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Status of Utah Bats

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Executive Summary

Bat populations and communities have been monitored in Utah for over 100 years, on 12 land owner types including department of defense (DoD) lands. The Legacy Resource Management Program (Phase I) funding enabled a consolidation of all known bat data in the State of Utah. This data base until the Legacy II funding award had not been analyzed across space and time within the state**.** DoD land managers use Integrated Natural Resources Management Plans (INRMPs) to guide sustainable management practices to ensure that testing and training areas continue to function without restrictions. This regional approach to managing bats within Utah and specifically understanding regional trends and patterns on DoD land directly supports stewardship objectives and goals fundamental to sound land management policies within the DoD**.** These data were analyzed within 6 objectives (survey effort, occurrence, diversity, abundance, roosting and breeding locations and environmental associations), across 6 scales (ecoregion, physiographic province, land cover, Utah Division of Wildlife Resources (UDWR) regions, land owner type, and county). Analysis was conducted with frequency distributions across bat events and associated objectives and scales. Survey effort was lowest in Utah's West Desert, the Uinta Basin, and extreme southeastern Utah. The Colorado Plateau ecoregion had the highest survey effort, occupancy, diversity and abundance. Bureau of Land Management (BLM) lands had the highest occupancy and diversity followed closely by National Park Service and DoD lands. Utah's 6 tier II sensitive bat species were most common in the Southern and Southeastern UDWR regions. The highest diversity land cover for bats in Utah was sagebrush grasslands. These grasslands are/were the primary land cover type on DoD lands in the State. The lowest bat diversity land cover type was annual forb dominated communities, which are often the state of degraded sagebrush grasslands. This analysis indicates that there is a need to develop statewide monitoring protocols as completed with Legacy II funding and risk assessment and threat evaluation and management as is proposed in the Legacy III project.

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INTRODUCTION

Many bat populations in North America are thought to be declining (Stebbings 1980, McCracken 1988, Richter et al.1993, Tudge 1994, Altingham 1996). The International Union for Conservation of Nature (IUCN) lists 10% of microchiroptera species as threatened (Mickleburgh et al. 2002). The combination of slow reproduction, natural rarity and genetic isolation make bats susceptible to population and range declines (Racey and Entwistle 2003). Of 45 bat species in the United States, six are listed as federally endangered and 19 are former candidates for listing (Code of Federal Regulations 1991; USFWS 2008). Of Utah's 18 species, 6 are tier II species of concern in the Utah comprehensive wildlife conservation strategy (WAP) (UDWR 2005). Apparent declines in bat species may be attributed, in part, to loss of suitable habitat due to increased human recreational activity (caving and climbing), mine closure programs, and urbanization (Humphrey and Kunz 1976).

Eighteen bat species have been documented in Utah (Oliver 2000). A nineteenth species, the Arizona myotis (*Myotis occultus*) has been categorized as a subspecies of little brown myotis (*Myotis lucifugus*) and as an independent species (Oliver 2000). In this document, we treat the Arizona myotis as an independent species. The WAP and the draft Utah Bat Conservation Plan identify specific threats to each tier II species and general action required to mitigate these threats (UDWR 2005; Oliver et al. draft).

Townsend's big-eared bat (*Corynorhinus townsendii*) is threatened by human disturbance (maternity roosts), habitat loss (mine closures), and a general lack of information. In order to mitigate these threats, the Utah Division of Wildlife Resources (UDWR) recommends control and monitoring of disturbance, restoration of degraded habitats, population level monitoring, and increased research.

Spotted bats (*Euderma maculatum*) are threatened by human activities. Direct and indirect human disturbances are the primary threats to this species. Rock climbing has the potential to disturb this crevice roosting species (Adams 2003). Scientific collecting and harvesting via mist nets is related to mortality. Environmental contamination and bioaccumulation via pesticides may also be linked to this species conservation status (Oliver et al. draft 2008). To mitigate these threats, the UDWR recommends habitat monitoring and research, control and monitoring of disturbance, and population monitoring and research.

Human activities threaten Allen's big-eared bat (*Idionycteris phyllotis*) populations. Direct human disturbances via mine closures and roost disturbances, along with environmental contamination and pesticide use and highway development (Oliver et al. draft 2008). The lack of information about this species also threatens populations. The UDWR recommends control and monitoring of disturbance, population monitoring and research, and habitat conservation.

Western red bats (*Lasiurus blossevillii*) are threatened by human disturbance. The development and alteration of riparian roosting habitats is a significant threat to populations of this species (UDWR 2005; Oliver et al. draft 2008). The lack of information on the taxonomy of this species also impacts management. These threats can be mitigated by control and monitoring of disturbance, population monitoring and research, as well as the protection and restoration of significant areas.

The fringed myotis (*Myotis thysanodes*) is threatened by roost disturbance, habitat loss in riparian zones, the general lack of information about population trends, and the impacts of habitat alteration. The UDWR recommends control and monitoring of disturbance, population monitoring and research, and habitat monitoring and research (UDWR 2005; Oliver et al. draft 2008).

The big free-tailed bat (*Nyctinomops macrotis*) is threatened by many of the same sources described above. Threats to this species include environmental contamination via pesticides, scientific collecting, and the limited distribution of this species (UDWR 2005; Oliver et al. draft 2008). To mitigate these threats the UDWR recommends population monitoring and research and investigations to determine and address factors limiting recovery.

Although the Arizona myotis (*Myotis occultus*) is not addressed independently in the above action plans, the threats and general recommendations likely align with mitigating direct and indirect human activities. The taxonomic uncertainty concerning this species is also a threat. The 12 bat species in the state that are not of direct conservation concern are also threatened by the above mentioned factors (Oliver et al. draft 2008).

Common among the above listed threats and actions are the lack of information on basic ecology and population trends and the need for more research. Therefore, in order to address bat declines and sensitive species management more fully, it is necessary to evaluate the current status, recognize ecological associations, identify potential threats, and avoid or mitigate those threats to bats (Racey and Entwistle 2003). Historical data collections provide a measure of species distribution and can be used to establish the current status of bats. The status of bats can then be used to discover ecological associations and to mitigate threats.

Bat species in Utah have been sampled by federal and state agencies, universities, local contractors, private researchers, and non-profit groups for 103 years. Although some of these data have been analyzed independently, there has been no comprehensive analysis of survey effort, occurrence, diversity, abundance, breeding and roosting habitat, environmental associations or (Pers. Comm. Oliver). Additionally, the existing data were scattered among federal, state, private, and university information holdings making large-scale questions of bat ecology and management difficult to address. To deal with that issue, biologists at Dugway Proving Ground in cooperation with members of the Utah Bat Conservation Cooperative (UBBC), an organization comprised of members from 14 land and resource management agencies, received DoD funded Legacy Resource funding to consolidate and organize all existing bat data in Utah into a centralized geodatabase (BATBASE). To date, the BATBASE data set is the result of 16 types of contributors, over 150 observers, 13,876 events (records), and 28,629 individual bat records (Table 1). These data provide a location and presence for species and number of individuals. The wide scale of contributors to the BATBASE dataset and the UBCC provide a level of collaboration that is rare in wildlife management. Using the BATBASE data set to evaluate the current status of bats in Utah addresses the threats to many bat species by increasing and consolidating the information on bats in the state. Determining the current status of bats meets the management goals of the DoD, UDWR, and partners within the UBCC.

Table 1. Number of individual bats and events recorded by each of 16 collection entity types.

Date source	Events	Individual bats
Bureau of Land Management (BLM)	2	2
Certificat or Registration (COR)	302	280
Consultants	57	645
Department of Defense (DoD)	20	54
Brad Lengas	7191	7191
Mine and cave surveys (Mine/Cave)	151	2664
Museum Records	38	38
National Park Service (NPS)	2260	2118
Publications	596	3113
Southern Nevada Water Authority (SNWA)	36	0
Southern Utah University	249	560
Utah Division of Wildlife Resources	2209	7221
Utah Natural History Program	439	4076
U.S. Forest Service (USFS)	286	586
Utah State University	6	34
Weber State University	34	10
Unknown	19	37
Total	13895	28629

Using the BATBASE data set to evaluate the current status of bats in Utah addresses the threats to many bat species by increasing and consolidating the information on bat species in the state. Determining the current status of bats meets the management goals of the UDWR and DoD. DoD land managers use Integrated Natural Resources Management Plans (INRMPs) to guide sustainable management practices to ensure that testing and training areas continue to function without restrictions. This regional approach to managing bats within Utah and specifically understanding regional trends and patterns on DoD land directly supports stewardship objectives and goals fundamental to sound land management policies within the DoD. DoD's three-phased Legacy effort has and will lead to collaborative management of all bat taxa by numerous agencies and partners. As a result, DoD land managers can be assured that the BLM, USFS, UDWR, and other land owners securing property surrounding military lands are doing their part to manage for species that could affect mission and essential testing and training activities on DoD lands. If all agencies are utilizing sufficient management practices for species that could affect mission readiness then military land managers can be assured that at some point in the future, DoD property will not be the sole location for federally listed threatened and endangered species that so many DoD installations throughout the United States have become. Only through active state-wide bat management can population decline be detected in meaningful timeframes.

In order to meet Mission sustainment objectives of the Department of Defense (DoD), a DoD Legacy Program Proposal was developed and coordinated with several federal and state agencies as well as the state bat working group (UBCC), targeting implementation of the UDWR's CWCS (WAP) and DoD's INRMPs. To meet the goals of the Legacy II proposal and UDWR, 6 objectives were created by synthesizing the goals of the 2 agencies (Tables 2, 3, and 4). The following objectives provided an estimation of the status of bats in Utah: (Objective 1) evaluate the survey effort across spatial scales in Utah, (Objective 2) determine the occurrence of bat species across the state on multiple scales, (Objective 3) estimate the bat species diversity across scales within the state, (Objective 4) create a measure of species abundance across space, (Objective 5) identify roosting and breeding habitat, and (Objective 6) identify broad-scale environmental associations.

Table 2. DoD needs stated in the DoD Legacy Program Phase II Proposal.

DoD Needs	
A	Diversity indices X Habitat Model
B	Occurrence X Elev. Gradients
C	Abundance X Site
D	Maternity and hibernaculum X Roost Locations
E	Survey effort / Time; species saturation curves/ County
F	Breeding season status and breeding range by species
G	Bat Activity X Temperature
H	Gap Analysis; Ecology and Biology
I	Measurable Conservation objectives

Table 3. UDWR needs stated in the DoD Legacy Program Phase II Proposal.

UWDR Needs	
1	Ecological quality by site (Presence data only)
2	Ecological value of a site via model
3	Increase habitat suitablility / Avoid Degradation
4	ID translocation and reintroduction
5	Ecologically and biologically informed Restoration of habitat

Table 4 . Combined needs for the DoD and UDWR expressed in six objectives.

Objectives	DoD needs	UDWR Needs
Survey effort/area	E, H, I	4, 5
Occurrence	B, C, I	1,5
Diversity	A, C, I	3, 5
Abundance indices	A, C, I	2, 3, 5
Roosting / Breeding habitat	D, F, I	1, 2, 3, 4, 5
Environmental associations	A, G, I	1, 2, 3, 4, 5

METHODS

All data were analyzed on 3 ecological scales: ecoregion (World Wildlife Fund global Ecoregions), physiographic province (Utah Geological Survey) and land-cover classification (SWGAP). This allowed for analysis of bat use and distribution at varying scales to address specific needs. The ecoregion scale provided us with a broad view of ecological associations while the physiographic provinces allowed for an evaluation of broad scale land-form relationships. Land cover was evaluated with southwestern Re-GAP (SW Re-GAP) data at a 30m pixel scale for interpretation of species and environmental associations. These three ecological scales provided an estimate of species and habitat associations in specific cover types.

We also analyzed all data on three managerial scales: landowner type, UDWR region, and county. The landowner analysis provided species occurrences under classes of management. UDWR's regions were used to establish a listing of species presence and magnitude. By analyzing these data on a county scale, we obtained a finer assessment by management scale. We used a frequency analysis (PROC FREQ) comparing the number of events by species in each of the 6 management scales in SAS®. This analysis serves as a descriptive data layout providing an overview of the entire data set (pers comm. S. Durham) with such a diverse (temporal, spatial, and methodological) data set.

The ecoregion scale had a total of 5 classes (Colorado Plateau shrublands, Great Basin shrub steppe, Mojave desert, Wasatch and Uinta montane forest, and Wyoming Basin shrub steppe) as did the physiographic province (Basin and Range, Colorado Plateau, Columbia Plateau, Middle Rocky Mountains, and Wyoming Basin). The land cover scale (SW Re-GAP) had 61 classes (Appendix I). We categorized landowner into 12 classes (Bureau of Land Management (BLM), DoD, National Park Service (NPS), Private, State Institutional Trust Land

Administration (SITLA), State Sovereign Land (SL& F), Tribal, UDWR, Parks and Recreation (USP), U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service (USFS), and Open Water), as well as 5 UDWR regions (Central, Northern, Northeastern, Southern, and Southeastern), and 29 counties (Appendix II).

Objective 1: Analysis of bat use was affected by total survey effort differences throughout Utah. Given that the data were collected by more than 150 separate observers, across 103 years and 16 management entities, survey effort is difficult to define and thus to evaluate. This entire data set was analyzed for the survey effort at each of the 6 scales and associated 116 classes. The resulting data set was then visually assessed for variation. Those locations with no event cover were considered to have had no survey effort, while those with a dark cover were assumed to have had high survey intensity. We also used a Chi-squared test to compare the percent of total events (observed) within each of the 6 analysis scales and the percent of Utah land cover within each scale (expected). Data collection methods were also compared across scales and classes with the use of a frequency analysis (PROCFREQ) in SAS®.

Objective 2: Evaluate overall bat occurrence, we used the number of capture events recorded in Utah by species and then created a frequency distribution across species and analyzed for each scale (i.e., ecoregion, physiographic province, land cover classification, land owner, UDWR region, and county). Analysis was conducted using PROCFREQ in SAS® and visual analysis in Excel®. The occurrence data were then used to create a diversity analysis.

Objective 3: Diversity was measured in two ways: number of species events and a diversity and evenness index in each of the 6 scales and associated 116 classes. Events were defined as number times a species was captured within each of the scales and associated classes. Events were used rather than number of individuals captured per event to reduce the influence of high magnitude capture events on species evenness. The six scales were analyzed via a frequency distribution across classes within scales. The Shannon-Weiner diversity index was used with each class across all scales, a total of 116 classes. These classes were then compared within each of the six scales. Both of these measures were used to evaluate diversity. Analysis was conducted with PROCFREQ in SAS® and Excel®.

In order to evaluate Objective 4, the overall relative abundance, we used a frequency analysis. The density of events was evaluated by comparing scale layers and event frequency. We buffered each point with a 5-km radius. This assumes that the bat event was detectable at this scale and this radius is a hedged estimate of the area of habitat represented by each event. This analysis was carried with ARCMAP GIS®, SAS® and Excel®.

Objective 5: distribution of breeding and roosting sites, provides an estimate of the distribution of breeding populations and associated roosts. Maternity roosts provide a secure location for females to give birth and rear their young throughout the summer season (Kunz 1982, Humphrey 1975). Hibernacula provide a winter refuge for bats (Johnson et al. 1998, Kuenzi et al. 1999, Raesly et al. 1986). Day roosts are used by non-reproductive individuals of both sexes while night roosts are utilized by all bats, regardless of reproductive status as a place to rest and to digest their prey between foraging bouts (Kerth et al. 2001, Lacki 1994). Night roosts are generally in different locations than day roosts and are used primarily at dawn and dusk (Anthony et al. 1981). Interim roosts are used in the spring before the young are born and again in the fall before retreating to the hibernation roosts (Dobkin et al. 1995, Twente 1955). To evaluate bat reproduction throughout the state we analyzed reproductive status records. Although the entire data set was categorized into common scales, only a subset (1247 of 13,847 events) of data recorded individual reproductive status. We categorized all events with reproductive data into reproductive or non-reproductive categories. Reproductive individuals were those reporting one or more of the following: gravid, lactating, post-lactating, or testes scrotal. We analyzed the number of reproductive events for each of the six scales and associated 116 classes. We used a frequency analysis (PROCFREQ) in SAS® and Excel®. To interpret bat roost use in Utah, we evaluated roost type records in the database. A small subset (less than 5%) of the total bat data set recorded roost type. We categorized roost data into 3 types: maternity, day, night or hibernation roost. A frequency analysis was used within scales across classes. This analysis was conducted with SAS® and Excel®.

Objective 6 addressed bat distribution throughout the state, the association between elevation and species occurrence. We evaluated elevation as a total model across all scales and within the ecoregion scale across classes. Each event was categorized into one of six elevation classes: <1000 m, 1001-1500 m, 1501-2000 m, 2001-2500 m, 2501-3000 m and >3000 m to represent variation on the landscape. A frequency analysis (PROCFREQ) was conducted in SAS® and Excel®. We used the habitat suitability scale developed for Legacy I and the density estimates created via the density measures from objective four to create a percent agreement between habitat suitability and density of events. The percent area for each of the suitable habitat models from suitable for 0 species to suitable for up to 15 species was calculated. We created a 10 level event density scale and calculated the percent of total events within each. The habitat suitability model was then used as the expected and the density measures the observed. Data were evaluated with a Chi-squared test.

RESULTS

Data Summary

A total of 19 species were recorded within the BATBASE data set. Silver-haired bat (*Lasionycteris noctivagans*) accounted for 1827 events, western pipistrelle (*Pipistrellus hesperus*) 1825, Townsend's big-eared bat 1309, big brown bat (*Eptesicus fuscus*) 1281, little brown myotis (*Myotis lucifugus*) 1131, long-legged myotis (*Myotis volans*) 1052, long-eared myotis (*Myotis evotis*) 946, pallid bat (*Antrozous pallidus*) 833, California myotis (*Myotis californicus*) 780, Brazilian free-tailed bat (*Tadarida brasiliensis*) 724, hoary bat (*Lasiurus cinereus*) 501, fringed myotis 416, western small-footed myotis (*Myotis ciliolabrum*) 378, Yuma myotis (*Myotis yumanensis*) 355, Allen's big-eared bat 166, big free-tailed bat 141, spotted bat 120, western red bat 19, and Arizona myotis 16.

Survey Effort (Objective 1)

Year

The majority of the data collected in the state of Utah over the last 103 years was concentrated between 1986 and 2004 (Fig. 1). It is important to note that 3290 of 13,847 total events lacked a date category, therefore many of the patterns observed in the data set across years are due to data absence not bat absence. The first bat capture events were recorded in 1905 for 11 species (pallid bat, Townsend's big-eared bat, big-brown bat, hoary bat, California myotis, western small-footed myotis, long-eared myotis, fringed myotis, long-legged myotis, western pipistrelle and Brazilian free-tailed bat). The silver-haired bat was first observed by 1914. While, Allen's big-eared bat was recorded in the data set by 1916 literature does not support records of this species until 1969 (Black 1970). Western red bats were first observed in the data set by 1994; however, Presnell and Hall recorded this species in Utah as early as 1937. The little brown myotis was first recorded in the literature in 1941 (Hardy), but does not appear in the data set until 1992. Woodbury recorded big free-tailed bats as early as 1937, but they do not appear in the data set until 1992. Spotted bats were not recorded in Utah in the data set until 1994 (Lengas), however, Durrant observed them as early as 1935. The highest diversity (number of species) was recorded from 1994 to 2008 and in 1903, 1941, 1942, and 1947. The lowest diversity was recorded from 1948 to 1986.

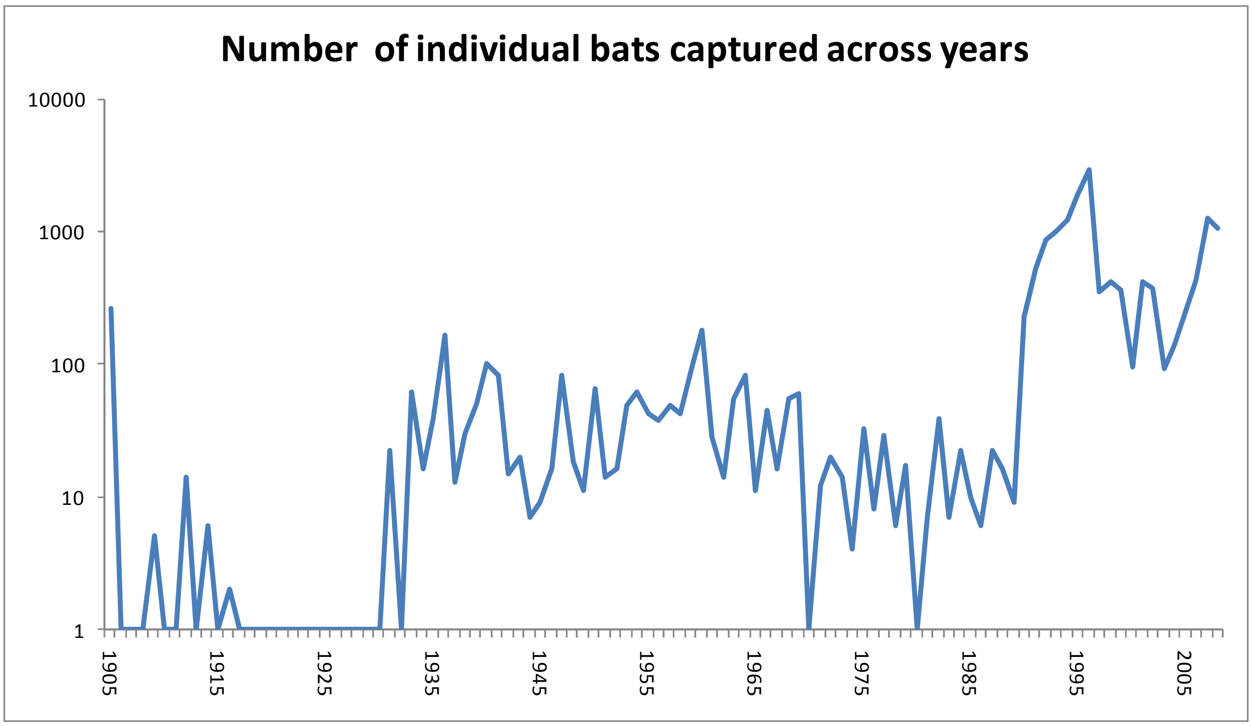

Figure 1. Number of individual bats captured across years for Utah's 19 bat species. Data is represented on a log base 10 scale to allow for comparison of data across magnitude. The sum of all species was used to control for the 24% of events that lacked a date variable.

Month

Most of Utah's bat species were only observed in a limited number of months (Fig. 2). As mentioned above, many of the patterns observed in the data set across months are due to data absence and not bat absence. The Townsend's big-eared bat and the fringed myotis were recorded from April to September in the data set. The spotted bat was only recorded from June to August. Allen's big-eared bat was observed from April to October. The western red bat was only observed in June and July. Arizona myotis records exist from February to July. The big free-tailed bat had records from all months except December. Big-brown bats, western pipistrelles and the Brazilian free-tailed bat had observations from all 12 months. Total observations were skewed heavily toward June, July, and August (7950 of 10,633 events). Cold season (Jan., Feb., Mar., Oct., Nov., and Dec.) data consisted of only 384 of the 10,633 events. Highest diversity (number of species) was recorded June to August.

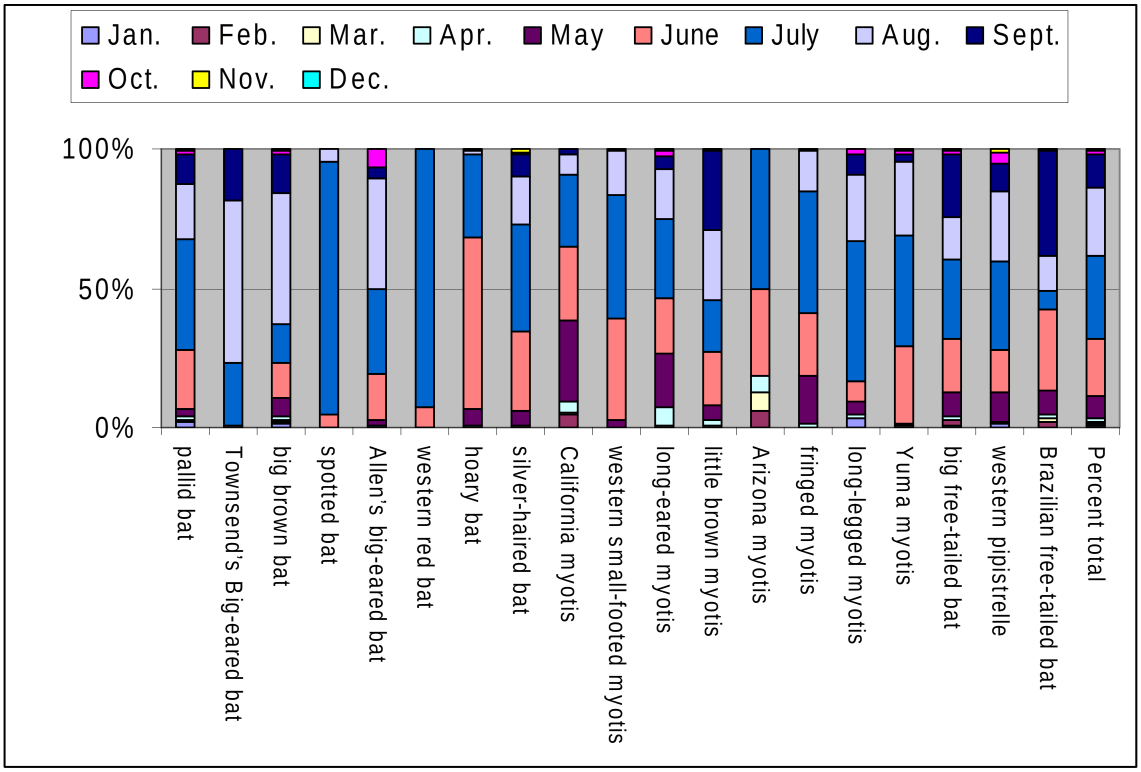

Figure 2. Percentage of capture events across months for Utah's 19 bat species.

Ecoregion

The total bat data set was dominated by capture events in the Colorado Plateau shrublands, accounting for 48% of all data, Wasatch and Uinta montane forests 31%, the Great Basin shrub steppe 19%, the Mojave Desert 1.6%, and the Wyoming Basin shrub steppe 0.4%. The Great Basin shrub steppe covers 35% of Utah, Colorado Plateau 33%, Wyoming Basin shrub steppe 14%, Mojave Desert 13%, and the Wasatch and Uinta montane forest 4% (Fig. 3). The expected event distribution based on percent area was significantly ($P < 0.001$) different from the actual distribution of events across ecoregions.

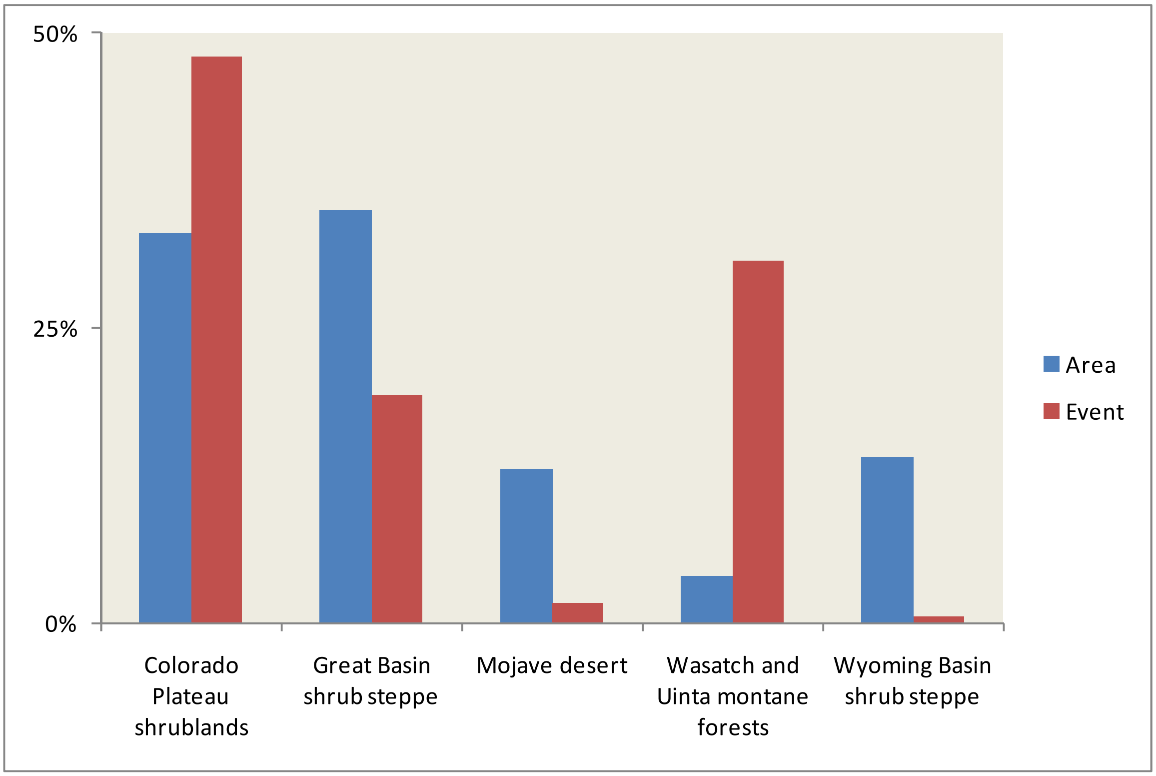

Figure 3. Percent of area and events recorded in each of 5 ecoregions.

Physiographic Province

The Colorado Plateau accounted for 51% of all capture events, the Basin and Range for 31%, Middle Rocky Mountains for 17%, and the Columbia Plateau and Wyoming Basin for < 0.05% (Fig. 4). Theses sampling intensities reflect the area represented by each of these ecoregions. The Colorado Plateau covers 49% of Utah, Basin and Range 40%, Middle Rocky mountains 11%, and < 1% for Columbia Plateau and Wyoming Basin (Fig. 4). The distribution of events across provinces did not differ significantly between the expected and actual distribution (P = 0.24).

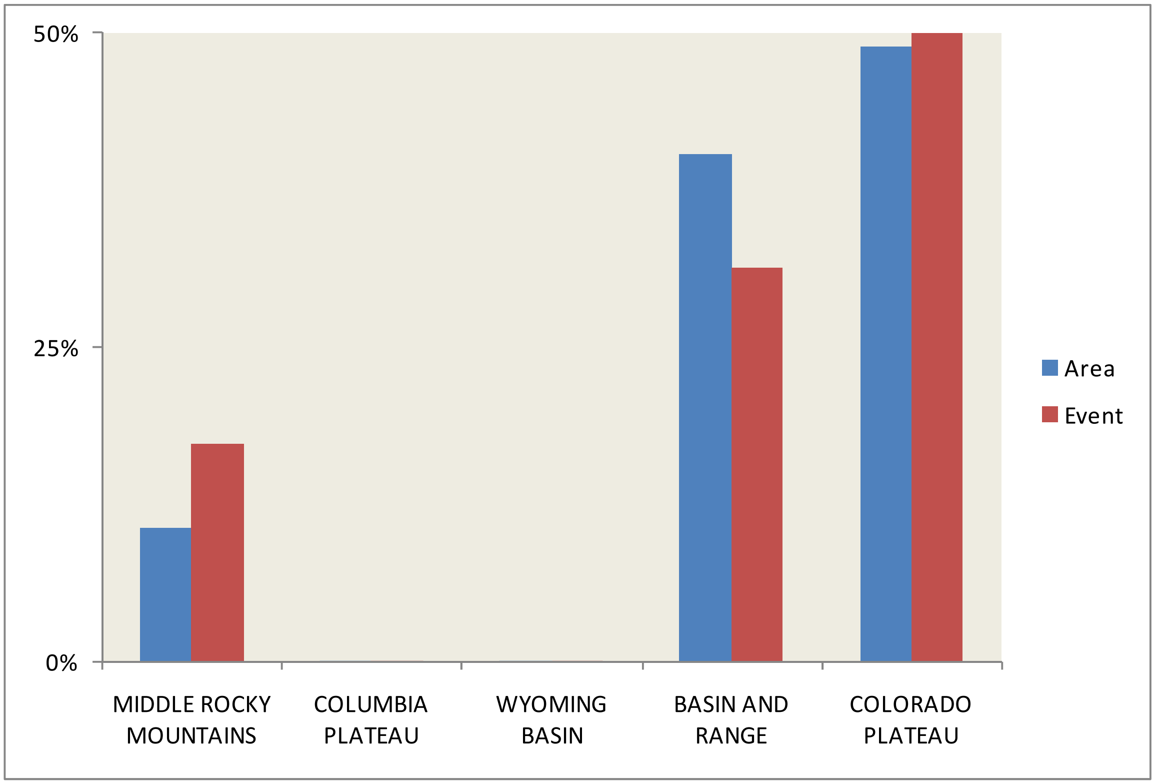

Figure 4. Percent of area and events recorded in each of 5 physiographic provinces.

Land Cover

Number of events varied across land cover types. Of the 13,876 events used in this analysis 10% (the largest single event cover) occurred in Colorado Plateau Mixed Bedrock Canyon and Tableland (9), 9% in Colorado Plateau Pinyon-Juniper Woodland each (36), 7% in Rocky Mountain Lower Montane Riparian Woodland and Shrubland (79), 6% in Colorado Plateau Blackbrush-Mormon-tea Shrubland (53), Inter-Mountain Basins Montane Sagebrush Steppe (62) and Developed, Open Space Low Intensity (111). Land cover types varied in area covered. Thirteen land cover types (9, 14, 36, 37, 46, 48, 53, 58, 62, 67, 82, 110 and 114) accounted for over 72% of total land area (Fig. 5) (Appendix I). Twenty land cover types made up a total of < 1% of land area and had no event records. Five cover types had a lower percentage of events than predicted by land area percentage (14, 48, 58, 67 and 114). Four cover types had an equal percentage of events and land area (36, 37, 46 and 62). Seven cover types had a higher percentage of events than percent area (9, 23, 34, 53, 60, 79 and 111) (Fig. 5) (Appendix I). The distribution of events across land cover area differed significantly from the expected ($P < 0.001$).

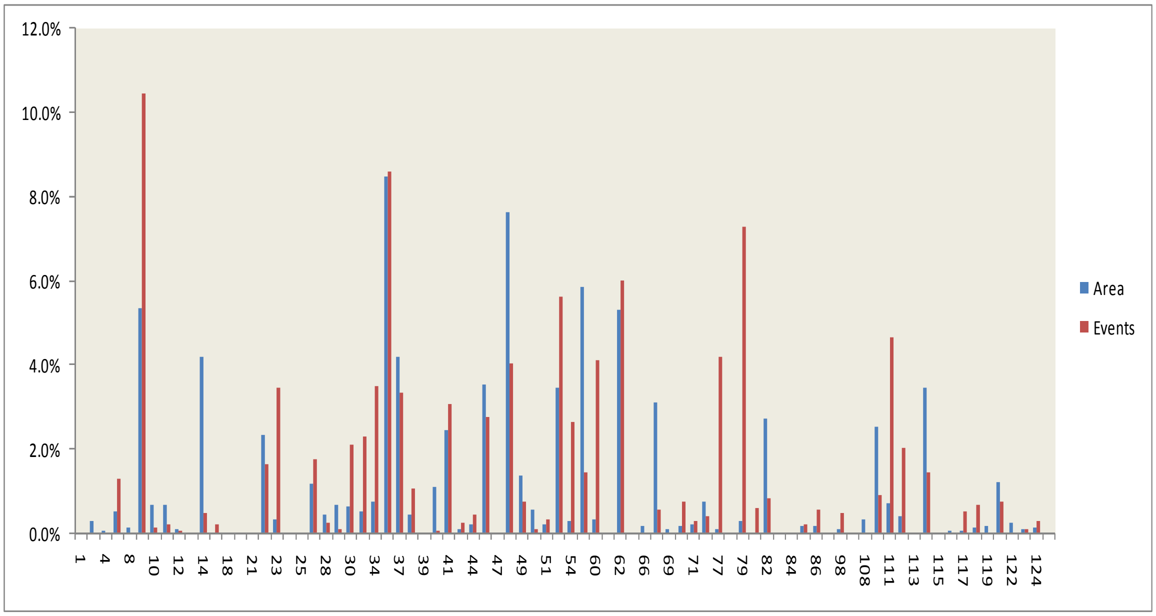

Figure 5. Percent of area and events recorded in each of Utah's land cover types (Appendix I).

UDWR Regions

Number of total events varied across UDWR Regions. The southern Region had 43% of all events, Southeastern 24%, Northern 16%, Central 11% and the Northeastern 6%. The total area varied across Regions. The Southern Region encompasses 32% of Utah, Southeastern 24%, Central 18%, Northern 15% and Northeastern 11% (Fig. 6). The expected event distribution based on percent area was not significantly different from the actual event distribution ($P=0.065$).

