex integra</i>	2.5	1							
<i>Carex multicosata</i>	2.5	1						X	
<i>Carex nebrascensis</i>	2.5	1							X
<i>Carex spectabilis</i>	2.5	1			X				
<i>Deschampsia</i>	2.5	1				X			
<i>Elymus</i>	7.5	3		X	X				
<i>Elymus elymoides</i>	2.5	1				X			
<i>Elymus elymoides ssp. elymoides</i>	10	4	X						
<i>Elymus glaucus</i>	5	2	X				X		
<i>Elymus glaucus ssp. glaucus</i>	7.5	3	X	X			X		
<i>Elymus trachycaulus ssp. Subsecundus</i>	2.5	1							
<i>Eragrostis pectinacea</i>	5	2			X	X			
<i>Festuca</i>	10	4	X					X	
<i>Festuca subulata</i>	2.5	1							
<i>Festuca viridula</i>	2.5	1				X			
<i>Glyceria elata</i>	2.5	1		X					
<i>Hordeum brachyantherum</i>	2.5	1		X					
<i>Juncus</i>	17.5	7	X	X	X	X	X	X	
<i>Juncus balticus</i>	2.5	1	X						
<i>Juncus covillei</i>	2.5	1	X						
<i>Juncus mertensianus</i>	5	2		X		X			

<b>Scientific Name</b>	<b>Pt. Occ. (O%)</b>	<b>Pts. Occ (#)</b>	<b>Jeffrey Pine (n = 7)</b>	<b>Lodgepole Pine (n = 3)</b>	<b>Red Fir (n = 9)</b>	<b>Sub Alpine Conifer (n = 7)</b>	<b>White Fir (n = 10)</b>	<b>Shrub (n = 2)</b>	<b>Wet Meadow (n = 1)</b>
<i>Juncus nevadensis</i>	2.5	1		X					
<i>Juncus parryi</i>	5	2		X		X			
<i>Leymus triticoides</i>	2.5	1	X						
<i>Poa cusickii</i>	2.5	1		X					
<i>Poa pratensis</i>	2.5	1					X		
<i>Poa secunda</i>	5	2	X			X			
<i>Trisetum canescens</i>	2.5	1	X						
<i>Trisetum spicatum</i>	2.5	1		X					
<b>Grass Species Richness</b>			<b>12</b>	<b>12</b>	<b>6</b>	<b>14</b>	<b>10</b>	<b>4</b>	<b>2</b>

**Appendix U.** Plant species richness observed at each center-point plot at the 40 monitoring points (e.g, E09, E10 etc.), mean (s.d.) richness across all points, as measured by 4 different survey techniques (15 minute searches, line transects, quadrats and 1/16 acre subplots) and the percent of total richness detected across all 40 points that was attributable to each technique. Species richness values include all plant species identified and any uniquely identified genera. See methods section for description of survey methods.

Point	Survey Method				Total Richness per Point
	15min Search	Transect	Quadrat	Subplot	
E09	2	5	6	8	13
E10	23	12	34	8	44
E36	4	2	5	2	7
E37	4	3	4	4	8
E38	4	4	11	9	15
E39	5	4	10	14	8
E40	4	7	19	10	26
N01	23	---	36	9	46
N02	2	6	12	9	16
N11	3	2	3	5	7
N12	21	28	38	4	47
N13	3	4	11	8	12
N14	3	0	6	8	11
N15	15	8	12	1	21
S03	17	3	25	11	39
S04	4	3	5	4	9
S05	19	14	33	6	39
S06	4	4	12	9	19
S16	2	2	5	2	7
S17	1	3	8	13	13
S18	4	5	5	3	11
S19	9	3	9	6	12
S20	19	7	23	5	35
S22	2	0	3	12	6
S23	18	5	14	9	27
S24	6	5	9	9	14
S25	4	4	7	2	13
S26	3	6	13	2	16
S27	3	2	3	4	6
S88	13	13	16	4	28
W07	4	0	5	9	10
W08	10	7	12	12	17
W28	36	7	24	6	53
W29	17	4	18	8	33
W30	25	13	23	9	36
W31	18	6	25	12	29
W32	10	10	33	9	39
W33	5	3	13	9	19
W34	22	11	25	12	35
W35	9	1	7	12	13