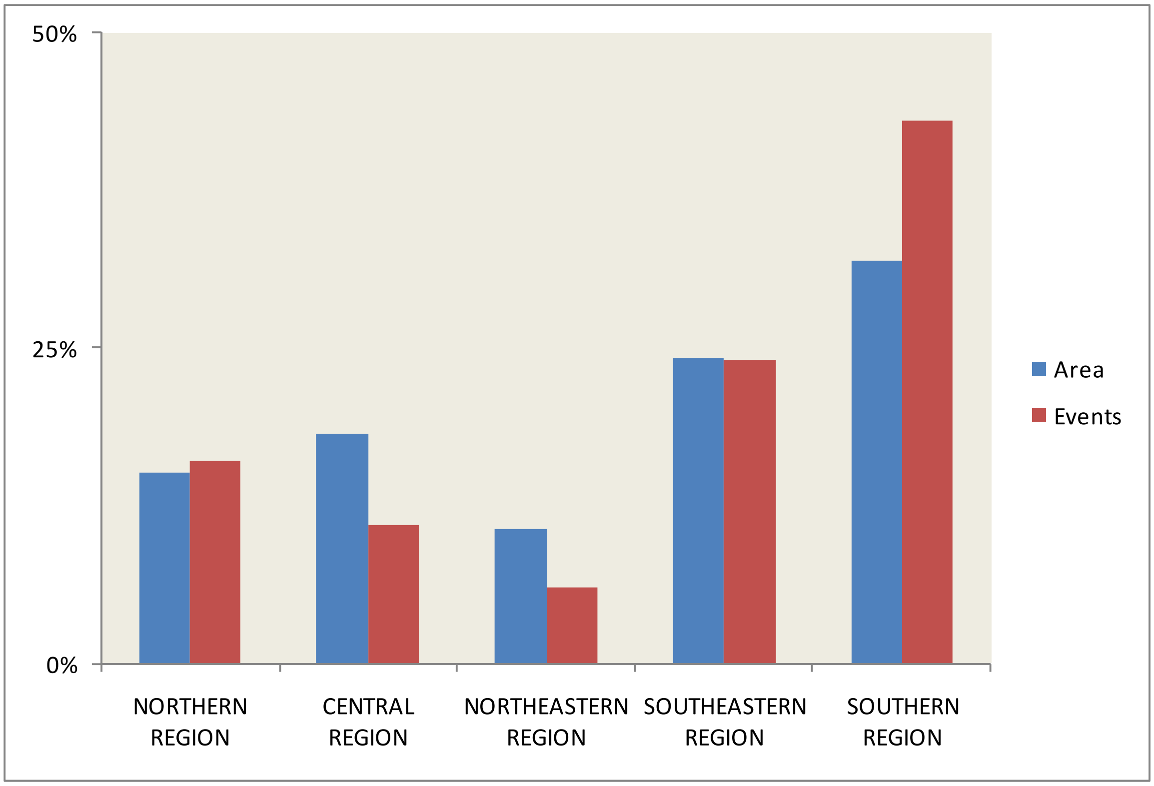

Figure 6. Percent of area and events recorded in each of 5 UDWR Regions.

Landowner

The expected survey based on the area of each landowner type differed from the actual ($P = 0.001$) (Fig. 7). DoD lands account for 3% of total land area and only 1% of events. BLM administered lands accounted for 42% of land cover and only 23% of events. Private lands were represented as expected by area (21%) making up 20% of events. USFS covers 15% of the land area and accounts for 23% of events. NPS lands account for only 4% of area yet, 19% of events occurred in these lands. SITLA, SL&F, and Tribal lands were all underrepresented. USFWS and USP lands cover a small area of Utah and account for a similar percentage of data.

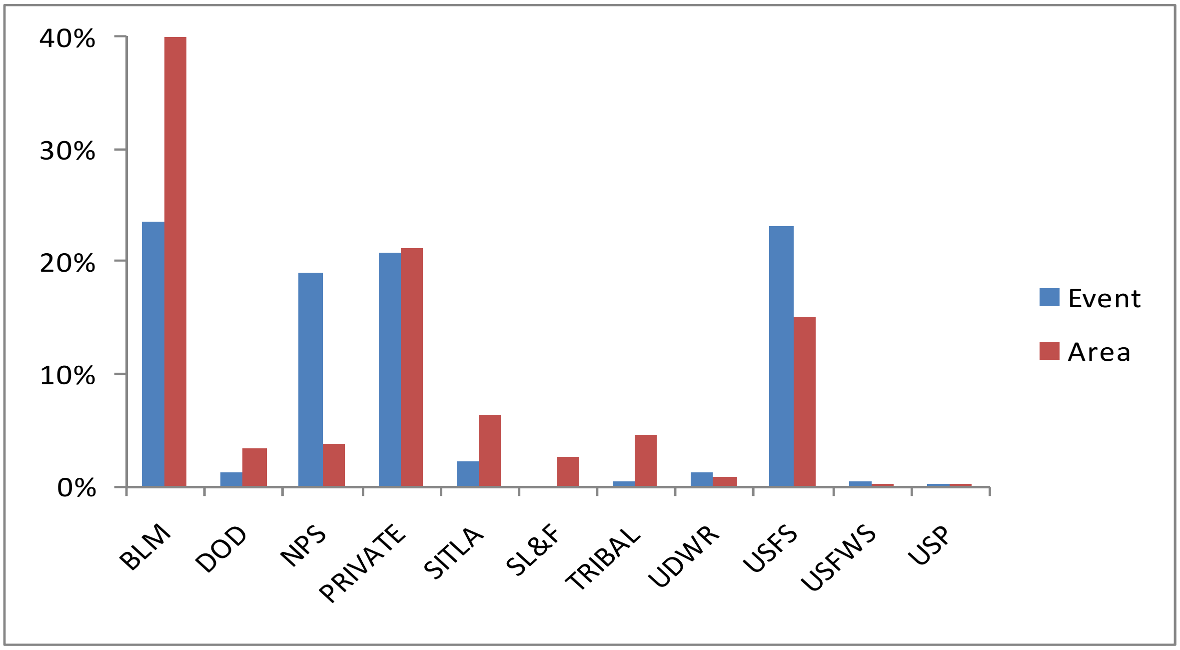

Figure 7. Percent of area and events recorded in each of 11 landowner types.

County

Number of events varied across Utah counties (Fig. 8). Thirteen percent of all event were recorded in Cache County, 12% in Washington, 9% in Garfield and Kane, and < 1% of total events were recorded in Box Elder, Carbon, Davis, Emery, Morgan, Rich and Wasatch counties. Total land area is dominated by Box Elder, Tooele, Millard, and San Juan counties (Fig. 8). The expected distribution of events based on land area of counties varied significantly from the expected ($P<0.001$).

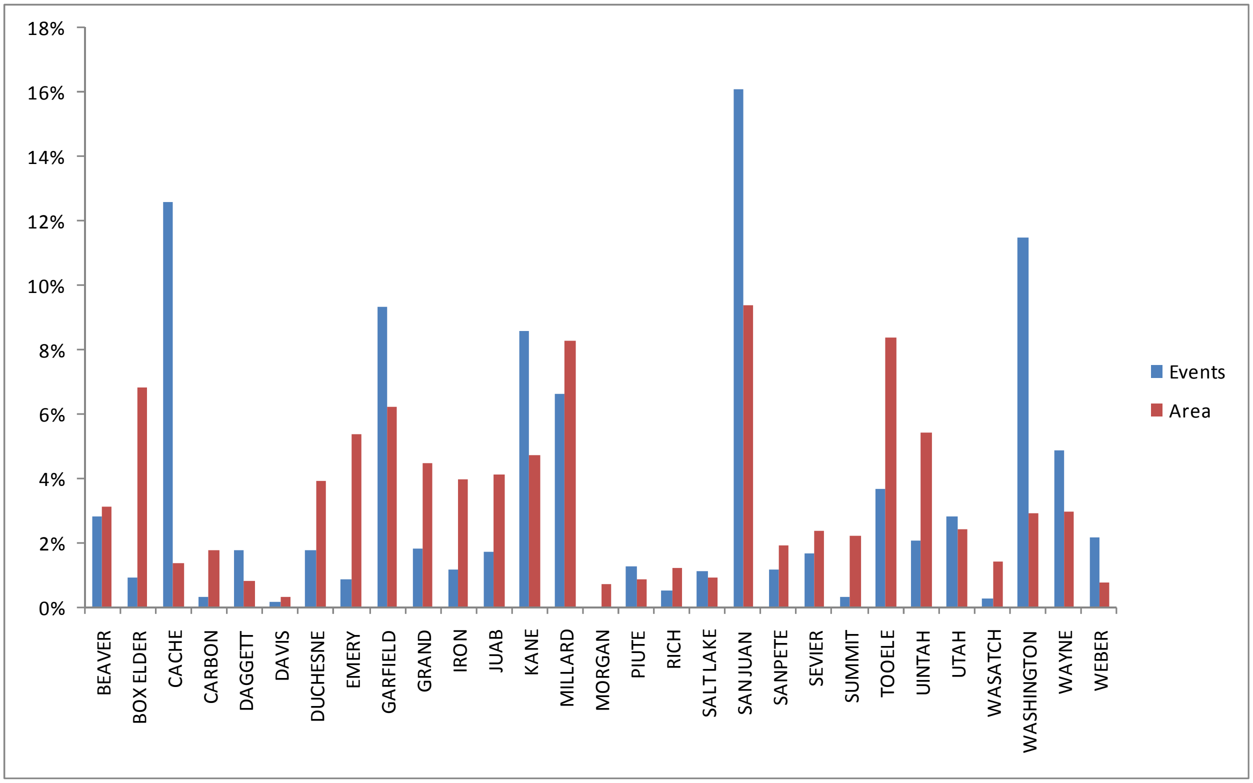

Figure 8. Percent of area and events recorded in each of 29 counties.

Data Gaps

Data gaps exist across months and areas within Utah (Fig. 9). Cold season records only account for 3% of the total data. Utah's West Desert has large areas that have not been monitored (Fig. 9). Data are also lacking for the north-slope of the Uinta Mountains, north of Fish Lake, areas adjacent to Desolation Canyon, the confluence of the San Juan and Colorado Rivers, the Uinta Basin and the southeastern corner of Utah.

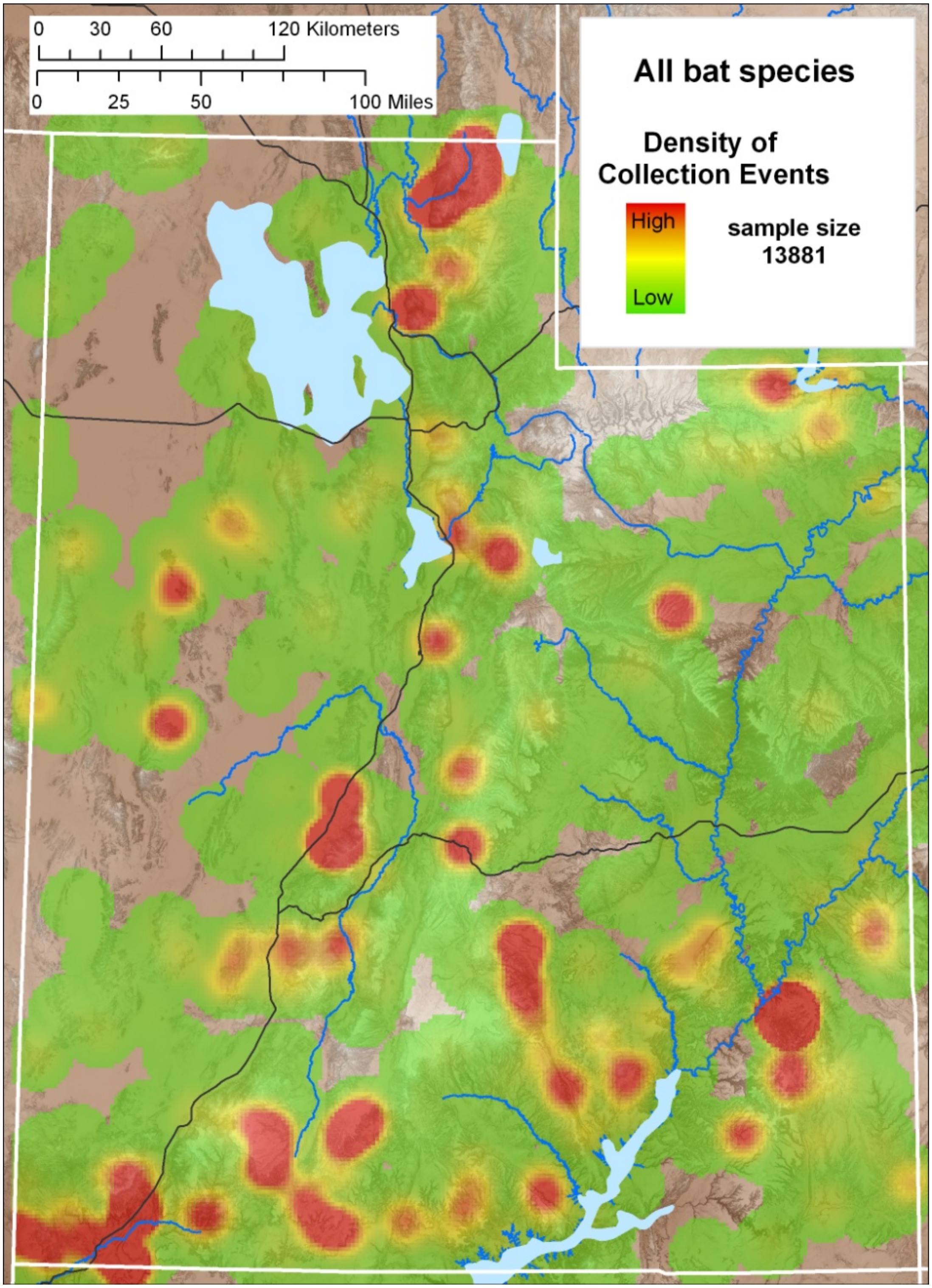

Figure 9. Density of data collection events in the State of Utah. Each data point has a 5 km radius of activity zone. A continuum of event densities from high (red) to low (green) areas indicates the magnitude of data collection. Areas with no density cover are those that lack data points.

Occurrence: Ecological Scales (Objective 2)

Ecoregions

While bat capture data exist for all five of Utah's ecoregions, there is considerable variation across ecoregions both within species and across species (Fig. 10). Eight species occurred in 5 ecoregions (pallid bat, big-brown bat, hoary bat, silver-haired bat, western small-footed myotis, long-eared myotis, little brown myotis, and long-legged myotis). Seven species occurred in all ecoregions except the Wyoming Basin shrub steppe (Townsend's big-eared bat, California myotis, fringed myotis, Yuma myotis, big free-tailed bat, western pipistrelle and Brazilian free-tailed bat). The spotted bat and the western red bat occurred in three, Colorado Plateau shrublands, Great Basin shrub steppe and Wasatch and Uintah montane forests. Allen's big-eared bat was recorded only in Colorado Plateau shrublands and the Mojave Desert ecoregions. The Arizona myotis was only observed in Colorado Plateau shrublands (Fig. 10). All 19 species occurred in Colorado Plateau shrublands; 17 in the Great Basin shrub steppe, and Wasatch and Uinta montane forests (Allen's big-eared bat and the Arizona myotis were absent); 14 in the Mojave Desert (spotted bat, western red bat, western small-footed myotis, long-eared myotis and Arizona myotis were absent); and only 8 (pallid bat, big-brown bat, hoary bat, silver-haired bat, western small-footed myotis, long-eared myotis, little brown myotis, and long-legged myotis) in the Wyoming Basin shrub steppe.

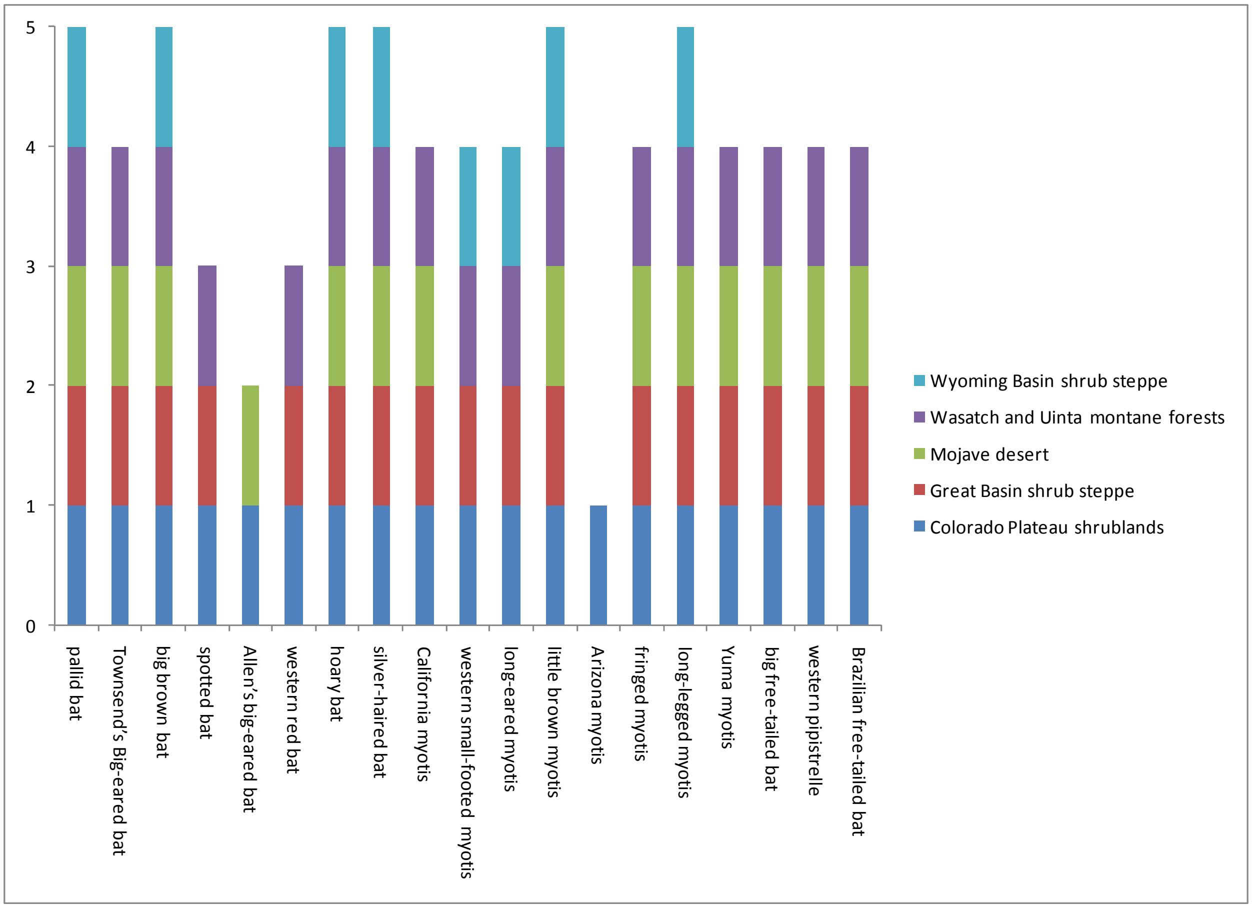

Figure 10. Bat presence across Utah's 5 ecoregions for 19 bat species. The lack of a bar indicates species absence from that ecoregion. These data do not measure magnitude, simply presence or absence.

Physiographic Provinces

Bat species occurrence varied across and within Utah's 5 physiographic provinces (Fig. 11). Only the long-legged myotis was detected in all five provinces. Four species (pallid bat, silver-haired bat, hoary bat, and little brown myotis) were observed in all provinces except the Columbia Plateau. Townsend's big-eared bats were observed in all provinces, with the exception of the Wyoming Basin. Ten species (big brown bat, spotted bat, western red bat, California myotis, western small-footed myotis, long-eared myotis, fringed myotis, Yuma myotis, western pipistrelle, and Brazilian free-tailed bat) occurred in the Basin and Range, Colorado Plateau, and

Middle Rocky Mountains. Allen's big-eared bat and the big free-tailed bat only occurred in the Basin and Range and Colorado Plateau. And the Arizona myotis was observed only in the Colorado Plateau. All 19 species occurred in the Colorado Plateau, 18 in the Basin and Range (Arizona myotis was absent), 16 in the Middle Rocky Mountains (Allen's big-eared bat, Arizona myotis, and big free-tailed bats were absent), 5 in the Wyoming Basin (pallid bat, hoary bat, silver-haired bat, little brown myotis, and long-legged myotis), and only two species in the Columbia Basin (Townsend's big-eared bat and long legged-myotis).

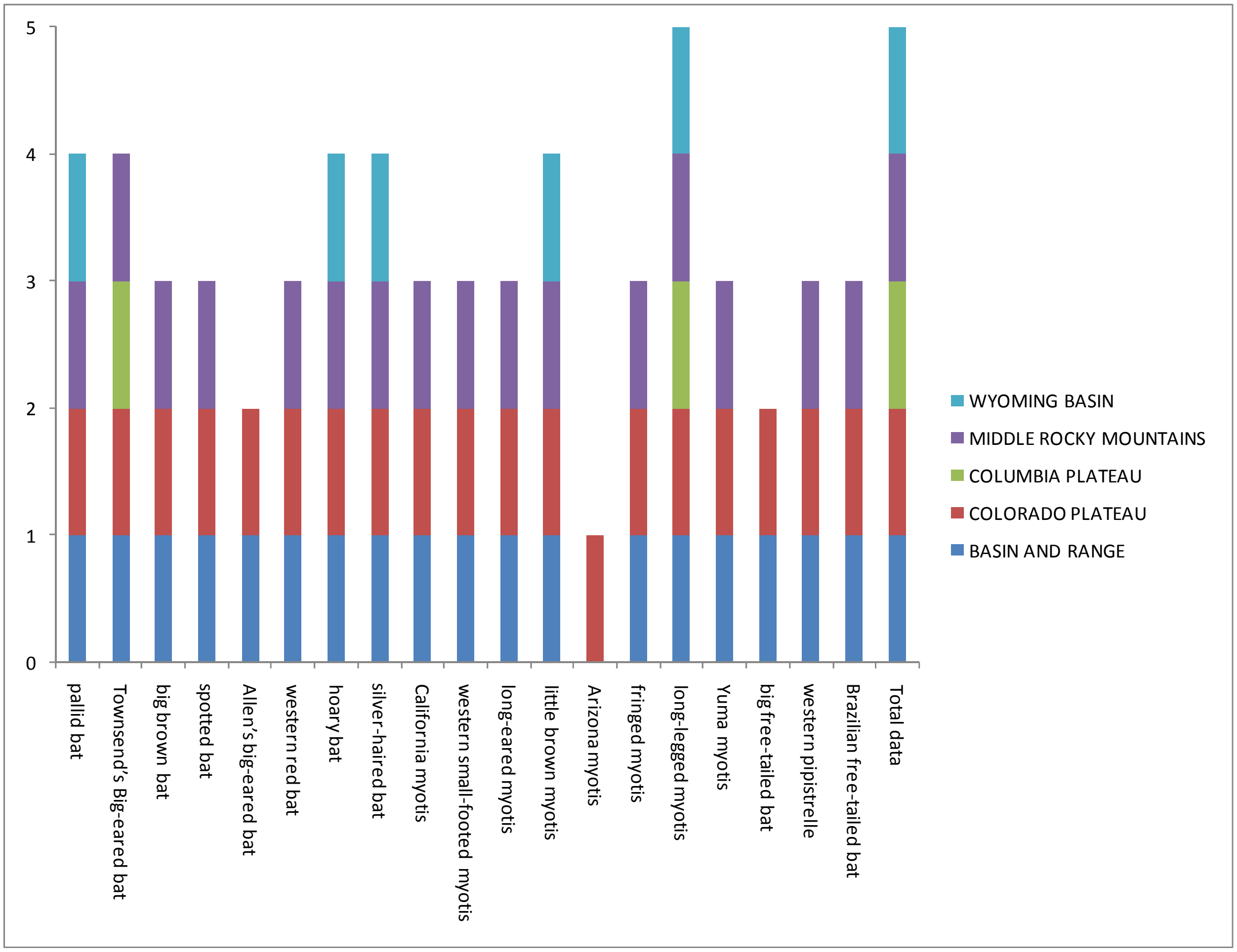

Figure 11. Bat presence across Utah's 5 physiographic provinces for 19 bat species. The lack of a bar for a given physiographic province indicates species absence. These data do not measure magnitude, simply presence or absence.

Land Cover

Bat species occurrences varied across and within land cover type. Bats were observed in 61 land cover types (Fig. 12) (Appendix I). Townsend's big-eared bat occurred in 44 cover types, spotted bat 23, Allen's big-eared bat 18, western red bat 4, Arizona myotis 3, fringed myotis 35, and the big free-tailed bat 26. Big-brown bats were observed in more cover types than any other species (49). All 19 species were recorded in the Colorado Plateau Pinyon-Juniper woodland (36), 18 species (western red bat was absent) in the Inter-Mountain Basins Big Sagebrush shrubland (48), 5 cover types, (Colorado Plateau Mixed Bedrock Canyon and Tableland (9), The Great Basin Pinyon-Juniper (37), Inter-Mountain Basins Mixed Salt Desert Scrub (58), Developed, Open Space - Low Intensity (111), and Developed, Medium - High Intensity) had 17 species.

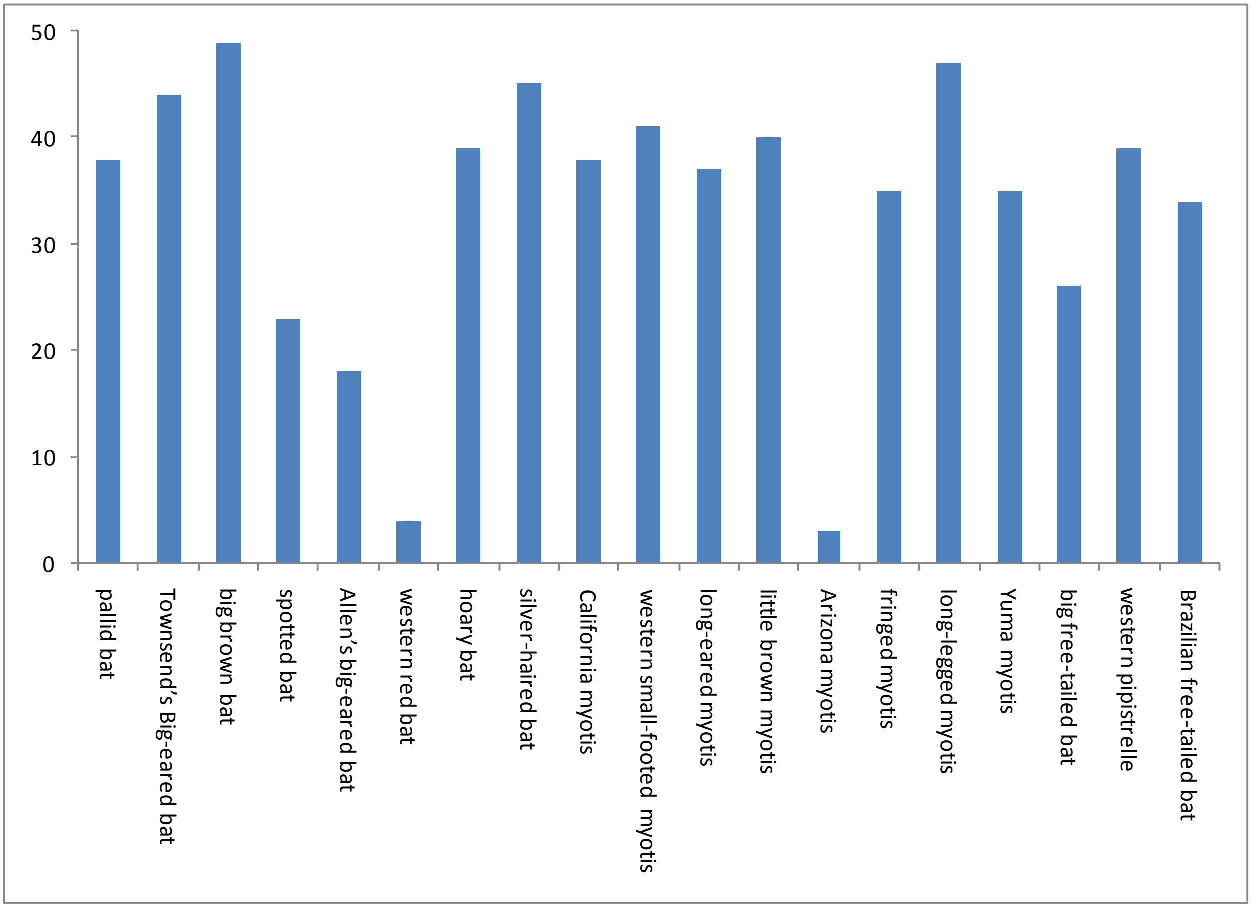

Figure 12. Number of cover types that each of 19 bat species was recorded in, across 61 (SW Re-GAP) land cover types.

Occurrence: Management Scales

Land Owner

Bat species occurrence varied across landowner and landowner varied across species (Fig. 13). Bats were observed in all 12 landowner types. Seven species (pallid bat, Townsend's big-eared bat, hoary bat, silver-haired bat, western small-footed myotis, Yuma myotis, and western pipistrelle) were observed in 12 land owner types. Two species (little brown myotis and Brazilian free-tailed bat) were absent in Tribal and USP, and SL&F, and USFWS, respectively, but occurred in 10 land owner types. Spotted bats were recorded in 6 landowner types (DoD, BLM, NPS, private, SITLA, and USFS). Allen's big-eared bat occurred on 5 types (BLM, NPS, private, SITLA, and USFS). Western red bats and Arizona myotis were only observed on two landowner types (private and UDWR, and BLM and private, respectively). Fringed myotis were detected on 9 landowner types (SL&F, Tribal, and water ownership types were absent). The big free-tailed bat was found on 8 landowner types (SITLA, SL&F, USFWS and water were absent). Only the private landowner type had records for all 19 bat species, BLM had 18 (western red bat was absent), NPS and USFS 17 (western red bat and Arizona myotis were absent), DoD had 16 (Allen's big-eared bat, western red bat, and Arizona myotis were absent).

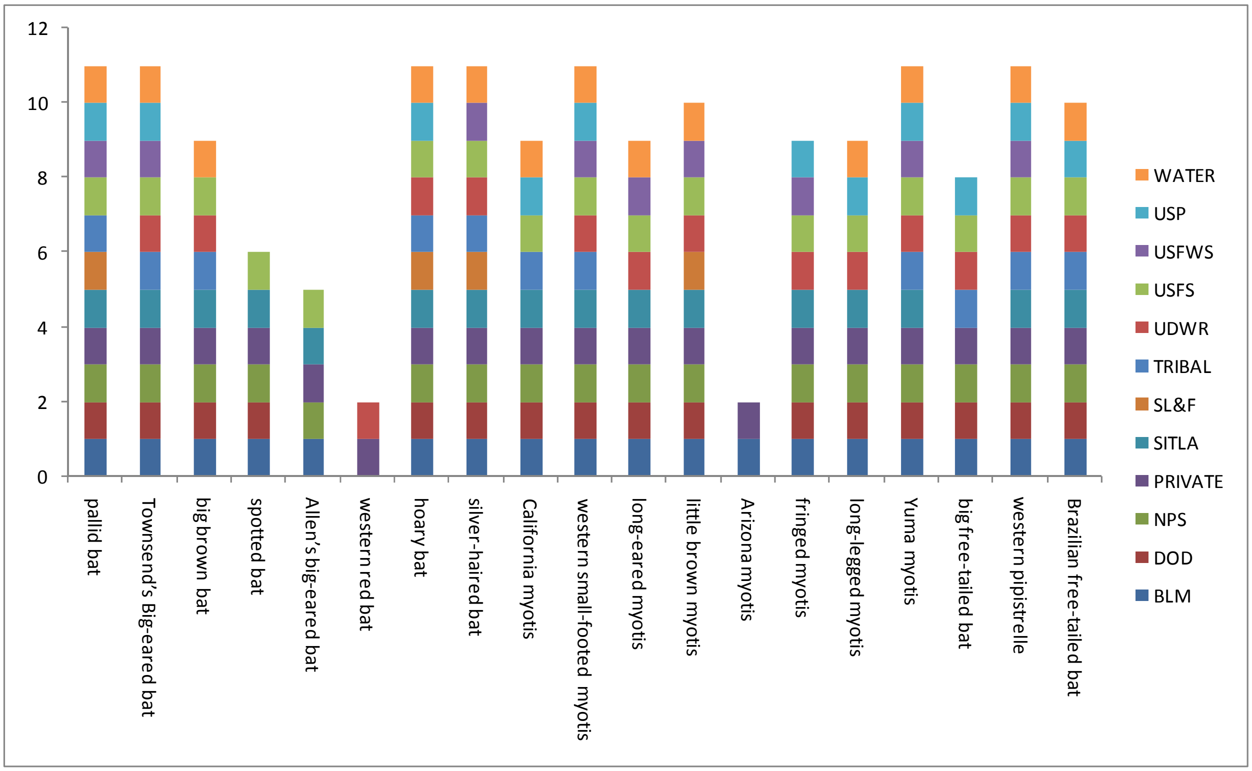

Figure 13. Presence of 19 bat species across 12 land owner types. The lack of a bar for a given landowner type indicates species absence. These data do not measure magnitude, simply presence or absence.

UDWR Regions

Bat species occurrence varied across and within UDWR Regions (Fig. 14). Fourteen species were observed in all five regions (spotted bat, Allen's big-eared bat, western red bat, Arizona myotis and the big free-tailed bat were absent). The spotted bat and big free-tailed bat were observed in all regions except the Northern Region. The western red bat was recorded in four regions, absent in the Northeastern Region. Allen's big-eared bat data were from the Southeastern and Southern Regions only. The Arizona myotis was only detected in the Southern Region. All 19 species occurred in the Southern Region, 17 in the Southeastern and Central regions (Allen's big-eared bat and Arizona myotis were absent), 16 in the Northeastern Region (Allen's big-eared bat, western red bat and Arizona myotis were absent), and 15 in the Northern (spotted bat, Allen's big-eared bat, Arizona myotis and big free-tailed bat were absent).

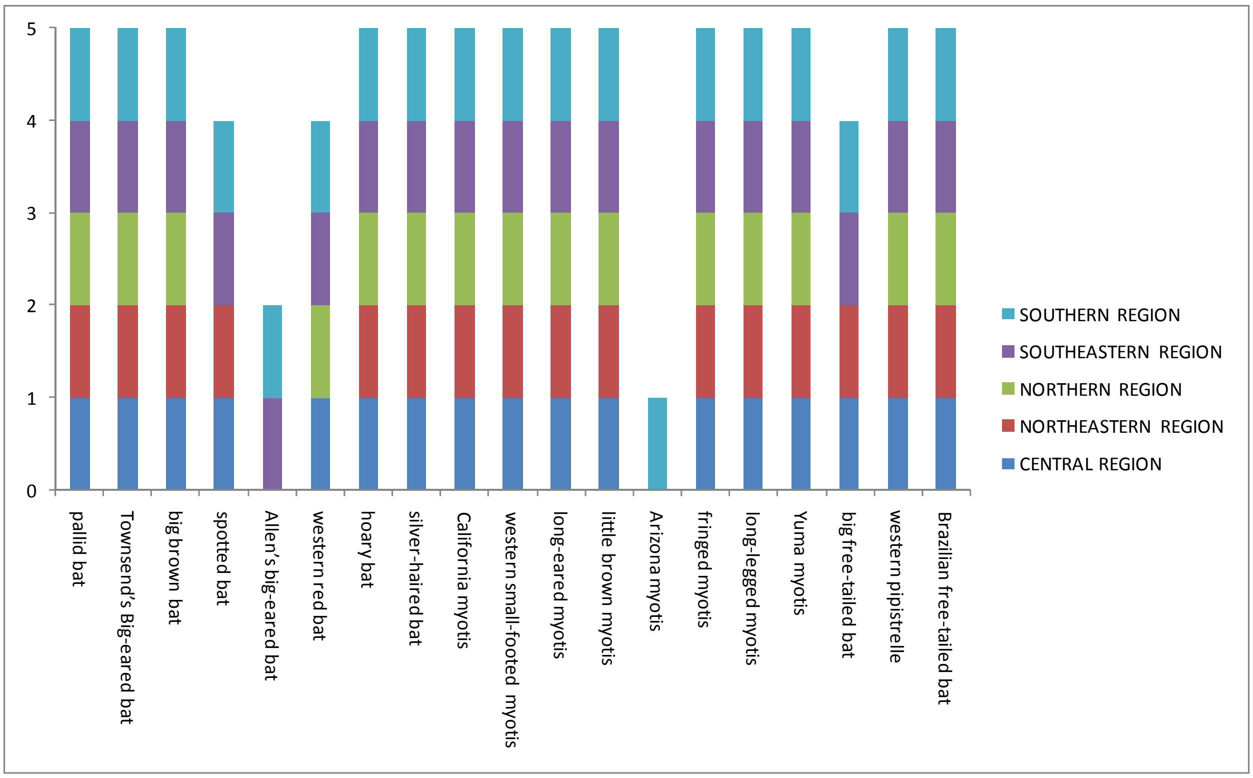

Figure 14. Presence of 19 bat species across the 5 UDWR Regions. The lack of a bar for a given Region indicates species absence. These data do not measure magnitude, simply presence or absence.

County

Bat species occurrence varied across counties and species (Fig. 15). Bats were observed in all of Utah's 29 counties. The long-legged myotis was the only species that occurred in all 29 counties. The silver-haired bat was recorded in 28 counties (Morgan was absent), Townsend's big-eared bats in all counties except Morgan and Rich, fringed myotis in 16, spotted bats 12, big free-tailed bat in 9 counties, Allen's big-eared bat and western red bat 6, and the Arizona myotis in 1. Kane (western red bat was absent), Washington and Wayne (Arizona myotis was absent) counties had 18 species, Garfield, Grand and San Juan had 17 species (western red bat and Arizona myotis were absent), Morgan, Rich and Summit counties only recorded 2, 5 and 4 species, respectively.

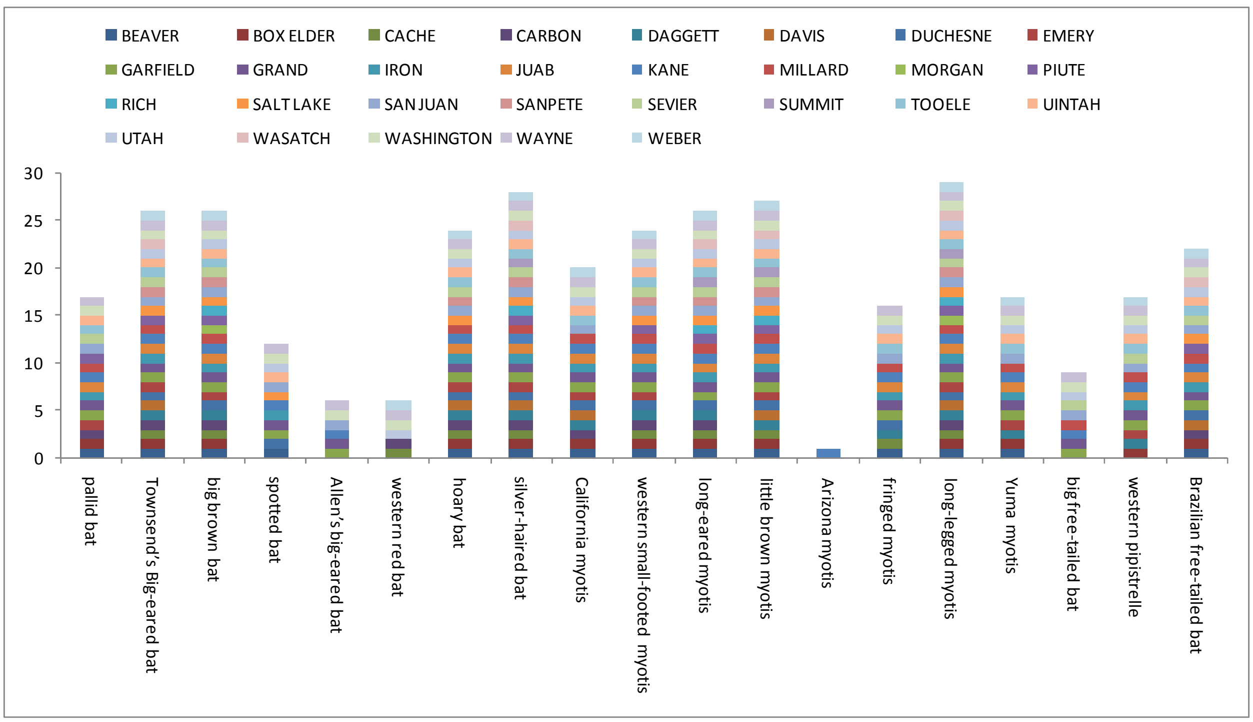

Figure 15. Presence of 19 bat species across 29 Utah counties. The lack of a bar for a given county indicates species absence. These data do not measure magnitude, simply presence or absence.

Ecoregions

Bat species diversity varied both across ecoregions (Fig. 16a-e). The Colorado Plateau accounted for more than 70% of capture events for 9 species (pallid bat, spotted bat, Allen's big-eared bat, western red bat, California myotis, Arizona myotis, fringed myotis, Yuma myotis, big free-tailed bat, and western pipistrelle). Over 35% of all Townsend's big-eared bat and Brazilian free-tailed bat capture events occurred in the Great Basin. Wasatch and Uinta montane forests accounted for over 45% of all events for the hoary bat, silver-haired bat, and little brown myotis. Fourteen species were recorded in the Mojave Desert making up from 11% (Brazilian free-tailed bat) to 0.02% (little brown myotis) of total records for each species. Eight species were observed in the Wyoming Basin shrub steppe, making up from 3 to < 0.001% (little brown myotis and silver-haired bat) of total species observations.

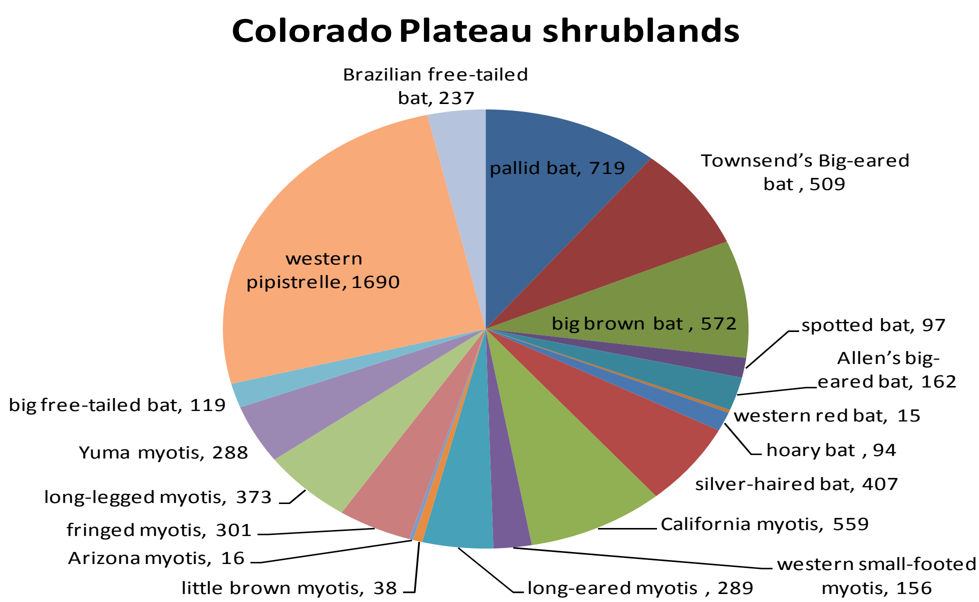

Figure 16a. Bat diversity in the Colorado Plateau shrublands, proportional abundance of 19 bat species.

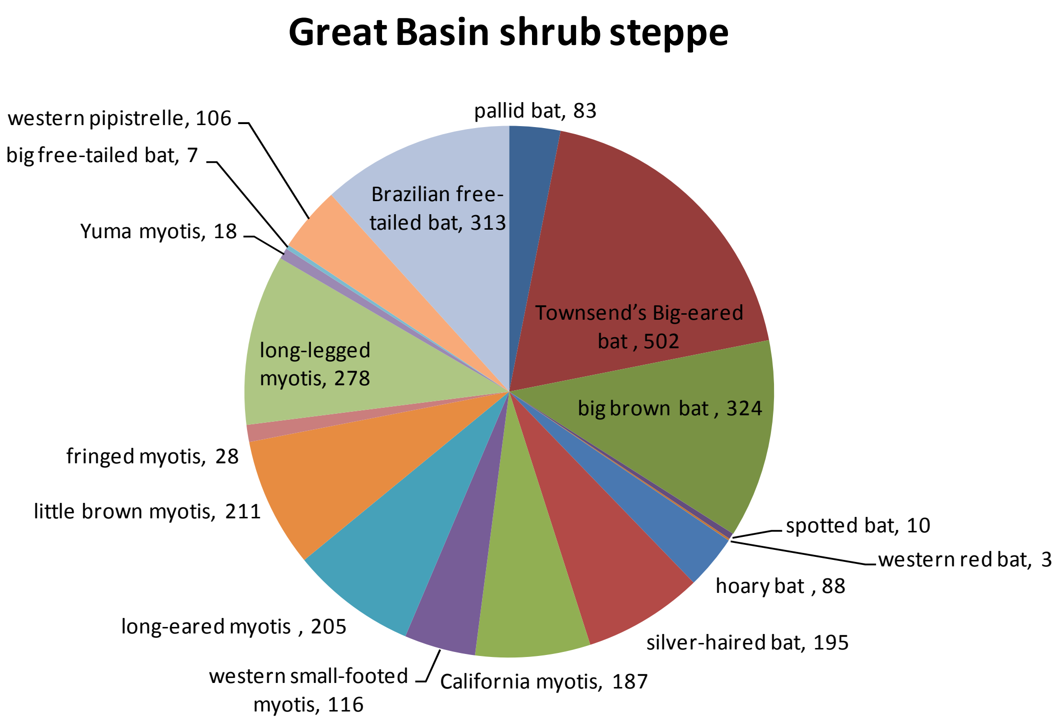

Figure 16b. Bat diversity in the Great Basin shrub steppe, proportional abundance of 19 bat species.

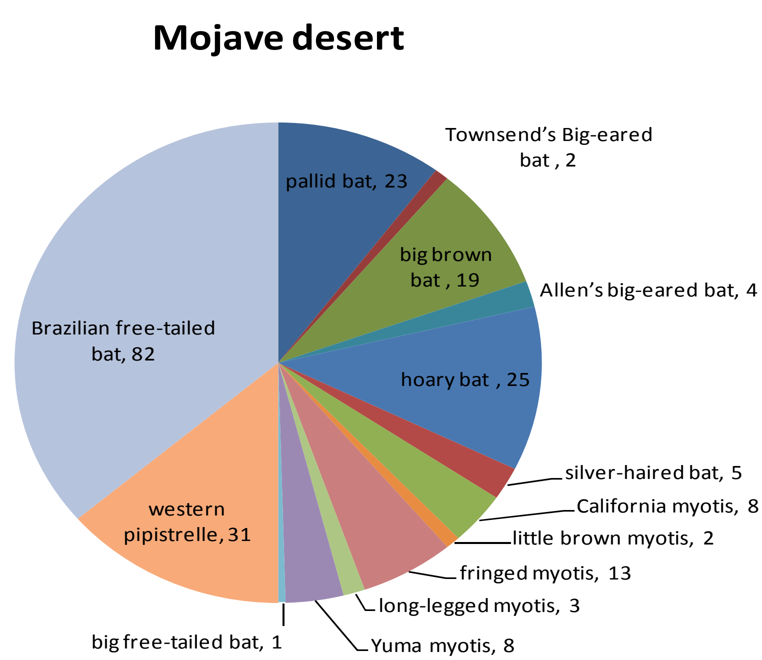

Figure 16c. Bat diversity in the Mojave Desert, proportional abundance of 19 bat species.

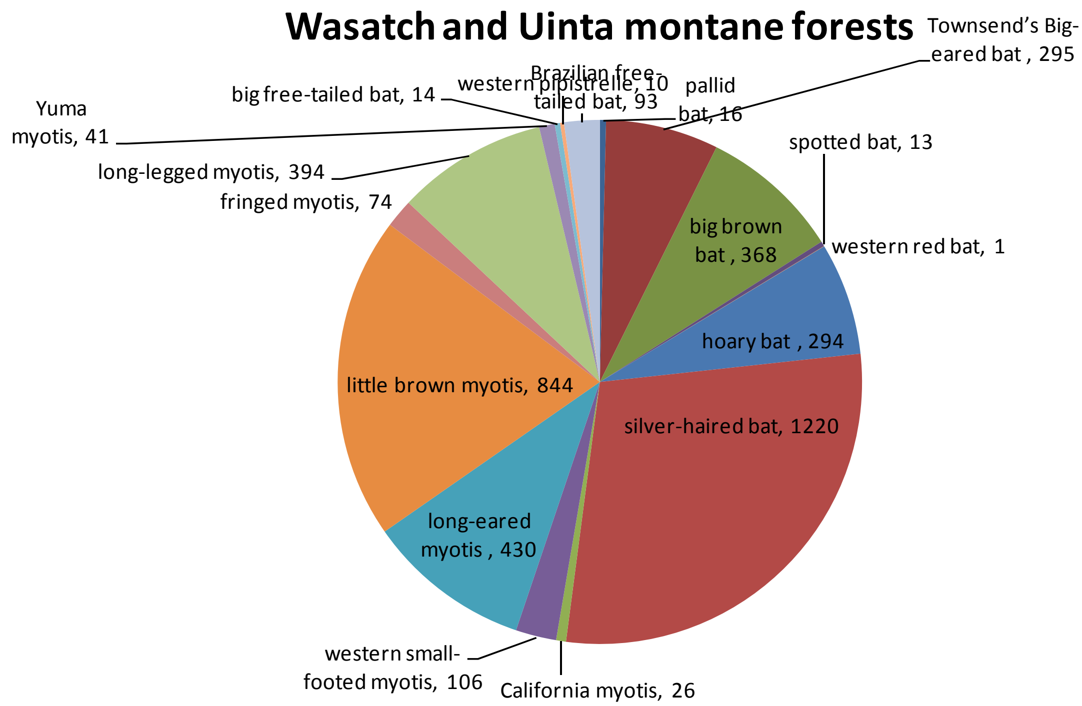

Figure 16d. Bat diversity in the Wasatch and Uinta montane forests, proportional abundance of 19 bat species.

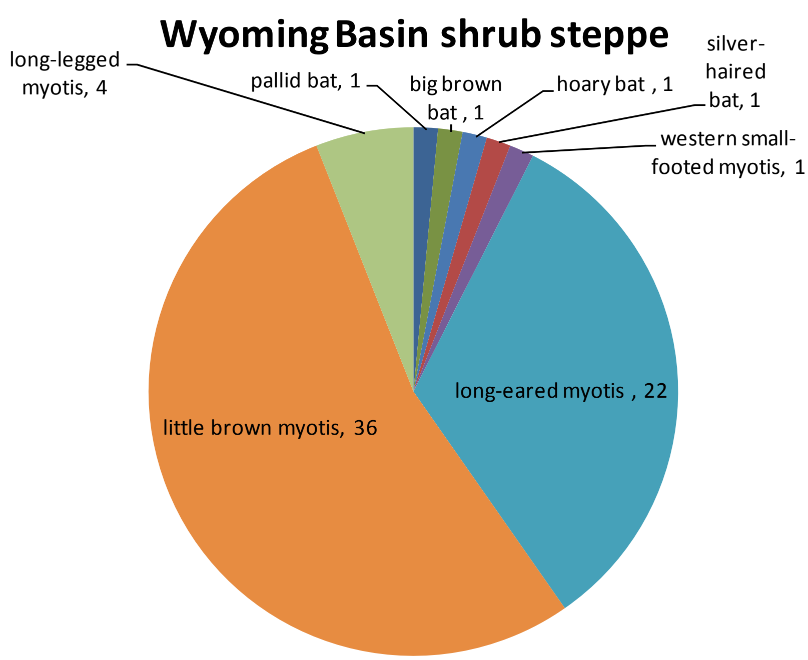

Figure 16e. Bat diversity in the Wasatch and Uinta montane forests, proportional abundance of 19 bat species

Shannon-Wiener Diversity

Diversity indices showed differing species evenness and diversity across ecoregions (Fig. 17). The Colorado Plateau shrublands had the highest diversity based on the index, followed by the Great Basin Shrub steppe, Wasatch and Uinta montane forests, Mojave Desert, and Wyoming Basin.

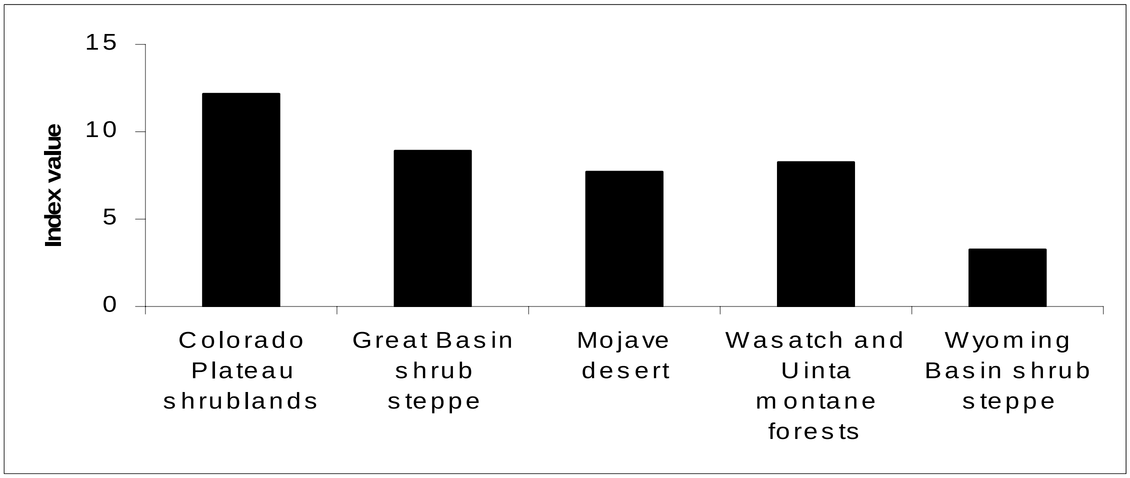

Figure 17. Shannon-Weiner diversity indices, based on the diversity and evenness of species across ecoregions.

Physiographic Provinces

Diversity was variable across Utah's 5 physiographic provinces (Fig. 18a-e). The Colorado Plateau accounted for more than 45% of the capture events for 13 species (pallid bat, big brown bat, spotted bat, Allen's big-eared bat, California myotis, western small-footed myotis, long-eared myotis, Arizona myotis, fringed myotis, long-legged myotis, Yuma myotis, big free-tailed bat and the western pipistrelle). The Basin and Range made up over 50% of observations for three species (Townsend's big-eared bat, western red bat and Brazilian free-tailed bat). The Middle Rocky Mountains accounted for over 40% of the capture events for three species (hoary bat, silver-haired bat and little brown myotis). In the Wyoming Basin, the five species recorded made <0.01% of the total observations for each of these species. The Columbia Plateau had two species recorded; the capture events for each represent <0.01% of species accounts.

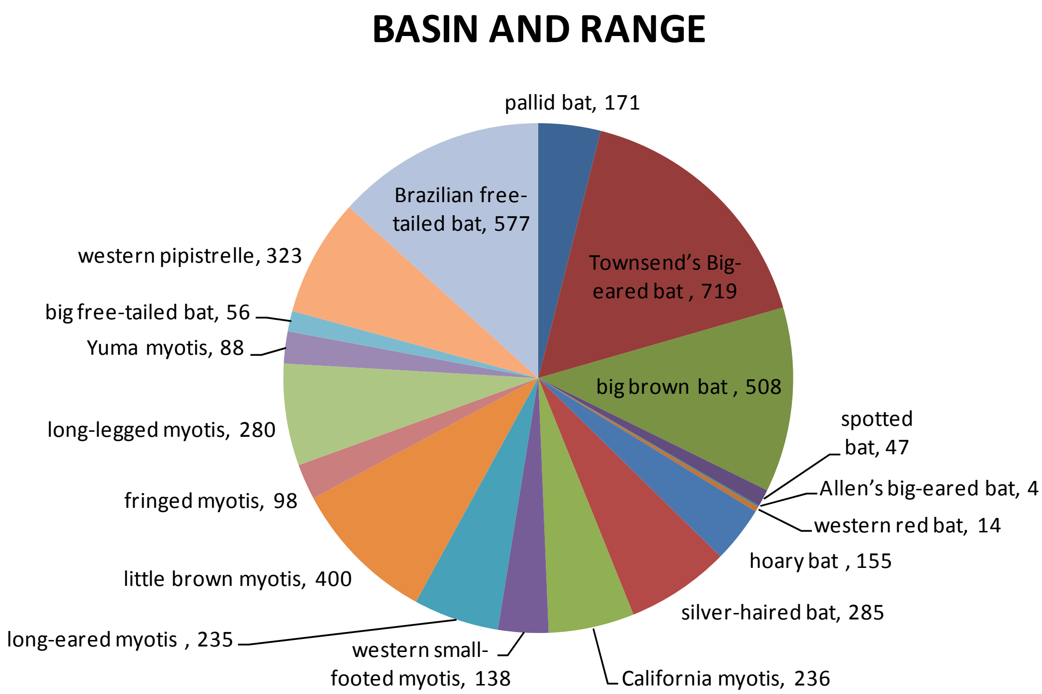

Figure 18a. Bat diversity for the Basin and Range physiographic provinces, proportional bat abundance in Utah.

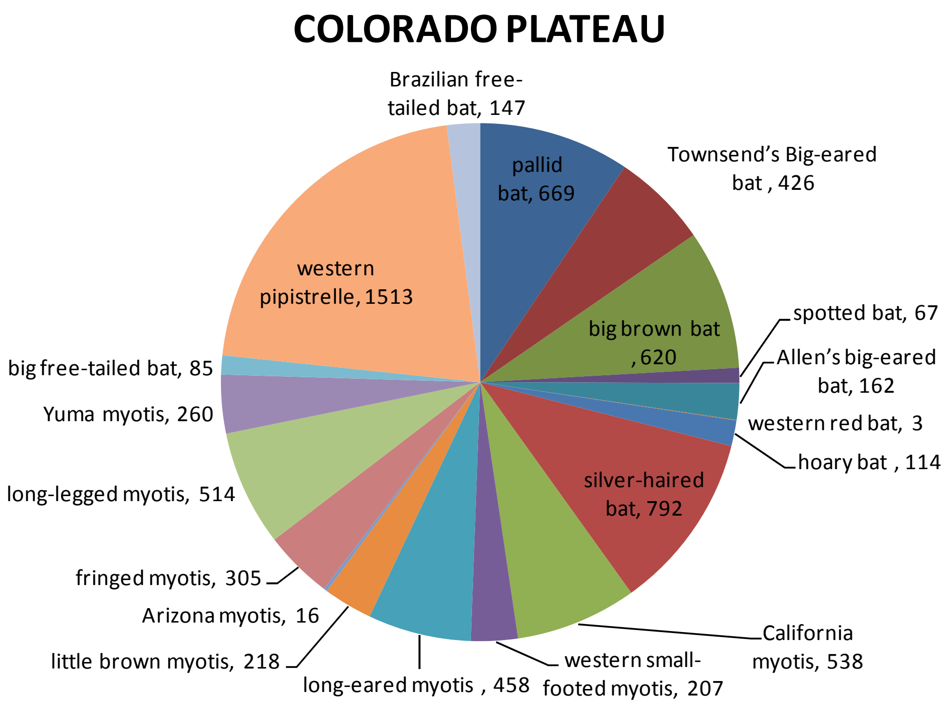

Figure 18b. Bat diversity for the Colorado Plateau physiographic provinces, proportional bat abundance in Utah.

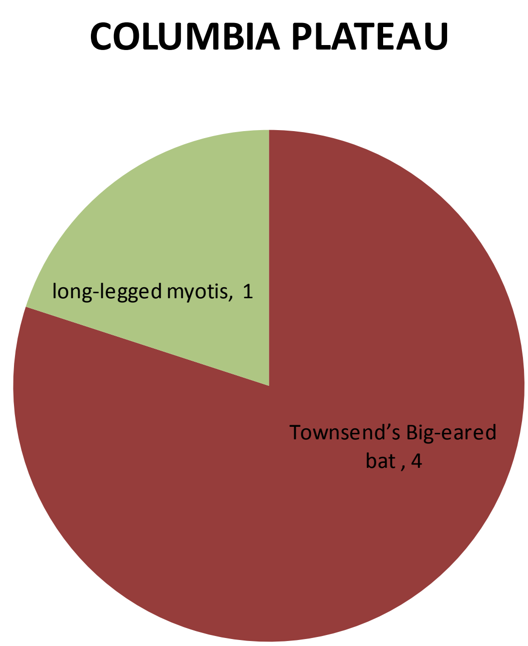

Figure 18c. Bat diversity for the Columbia Plateau physiographic provinces, proportional bat abundance in Utah.

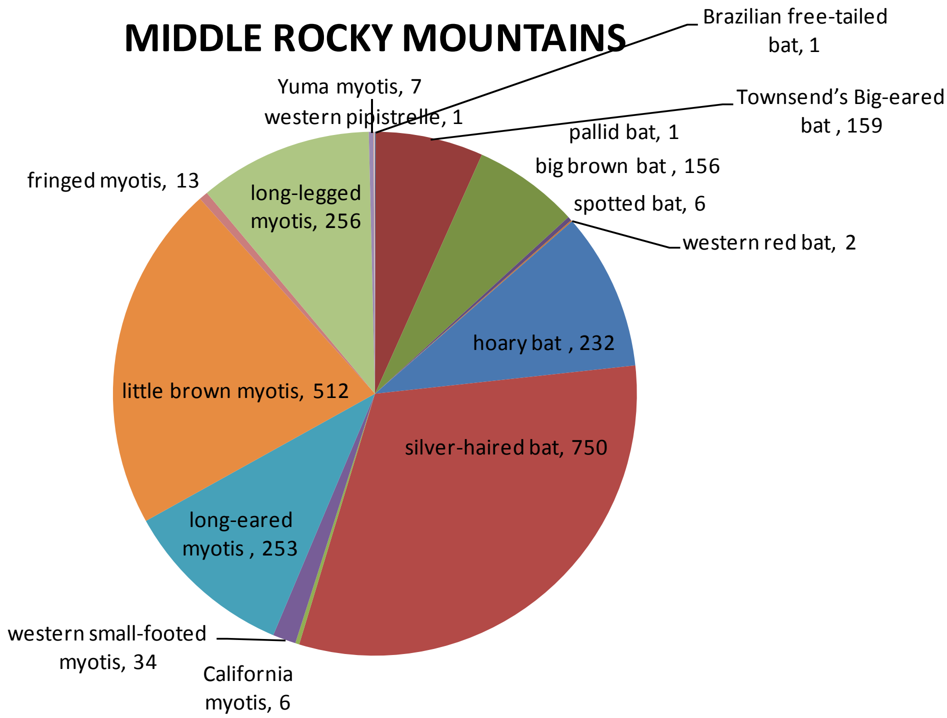

Figure 18d. Bat diversity for the Middle Rocky Mountains physiographic provinces, proportional bat abundance in Utah.

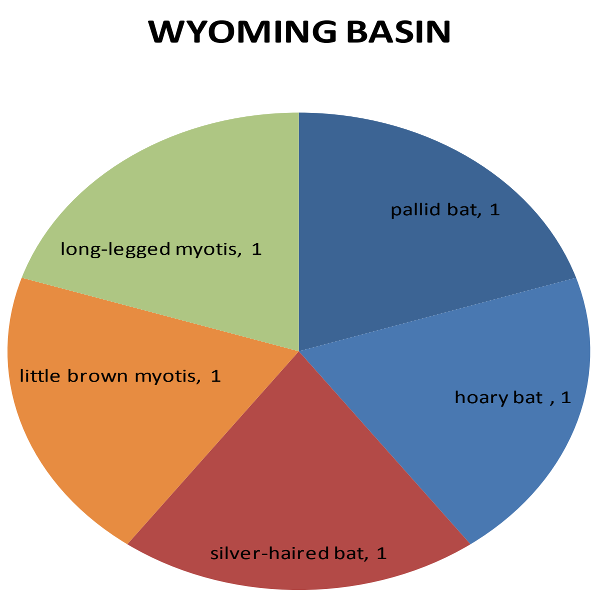

Figure 18e. Bat diversity for the Basin and Range physiographic provinces, proportional bat abundance in Utah.

Shannon-Wiener Diversity

The Shannon-Weiner index showed differences in species diversity and evenness across physiographic provinces (Fig. 19). The Colorado Plateau had the highest diversity followed closely by the Basin and Range, and the Middle Rocky Mountains and Wyoming Basin. The lowest diversity was in the Columbia Plateau.

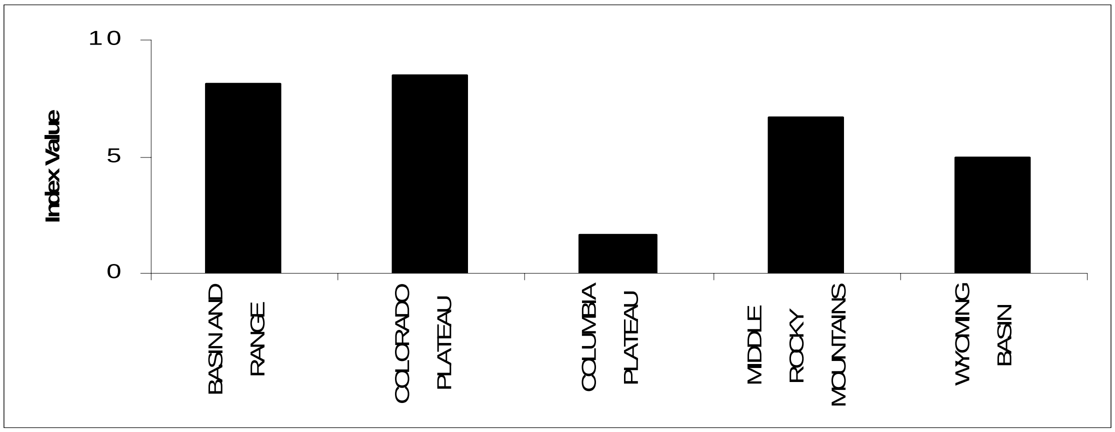

Figure 19. Shannon-Weiner diversity indices, based on the diversity and evenness of species across physiographic provinces.

Land Cover

Bat diversity varied across vegetation types (Fig. 20; Appendix II). Colorado Plateau Mixed Bedrock Canyon and Tableland (9) accounted for more than 5% of total capture events for 15 species (pallid bat, Townsend's big-eared, big brown bat, spotted bat, Allen's big-eared bat, California myotis, western small-footed myotis, long-eared myotis, Arizona myotis, fringed myotis, long-legged myotis, Yuma myotis, big free-tailed bat, western pipistrelle, and Brazilian free-tailed bat). Over 5% of total records for 16 species (Townsend's big-eared bat, big brown bat, spotted bat, Allen's big-eared bat, western red bat, hoary bat, silver-haired bat, western small-footed myotis, long-eared myotis, little brown myotis, Arizona myotis, fringed myotis, long-legged myotis, Yuma myotis, big free-tailed bat, and Brazilian free-tailed bat) were in

Colorado Plateau Pinyon-Juniper Woodlands (36). Developed, Open Space - Low Intensity (111) habitats had 5 species with greater than 5% of their total capture events (big brown bat, spotted bat, western red bat, California myotis, and Brazilian free-tailed bat). Rocky Mountain Lower Montane Riparian Woodland and Shrublands (79) had 9 species (pallid bat, big brown bat, Allen's big-eared bat, hoary bat, silver-haired bat, California myotis, little brown myotis, big free-tailed bat, and western pipistrelle) with more than 5% of their total capture events in this habitat. Over 5% of capture events for 5 species (pallid bat, spotted bat, hoary bat, big free-tailed bat, western pipistrelle, and Brazilian free-tailed bat,) were in Sonora-Mojave Creosotebush-White Bursage Desert Scrub (60). Other vegetation types which accounted for a high percentage of multiple species capture events were Colorado Plateau Blackbrush-Mormon-tea Shrubland (53), Inter-Mountain Basins Montane Sagebrush Steppe (62), and Inter-Mountain Basins Big Sagebrush Shrubland (48). Twenty six vegetation types did not account for over 5% of any one species.

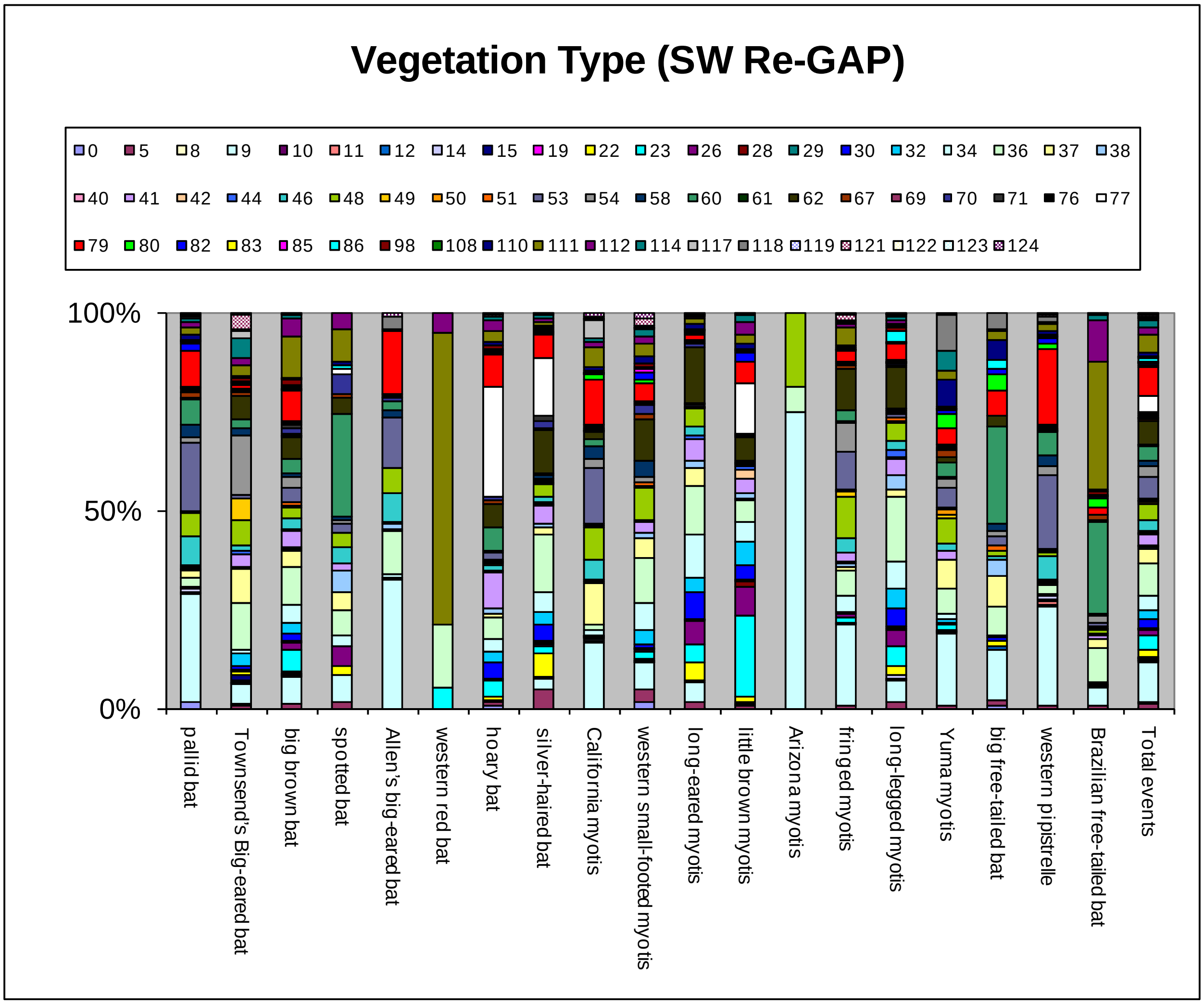

Figure 20. Proportion of total bat inventory events for each of Utah's 19 bat species across 61 SW Re-GAP vegetation types.

Shannon-Wiener Diversity

The Shannon-Weiner index showed differences in species diversity and evenness across community types (Fig. 21). The highest diversity was recorded in Inter-Mountain Basins Big Sagebrush Shrubland (48) followed by; North American Arid West Emergent Marsh (85), Open Water (110), Colorado Plateau Pinyon-Juniper Woodland (36), Great Basin Pinyon-Juniper Woodland (37), Mogollon Chaparral (51) and Inter-Mountain Basins Semi-Desert Shrub Steppe (67). The lowest diversity was in the Inter-Mountain Basins Cliff and Canyon (8), North

American Warm Desert Wash (19), Sonora-Mojave Mixed Salt Desert Scrub (61), Rocky Mountain Dry Tundra (69) and Invasive Annual and Biennial Forbland (122).

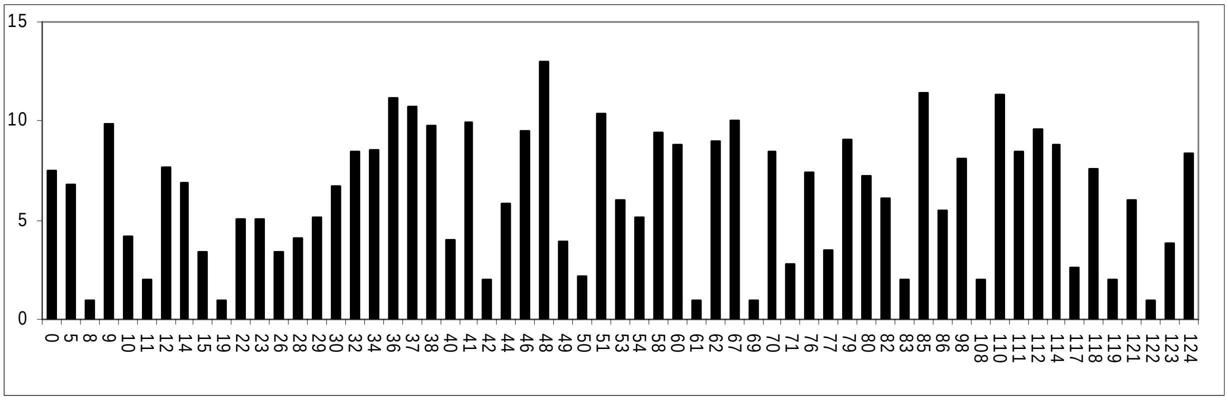

Figure 21. Shannon-Weiner diversity index, based on the diversity and evenness of species across 61 cover types.

Diversity: Management Scales

Land Owner

Bat species diversity varied across and within land owner types (Fig. 22a-l). DoD managed lands accounted for over 10% of total records for 5 species (Townsend's big-eared bat, California myotis, western small-footed myotis, little brown myotis, and Brazilian free-tailed bat). Twenty percent of total records for 12 species (pallid bat, Townsend's big-eared bat, spotted bat, Allen's big-eared bat, California myotis, Arizona myotis, fringed myotis, long-legged myotis, Yuma myotis, big free-tailed bat, western pipistrelle, and Brazilian free-tailed bat were on BLM managed lands. Private lands accounted for more than 20% of total capture events for 9 species (Townsend's big-eared bat, big brown bat, spotted bat, western red bat, hoary bat, silver-haired bat, little brown bat, Arizona myotis, and Brazilian free-tailed bat). USFS managed lands accounted for over 20% of total records for 8 species (big brown bat, spotted bat, hoary bat, silver-haired bat, western small-footed myotis, long-eared myotis, little brown myotis, and long-legged myotis). NPS administered lands accounted for more than 20% of the total data set for 6 species (pallid bat, Allen's big-eared bat, California myotis, fringed myotis, Yuma myotis, and western pipistrelle). Land s administered by USFWS, USP, STILA, SL&F, Tribal, UDWR, and open water did not account for over 10% of records for any one species.