Point	Survey Method				Total Richness per Point
	15min Search	Transect	Quadrat	Subplot	
Mean Species Richness	10.0	5.8	14.6	7.5	21.5
s.d.	8.6	5.2	10.2	3.5	13.6
% total species detected	46.4	27.8	67.2	35.5	

**Appendix V.** Aquatic amphibian and reptile species detected during visual encounter surveys conducted at 45 le the Lake Tahoe basin from 11 June to 29 August 2002. The observed (O%) and estimated (E%) proportion of p species, the associated bootstrapped standard error and Probability of detection (Pd) for each species are listed. T proportion of points occupied, associated bootstrap s.e. and Pd were calculated by the program PRESENCE (Mc using data from all survey visits to all sites (11 sites with 2 visits, 34 sites with one visit). No special status spec Management indicator species, Forest Service sensitive species, Tahoe Regional Planning Agency indicator spec species of special concern) were detected.

Taxa Code	Scientific Name	Common Name	Pts. Occupied	Site Occupancy (O%)	Site Occupancy (E%)	Bootstrap S.E.
<b>Amphibians</b>						
HYRE	<i>Hyla regilla</i>	Pacific tree frog	25	55.6	69.6	14.5
AMMA	<i>Ambystoma macrodactylum sigillatum</i>	Southern long-toed salamander	6	13.3	100	29.3
BUBO	<i>Bufo boreas</i>	Western toad	4	8.9	100	28.3
RACA	<i>Rana catesbeiana</i>	Bullfrog	3	6.7	6.8	3.8
HYLA	<i>Hyla spp.</i>	Tree Frogs	25	55.6	69.6	14.5
<b>Reptiles</b>						
THSI	<i>Thamnophis sirtalis</i>	Common garter snake	10	22.2	38.5	30
THEL	<i>Thamnophis elegans</i>	Western terrestrial garter snake	7	15.6	15.9	5.6
THCO	<i>Thamnophis couchii</i>	Western aquatic garter snake	2	4.4	4.6	3.2
SCOC	<i>Sceloporus occidentalis</i>	Western fence lizard	1	2.2	2.3	2.2
ELGA	<i>Elgaria spp.</i>	Alligator lizards	1	2.2		
EUSK	<i>Eumeces skiltonianus</i>	Western skink	1	2.2	2.3	2.2
THAM	<i>Thamnophis spp.</i>	Garter snake	18	40.0		

**Appendix W.** Average frequency of detection (mean number of detections per life stage per point) for amphibia across 4 size by habitat classes. A total of 46 lentic sites within the Lake Tahoe basin were surveyed during summer reported per life stage per species include: average number of detections across sites at which each species was (where present), average detections and associated standard deviation across all 46 sites surveyed (Ave. Abund. C s.d.), and mean detections with associated standard deviation (s.d.) across sites within each of 4 size by habitat class (small and large lakes/ponds and wet meadows). Abundance and point occupancy values per species were calculated using mean detections across all visits to each site (35 sites with one visit and 11 sites with two visits). Sites with 2 visits were across all three size by habitat classes: small lakes/ponds (n = 4 sites), medium lakes/ponds (n = 3 sites) and large lakes/ponds (n = 10 sites).