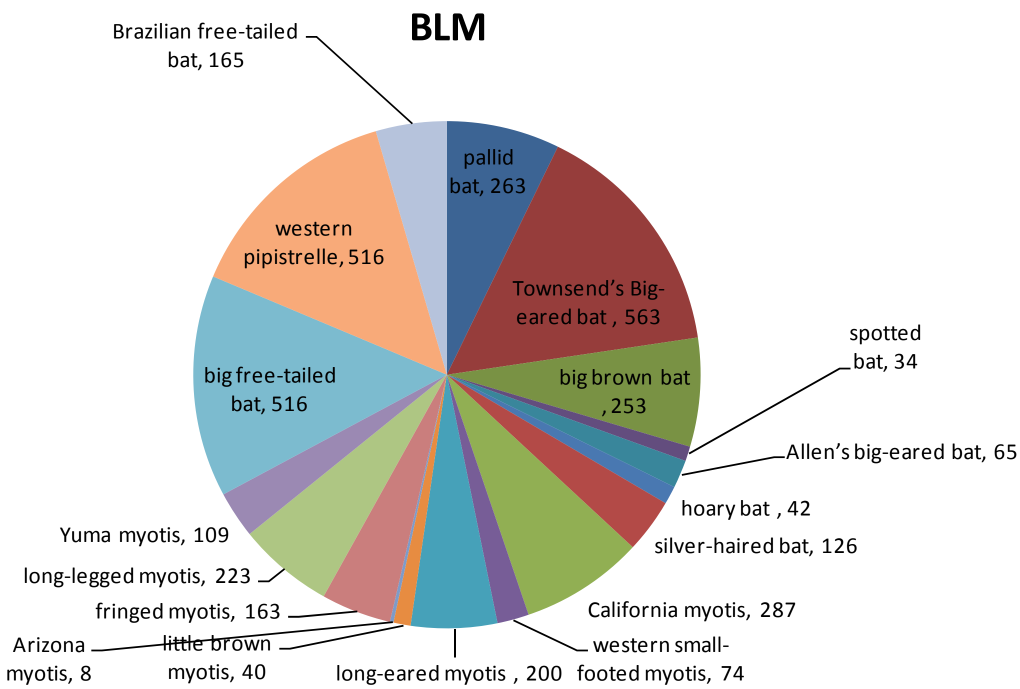

Figure 22a. Proportion of total bat inventory events for each of Utah's 19 bat species on the BLM landowner type.

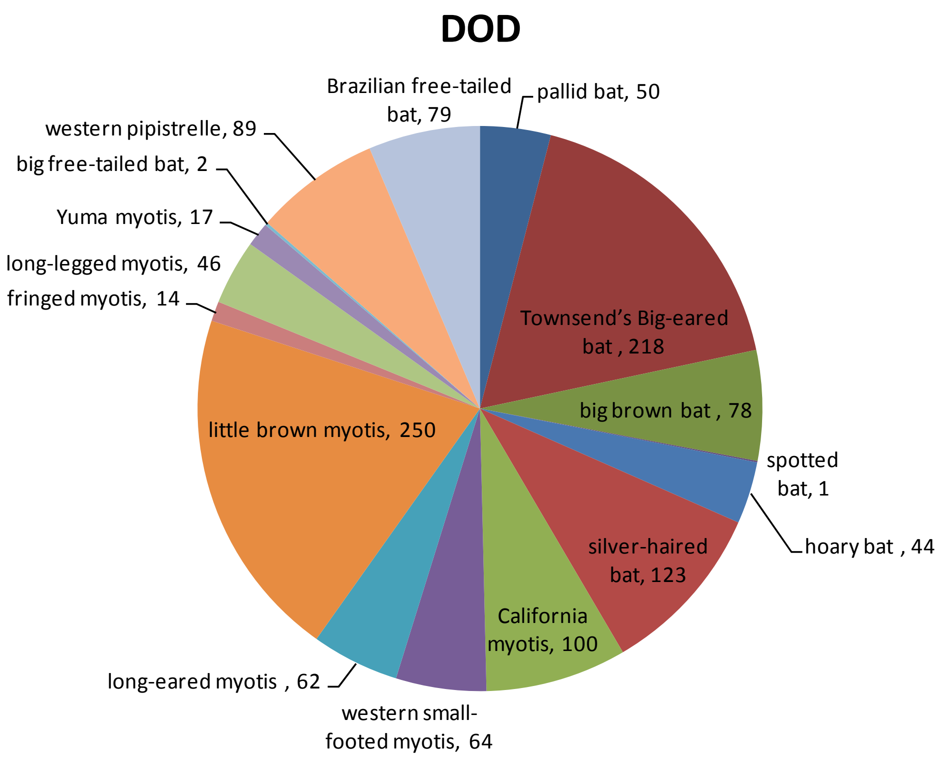

Figure 22b. Proportion of total bat inventory events for each of Utah's 19 bat species on the DoD landowner type.

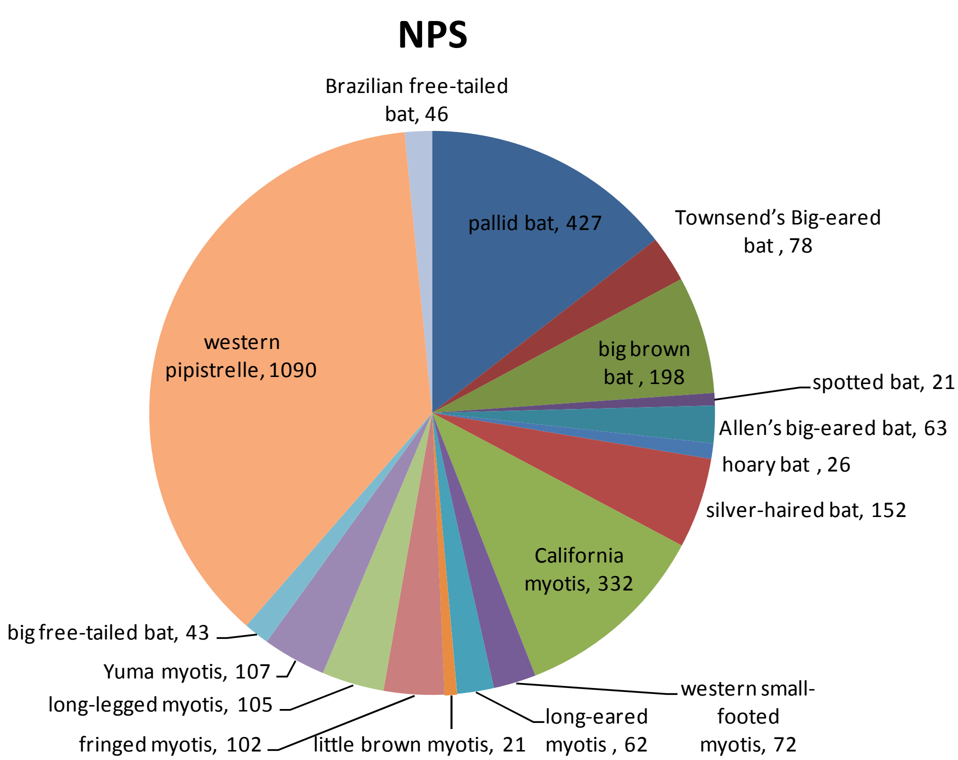

Figure 22c. Proportion of total bat inventory events for each of Utah's 19 bat species on the NPS landowner type.

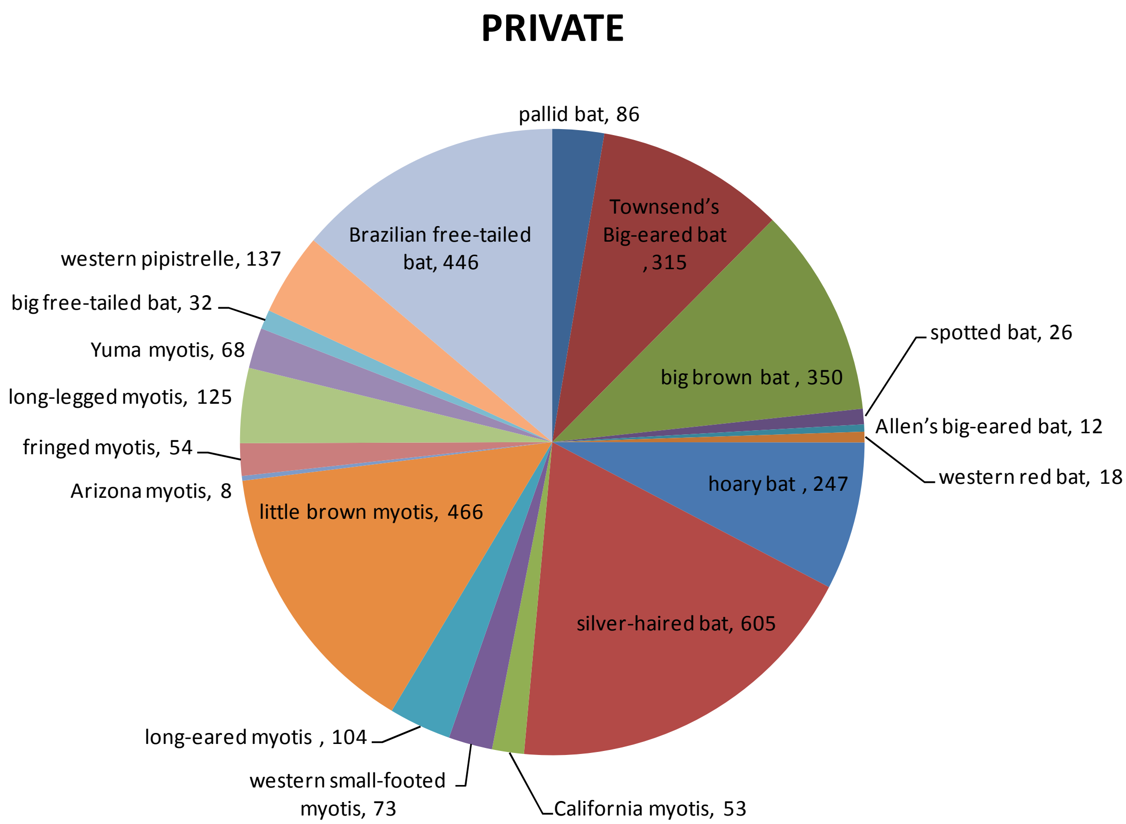

Figure 22d. Proportion of total bat inventory events for each of Utah's 19 bat species on the Private landowner type.

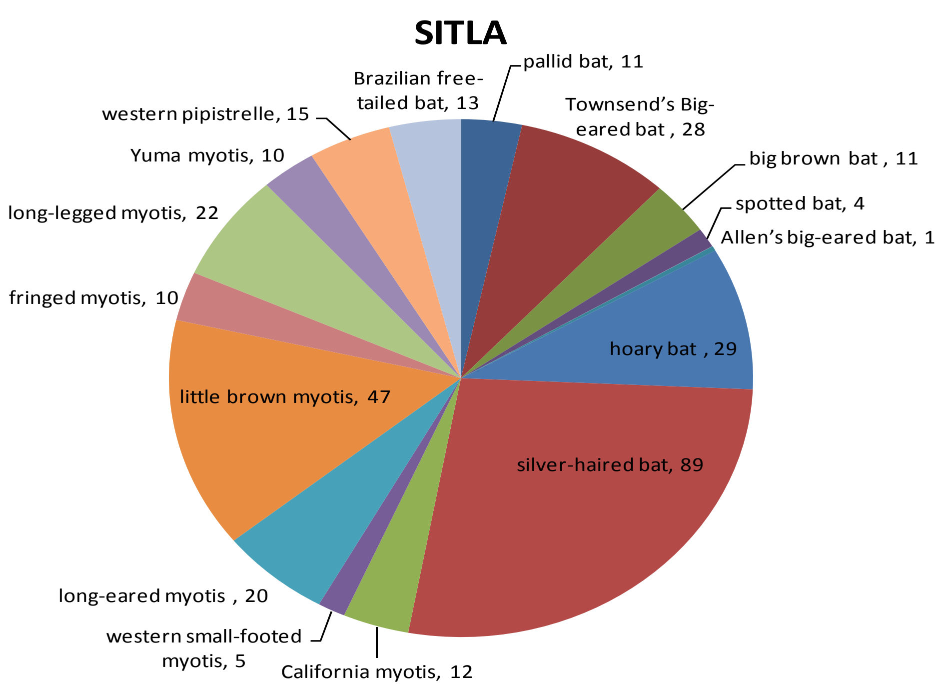

Figure 22e. Proportion of total bat inventory events for each of Utah's 19 bat species on the SITLA landowner type.

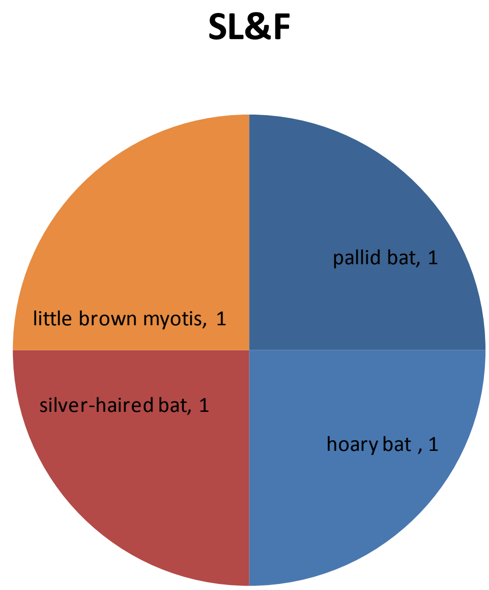

Figure 22f. Proportion of total bat inventory events for each of Utah's 19 bat species on the SL&F

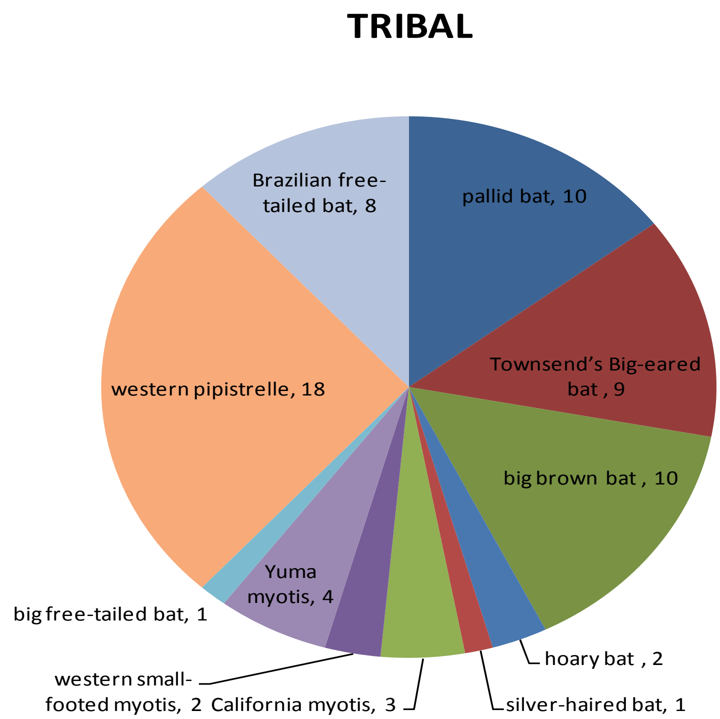

Figure 22g. Proportion of total bat inventory events for each of Utah's 19 bat species for Tribal Lands.

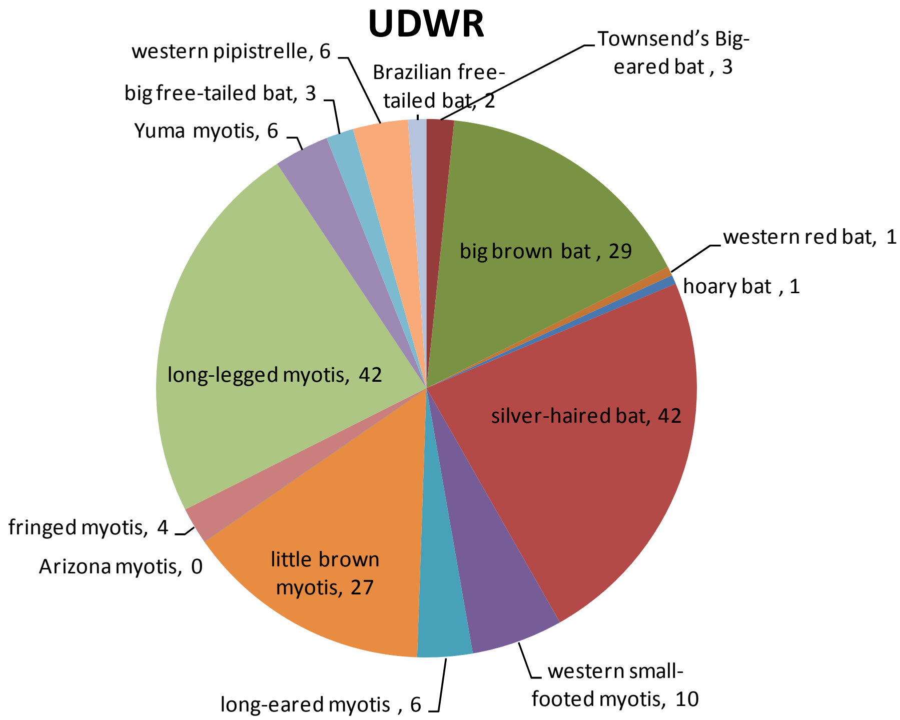

Figure 22h. Proportion of total bat inventory events for each of Utah's 19 bat species on the UDWR landowner type.

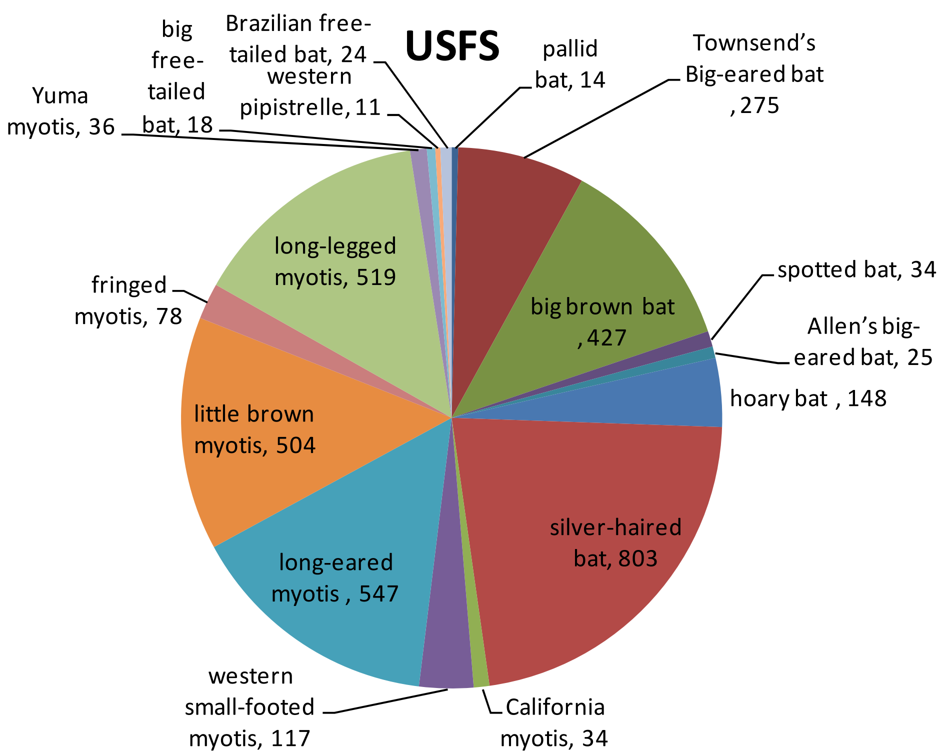

Figure 22i. Proportion of total bat inventory events for each of Utah's 19 bat species on the USFS landowner type.

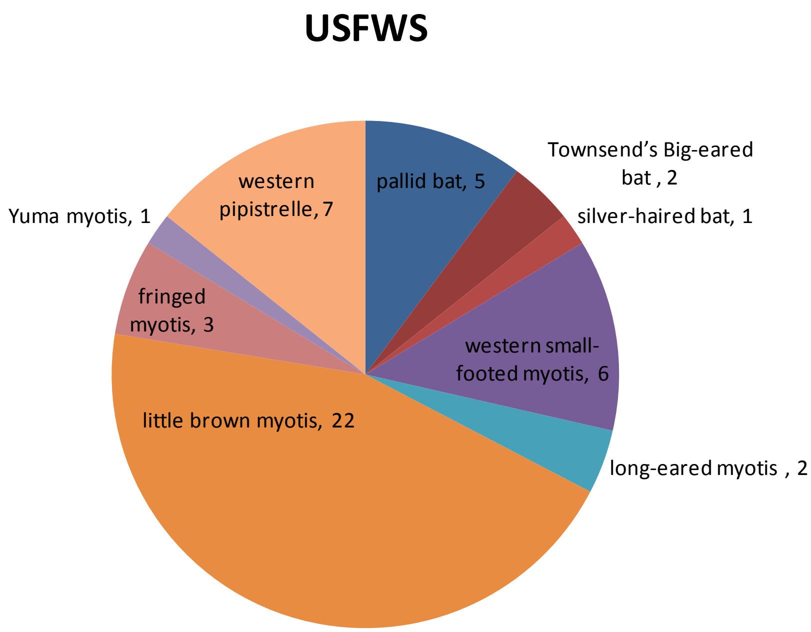

Figure 22j. Proportion of total bat inventory events for each of Utah's 19 bat species on the USFWS landowner type.

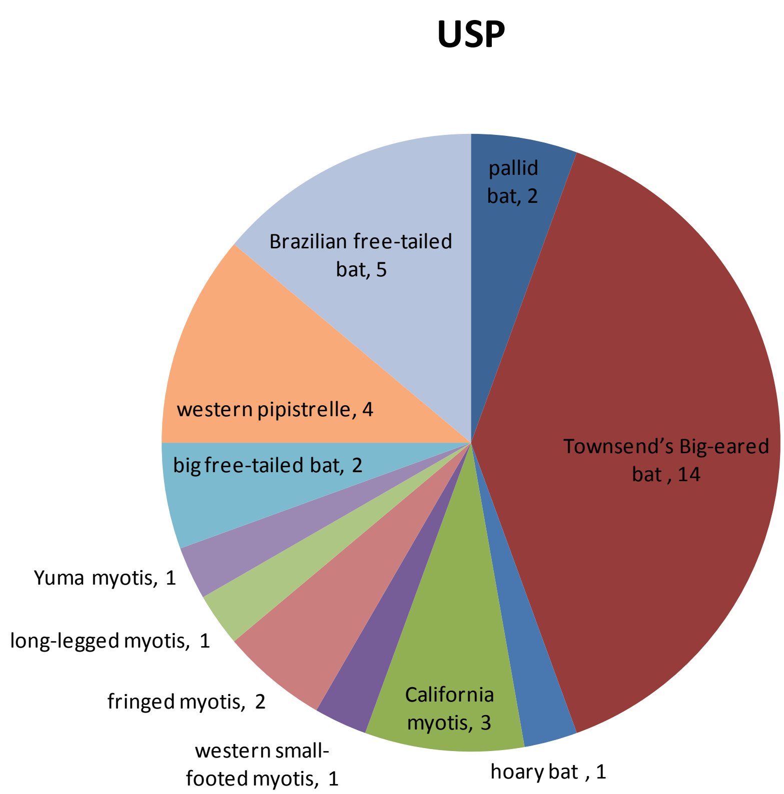

Figure 22k. Proportion of total bat inventory events for each of Utah's 19 bat species on the USP landowner type.

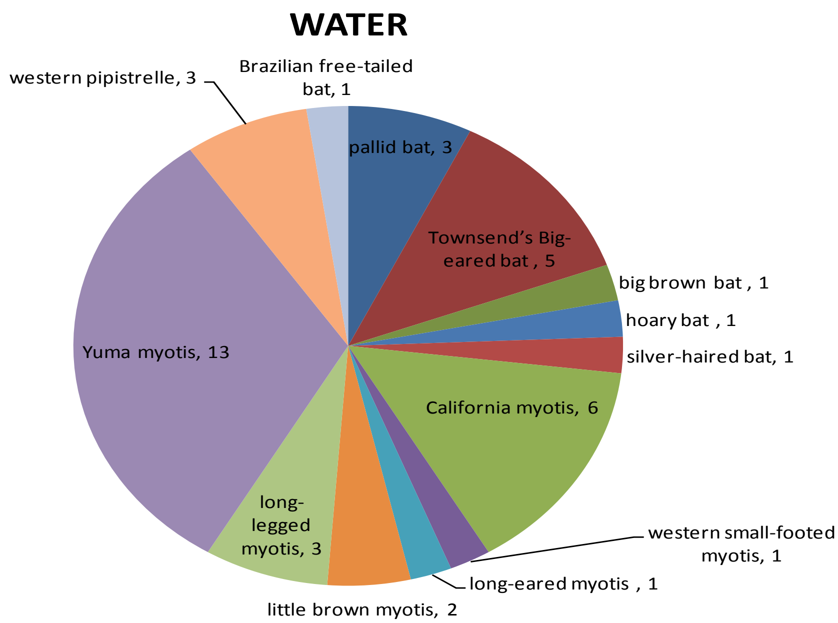

Figure 22l. Proportion of total bat inventory events for each of Utah's 19 bat species on the Water landowner type.

Shannon-Wiener Diversity

An index of diversity showed differences in species diversity and evenness across landowner types (Fig. 23). BLM managed lands had the highest diversity index value, followed by private, DoD, STILA, USFS, NPS, open water, UDWR, Tribal, USP, USFWS, and SL&F.

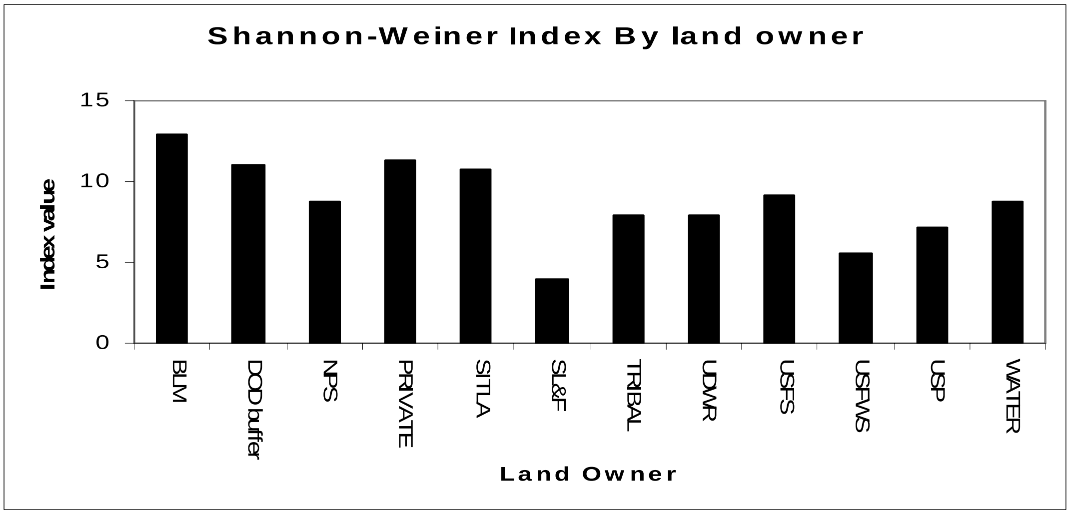

Figure 23. Shannon-Weiner diversity indices, based on the diversity and evenness of species across land owner types.

UDWR Regions

Bat species diversity varied within and across UDWR Regions (Fig. 24a-e). The Southern Region accounted for more than 50% of the total data for 9 species (Townsend's big-eared bat, big brown bat, spotted bat, western red bat, Arizona myotis, fringed myotis, Yuma myotis, big free-tailed bat, and Brazilian free-tailed bat). The Southeastern Region accounted for more than 50% of total bat capture events for 2 species (Allen's big-eared bat and western pipistrelle). Sixty-three percent of little brown bat capture events were in the Northern Region (Fig. 24c). Data within the Northeastern Region accounted for over 10% of events for 3 species (western small-footed myotis, long-eared myotis, and long-legged myotis) (Fig. 24d). The Central Region accounted for over 10% of events for 10 species (Townsend's big-eared bat, big brown bat, western red bat, hoary bat, silver-haired bat, California myotis, western small-footed myotis, long-eared myotis, little brown myotis, long-legged myotis, and Brazilian free-tailed bat) (Fig. 24e).

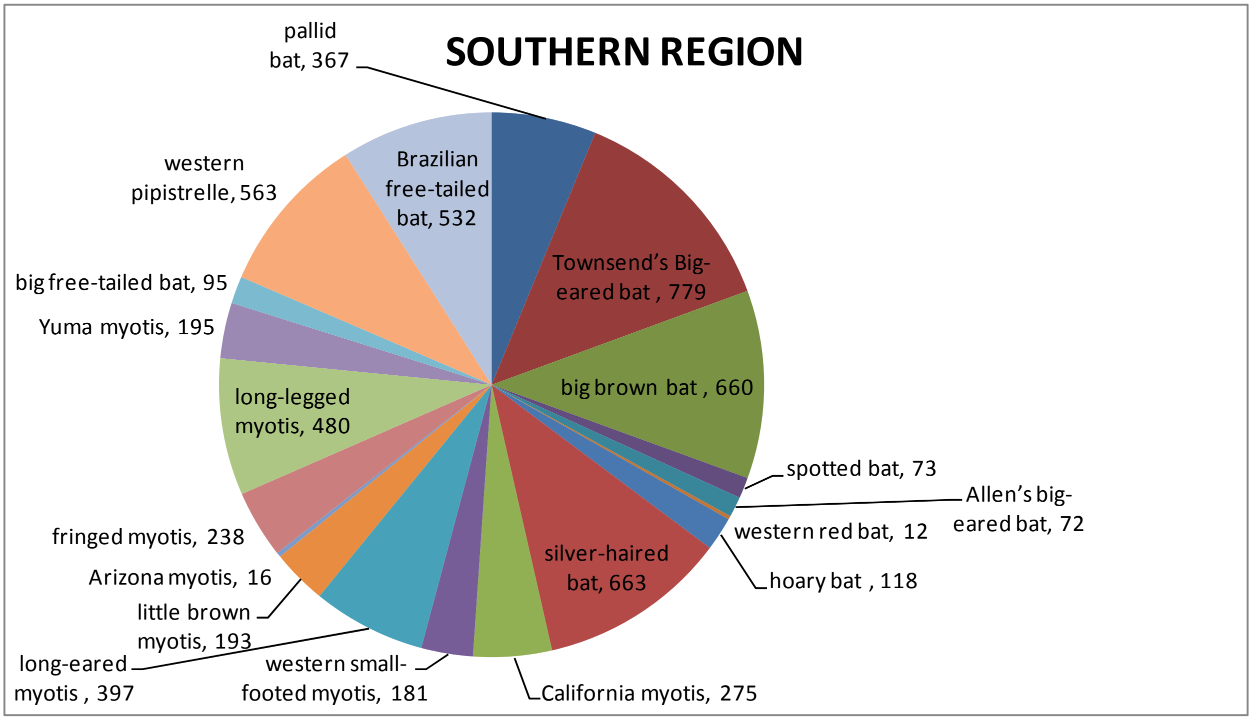

Figure 24a. Proportion of total bat inventory events for each of Utah's 19 bat species within the Southern UDWR region.

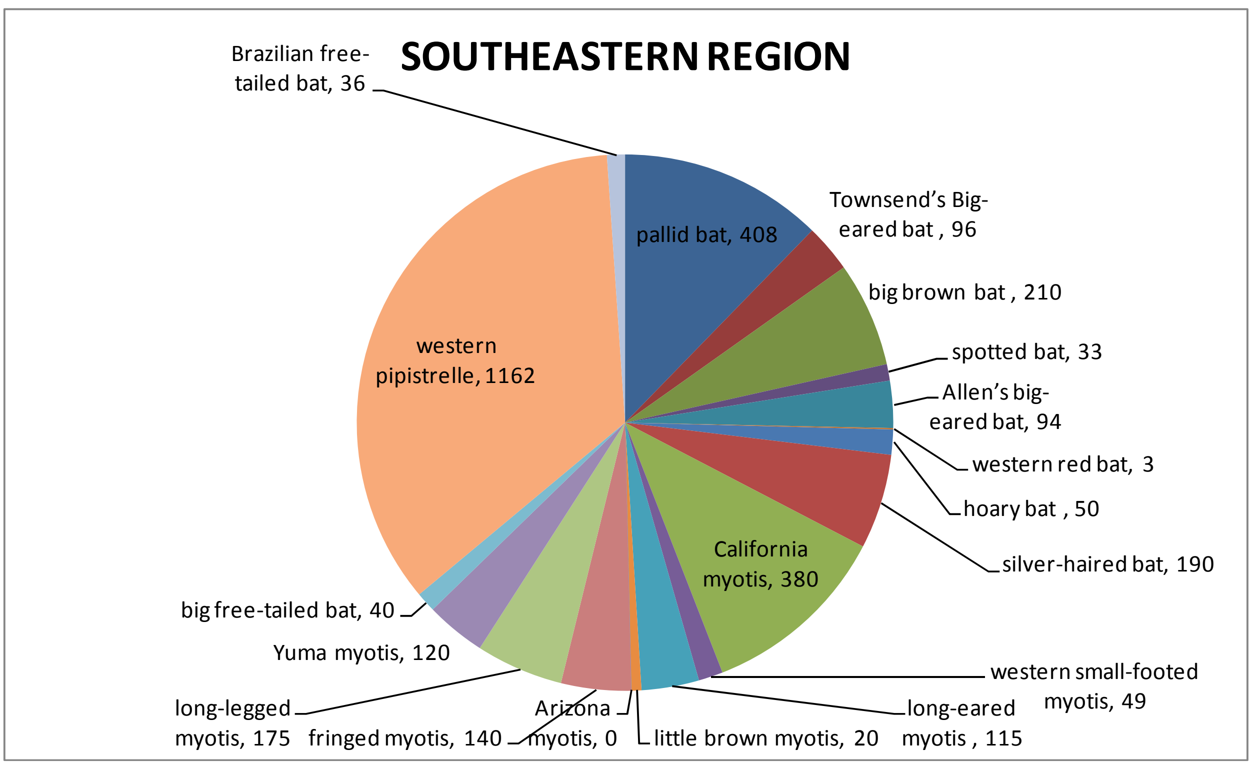

Figure 24b. Proportion of total bat inventory events for each of Utah's 19 bat species within the Southeastern UDWR region.

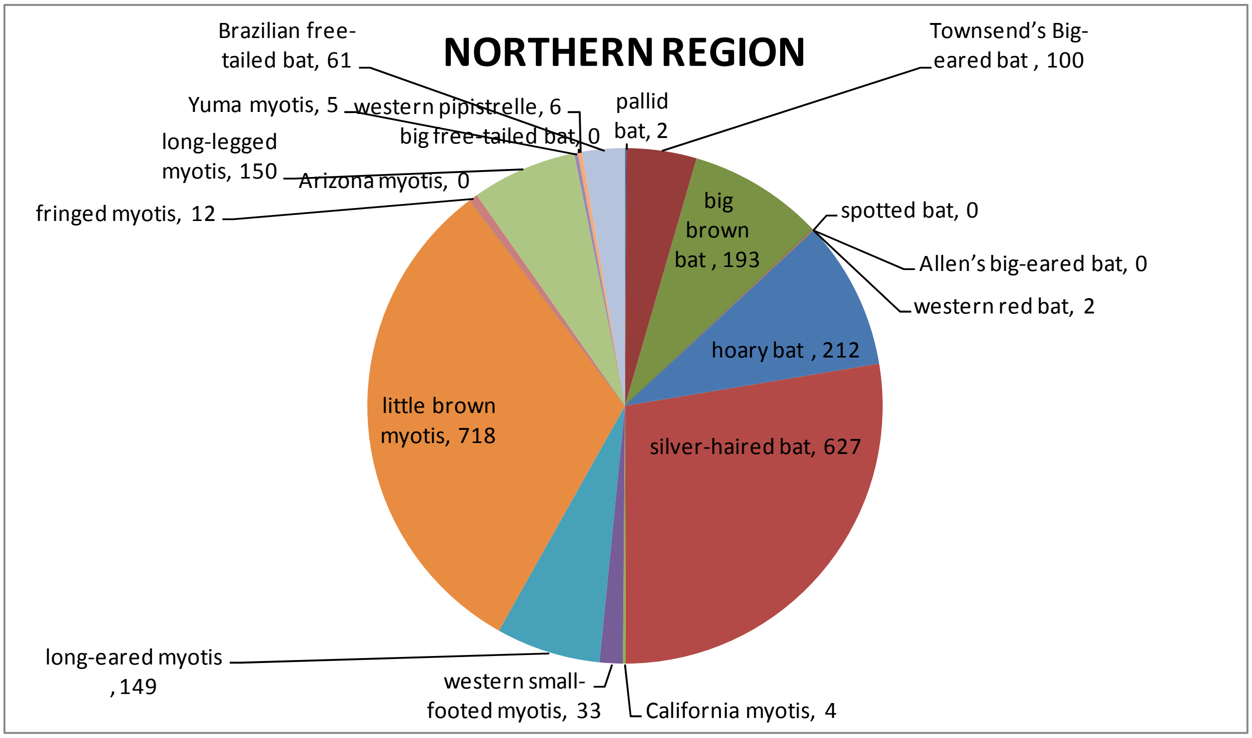

Figure 24c. Proportion of total bat inventory events for each of Utah's 19 bat species within the Northern UDWR region.

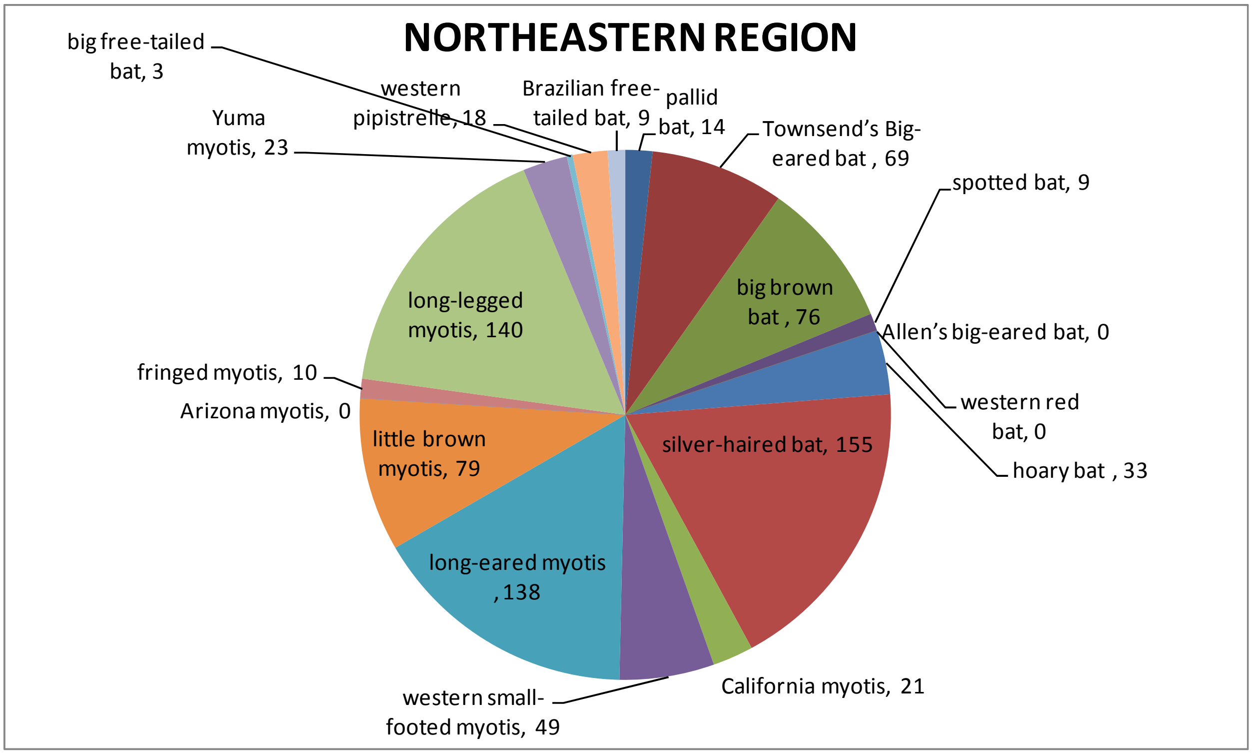

Figure 24d. Proportion of total bat inventory events for each of Utah's 19 bat species within the Northeastern UDWR region.

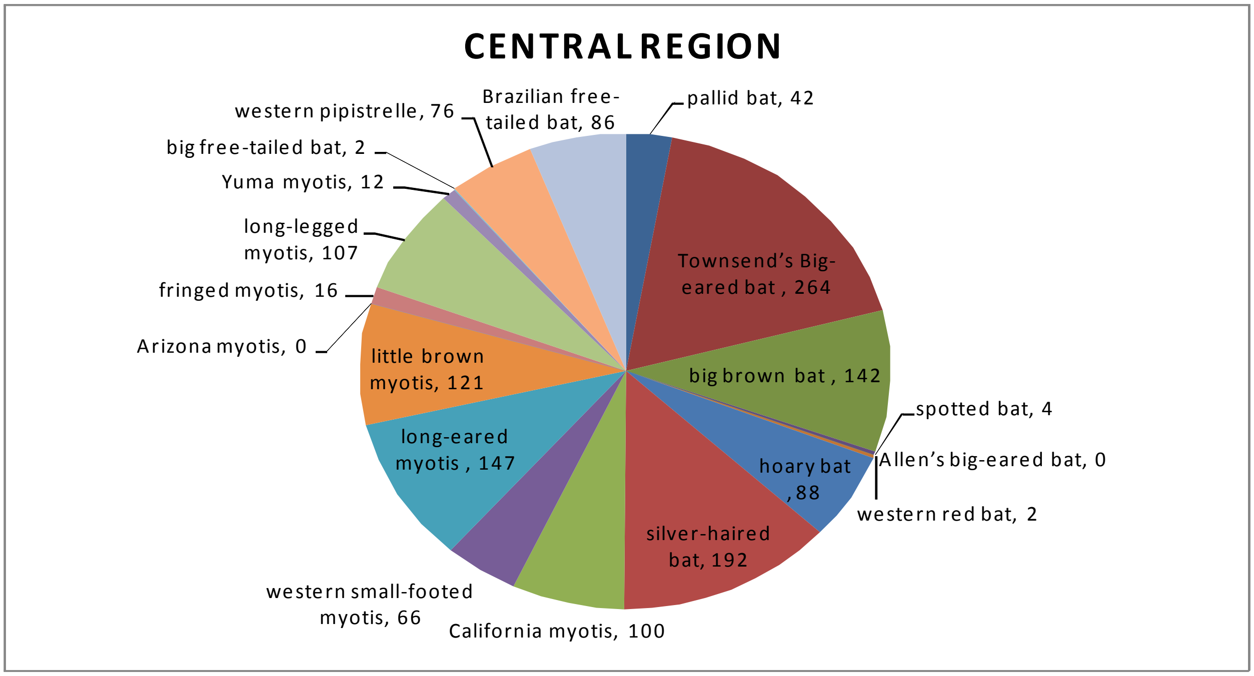

Figure 24e. Proportion of total bat inventory events for each of Utah's 19 bat species within the Central UDWR.

Shannon-Wiener Diversity

An index of diversity showed differences in species diversity and evenness across UDWR Regions (Fig. 25). The Southern Region had the highest diversity score, followed by the Central, Northeastern, Southeastern and Northern Regions.

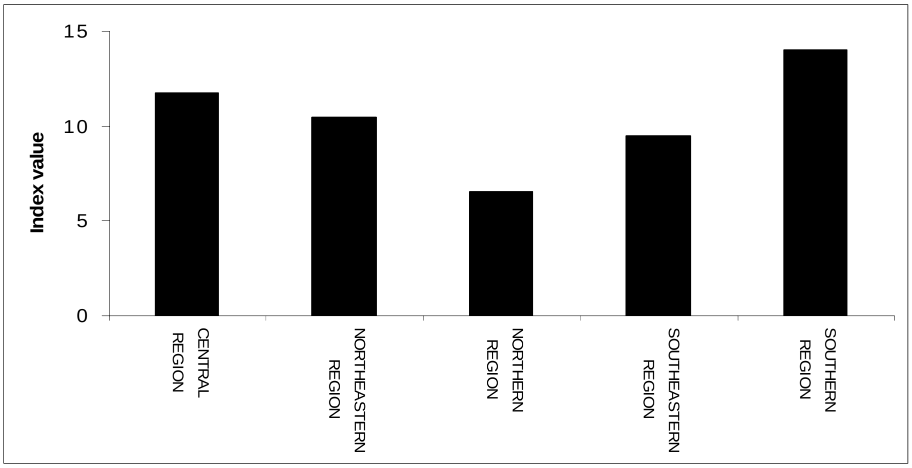

Figure 25. Shannon-Weiner diversity indices, based on the diversity and evenness of species across UDWR Regions.

County

Bat species diversity varied within and across Utah's 29 counties (Fig. 26a-s). Washington County accounts for over 10% of total data for 9 species (pallid bat, Townsend's big-eared bat, big brown bat, spotted bat, western red, fringed myotis, Yuma myotis, big free-tailed bat, western pipistrelle, and Brazilian free-tailed bat). San Juan County contained over 10% of the total data for 8 species (pallid bat, big brown bat, spotted bat, Allen's big-eared bat, California myotis, fringed myotis, Yuma myotis, and western pipistrelle). Kane County accounted for over 10% of the total data for 7 species (Pallid bat, big brown bat, Allen's big-eared bat, long-eared myotis, Arizona myotis, fringed myotis, and Yuma myotis). Garfield county recorded over 10% of the total data for 9 species (big brown bat, Allen's big-eared bat, California myotis, western small-footed myotis, long-eared myotis, fringed myotis, long-legged myotis, Yuma myotis, and big free-tailed bat). Cache County accounted for over 10% of the total data set for 6 species (big brown bat, hoary bat, silver-haired bat, long-eared myotis, little brown myotis, and long-legged myotis). Millard County accounted for over 10% of the total data set for 3 species (California myotis, long-eared myotis, and Brazilian free-tailed bat). Emery, Morgan, Rich, Summit and Wasatch Counties did not account for over 5% of any species data.

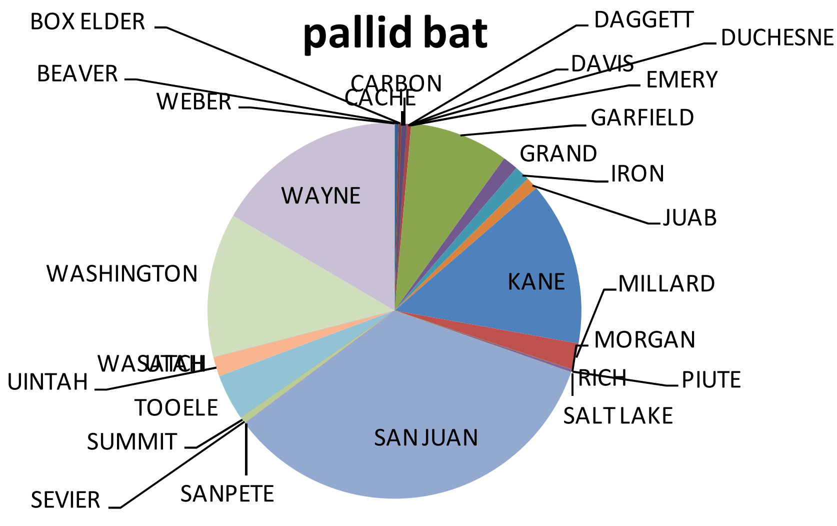

Figure 26a. Proportion of pallid bat events for each of Utah's 29 Utah counties.

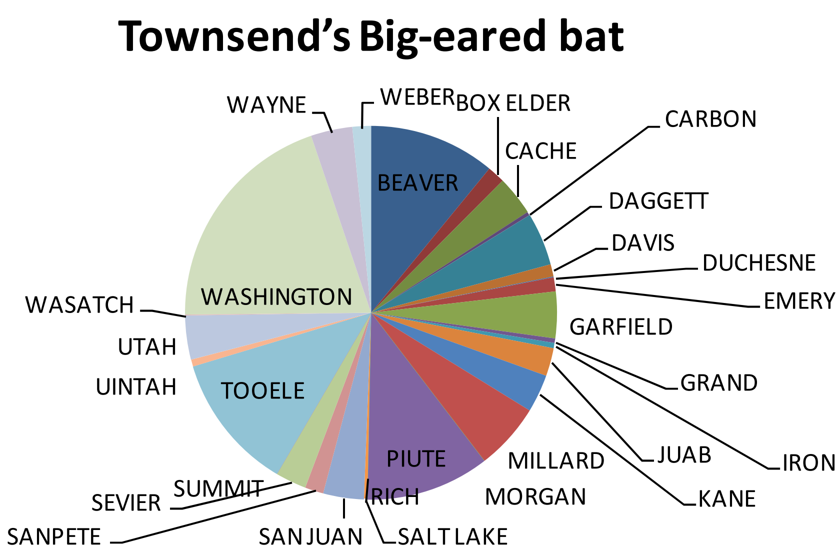

Figure 26b. Proportion of Townsend's big-eared bat events for each of Utah's 29 Utah counties.

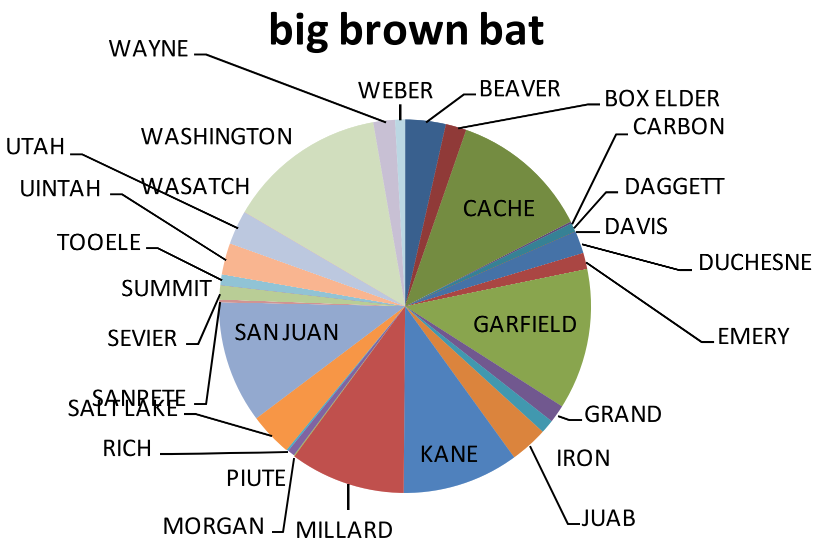

Figure 26c. Proportion of big brown bat events for each of Utah's 29 Utah counties.

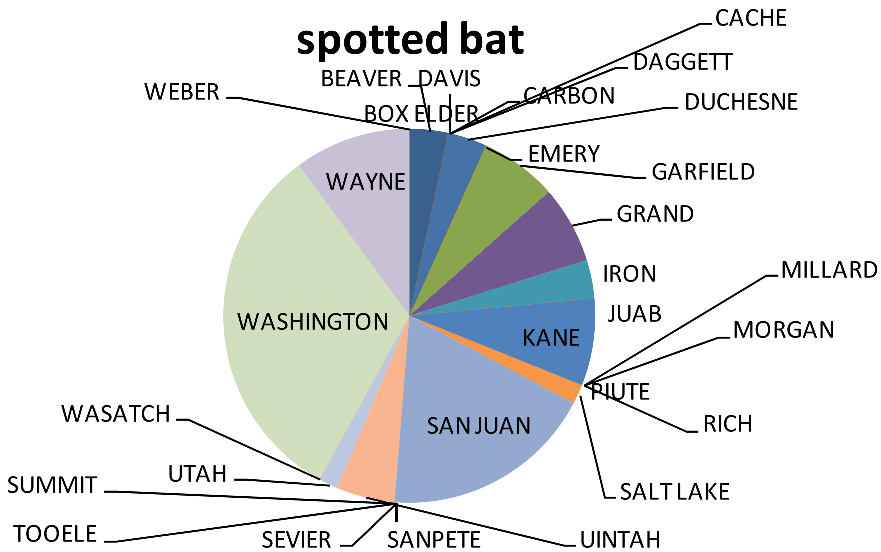

Figure 26d. Proportion of spotted bat events for each of Utah's 29 Utah counties.

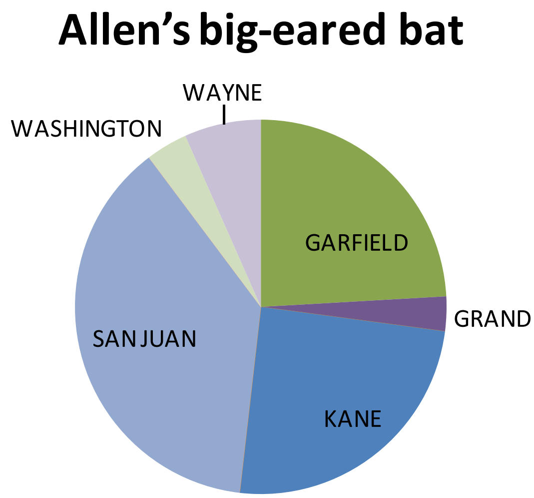

Figure 26e. Proportion of Allen's big-eared bat events for Utah's counties in which it occurs.

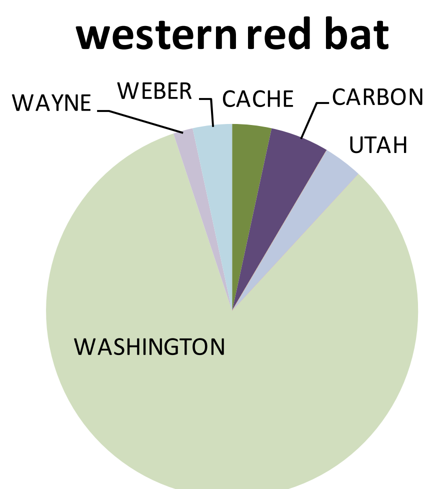

Figure 26f. Proportion of western red bat events for Utah's counties in which it occurs.

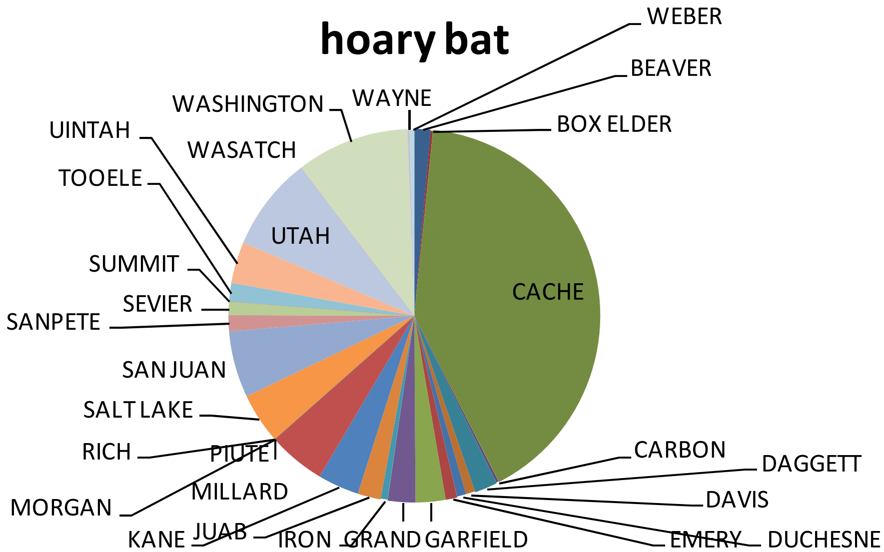

Figure 26g. Proportion of hoary bat events for each of Utah's 29 Utah counties.

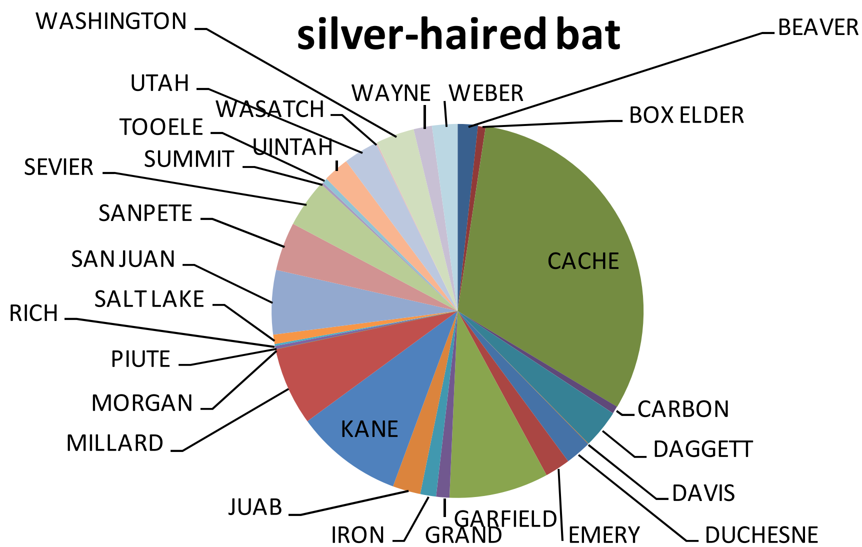

Figure 26h. Proportion of silver-haired bat events for each of Utah's 29 Utah counties.

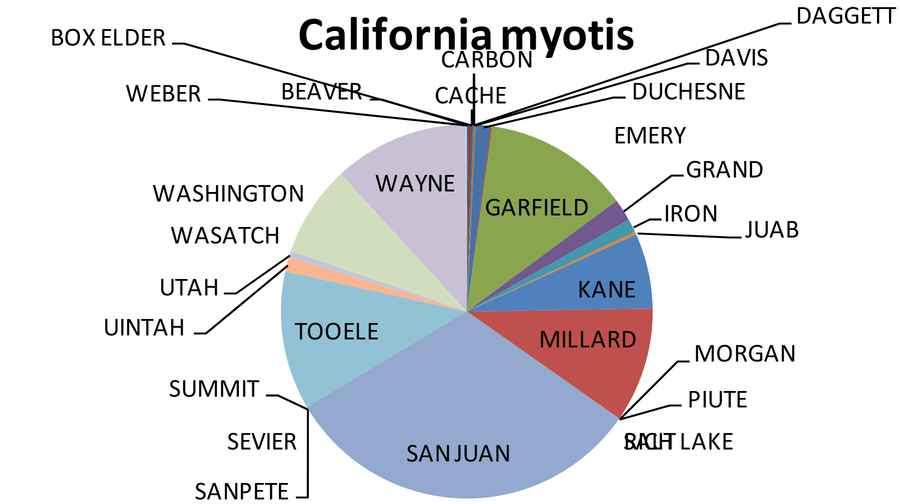

Figure 26i. Proportion of California myotis events for each of Utah's 29 Utah counties.

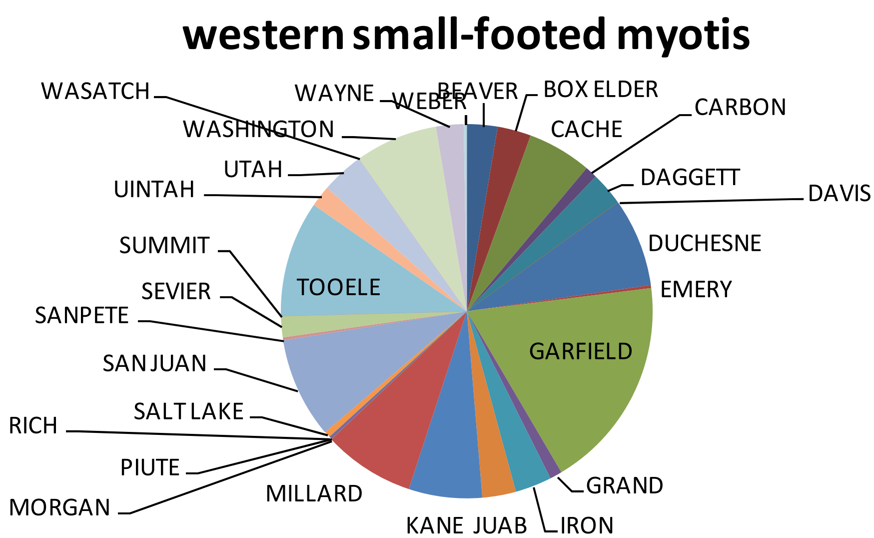

Figure 26j. Proportion of western small-footed myotis events for each of Utah's 29 Utah counties.

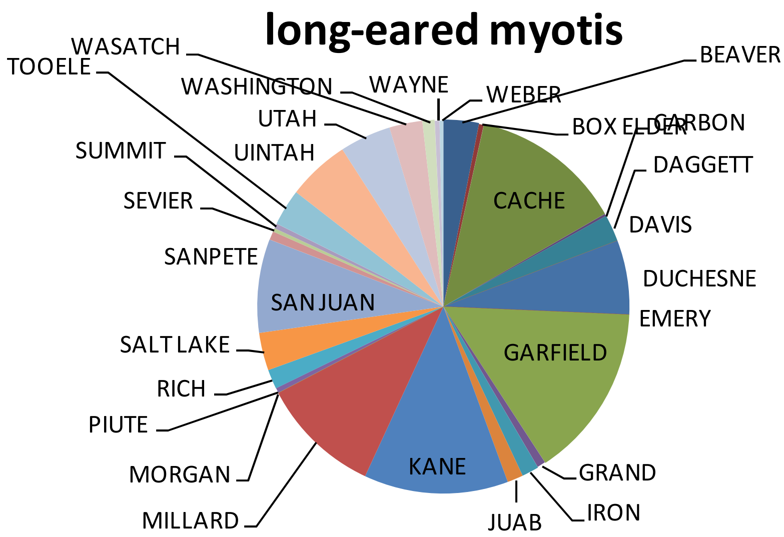

Figure 26k. Proportion of long-eared myotis events for each of Utah's 29 Utah counties.

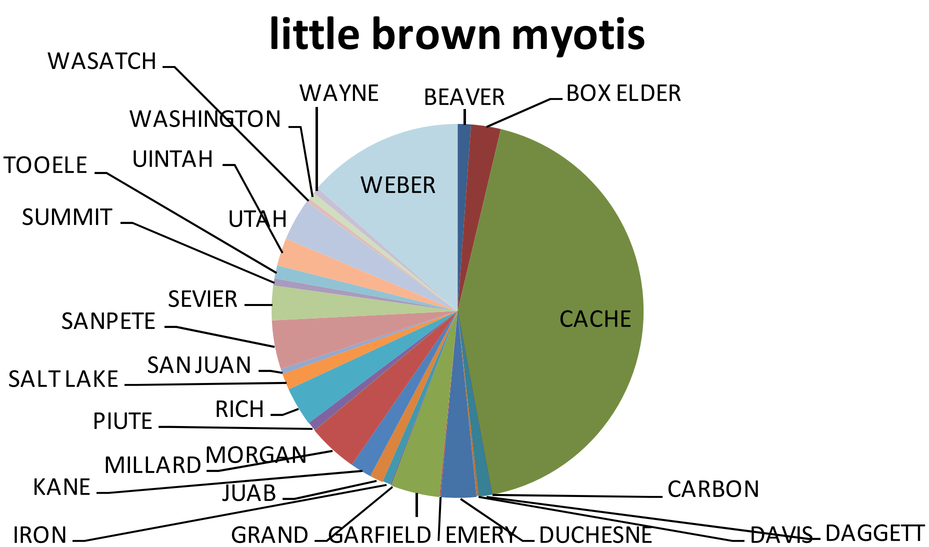

Figure 26l. Proportion of little brown myotis events for each of Utah's 29 Utah counties.

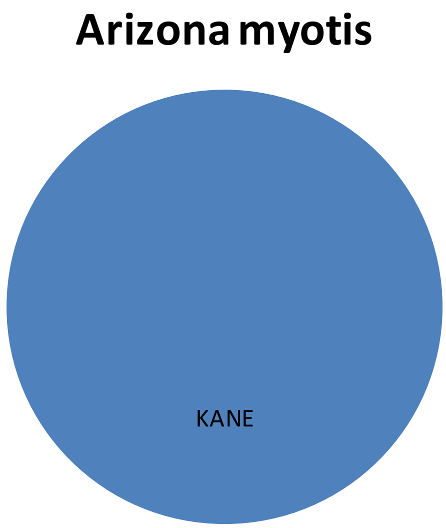

Figure 26m. Proportion of Arizona myotis events for Utah's counties in which it occurs.

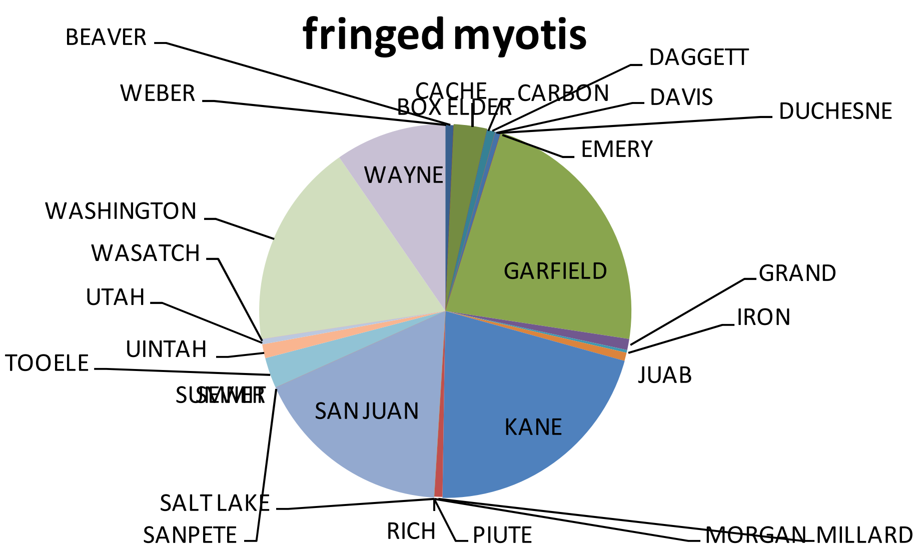

Figure 26n. Proportion of fringed myotis events for each of Utah's 29 Utah counties.

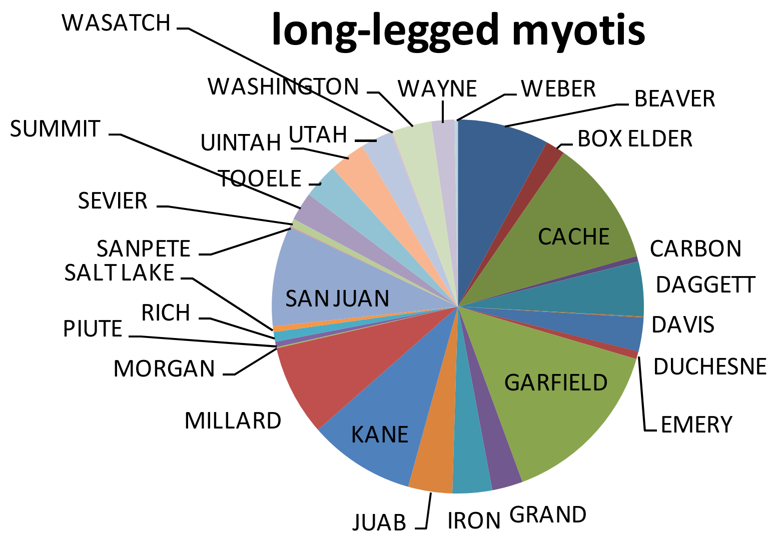

Figure 26o. Proportion of long-legged myotis events for each of Utah's 29 Utah counties.

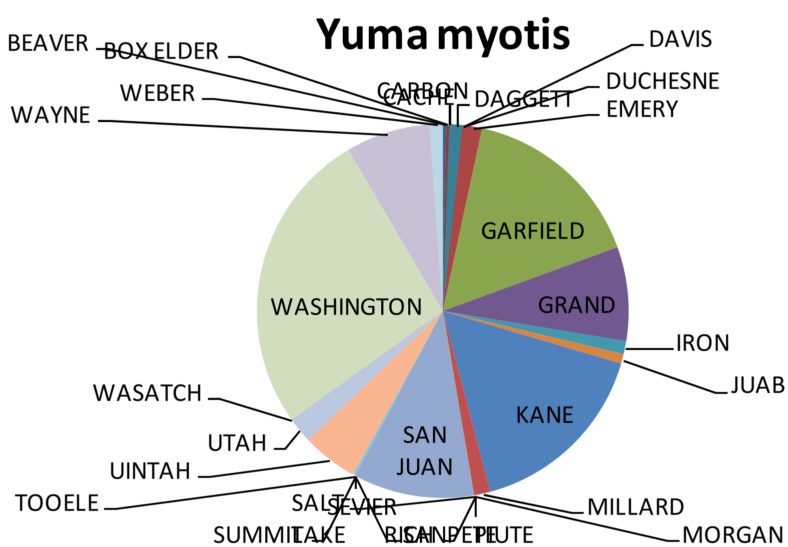

Figure 26p. Proportion of Yuma myotis events for each of Utah's 29 Utah counties.

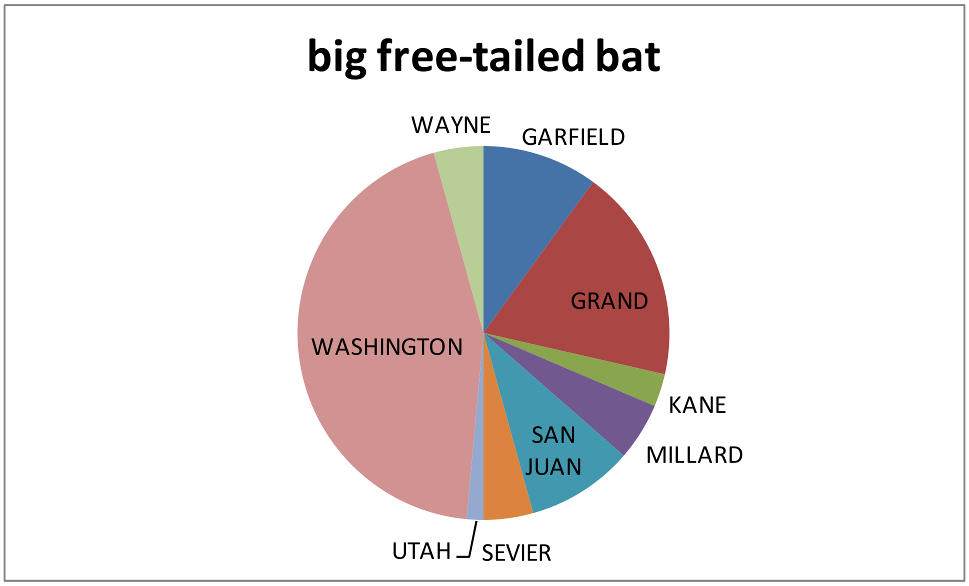

Figure 26q. Proportion of big free-tailed bat events for each of Utah's counties in which it occurs.

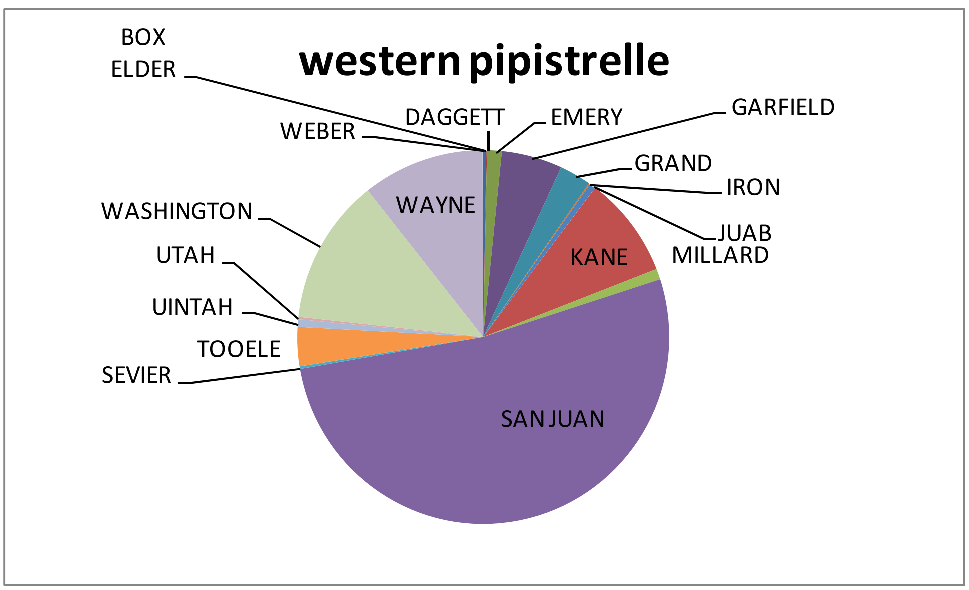

Figure 26r. Proportion of western pipistrelle events for each of Utah's counties in which it occurs.

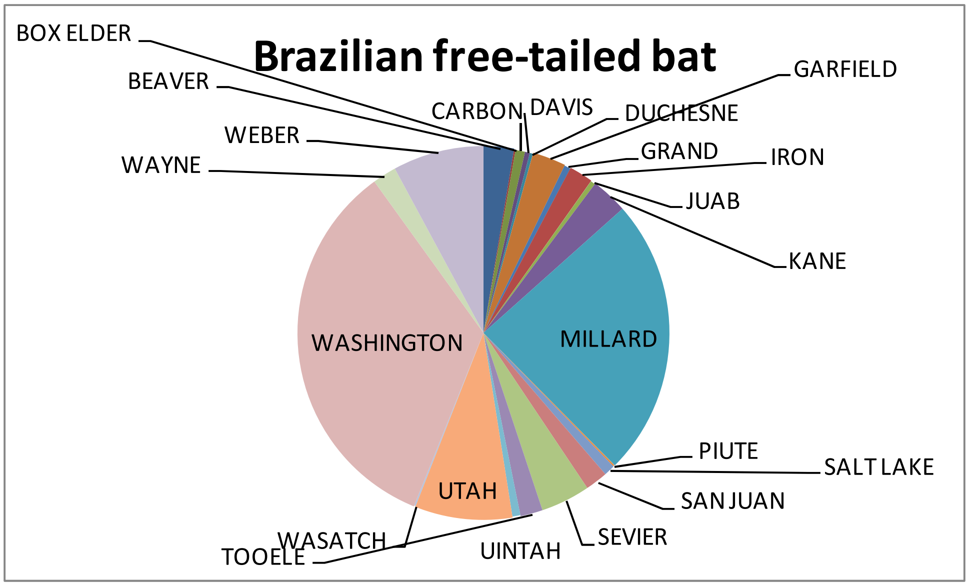

Figure 26s. Proportion of Brazilian free-tailed bat events for each of Utah's 29 Utah counties in which it occurs.

Shannon-Wiener Diversity

An index of diversity showed differences in species diversity and evenness across Counties (Fig. 27). Garfield had the highest diversity index value followed by, Kane, Washington, Grand, Iron, Millard, Juab and Utah. The lowest diversity scores were for Rich, Piute, Wasatch and Morgan.