Scientific Name	Life Stage	Small Lakes/Ponds (n = 15)			Medium Lakes/Ponds (n = 12)			Large Lakes/Ponds (n = 10)				
		Ave. Abund. where present	Ave. Abund. Overall	Overall s.d.	Mean	s.d.	Pts. Occ. %	Mean	s.d.	Pts. Occ. %	Mean	s.d.
		<b>Amphibians</b>										
<i>Ambystoma macrodactylum</i>	Larvae	13.2	1.8	7.0	4.3	11.8	20.0	0.7	1.6	16.7	0.0	0.0
<i>Bufo boreas</i>	Subadult	2.0	0.1	0.4	0.0	0.0	0.0	0.3	0.8	25.0	0.0	0.0
	Larvae	27149.3	1810.0	8680.9	0.0	0.0		6752.7	16281.1		0.0	0.0
	Egg masses	1.0	0.0	0.1	0.0	0.0		0.1	0.3		0.0	0.0
<i>Hyla regilla</i>	Adult	2.0	0.2	0.8	0.0	0.0	66.7	0.1	0.3	41.7	0.3	0.7
	Subadult	63.5	14.1	63.9	11.4	23.8		37.1	121.4		0.1	0.3
	Larvae	533.4	260.8	1054.6	605.4	1794.2		85.8	184.2		0.9	2.5
	Egg masses	1.0	0.1	0.3	0.0	0.0		0.1	0.3		0.0	0.0
<i>Rana catesbeiana</i>	Adult	10.3	0.7	2.9	0.9	3.6	6.7	1.1	3.8	8.3	0.4	1.3
	Subadult	1.0	0.0	0.2	0.0	0.0		0.1	0.3		0.1	0.3
	Larvae	19.5	1.3	5.1	1.3	4.9		2.2	7.6		1.3	4.1
<i>Hyla spp.</i>	Adult	3.3	0.4	1.7	0.7	2.6	66.7	0.1	0.3	41.7	0.3	0.7
	Subadult	66.5	14.8	64.5	13.4	28.9		37.1	121.4		0.1	0.3
	Larvae	601.5	294.1	1071.4	705.4	1802.8		85.8	184.2		0.9	2.5
	Egg masses	1.0	0.1	0.3	0.0	0.0		0.1	0.3		0.0	0.0
<b>Reptiles</b>												
<i>Thamnophis sirtalis</i>	Adult	4.5	1.0	3.3	2.1	5.5	26.7	0.6	1.2	25.0	0.2	0.4
	Subadult	12.8	1.1	5.7	3.2	9.8		0.2	0.6		0.0	0.0
<i>Thamnophis elegans</i>	Adult	2.1	0.3	1.0	0.0	0.0	0.0	0.8	1.7	25.0	0.4	0.7
	Subadult	3.0	0.1	0.7	0.0	0.0		0.5	1.2		0.0	0.0

Scientific Name	Life Stage	Small Lakes/Ponds (n = 15)					Medium Lakes/Ponds (n = 12)			Large Lakes (n = 10)				
		Ave. Abund. where present	Ave. Abund. Overall	s.d.	Mean	s.d.	Pts. Occ. %		Mean	s.d.	Pts. Occ. %		Mean	s.d.
<i>Thamnophis couchii</i>	Adult	3.5	0.2	0.8	0.0	0.0	0.0	0.4	1.4	8.3	0.2	0.6		
	Subadult	2.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.6			
<i>Elgaria spp.</i>	Subadult	1.0	0.0	0.1	0.0	0.0	0.0	0.1	0.3	8.3	0.0	0.0		
<i>Eumeces skiltonianus</i>	Adult	1.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3		
<i>Sceloporus occidentalis</i>	Adult	2.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6		
<i>Thamnophis spp.</i>	Adult	4.2	1.7	3.6	2.2	5.4	33.3	2.3	2.6	58.3	0.8	1.0		
	Subadult	10.7	1.4	5.8	3.2	9.8	0.8	1.8	0.2	0.6				
<b>Species Richness</b>			<b>1.4</b>	<b>1.2</b>	<b>1.3</b>	<b>1.1</b>		<b>1.7</b>	<b>1.5</b>		<b>1.3</b>	<b>1.2</b>		
<b>Amphibian Species Richness</b>			<b>0.8</b>	<b>0.8</b>	<b>0.9</b>	<b>0.8</b>		<b>0.9</b>	<b>1.0</b>		<b>0.5</b>	<b>0.7</b>		
<b>Reptile Species Richness</b>			<b>0.5</b>	<b>0.7</b>	<b>0.3</b>	<b>0.5</b>		<b>0.8</b>	<b>0.8</b>		<b>0.8</b>	<b>0.8</b>		
<b>Total Richness</b>			<b>10</b>		<b>4</b>			<b>8</b>			<b>7</b>			

**Appendix X.** Average frequency of detection (mean number of detections per life stage per point) for amphibians detected within each spatial orientation around Lake Tahoe. Orientations are defined in Manley and Schlesinger lentic sites within the Lake Tahoe basin were surveyed during summer 2002. Mean abundance, point occupancy values were calculated using the sum of detections across all survey visits to each site. Two survey visits were c 22%, 17% and 27% of sites in each orientation (north, south, east and west, respectively).