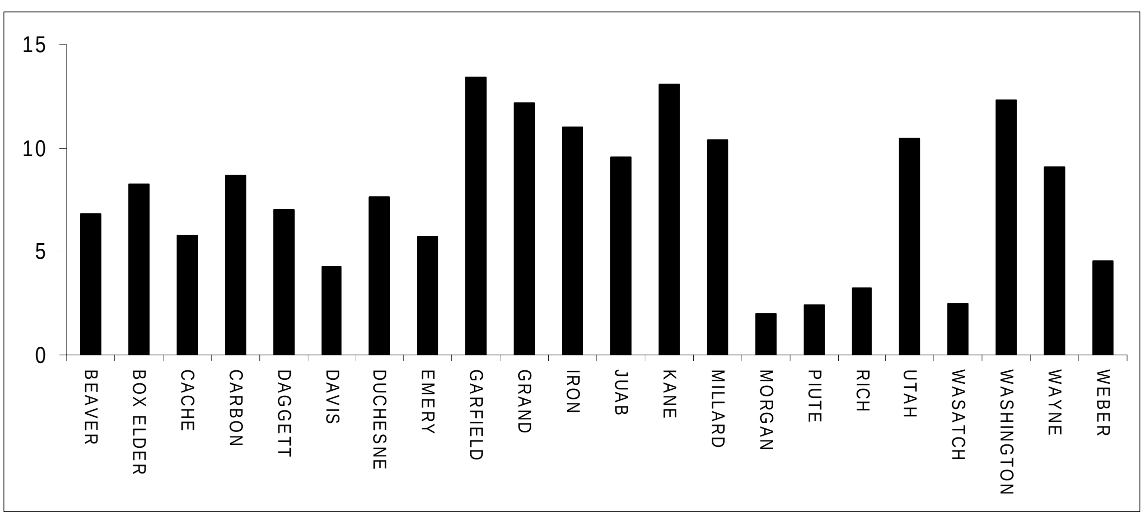

Figure 27. Shannon-Weiner diversity index, based on the diversity and evenness of species across Utah's 29 counties.

Abundance Indices (Objective 4)

Abundance indices provide some estimation the intensity of bat species use across the state. Townsend's big-eared bat abundance is highest in the west desert mountain ranges, the mountainous areas along the Interstate 15 corridor and the north slope of the Uinta Mountains (Fig. 28). The highest density of spotted bat events were in the Virgin River watershed in the Mojave Desert and southeast of the confluence of the Colorado and Dolores rivers in eastern Utah (Fig. 29). Spotted bat events were primarily in eastern Utah. Allen's big-eared bats were recorded in the Colorado Plateau and Mojave Desert in southern and southeastern Utah (Fig. 30). Most events occurred near Lake Powell. Western red bats were observed across the state the highest density in the Virgin River watershed in southwestern Utah (Fig. 31). All Western Red bat events were associated with riparian zones. The Arizona myotis was only recorded in south central Utah in Kane County (Fig. 32). Fringed myotis were at high densities in southwestern and eastern Utah. Density for this species was highest east of Interstate 15 and south of Interstate 70 (Fig. 33). The big free-tailed bat occurred in low densities in the same area described for the fringed myotis (Fig. 34). The other 12 species that are not designated as tier II and will not be discussed here for figure space limitations see Appendix III.

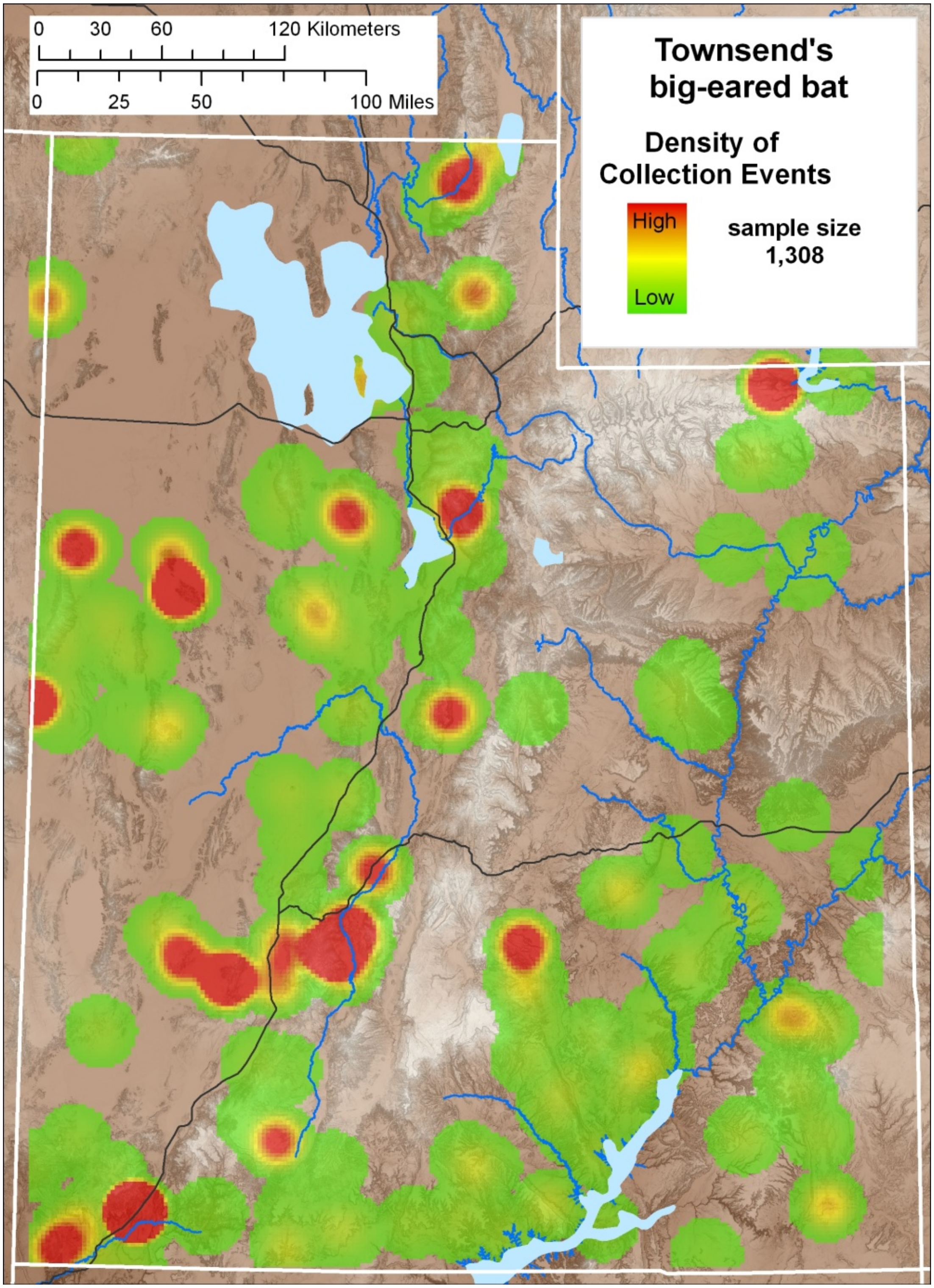

Figure 28. Density of Townsend's big-eared bat data collection events in the State of Utah. Each data point has a 5 km radius of activity zone. A continuum of event densities from high (red) to low (green) areas indicates the magnitude of data collection. Areas with no density cover lack data points.

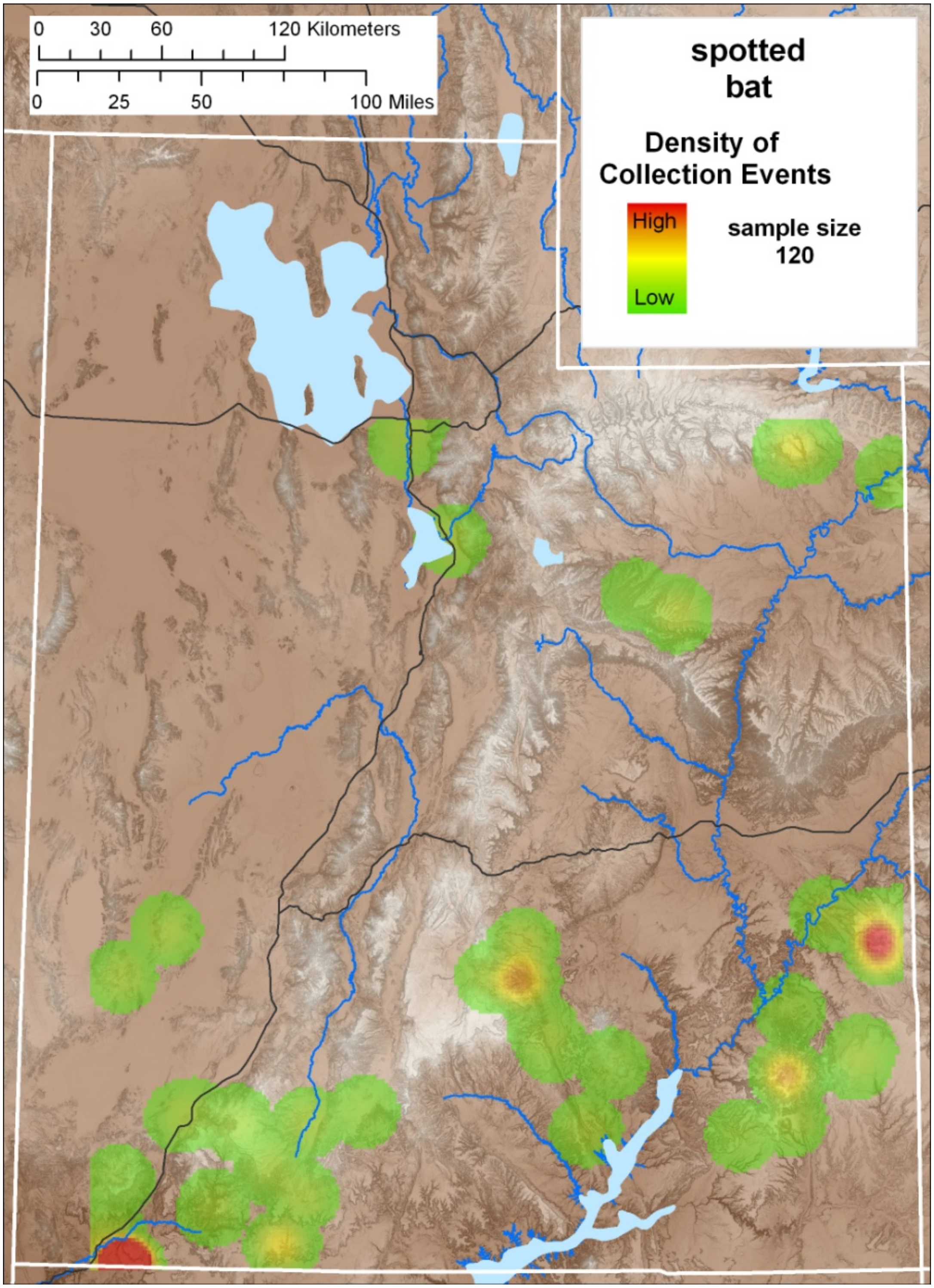

Figure 29. Density of spotted bat data collection events in the State of Utah. Each data point has a 5 km radius of activity zone. A continuum of event densities from high (red) to low (green) areas indicates the magnitude of data collection. Areas with no density cover lack data points.

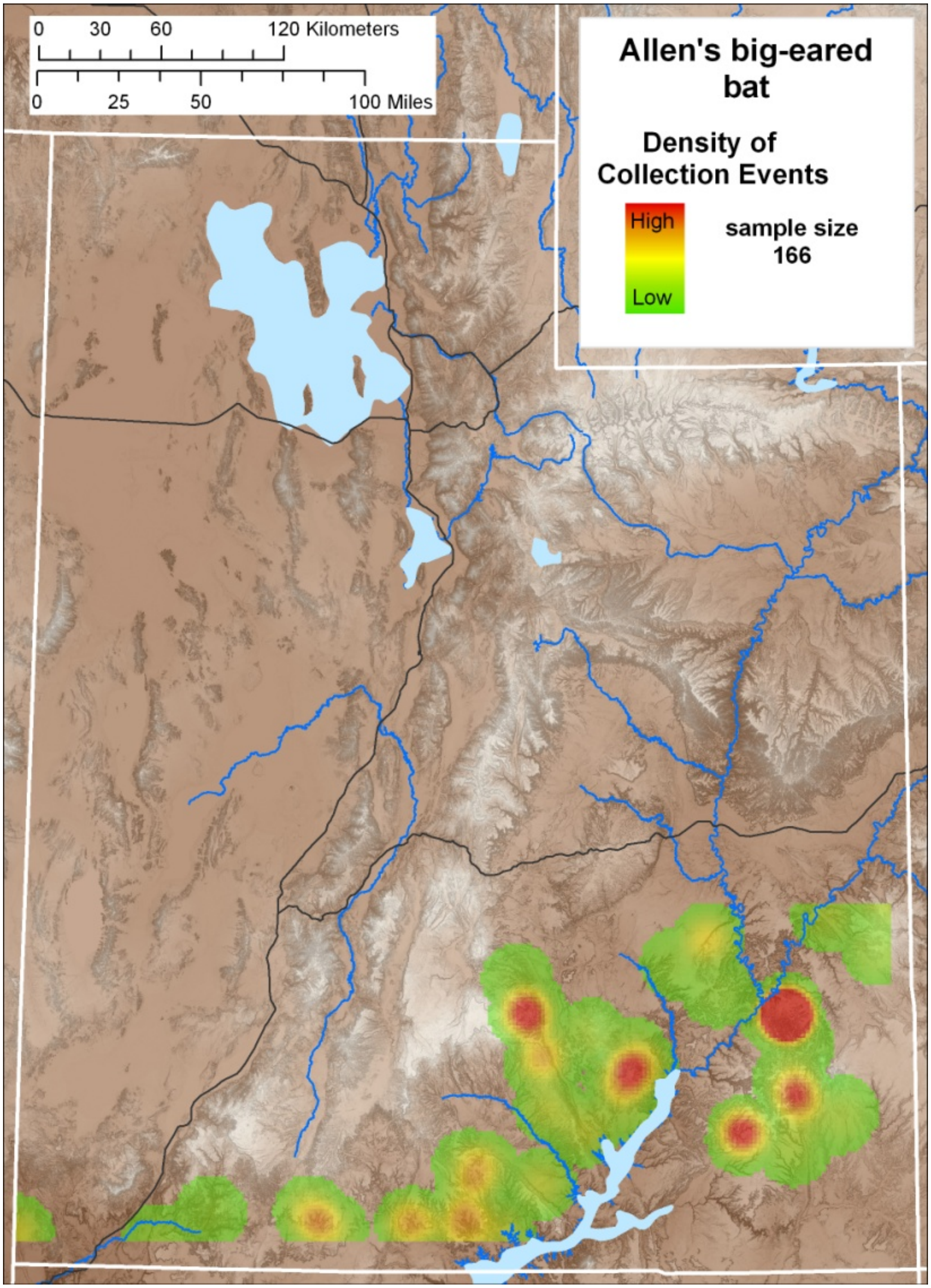

Figure 30. Density of Allen's big-eared bat data collection events in the State of Utah. Each data point has a 5 km radius of activity zone. A continuum of event densities from high (red) to low (green) areas indicates the magnitude of data collection. Areas with no density cover lack data points.

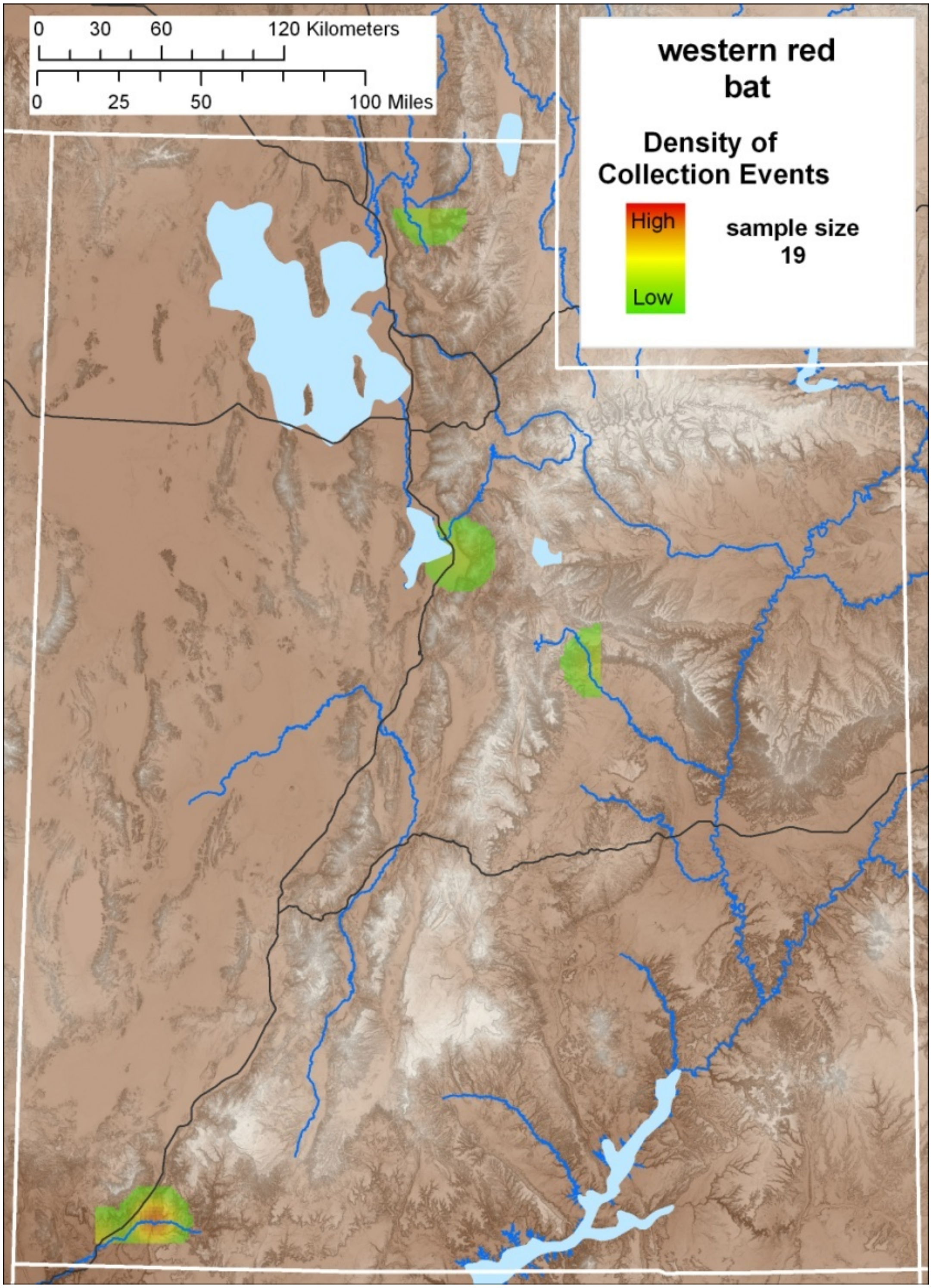

Figure 31. Density of western red bat data collection events in the State of Utah. Each data point has a 5 km radius of activity zone. A continuum of event densities from high (red) to low (green) areas indicates the magnitude of data collection. Areas with no density cover lack data points.

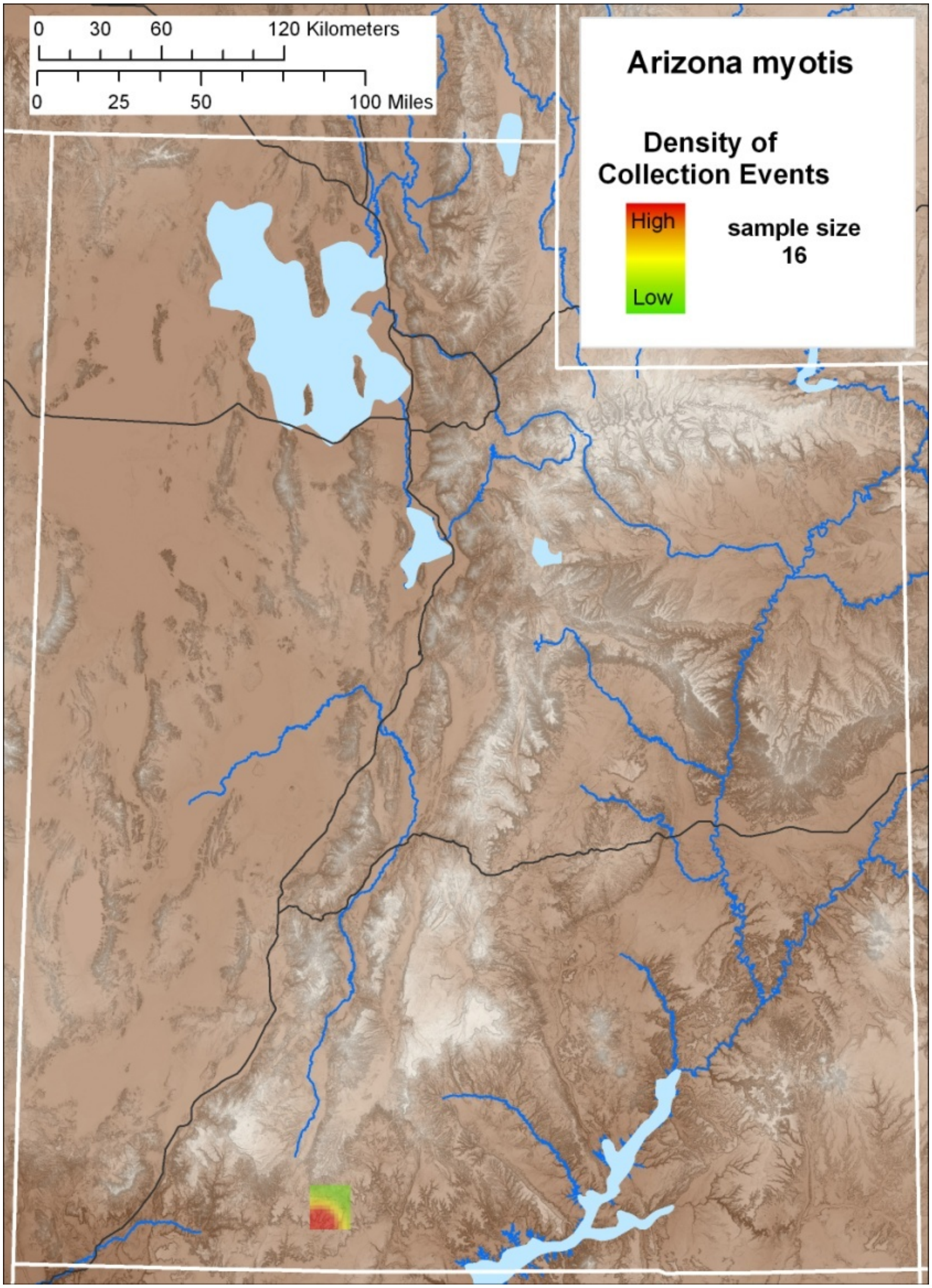

Figure 32. Density of Arizona myotis data collection events in the State of Utah. Each data point has a 5 km radius of activity zone. A continuum of event densities from high (red) to low (green) areas indicates the magnitude of data collection. Areas with no density cover lack data points.

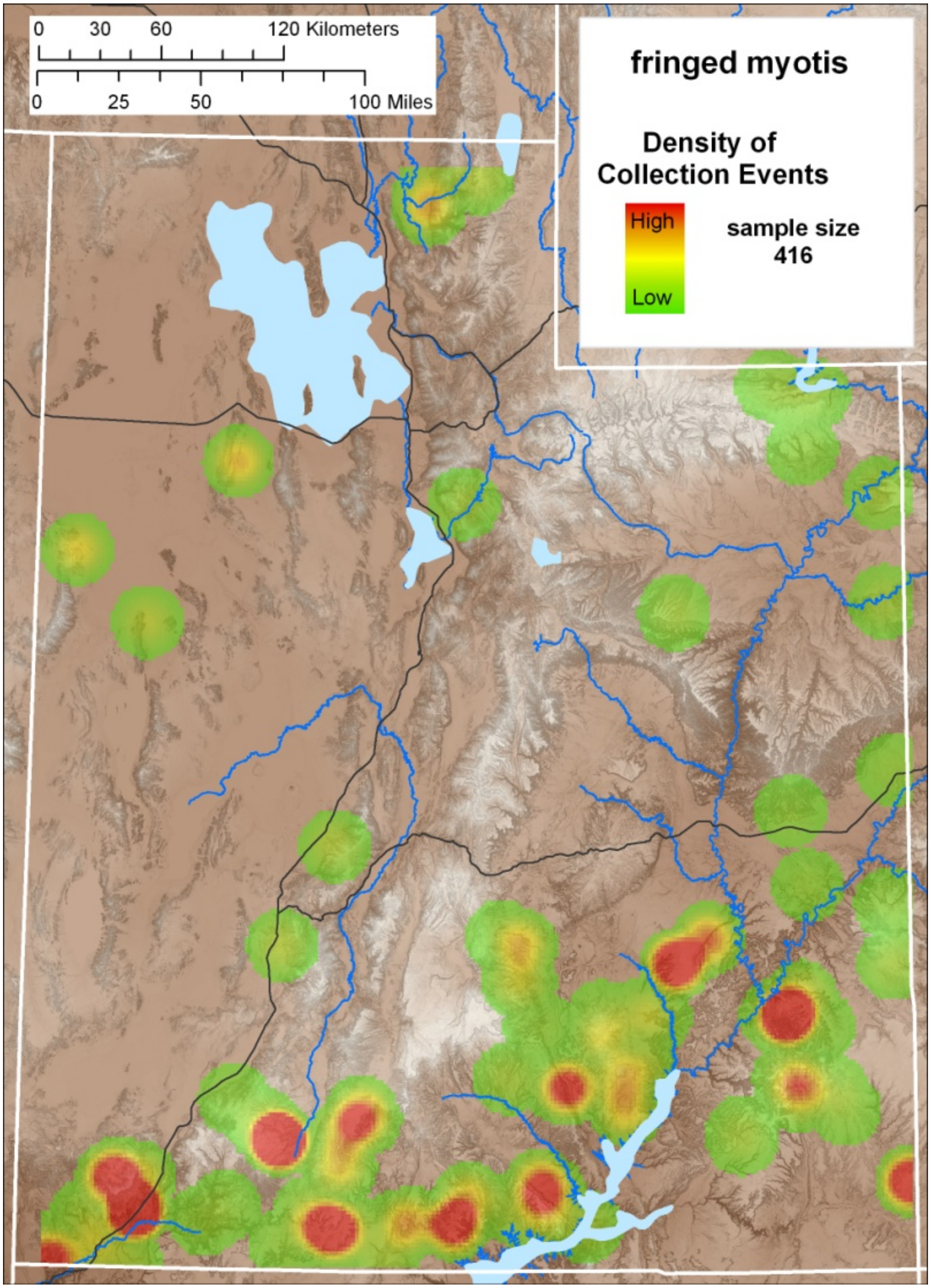

Figure 33. Density of fringed myotis data collection events in the State of Utah. Each data point has a 5 km radius of activity zone. A continuum of event densities from high (red) to low (green) areas indicates the magnitude of data collection. Areas with no density cover lack data points.

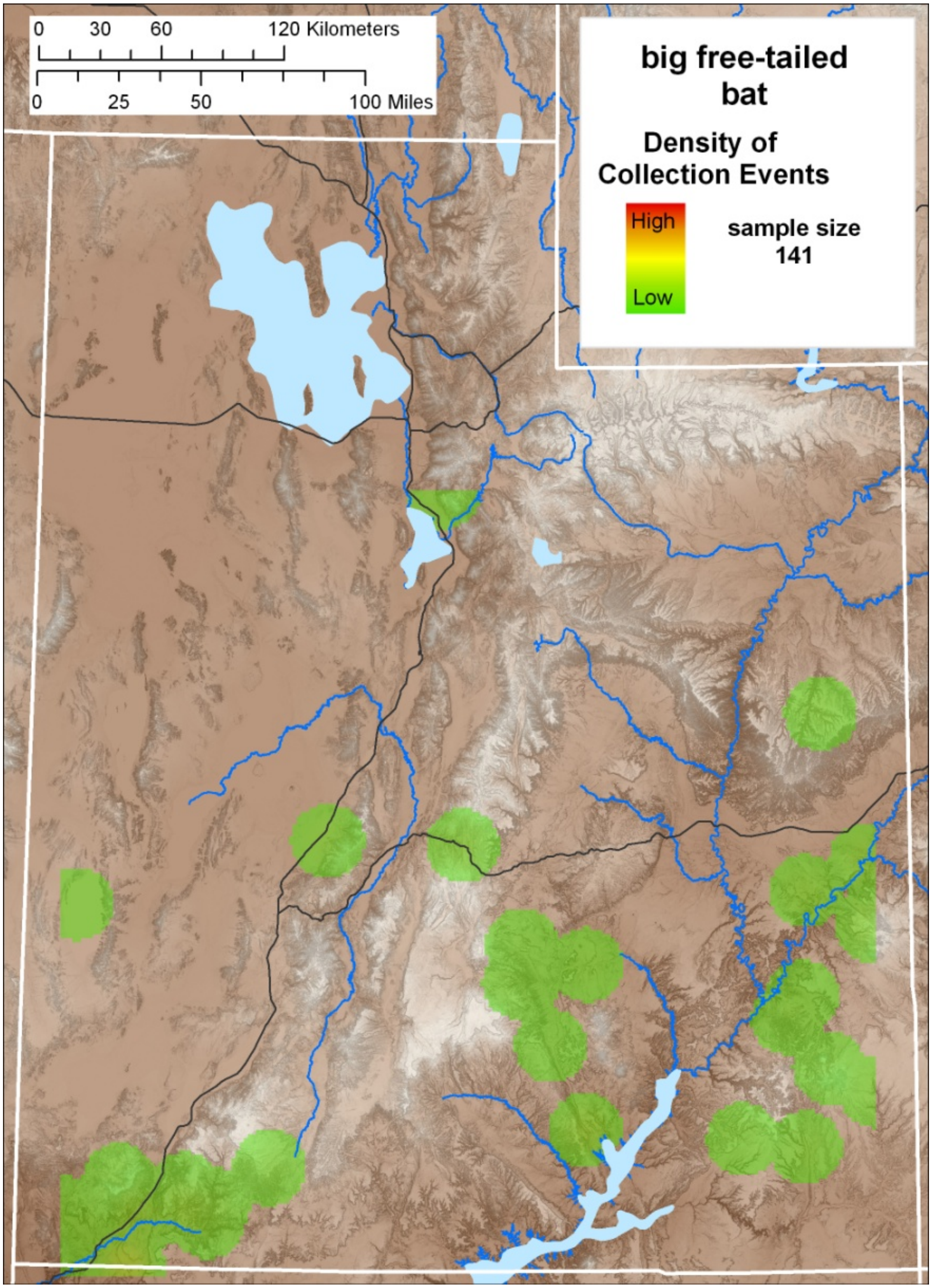

Figure 34. Density of big-free tailed bat data collection events in the State of Utah. Each data point has a 5 km radius of activity zone. A continuum of event densities from high (red) to low (green) areas indicates the magnitude of data collection. Areas with no density cover lack data points.

Breeding Habitat (Objective 5)

Reproductive individuals were observed for all 19 of Utah's bat species. While these data do indicate broad scale patterns they are by no means complete. A total of 1,249 reproductive individuals were observed of 28,393 total bat individuals. The combination of this low sample size and missing reproductive data limits any analysis of this portion of the data set.

Roosting and Foraging Habitat

Roosting and foraging habitat events varied across species (Fig. 35). Ten species were observed day roosting. Four species were observed at hibernacula, 3 species at night roosts, 2 at maternity roosts. The majority of data events were recorded during foraging bouts for 17 species. least reports Townsend's big-eared bats were observed hibernating, in 35%, foraging and day roosting in 30% each, and maternity and night roosts 2.5% of events. All spotted bat, Allen's big-eared bat and Arizona myotis events were during foraging bouts. Fringed myotis were observed foraging in 60% of events, and 20% in day roosting and hibernaculum events. Big free-tailed bats were observed foraging in 85% of events and day roosts in 15% of events. However, antidotal reports indicate that these patterns are a severe underestimation of roosting and foraging habitat.

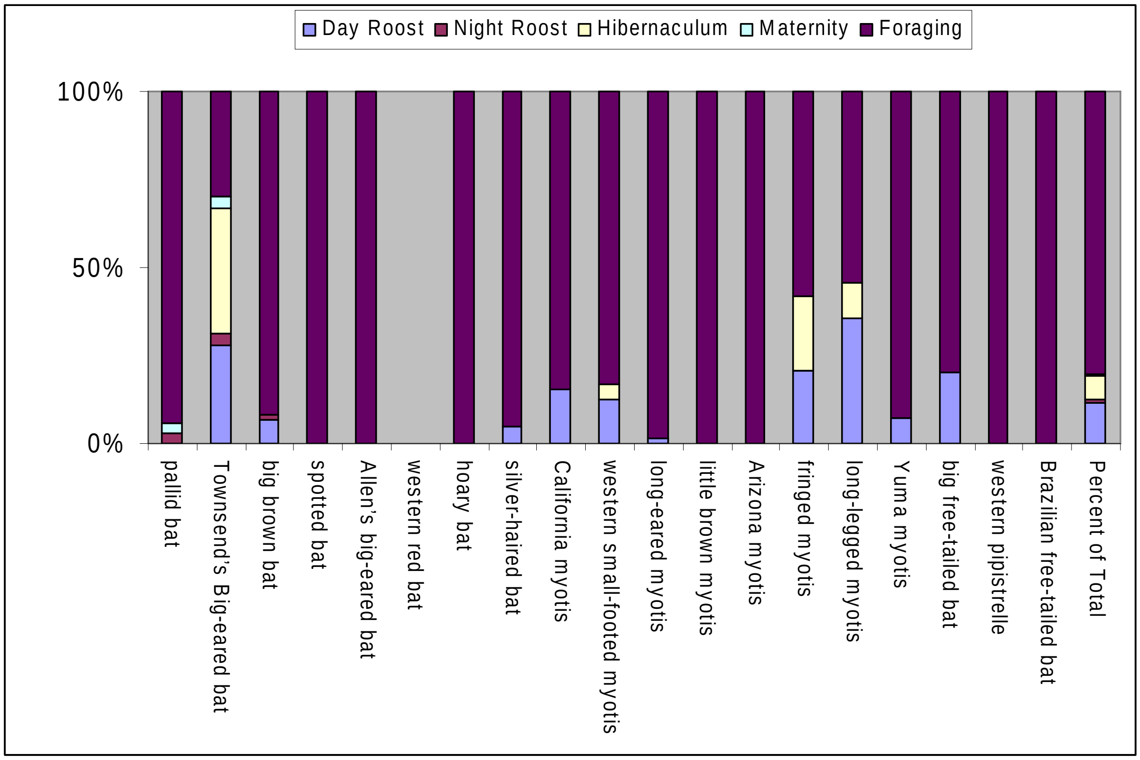

Figure 35. Utah bat species activity allocation between day and night roosting, hibernation, maternity roosting and foraging behaviors.

Elevation

Species varied within and across elevation (Fig. 36). All species were observed at 1501-2000 m elevation, 18 species at 2001-2500 m and 1001-1500 (Arizona myotis was absent), 14 species at <1000 m (silver-haired bat, long-eared myotis, little brown myotis, Arizona myotis and long-legged myotis were absent), and 2501-3000m (pallid bat, western red bat, Arizona myotis, western pipistrelle and Brazilian free-tailed bat were absent), and 6 species were observed at >3000 m (spotted bat, Allen's big-eared bat, hoary bat, western small-footed myotis, long-eared myotis and long-legged myotis). Townsend's big-eared bats were observed at 1501-2000 m in 50% of events, 2001-2500 m and 1001-1500 m in 20%. Spotted bat events were distributed across elevations, 30% at <1000 m, 15% at Allen's big-eared bat was observed at 1501-2000 m in 70% of events. Western red bat events occurred <1000 m for 60% of events. All Arizona myotis events occurred at 1501-2000 m. Fringed myotis was observed across middle elevations. Big free-tailed bat events generally occurred below 2000 m. It is important to note that these are Geographic Position System (GPS) derived elevations and are thus, directly impacted by the precision of the data. The majority of the data set is of above moderate precision and indicates that these association are due to elevational relationships

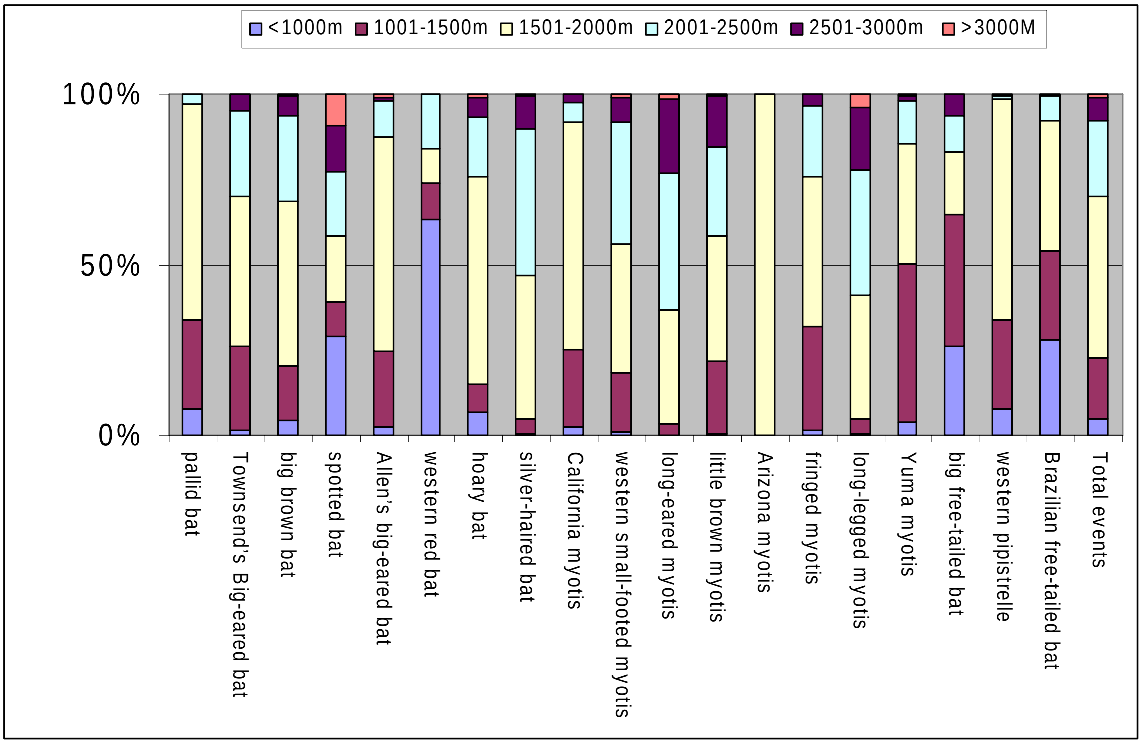

Figure 36. Utah bat species elevational distribution.

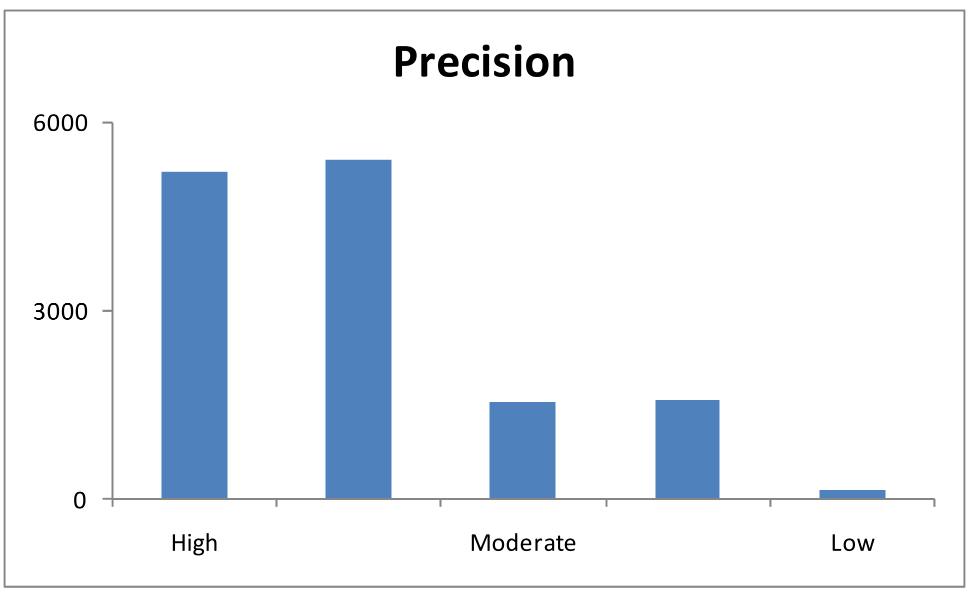

Figure 37. Location precision for the data set from high to low for 13,893 total bat events.

DISCUSSION

The consolidation, evaluation and analysis of bat data in the state of Utah were facilitated by Legacy I (project number 07-346) and Legacy II (project number 08-346). The health of Utah's bat populations could not have been accessed without the foresight of the Legacy program. This analysis indicates that Department of Defense lands support a variety of bat populations including 4 sensitive species; Townsend's big-eared bat, spotted bat, fringed myotis and big free-tailed bat. Military lands in Utah provide a refuge from urban development, and human recreational activities, and provide a baseline that will allow for a more proactive management and monitoring of bat populations. The analysis of spatially explicit bat data in the state of Utah has increased our understanding of survey needs, occurrence, diversity, abundance, and roosting and breeding habitat.

Department of Defense

Department of Defense lands accounted for a high percentage of bat record events for 5 species and had diversity index values higher than all other ownership types except, BLM and privately held land; even though DoD lands in Utah are 1/14 and 1/7 the land area of the BLM and private lands. DoD in Utah also lacks open water coverage such as that scattered across BLM lands and prominent on privately held lands. This high bat diversity is related to the unique DoD land holdings in Utah. The land cover type that supports the most diverse bat fauna in Utah is the Inter-Mountain Basins Big Sagebrush Grasslands was the dominate cover type on DoD holdings in the state. Most DoD lands are within the Great Basin Shrub steppe ecoregion, which also supports a very diverse bat fauna. While sagebrush grasslands have declined precipitously over the last 103 years (Knapp 1996), many intact stands exist across DoD lands in the western

North America. These land holdings provide a refuge for bat populations and communities. However, degraded sagebrush grasslands are often characterized by non-native invasive forblands. This land cover type has increased on DoD lands over the last 103 years. Management of DoD bat populations should be focused on habitat manipulations that promote the recovery of sagebrush grasslands. An Analysis and Risk/Management Plan (Legacy III proposal) should focus on monitoring and on increasing sagebrush grasslands on DoD lands.

Year

Sampling of bat populations began in 1905 and number of records (events) per year peaked between 1986 and 1994. This peak in events relates directly to survey effort which increased profoundly during this period (Oliver 2000). This portion of the analysis is limited by record completeness. Many records from existing databases were imported into the data set but had yet to be totally integrated. This leads to appearance of several species in the literature prior to bat event records. A subset of historical data has yet to be formatted into the BATBASE data set. We consolidated bat event data from many sources; however, the older data sets are unclear or incomplete with regard to specific species capture events and thus have not been added to BATBASE. The high diversity of species reported in the 1940s, 1900s and 2000s are the result of increased survey effort rather than changes in diversity across time.

Month

Typically, field work for most bat species in Utah occurs after the first of April and concludes at the end of September. The BATBASE data set consists of 97% warm season (April-September) data and 3% cold season (October-March) data. Not only did this data set reflect the survey effort, but possibly the actual pattern of bat activity. Four of Utah's sensitive bat species hibernate during the cold season, as does the Arizona myotis. The western red bat and big free-tailed bat are migratory (Adams 2003). Thus, bat activity drops off drastically during the cold season. Another source of variation in the cold to warm season bat data is the roosting ecology of bats. Our winter data consist primarily of cave and mine survey data that precludes the detection of vegetation and crevice roosting species. Other forms of winter data come from mortality, bats captured in torpor in urban areas and bats that are active during the cold season. Monthly diversity patterns are both a result of survey effort and actual diversity. The high diversity in mid-summer (June, July, and August) is related to the presence of migratory species and high activity levels of resident species.

Ecoregion

Survey effort across ecoregions was not equivalent to the percentage of area covered by each. In the Colorado Plateau shrubland, the percentage of total events was higher than the percent area of the ecoregion. This high percentage of events is likely a result of the number of agencies collecting data (NPS, BLM, UDWR, and USFS) in this ecoregion. The Wasatch and Uinta montane forest ecoregion is adjacent to urban areas and offices of management agencies. The high percentage of records (events) compared to area in the Wasatch and Uinta montane forests is likely the result of density of agencies and water sources in adjacent urban areas. Bat records in the Great Basin shrub steppe, Wyoming Basin shrub steppe and Mojave Desert shrubland are related to number of water sources which facilitate bat capture. The arid characteristics of these ecoregions limit capture opportunity due to low density of water sources.

More species capture records were documented in the Colorado Plateau shrubland ecoregion than all others. All 19 species were recorded in this ecoregion, with > 50% of the total data for 9 species being from this single ecoregion. Diversity indices also show that the most diverse and evenly represented ecoregion is the Colorado Plateau shrublands. The Great Basin shrub steppe also had a high diversity score and included data events for 17 species. Wasatch and Uinta montane forests had diversity measures only slightly above the Mojave Desert. The Wyoming Basin was the least diverse.

Physiographic province

The pattern observed between the percentage of total records and percentage of total area for 5 physiographic provinces is the result of survey effort and species diversity. The Colorado Plateau had equivalent percentage of events and area. The Colorado Plateau again has a high density of data collectors as well as high percent of total area. The Middle Rocky Mountains was overrepresented in percentage of events. This is likely related to the water source density and proximity to urban areas. The Basin and Range province has lower percent of total records than expected from the area of the province. This is related to the scarcity of water sources in this province, and the large distance from most population centers. The majority of military lands lie in this area. The Columbia Plateau and Wyoming Basin make up less than 1% of land area in Utah, and each had a low representation of events.

Diversity trends across physiographic provinces mirror that of the ecoregion diversity. The Colorado Plateau supports all 19 species and accounts for > 45% of the total events for 13 of those species. The Shannon-Weiner diversity index indicates that the Colorado Plateau is the most diverse and even of the 5 physiographic provinces in terms of bat fauna. Of the 18 species recorded in the Basin and Range more than 50% of total events for 3 species were within this province. Twelve species were observed in the Wasatch and Uinta montane forest. This province accounted for over 40% of events for 3 species. The small area and low sampling effort in both the Wyoming Basin and the Columbia Plateau are causes of the seemingly low diversity and evenness in these provinces.

Land cover type

Aerial extension of particular land cover types and percentages of bat capture events were related to ecoregion, landowner type, and proximity to urban areas. Seven land cover types had a higher percentage of events than expected based on land area. The Colorado Plateau had 2 over-represented land cover types (9, 53) (Appendix 1), Wasatch and Uinta montane forests had 3 (23, 34, 79), Urban areas 1 (111) as did the Mojave Desert (60). The densities of events for the Colorado Plateau and Wasatch and Uinta montane forest have been discussed above. The high density of events in Sonora-Mojave Creosotebush-White Bursage Desert Scrub (60) was the result of extensive work conducted by UDWR, BLM and Southern Utah University.

Patterns of bat diversity are related to vegetative cover. As in the ecoregion and physiographic province analysis, the Colorado Plateau Mixed Bedrock canyon and Tableland accounted for a higher percentage of records for more species than any other cover type. Colorado Plateau Pinyon-Juniper woodlands also had high bat species diversity and accounted for a high percentage of total events for 16 species. Low Intensity Developed open space also had a high diversity of species, as did the multiple riparian land cover types and Mojave Desert land cover types. Diversity indices indicated that the Inter-Mountain Basins Big Sagebrush Grasslands have the highest diversity and evenness. This is the cover type that characterizes most

Department of Defense lands in the west. Colorado Plateau and Great Basin Woodlands also had high diversity and evenness scores, as did North American Arid West Emergent Marsh. Chaparral and shrub steppe land cover types also appear to have a relatively high diversity. The lowest diversity was found in Inter-Mountain Cliff and Canyon, warm desert washes, salt desert scrub, tundra, and invasive annual dominated cover types. The highest diversity land cover types are characterized by southern distribution or proximity to water or prey resources. Bat diversity appears to decrease with increasing latitude in the northern hemisphere (Kauffman 1995) as we observed here.

Landowner

More species at a higher number of events were observed on BLM lands than any other type. BLM managed lands account for more area than all other types and these lands are characterized by the high diversity land cover types discussed above. BLM land holdings are primarily within the Great Basin shrub steppe and Colorado Plateau shrublands. These 2 ecoregions are composed of shrublands and woodlands the most diverse of the land cover types. DoD lands also had a high species diversity and bat density. DoD lands are located almost exclusively in the Great Basin shrub steppe, which as mentioned above has the highest diversity land cover types. USFS lands were also fairly diverse, likely a result of forested habitat. All but the western red bat and the Arizona myotis were observed on USFS lands. The Wasatch and Uinta montane forest ecoregion is primarily administered by the USFS. The same values which promote diversity and high population density for multiple species in this ecoregion account for bat event patterns on USFS lands. Private lands are often characterized by higher available surface waters than adjacent lands. STILA lands were also very diverse likely due to the statewide distribution of this land owner type across ecological boundaries.

UDWR region

The Southern and Southeastern UDWR Regions accounted for >50% of 11 species events. These two regions are dominated by the most diverse land cover types and ecoregions. The Southern Region had the highest diversity index score followed by the Central, Northeastern, Southeastern and Northern Regions. Measures of diversity and evenness are hindered by high events for a few species and low events for the others as in the Southeastern Region. The Central Region had a low number of total events but those events were spread evenly across species. The Northeastern Region incorporates the northern end of the most diverse ecoregion (Colorado Plateau shrubland) and has more open water than all UDWR Regions except the Southeastern.

County

Six counties accounted for a greater percentage of total events for more species than all others. Garfield County had the highest diversity score, the location of this county in Montane and Colorado Plateau ecoregions and the high diversity of land cover type in this county account for the high diversity. Kane County also had high diversity scores this is likely due to the southern location in the Colorado Plateau which facilitates mixing of northern and southern species and the high diversity of land cover types. Washington County was also very diverse. This county is the primary location of the Mojave Desert ecoregion in Utah. The southern location of this county and the combination of 3 ecoregions (Mojave Desert, Colorado Plateau shrubland and Montane forests) and high diversity land cover types explain the high diversity here. Grand and Iron Counties are also characterized by multiple ecoregions and associated diverse land cover types. Some central Utah Counties (Millard, Utah, and Juab) also showed high diversity scores. These three counties are primarily characterized the most diverse land cover type (Inter-Mountain Basins Big Sagebrush Grasslands) and a central location which facilitates southern and northern species mixing. Tooele County had 14 species and accounted for 4% of all events. Rich, Piute, Wasatch and Morgan had very low diversity scores and number of species. While the two northern counties (Rich and Morgan) only contain a single ecoregion and have a comparatively simple land cover Wasatch and Piute counties have a more diverse landscape. The low diversity for Morgan and Rich Counties may be due to actual diversity patterns. In contrast, diversity of adjacent counties indicates that Wasatch and Piute diversity scores are a result of low sampling density rather than actual diversity

Elevation

More species (19) were observed between 1501-2000 m elevation than all other elevations. This elevational band corresponds to the base of the Wasatch Uinta montane forest, the location of much of Utah's open water. All species were observed at 1501-2000 m elevation, 18 species at 2001-2500 m and 1001-1500 m (Arizona myotis was absent), 14 species at <1000 m (silver-haired bat, long-eared myotis, little brown myotis, Arizona myotis and long-legged myotis were absent), and 2501-3000 m (pallid bat, western red bat, Arizona myotis, western pipistrelle and Brazilian free-tailed bat were absent), and 6 species were observed at >3000 m (spotted bat, Allen's big-eared bat, hoary bat, western small-footed myotis, long-eared myotis and long-legged myotis).

Townsend's big-eared bat

Townsend's big-eared bat was detected in all ecoregions except the Wyoming Basin shrub steppe. The Wyoming Basin shrub steppe covers a much smaller portion of Utah than the other 4 ecoregions. This smaller size resulted in less of the total data in this ecoregion. Along with data collection, the roosting ecology of Townsend's big-eared bat may explain the lack of records in the Wyoming Basin. This species is a cavern-roosting specialist. The lack of cavern habitat in the Wyoming Basin may account for this species distribution. Records of Townsend's big-eared bats were also absent from the Wyoming Basin physiographic province, likely for the same reasons discussed above. This species was observed in 44 of 61 land cover types, the majority of these land cover types were characterized by rocky outcrops or montane systems. The cavern habitat requirements of this species for maternity and hibernacula roosts indicate that it is associated with natural caves and abandoned mines (Oliver 2000). These caves and mines are located in parent material, thus land cover for this species is dependent on cavern or mineral bearing rock types. Townsend's big-eared bat was recorded on all land owner types except State Sovereign Lands (SL&F). Once again this species is associated with a variety of land owner types and is located within all 5 UDWR Regions and all counties except Morgan and Rich. The common theme of these data, again, is that cavern locations transcend management boundaries. Townsend's big-eared bat is strongly associated with cavern habitat (Sherwin et al. 2000). The density of events for this species reflected that affinity. The highest density of records for this species were in mountainous terrain, which is characterized by caves and abandoned mines, the roosting habitat specificity of this species dictates density.

Townsend's big-eared bat as mentioned above is a cavern roosting obligate species. Cave and mine density is highest in the Colorado Plateau shrublands (uranium mines), Great Basin shrub steppe (hard rock mines) and Wasatch and Uinta montane forest where breeders for this species were observed. Townsend's big-eared bats were observed primarily between 1001 to 2500 m. Once again, this is likely due to the relationship between cavern habitat at these elevations and this species.

Spotted Bat

Spotted bats were only recorded in Colorado Plateau shrublands and the Great Basin shrub steppe. This species is associated with arid systems and roosts in crevices high on rock walls (Watkins 1977). These two ecoregions are both arid and contain a large number of available crevice roosts. Physiographically, this species occupied the Basin and Range, Colorado Plateau and Middle Rocky Mountains. While the first 2 provinces overlap the ecoregions described above, the Middle Rocky Mountains supplies the open ponderosa habitat this species is strongly associated with (Watkins 1977). The spotted bat was recorded in 23 land cover types. These land cover types are characterized by cliffs, canyons and tablelands, and woody vegetation. This species was observed in 6 land owner types including DoD lands. Spotted bats were observed in all UDWR Regions except the Northern, and in 12 Utah counties. This distribution was also noted by Black 1970; Armstrong 1974; Foster et al. 1997; and Oliver 2000. The distribution of spotted bat occurrence indicates a statewide distribution as hypothesized by Oliver (2000). Data points in Duchesne and Uintah counties indicate spotted bat use multiple loci in northern Utah. Although data from extreme western locations is still lacking, the common theme behind spotted bat occurrence is the presence of crevice roosting habitat, riparian woodlands and forested foraging habitat (Wilson and Ruff 1999). The habitat specificity of this species likely limits distribution and population density (Pierson and Rainey 1998). Spotted bats are generally associated with desert and crevice habitats (Watkins 1977). Ruffner et al. (1979) noted spotted bats in the Virgin River Drainage and Jackson and Herder (1997) observed a higher density of capture events in riparian zones.

The spotted bat is a crevice roosting species associated with exposed parent material as in the Great Basin shrub steppe and Colorado Plateau shrublands. Spotted bat events were distributed across elevations, but most prominent at lower elevations. Findley et al. (1975) also noted that this species was associated with lower elevations in Colorado.

Allen's big-eared bat

Allen's big-eared bats were recorded in 3 ecoregions: Colorado plateau shrublands, Mojave Desert and Wasatch and Uinta montane forests, and 2 physiographic provinces (Basin and Range and Colorado Plateau). This big-eared bat was recorded in 5 land owner types, but only in the Southern and Southeastern UDWR Regions and 6 counties. This county level distribution was also noted by Black (1970), Armstrong (1974), Foster et al. (1997) and Oliver (2002). While the ecology of this rare species is poorly understood, some habitat associations have been noted (Rabe et al. 1998; Adams 2003). Allen's big-eared bat observations generally occurred in patchy forested habitat such as ponderosa pine forest, pinyon-juniper, riparian, and oak woodlands, and fir forest (Wilson and Ruff 1999). Of the 18 land cover types this species was detected in the above habitats were occupied as well as a variety of shrublands, grasslands, and developed cover types.

Allen’s big eared bat is generally associated with canyon habitat (Adams 2003). The high density of activity in southern and southeastern Utah was likely associated with canyon habitat density. Allen’s big-eared bat breeders were only observed in the Colorado Plateau shrublands.

Allen’s big-eared bat was observed more often at 1501-2000 m elevation. While this species is associated with lower elevation (Adams 2003), the majority of the Colorado shrublands ecoregion is within this elevational range.

Western red bat

Western red bats were only detected in 19 events. The limited records for this species does however, indicate a distributional pattern. This species was detected in 3 ecoregions, primarily Colorado Plateau shrublands, but events also exist in the Great Basin shrub steppe and a single record from Wasatch and Uinta montane forest. This pattern is also reflected in physiographic provinces, with detection in the Colorado plateau, Basin and Range and the Middle Rocky Mountains. Red bats were only observed in 2 land cover types: Rocky Mountain Bigtooth Maple Ravine and Colorado Plateau Pinyon-Juniper Woodlands. This species is a foliage rooster and is associated with edge habitat near riparian land cover (Barbour and Davis 1969; Kunz 1982). It is likely that this species occurrence is a function of vegetation structure and the proximity to perennial water sources (Wilson and Ruff 1999). All capture events occurred within 10 km of a perennial water source. Western red bats were recorded in 6 Utah counties, including Cache, Carbon, Utah and Washington counties as noted by Bogan (1997), and Wayne and Weber counties yet to be mentioned in the literature. This species was recorded primarily on private lands with a single observation from UDWR lands. The western red bat was recorded in all UDWR Regions except the Northeastern. The association of this species with deciduous foliage and riparian zones likely dictates its occurrence in Utah. While the records of this species are distributed across the State, the habitat in which they were recorded in is rare on the landscape. The western red bat is likely a migratory visitor to the state. Western red bats are solitary foliage roosters and are associated with riparian habitats (Adams 2003). The density of activity in Utah is the result of this species affinity for riparian habitats. No western red bat breeders were observed, likely due missing reproductive data rather than the ecology of this species. Western red bat events occurred at less than 1000 m for 60% of events. Others have also noted that this species occurs at lower elevation riparian zones (Wilson and Ruff 1999).

Arizona myotis

Arizona myotis was observed on a limited spatial and temporal scale. Records for this species were dominated by capture events in June and July. This species was only observed in the Colorado Plateau shrublands ecoregion and Colorado Plateau physiographic province. This species was recorded in 3 Colorado Plateau land cover types, characterized by woodlands, shrublands, and tablelands. Arizona myotis occurred only on BLM and privately held lands in the UDWR Southern Region in Kane County. While the taxonomy of this species is yet to be resolved (Oliver 2000) the occurrence pattern in the State augments Adams' (2003) distribution in Arizona. Records of this species exist over a long time frame but are clustered in mid-summer. These patterns indicate that this species, or sub-species, is at its northern most distribution in Utah.

The density of the Arizona myotis is likely the result of taxonomic confusion with this species (Oliver 2000). The data events that recorded this species only exist in a single county. Until the taxonomic uncertainties can be addressed, the distribution and density of this species or subspecies cannot be determined. Arizona myotis breeders were only observed in the Colorado Plateau shrublands. All Arizona myotis events all occurred between 1501 2000 m. This trend is likely due to the limited distribution records for this species in Utah.

Fringed myotis

The fringed myotis was recorded in all ecoregions except the Wyoming Basin shrub steppe, 3 physiographic provinces; Basin and Range, Colorado Plateau and Middle Rocky Mountains and 35 land cover types. Managerially, this species was detected on 9 land owner types including DoD, all UDWR regions, and 16 Utah counties. This species is associated with middle elevations in grassland, desert, woodland and montane habitats (Reduker et al. 1983). This species appears to behave as a foliage gleaner (Wilson and Ruff 1999). The magnitude of observations for this species was greater in the Southern and Southeastern UDWR Regions. This skewed distribution was hypothesized by (Adams 2003). The occurrence of this species is dependent on land cover type and associated cavern roosting habitat.

The fringed myotis is often associated with pinion and oak woodlands however this species has been captured in a wide variety of habitats (Foster et al. 1997). The highest density of fringed myotis events were recorded in southern Utah. This trend was mentioned by Adams (2003). The medium density records of the species on DoD lands in the west desert may indicate an extension in range (Adams 2003).

The fringed myotis as mentioned above is a cavern roosting obligate species. Cave and mine density is highest in the Colorado Plateau shrublands (Uranium mines), Great Basin shrub steppe (hard rock mines) and Wasatch and Uinta montane forest where breeders for this species were observed. Fringed myotis was observed across middle elevations, again, this likely the result of the distribution of cavern habitat in Utah.

Big free-tailed bat

Big free-tailed bats occurred across scales at a low density. There were records for this species in all but the Wyoming Basin ecoregion. Big free-tailed bats were observed in the Basin and Range and the Colorado Plateau physiographic provinces and in 26 land cover types. Cover types varied from high intensity developed lands to Mojave Desert scrub and montane riparian areas. The majority of data for this species was concentrated in Sonora-Mojave Creosotebush-White Bursage Desert Scrub and Colorado Plateau Mixed Bedrock Canyon and Tableland. While the highest density of collection events is in the Colorado Plateau records from Basin and Range and montane forests indicate a range extension into southern Utah. Schmidly (1991) and Adams (2003) hypothesized a range limited to extreme southern and Eastern Utah. The mobility and migratory nature of this species likely account for this broader scale of distribution in Utah.

The big free-tailed bat is migratory and roosts high on cliff walls (Adams 2003). This accounts for the southerly distribution in the Colorado Plateau. Records of this species from the west desert and Wasatch montane forests are likely the result of migratory behavior; the lack of any high density activity is related to the rarity and solitarily of this species. Big free-tailed bat breeders were only observed in the Colorado Plateau shrublands. Big free-tailed bat events generally occurred below 2000m. Jones (1965) recorded this species as high as 2400 m, however, this species appears to be associated with lower elevations as recorded with this data set (Adams 2003).

IMPLICATIONS

By defining the current status of bat distributions in Utah we have begun a new stage in bat monitoring and research. This data set provides a base for protocol development, species habitat modeling and sensitive species monitoring. The patterns observed in the data set indicate that a protocol for monitoring bat populations should be fitted to the distribution of the bat species of interest. The data set also shows that a monitoring protocol needs to take into account underrepresented locations and cover types. These data allude to associations of bat species and environmental factors. The data set provides the basis of understanding needed to implement an occupancy based model. These results provide a list of managerial monitoring needs via un-surveyed areas and recorded location of sensitive species or communities. These findings also indicate that there is a need to manage risks and identify threats to bat species as detailed in the Legacy III project proposal.

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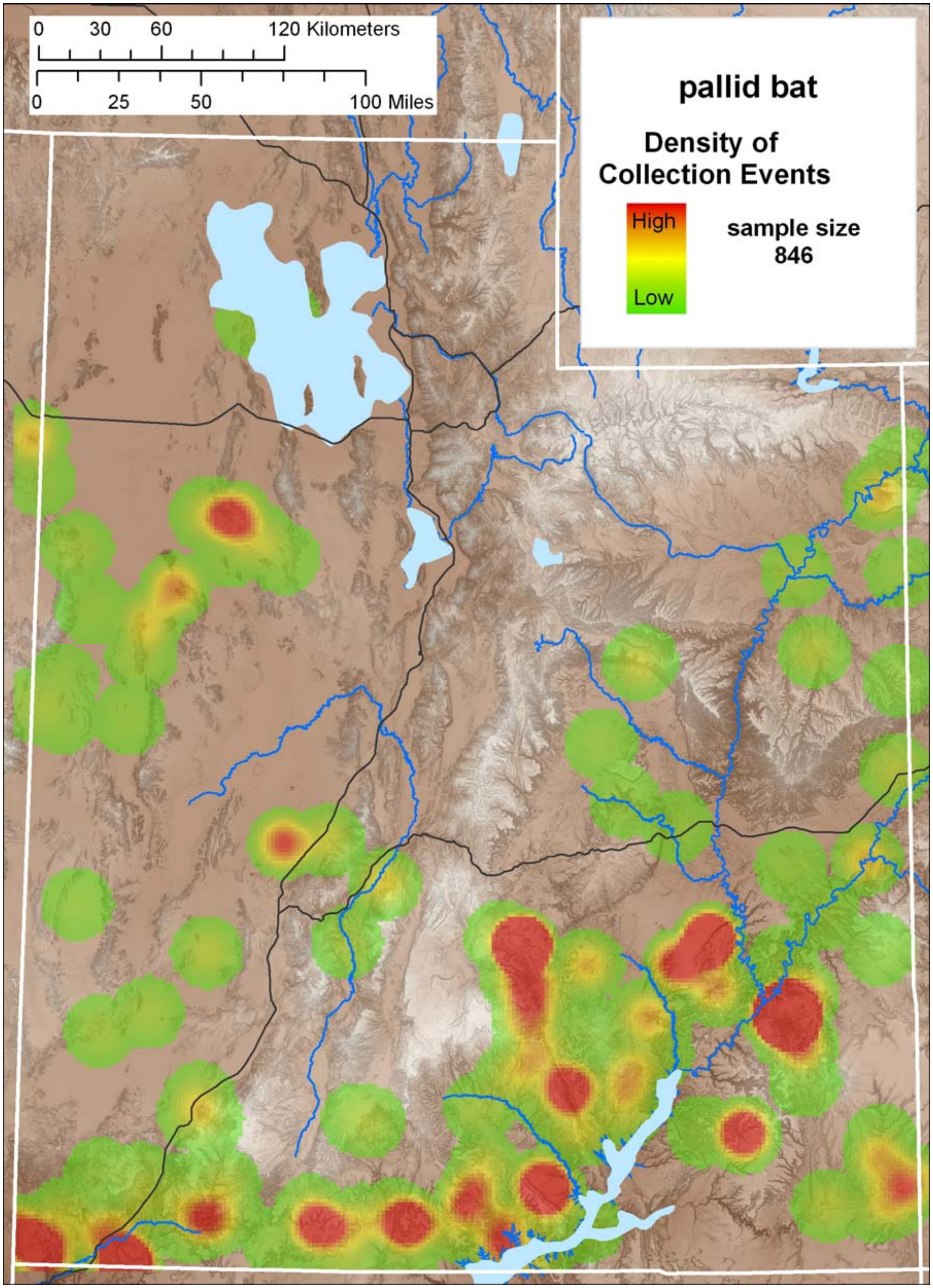
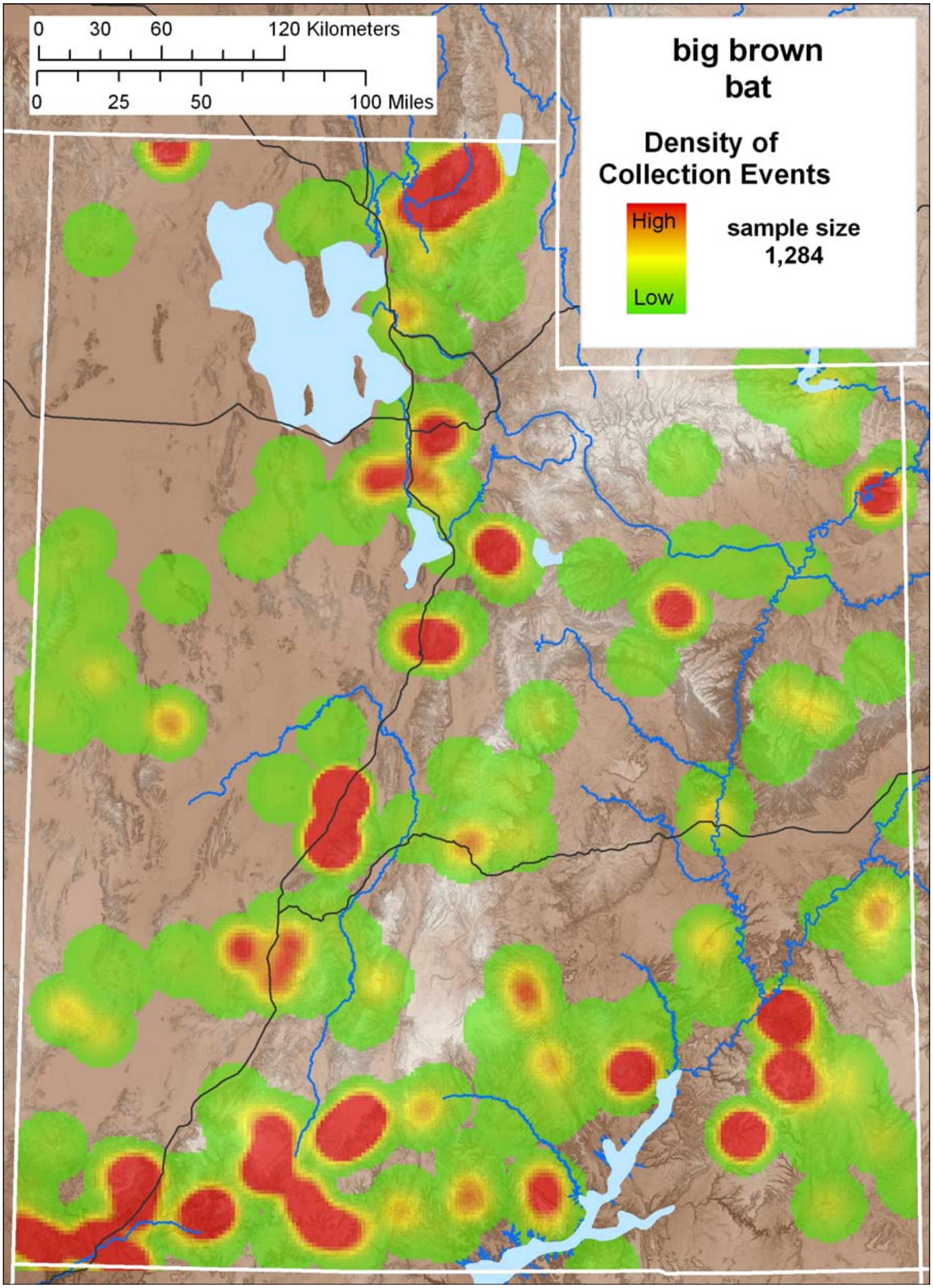
Appendix I. Identifier for each land cover type used in the above analysis.