Scientific Name	Life Stage	North (n = 6 points)			South (n = 18 points)			East (n = 6 points)		
		Mean Abund.	s.d.	Pts. Occup. (%)	Mean Abund.	s.d.	Pts. Occup. (%)	Mean Abund.	s.d.	Pts. Occup. (%)
<b>Amphibians</b>										
<i>Ambystoma macrodactylum</i>	Larvae	0.0	0.0	0.0	2.9	10.3	16.7	0.0	0.0	0.0
<i>Bufo boreas</i>	Subadult	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0
	Larvae	8333.3	20412.4		0.0	0.0		0.0	0.0	
	Egg masses	0.0	0.0		0.0	0.0		0.0	0.0	
<i>Hyla regilla</i>	Adult	0.2	0.4	66.7	0.2	0.5	55.6	0.8	2.0	16.7
	Subadult	10.7	24.2		23.4	99.5		0.0	0.0	
	Larvae	49.3	96.4		76.8	180.9		8.3	20.4	
	Egg masses	0.0	0.0		0.1	0.2		0.0	0.0	
<i>Rana catesbeiana</i>	Adult	0.0	0.0	0.0	1.7	4.4	16.7	0.0	0.0	0.0
	Subadult	0.0	0.0		0.1	0.3		0.0	0.0	
	Larvae	0.0	0.0		3.3	7.8		0.0	0.0	
<i>Hyla spp.</i>	Adult	1.8	4.0	66.7	0.2	0.5	55.6	0.8	2.0	16.7
	Subadult	15.7	36.5		23.4	99.5		0.0	0.0	
	Larvae	299.3	620.2		76.8	180.9		8.3	20.4	
	Egg masses	0.0	0.0		0.1	0.2		0.0	0.0	
<b>Reptiles</b>										
<i>Thamnophis sirtalis</i>	Adult	0.7	1.0	33.3	0.1	0.3	11.1	0.2	0.4	16.7
	Subadult	0.3	0.8		0.0	0.0		0.0	0.0	
<i>Thamnophis elegans</i>	Adult	0.2	0.4	16.7	0.4	1.0	16.7	0.0	0.0	0.0
	Subadult	0.3	0.8		0.0	0.0		0.0	0.0	
<i>Thamnophis couchii</i>	Adult	0.0	0.0	0.0	0.4	1.2	11.1	0.0	0.0	0.0
	Subadult	0.0	0.0		0.1	0.5		0.0	0.0	
<i>Elgaria spp.</i>	Subadult	0.0	0.0	0.0	0.1	0.2	5.6	0.0	0.0	0.0
<i>Eumeces skiltonianus</i>	Adult	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Scientific Name	Life Stage	North (n = 6 points)			South (n = 18 points)			East (n = 6 points)		
		Mean Abund.	s.d.	Pts. Occup. (%)	Mean Abund.	s.d.	Pts. Occup. (%)	Mean Abund.	s.d.	Pts. Occup. (%)
<i>Sceloporus occidentalis</i>	Adult	0.0	0.0	0.0	0.1	0.5	5.6	0.0	0.0	0.0
<i>Thamnophis spp.</i>	Adult	1.0	1.7	33.3	1.1	2.0	33.3	0.2	0.4	16.7
	Subadult	0.8	2.0		0.1	0.5		0.0	0.0	
<b>Species Richness</b>		<b>1.3</b>	<b>1.4</b>		<b>1.4</b>	<b>1.2</b>		<b>0.3</b>	<b>0.5</b>	
<b>Amphibian Species Richness</b>		<b>0.8</b>	<b>0.8</b>		<b>0.9</b>	<b>0.8</b>		<b>0.2</b>	<b>0.4</b>	
<b>Reptile Species Richness</b>		<b>0.5</b>	<b>0.8</b>		<b>0.5</b>	<b>0.8</b>		<b>0.2</b>	<b>0.4</b>	
<b>Total Richness</b>		<b>4</b>			<b>8</b>			<b>2</b>		

**Appendix Y.** Number of detections per site for aquatic associated bird species detected at the 46 lentic sites with basin during summer 2002. Values reported per species are: average abundance across only those sites at which detected (Ave. Abund. where present), average abundance and associated standard error across all 45 sites (Ave. Overall s.e.), and mean abundance with associated standard deviation (s.d.) across sites within each of 4 size/hab lakes/ponds, medium lakes/ponds, large lakes/ponds and wet meadows). All values were calculated using the su detections from all survey visits to sites.