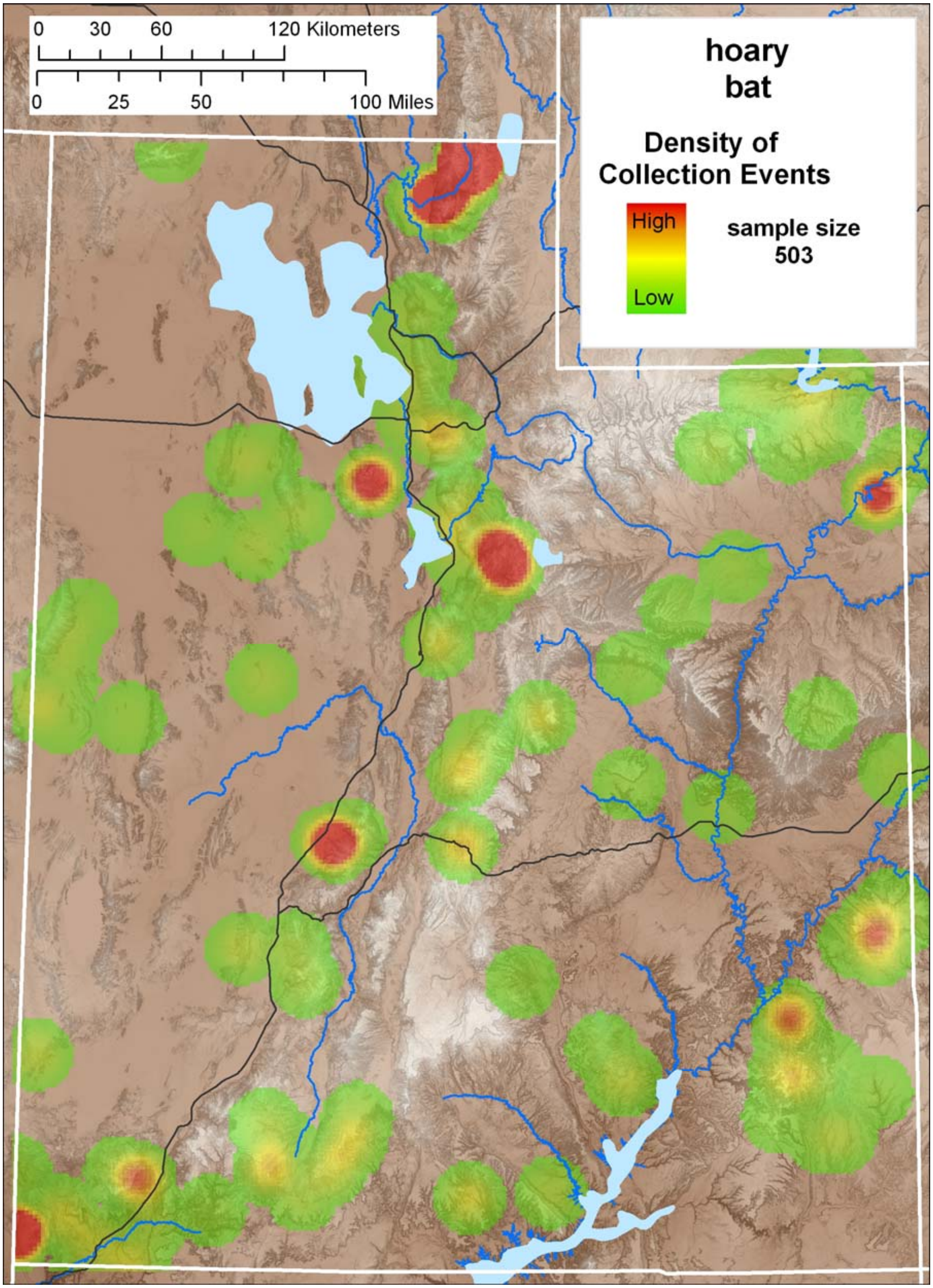
Identifier	Land cover Type
0	No type
5	Rocky Mountain Cliff and Canyon
8	Inter-Mountain Basins Cliff and Canyon
9	Colorado Plateau Mixed Bedrock Canyon and Tableland
10	Inter-Mountain Basins Shale Badland
11	Inter-Mountain Basins Active and Stabilized Dune
12	Inter-Mountain Basins Volcanic Rock and Cinder Land
14	Inter-Mountain Basins Playa
15	North American Warm Desert Bedrock Cliff and Outcrop
19	North American Warm Desert Wash
22	Rocky Mountain Aspen Forest and Woodland
23	Rocky Mountain Bigtooth Maple Ravine Woodland
26	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
28	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
29	Rocky Mountain Lodgepole Pine Forest
30	Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland
32	Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland
34	Rocky Mountain Ponderosa Pine Woodland
36	Colorado Plateau Pinyon-Juniper Woodland
37	Great Basin Pinyon-Juniper Woodland
38	Inter-Mountain West Aspen-Mixed Conifer Forest and Woodland Complex
40	Inter-Mountain Basins Mat Saltbush Shrubland
41	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
42	Rocky Mountain Lower Montane-Foothill Shrubland
44	Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland
46	Colorado Plateau Pinyon-Juniper Shrubland
48	Inter-Mountain Basins Big Sagebrush Shrubland
49	Great Basin Xeric Mixed Sagebrush Shrubland
50	Colorado Plateau Mixed Low Sagebrush Shrubland
51	Mogollon Chaparral
53	Colorado Plateau Blackbrush-Mormon-tea Shrubland
54	Mojave Mid-Elevation Mixed Desert Scrub
58	Inter-Mountain Basins Mixed Salt Desert Scrub
60	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
61	Sonora-Mojave Mixed Salt Desert Scrub
62	Inter-Mountain Basins Montane Sagebrush Steppe
67	Inter-Mountain Basins Semi-Desert Shrub Steppe
69	Rocky Mountain Dry Tundra
70	Rocky Mountain Subalpine Mesic Meadow
71	Southern Rocky Mountain Montane-Subalpine Grassland
76	Inter-Mountain Basins Semi-Desert Grassland
77	Rocky Mountain Subalpine-Montane Riparian Shrubland
79	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
80	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
82	Inter-Mountain Basins Greasewood Flat
83	North American Warm Desert Riparian Woodland and Shrubland

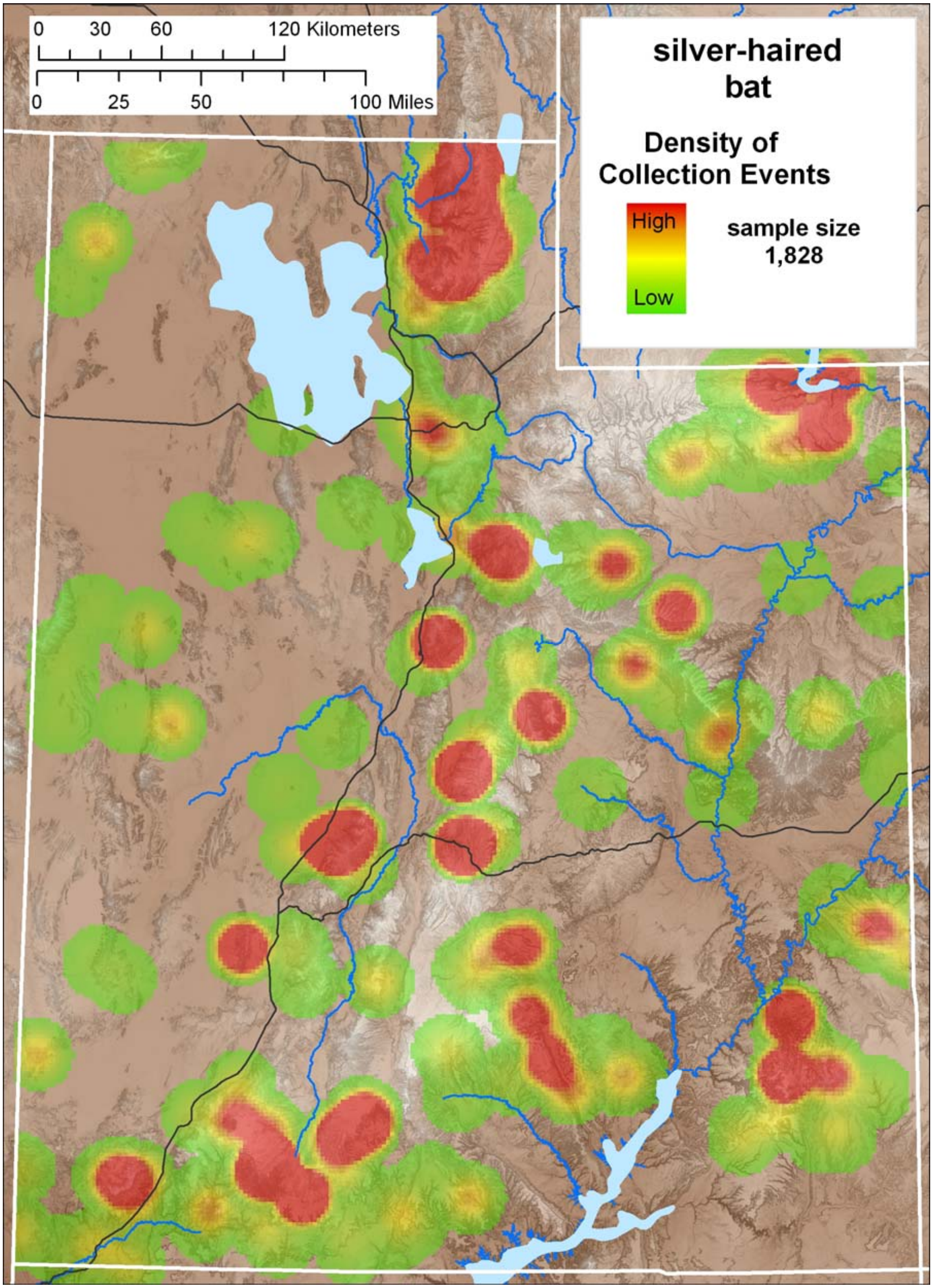
85	North American Arid West Emergent Marsh
86	Rocky Mountain Alpine-Montane Wet Meadow
98	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
108	Southern Colorado Plateau Sand Shrubland
110	Open Water
111	Developed, Open Space - Low Intensity
112	Developed, Medium - High Intensity
114	Agriculture
117	Recently Mined or Quarried
118	Invasive Southwest Riparian Woodland and Shrubland
119	Invasive Perennial Grassland
121	Invasive Annual Grassland
122	Invasive Annual and Biennial Forbland
123	Recently Logged Areas
124	Recently Chained Pinyon-Juniper Areas

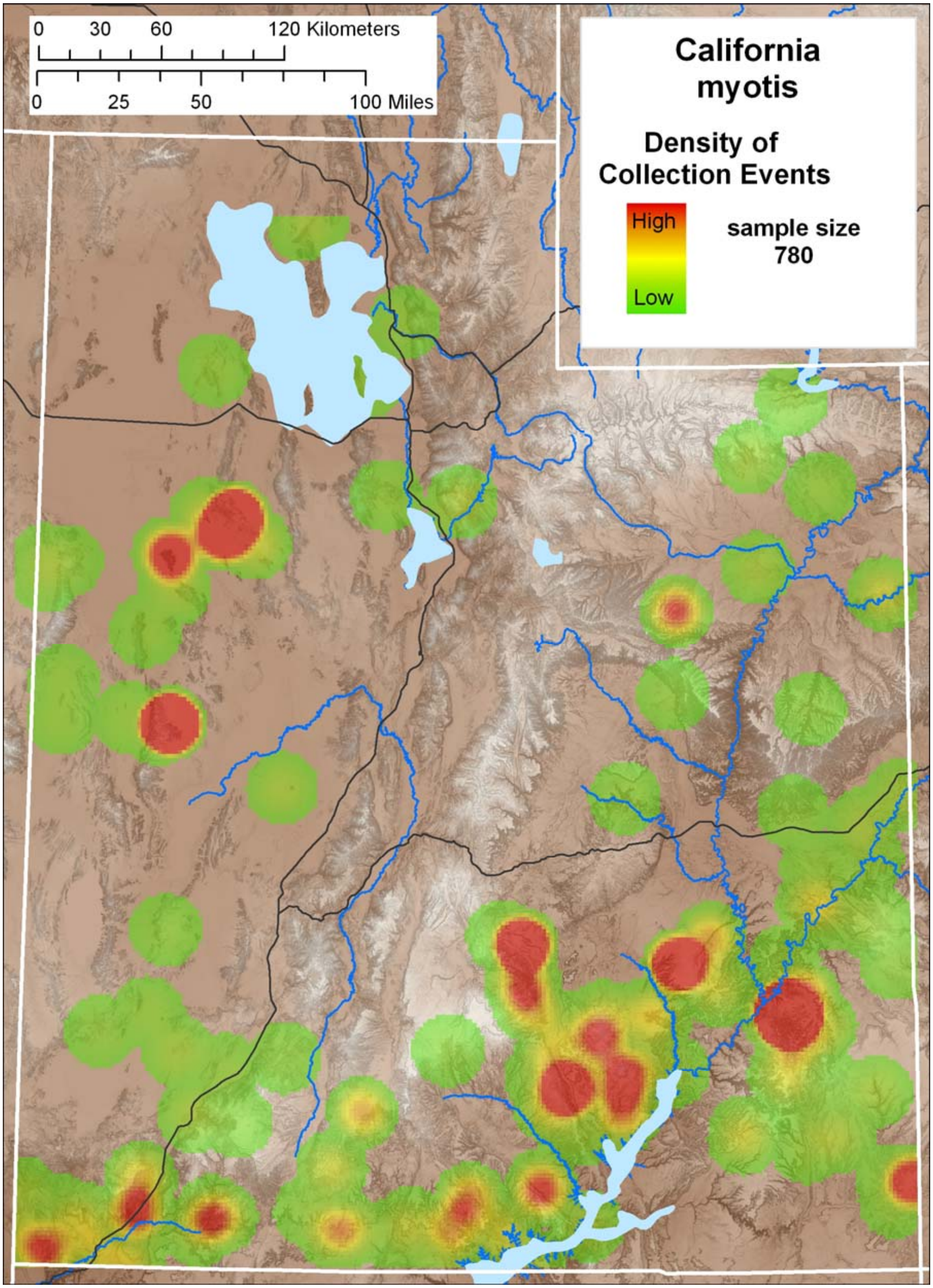
Appendix II. Density of events for the 12 non-sensitive species.

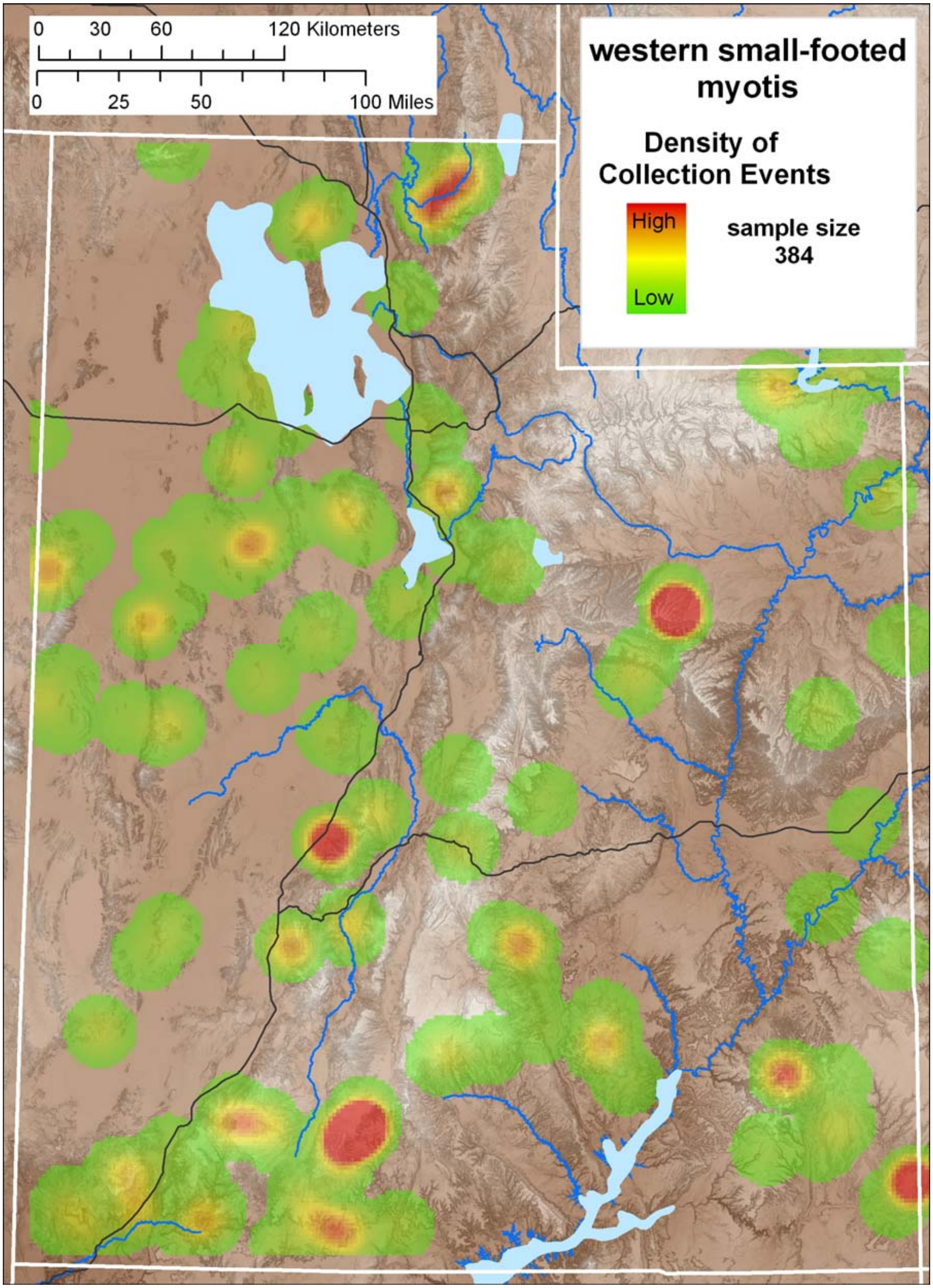

0 30 60 120 Kilometers
0 25 50 100 Miles
pallid bat
Density of Collection Events
High
Low
sample size
846

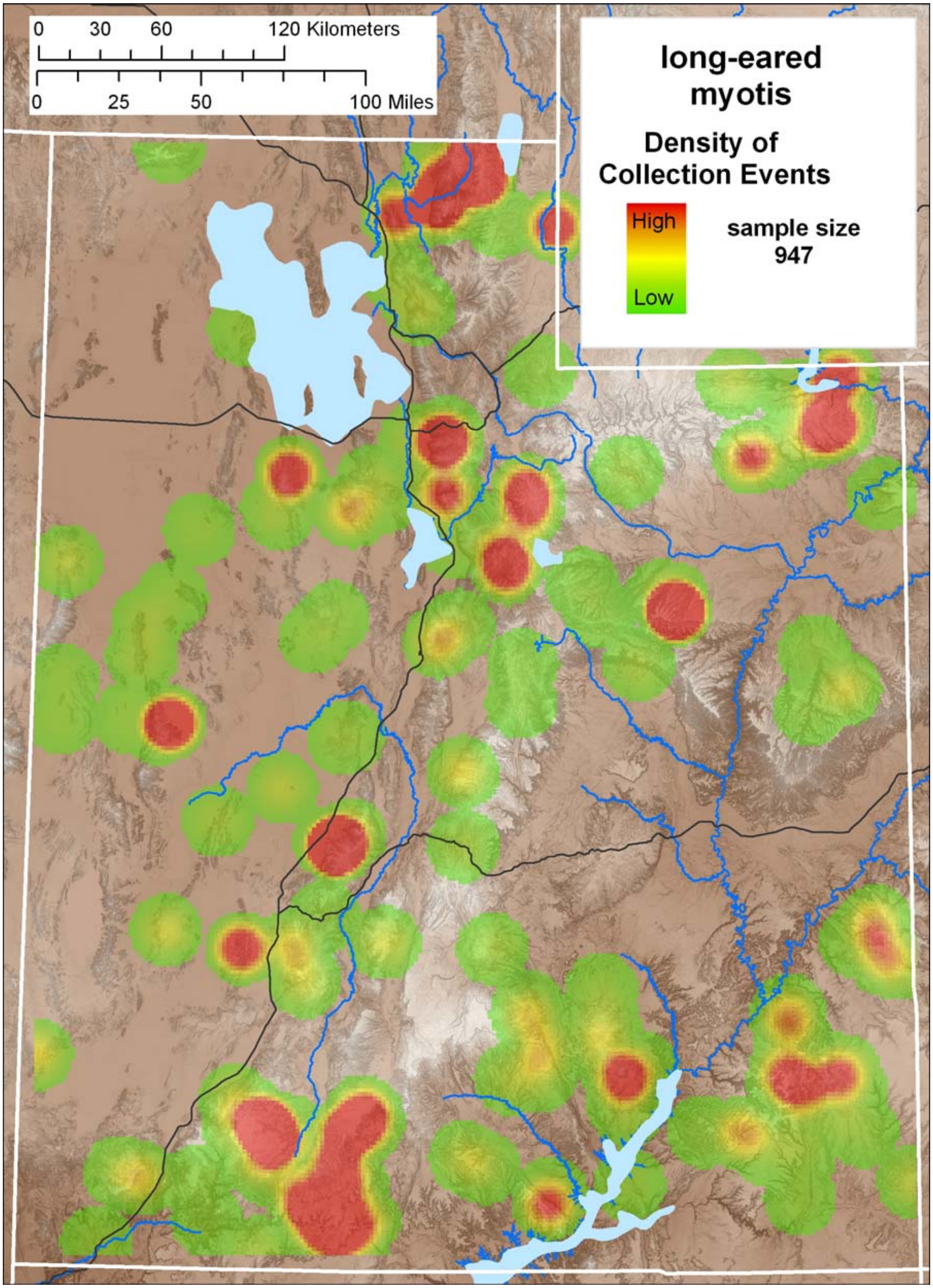

0
30
60
120 Kilometers
0
25
50
100 Miles
big brown bat
Density of Collection Events
High
Low
sample size 1,284

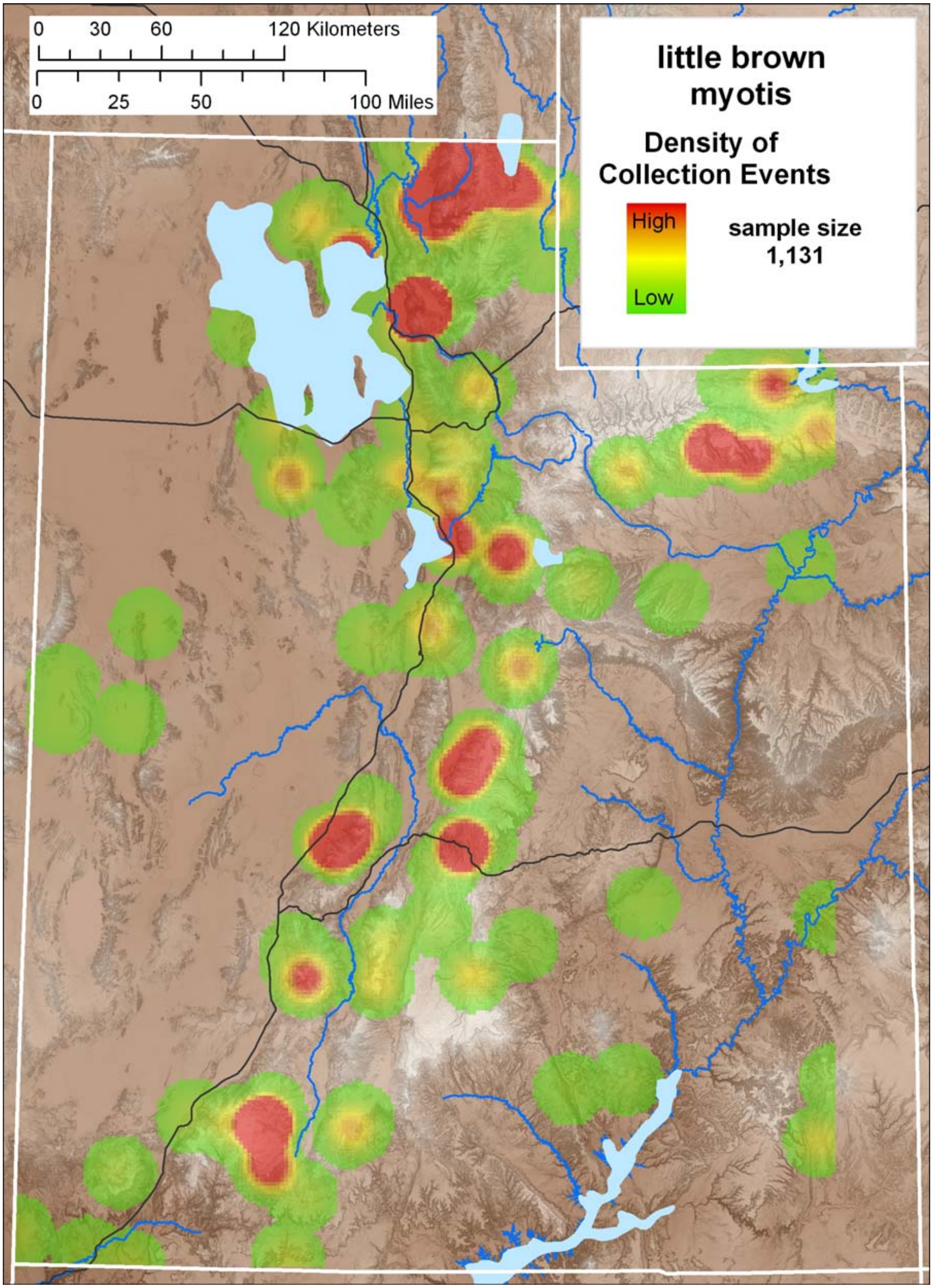

0 30 60 120 Kilometers
0 25 50 100 Miles
hoary bat
Density of Collection Events
High
Low
sample size 503

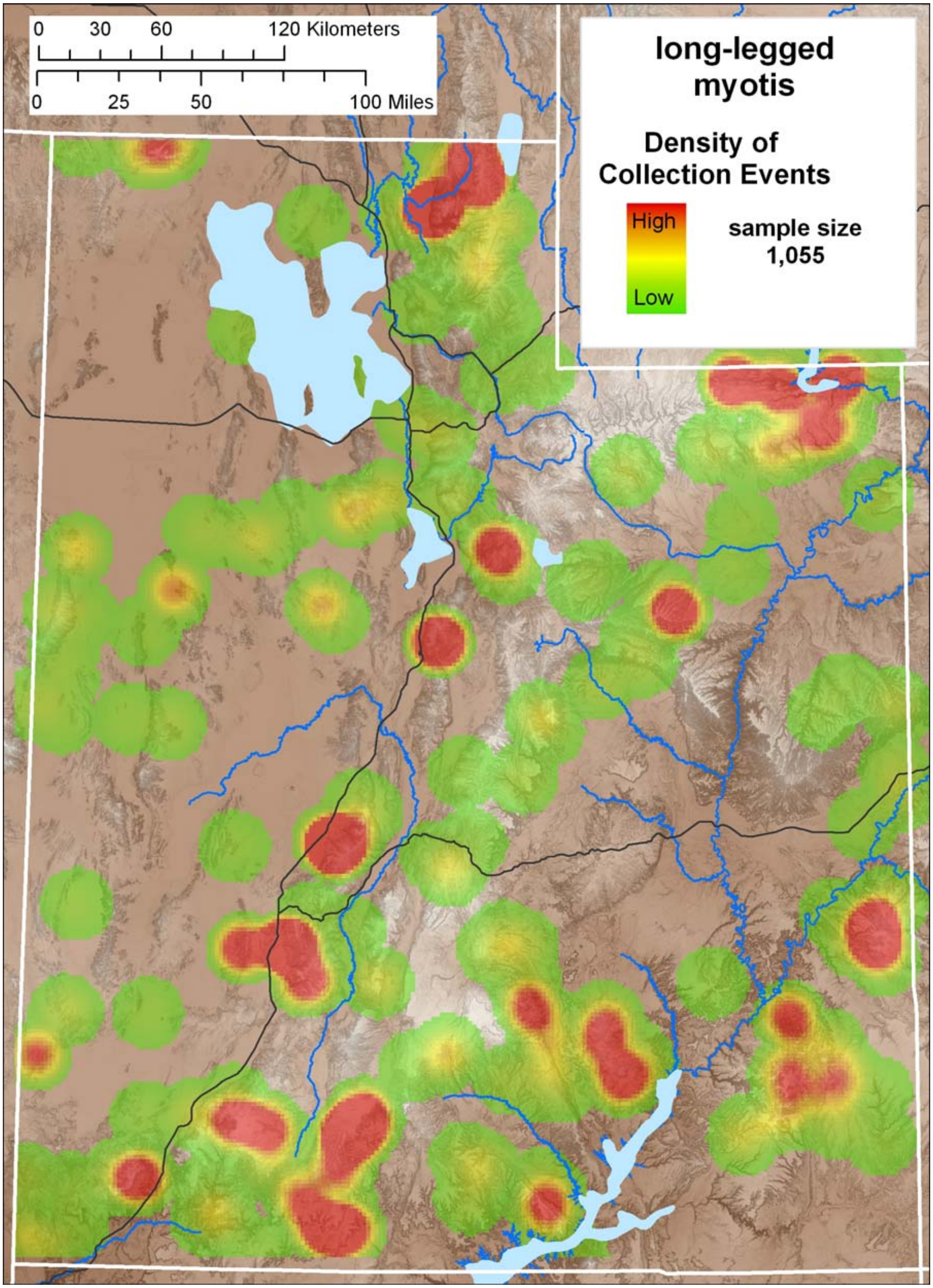

0 30 60 120 Kilometers
0 25 50 100 Miles
silver-haired bat
Density of Collection Events
High
Low
sample size 1,828

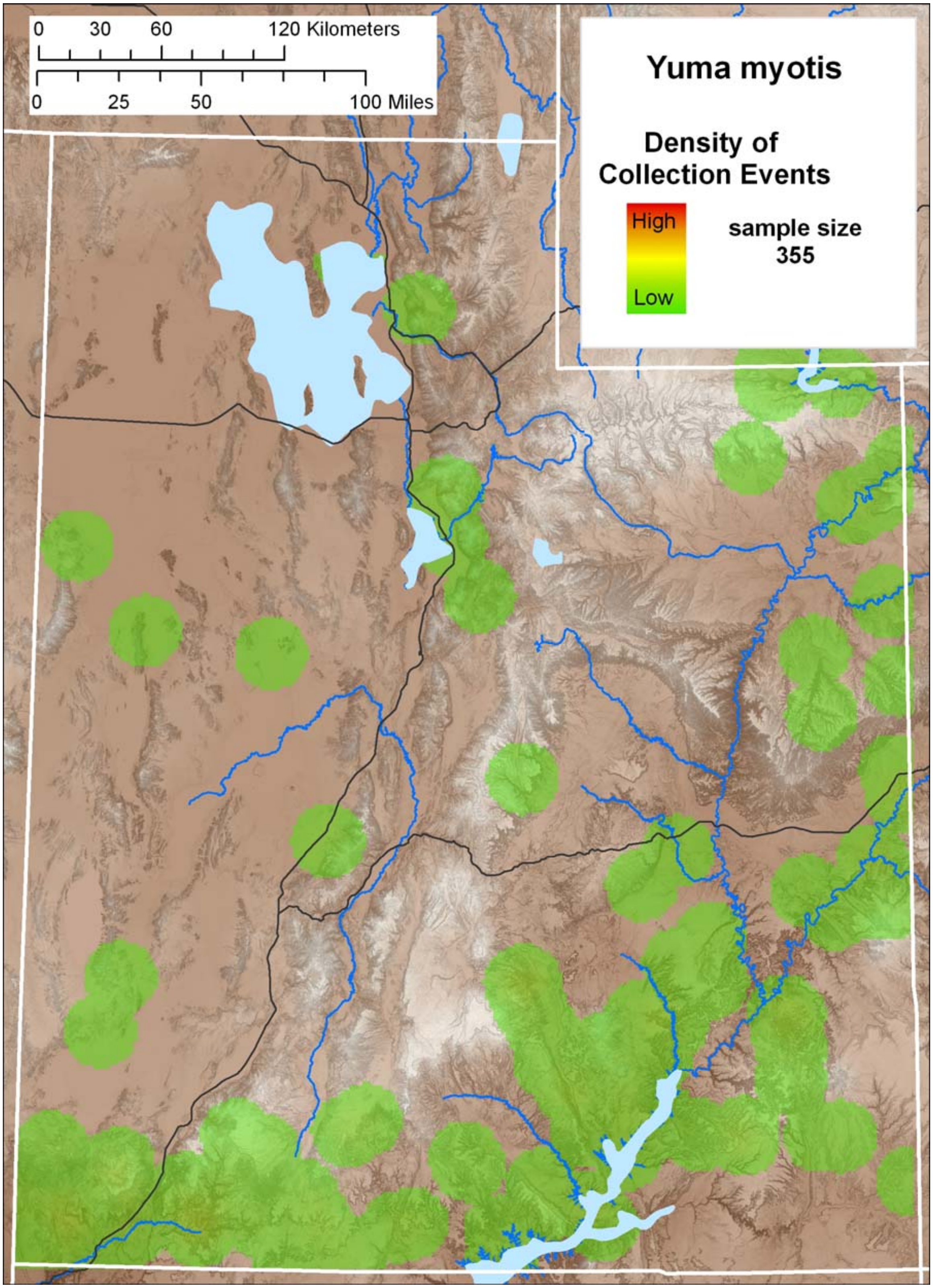

0 30 60 120 Kilometers
0 25 50 100 Miles
California myotis
Density of Collection Events
High
Low
sample size 780

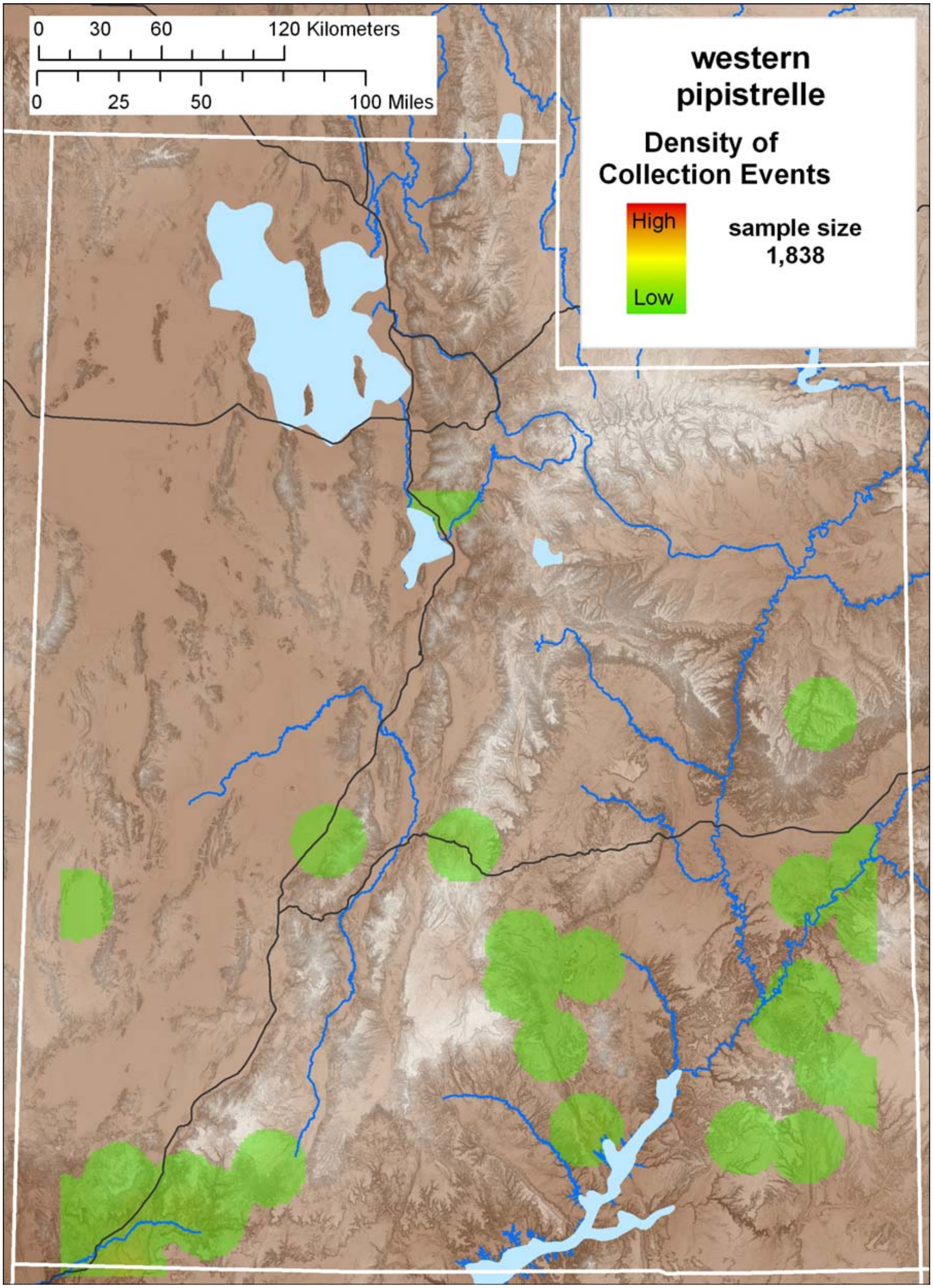

0
30
60
120 Kilometers
0
25
50
100 Miles
western small-footed myotis
Density of Collection Events
High
Low
sample size
384


0 30 60 120 Kilometers
0 25 50 100 Miles
long-eared myotis
Density of Collection Events
High
Low
sample size 947

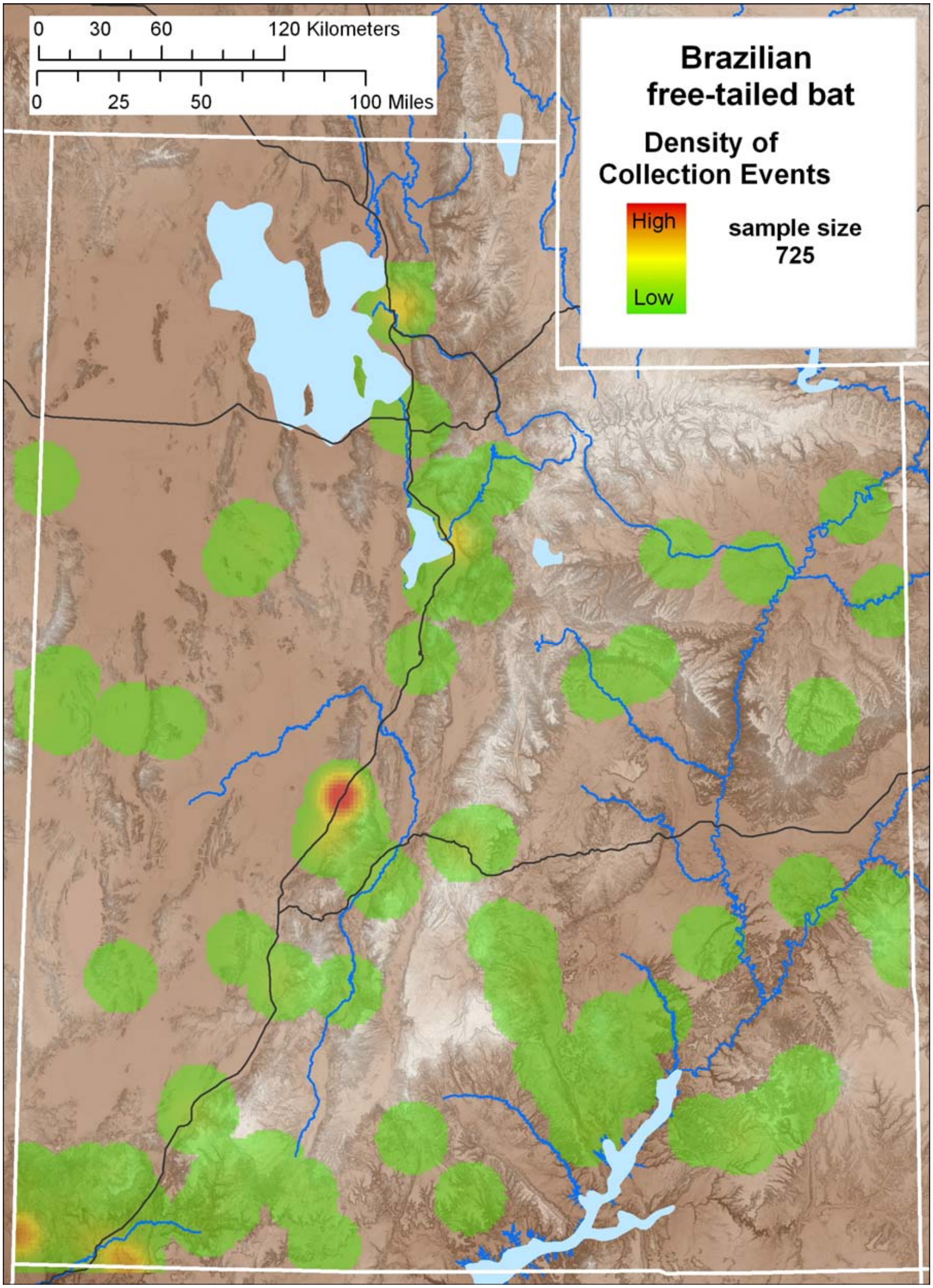

0 30 60 120 Kilometers
0 25 50 100 Miles
little brown myotis
Density of Collection Events
High
Low
sample size 1,131


0
30
60
120 Kilometers
0
25
50
100 Miles
long-legged myotis
Density of Collection Events
High
Low
sample size 1,055


0 30 60 120 Kilometers
0 25 50 100 Miles
Yuma myotis
Density of Collection Events
High
Low
sample size 355



0 30 60 120 Kilometers
0 25 50 100 Miles
western pipistrelle
Density of Collection Events
High
Low
sample size 1,838


0
30
60
120 Kilometers
0
25
50
100 Miles
Brazilian free-tailed bat
Density of Collection Events
High
Low
sample size
725