Common Name	Small Lakes/Ponds (n = 15)						Medium Lakes/Ponds (n = 12)			Large Lakes/Ponds (n = 10)		Wet Mead (n = 8)		
	Ave. Abund. where present	Ave. Abund. Overall	Overall s.d.	Mean	s.d.	Pts. Occ. %	Mean	s.d.	Pts. Occ. %	Mean	s.d.	Pts. Occ. %	Mean	s.d.
	American Coot	17.00	0.38	2.53	0.00	0.00	0.00	1.42	4.91	9.09	0.00	0.00	0.00	0.00
Barn Swallow	1.00	0.02	0.15	0.00	0.00	0.00	0.08	0.29	9.09	0.00	0.00	0.00	0.00	0.00
Black-crowned Night Heron	1.00	0.02	0.15	0.00	0.00	0.00	0.08	0.29	9.09	0.00	0.00	0.00	0.00	0.00
Brewer's Blackbird	3.13	0.56	1.69	0.20	0.56	14.29	0.58	1.24	27.27	0.00	0.00	0.00	1.88	3.48
Bufflehead	1.75	0.16	0.64	0.00	0.00	0.00	0.08	0.29	9.09	0.60	1.26	25.00	0.00	0.00
Canada Goose	36.40	4.04	23.11	0.00	0.00	0.00	13.58	44.59	18.18	1.90	3.60	25.00	0.00	0.00
California Gull	13.00	0.58	3.32	0.00	0.00	0.00	0.00	0.00	0.00	2.60	6.93	16.67	0.00	0.00
Common Merganser	4.00	0.44	1.65	0.00	0.00	0.00	0.33	0.89	18.18	1.60	3.20	25.00	0.00	0.00
Great Blue Heron	1.00	0.02	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.32	8.33	0.00	0.00
Greater Scaup	6.00	0.13	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.60	1.90	8.33	0.00	0.00
Killdeer	1.67	0.11	0.44	0.00	0.00	0.00	0.17	0.58	9.09	0.10	0.32	8.33	0.25	0.71
Mallard	8.36	2.60	7.33	0.13	0.35	14.29	5.00	12.48	45.45	3.90	5.24	50.00	2.00	5.66
Ring-necked Duck	2.00	0.04	0.30	0.00	0.00	0.00	0.17	0.58	9.09	0.00	0.00	0.00	0.00	0.00
Red-Winged Blackbird	2.43	0.38	0.96	0.33	0.90	14.29	0.58	1.38	18.18	0.20	0.63	8.33	0.38	0.74
Spotted Sandpiper	1.00	0.07	0.25	0.13	0.35	14.29	0.08	0.29	9.09	0.00	0.00	0.00	0.00	0.00
Tree Swallow	1.00	0.02	0.15	0.07	0.26	7.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Violet-Green Swallow	6.00	0.13	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	2.12
Yellow-Headed Blackbird	1.50	0.07	0.33	0.20	0.56	14.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Swallow	2.00	0.04	0.30	0.00	0.00	0.00	0.17	0.58	9.09	0.00	0.00	0.00	0.00	0.00
<b>Species Richness</b>	<b>2.5</b>	<b>1.4</b>	<b>1.9</b>	<b>0.7</b>	<b>1.4</b>		<b>1.8</b>	<b>2.4</b>		<b>2.1</b>	<b>1.9</b>		<b>1.0</b>	<b>1.8</b>
<b>Total Richness</b>		<b>18</b>		<b>6</b>			<b>12</b>			<b>9</b>			<b>5</b>	

**Appendix Z.** Frequency of occurrence of bird species detected during 30 minute aquatic visual surveys at 46 sit Tahoe basin during 2002. Observed number and percent of points occupied (Pt. Occup. (O%)), estimated point ( associated bootstrap standard error (s.e.), as determined by the program PRESENCE (McKenzie et al. 2002), and detection (Pd) for each species are recorded. Species with standard error values of 0.0 were detected too infrequently to estimate point occupancy.

Taxa Code	Scientific Name	Common Name	Pt.s Occ.	Pt. Occup. (O%)	Pt. Occup. (E%)	Bootstrap S.E.	Pd
AMCO <sup>c</sup>	<i>Fulica americana</i>	American Coot	1	2.22	2.3	2.3	1
BARS	<i>Hirundo rustica</i>	Barn Swallow	1	2.22			
BCNH <sup>a,c</sup>	<i>Nycticorax nycticorax</i>	Black-crowned Night Heron	1	2.22			
BRBL	<i>Euphagus cyanocephalus</i>	Brewer's Blackbird	8	17.78	30.6	33.3	0.52
BUFF <sup>a,c</sup>	<i>Bucephala albeola</i>	Bufflehead	4	8.89	100	10.6	0.07
CAGO <sup>c</sup>	<i>Branta canadensis</i>	Canada Goose	5	11.11	24.5	37.9	0.41
CAGU <sup>a,c</sup>	<i>Larus californicus</i>	California Gull	2	4.44	4.6	3.2	1
COME <sup>c</sup>	<i>Mergus merganser</i>	Common Merganser	5	11.11	19	26.3	0.55
GBHE <sup>a,c</sup>	<i>Ardea herodias</i>	Great Blue Heron	1	2.22			
GRSC <sup>a,c</sup>	<i>Aythya marila</i>	Greater Scaup	1	2.22	2.3	2.3	1
KILL <sup>c</sup>	<i>Charadrius vociferus</i>	Killdeer	3	6.67	6.8	3.7	1
MALL <sup>c,e</sup>	<i>Anas platyrhynchos</i>	Mallard	14	31.11	40.8	15.7	0.74
MODO <sup>b</sup>	<i>Zenaidura macroura</i>	Mourning Dove	1	2.22			
RNDU <sup>a,c</sup>	<i>Aythya collaris</i>	Ring-necked Duck	1	2.22	2.3	2.3	1
RTHA <sup>b</sup>	<i>Buteo jamaicensis</i>	Red-tailed Hawk	3	6.67	100	33.8	0.05
RWBL	<i>Agelaius phoeniceus</i>	Red-Winged Blackbird	7	15.56	32.1	37.4	0.42
SPSA <sup>c</sup>	<i>Actitis macularia</i>	Spotted Sandpiper	3	6.67	100	32.5	0.05
TRES	<i>Tachycineta bicolor</i>	Tree Swallow	1	2.22	2.3	2.3	1
VGSW	<i>Tachycineta thalassina</i>	Violet-Green Swallow	1	2.22	2.3	2.2	1
YHBL	<i>Xanthocephalus xanthocephalus</i>	Yellow-Headed Blackbird	2	4.44	4.6	3.2	1
HIRU	<i>Hirundo sp.</i>	Swallow	1	2.22			

<sup>a</sup> Species detected uniquely with aquatic bird surveys

<sup>b</sup> Non-aquatic associated species (Is not dependent upon or does not use aquatic or riparian habitat)

<sup>c</sup> USFS Management indicator species

<sup>d</sup> TRPA special interest species

<sup>e</sup> California State Species of Special Concern (SSC)

**Appendix AA.** Bird species detected at 45 lentic sites surveyed in the Lake Tahoe basin, mean abundances per site and percentage of sites occupied (Pts. Occup.%) for each species at sites within each spatial orientation around the Lake Tahoe basin are defined in Manley and Schlesinger (2001). All values were calculated using the sum of all bird detections from all sites. Two survey visits were conducted to 33%, 22%, 17% and 27% of sites in each orientation (north, south, east, and west, respectively).

Common Name	North (n = 6 points)			South (n = 18 points)			East (n = 6 points)			M Ab
	Mean Abund.	s.d.	Pts. Occup. (%)	Mean Abund.	s.d.	Pts. Occup. (%)	Mean Abund.	s.d.	Pts. Occup. (%)	
American Coot	0.00	0.00	0.00	0.47	2.00	5.56	0.00	0.00	0.00	0
Barn Swallow	0.00	0.00	0.00	0.03	0.12	5.56	0.00	0.00	0.00	0
Black-crowned Night Heron	0.00	0.00	0.00	0.03	0.12	5.56	0.00	0.00	0.00	0
Brewer's Blackbird	0.33	0.82	16.67	0.61	2.35	11.11	0.50	0.84	33.33	0
Bufflehead	0.00	0.00	0.00	0.25	0.94	11.11	0.08	0.20	16.67	0
Canada Goose	0.00	0.00	0.00	5.36	18.24	22.22	0.58	1.43	16.67	0
California Gull	0.00	0.00	0.00	0.83	2.71	11.11	0.00	0.00	0.00	0
Common Merganser	0.00	0.00	0.00	0.42	1.24	11.11	0.50	1.22	16.67	0
Great Blue Heron	0.00	0.00	0.00	0.03	0.12	5.56	0.00	0.00	0.00	0
Greater Scaup	0.00	0.00	0.00	0.33	1.41	5.56	0.00	0.00	0.00	0
Killdeer	0.33	0.82	16.67	0.06	0.24	5.56	0.33	0.82	16.67	0
Mallard	2.67	6.53	16.67	2.22	4.00	50.00	7.50	17.89	33.33	0
Ring-necked Duck	0.00	0.00	0.00	0.11	0.47	5.56	0.00	0.00	0.00	0
Red-Winged Blackbird	0.17	0.41	16.67	0.39	0.92	16.67	0.50	1.22	16.67	0
Spotted Sandpiper	0.08	0.20	16.67	0.06	0.24	5.56	0.17	0.41	16.67	0
Tree Swallow	0.00	0.00	0.00	0.06	0.24	5.56	0.00	0.00	0.00	0
Violet-Green Swallow	1.00	2.45	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0
Yellow-Headed Blackbird	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.41	16.67	0
Swallow	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.82	16.67	0
<b>Species Richness</b>	<b>1.0</b>	<b>2.0</b>		<b>1.8</b>	<b>2.3</b>		<b>2.0</b>	<b>2.0</b>		<b>0</b>
<b>Total Richness</b>	<b>6</b>			<b>16</b>			<b>10</b>			

**Appendix AB.** Comparison of life history traits represented by aquatic bird species detected most frequently (>5 occupancy) during 2002 and all species expected to occur in the Tahoe basin (Appendix B). Number and percent each life history category are shown to highlight similarities/differences in respective distributions

Variable	Category Level	No. species		% species	
		Freq. >5 - ≤50%	Expected species	Freq. > 50%	Expected species
Habitat specificity	Habitat specialists	6	61	100.0	96.8
	Moderate specialists	0	0	0.0	0.0
	Habitat generalist	0	2	0.0	3.2
Late seral/ old growth dependency	Old growth dependent utilizes old growth	0	1	0.0	1.6
	doesn't use old growth	6	62	100.0	98.4
Riparian Dependent	Riparian dependent	4	39	66.7	61.9
	utilizes riparian habitat	2	10	33.3	15.9
	doesn't use riparian habitat	0	14	0.0	22.2
Aquatic Association	Terrestrial species	0	0	0.0	0.0
	Semi-aquatic	6	46	100.0	73.0
	Aquatic	0	17	0.0	27.0
Trophic Level	Carnivore	4	44	66.7	69.8
	Scavenger	0	0	0.0	0.0
	Omnivore	0	6	0.0	9.5
	Herbivore	2	13	33.3	20.6
Home Range Size	1-1000 m <sup>2</sup>	0	6	0.0	9.5
	1,001 - 400,000 m <sup>2</sup>	3	30	50.0	47.6
	> 400,001 m <sup>2</sup>	3	27	50.0	42.9
Listing Status	Federal, State listed Threatened or Endangered or California species of concern	0	11	0.0	17.5
	Not Federal or State listed	6	52	100.0	82.5

**Appendix AC.** Observer names and their respective codes for all individuals collecting data for this multi-specific during 2002 within LTBMU. The primary survey protocol is listed per observer.

<b>Observer Name</b>	<b>Observer Code</b>	<b>Primary Survey Type</b>
Carol Campbell	CLC	point counts
Jim Campbell	JRM	point counts
Matt Schlesinger	MDS	point counts
Patricia Manley	PNM	point counts
Aaron Bilyeu	ALB	point counts
Jennifer Williams	JLW	small mammal trapping
Andrew Kinter	AHK	small mammal trapping
Denis Poole	DCP	small mammal trapping
Chris Hogle	CJH	small mammal trapping
Scott Weller	SYW	small mammal trapping
Jack Allgeier	JEA	carnivore surveys
Darryl Calvo	DVC	carnivore surveys
Jason Flaherty	JJF	carnivore surveys
Wesley Davis	WBD	carnivore surveys
Doug Powers	DEP	aquatic vertebrates and habitat
Darren Weston	DEW	aquatic vertebrates and habitat
Claire Knopp	CMK	pitfall and coverboards
Megan Fidell	MSF	pitfall and coverboards
Erin McDermott	ELM	Botany and Habitat
Mark Lynch	ML	Botany and Habitat
Asta Barcus	ARB	Habitat
Mary J. Curry	MJC	Habitat
Todd Valentine	TBV	Habitat
Kristen Streng	KLS	Habitat
Julie Roth*	JKR	
Ted Thayer**	TCT	

\* individual occasionally conducted aquatic vertebrate and habitat surveys

\*\* individual occasionally conducted terrestrial habitat surveys



