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Small Mammal Diversity, Rattlesnake Demographics, and Resource Utilization in the Great Basin: Implications for Management and Stable Isotope Proxies

Bryan T. Hamilton

A dissertation submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

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ABSTRACT

Small Mammal Diversity, Rattlesnake Demographics, and Resource Utilization in the Great Basin: Implications for Management and Stable Isotope Proxies

Bryan T. Hamilton
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Doctor of Philosophy

Plant carbon isotopes were used to track assimilation of riparian resources by small mammals. Voles and shrews derived significant portions of their carbon from riparian vegetation. Deer and harvest mice were abundant in riparian habitat but assimilated little riparian vegetation indicating that the riparian corridor provided resources other than food. This is first use of stable carbon isotopes to trace riparian resources into a vertebrate community.

Conifer encroachment in sagebrush ecosystems negatively affects many wildlife populations. Conifer removal is recommended across millions of hectares in the Great Basin. However the effects of conifer encroachment and conifer removal are unknown for most wildlife species. We show that the consequences of conifer encroachment, a press impact, far outweigh the pulse impact of sagebrush restoration, on small mammal diversity.

Lack of demographic data limit the development of effective management, conservation and recovery goals for rattlesnakes. We used a long-term dataset and capture mark recapture models to quantify demography of four rattlesnake populations. Mean population growth indicated an overall stable population across the study, with two of the four sites declining. Survival overwhelmingly contributed to population growth relative to recruitment.

No small mammals drank stream water even during periods of environmentally high water stress and high aridity, extension of the linear regression equation for small mammal body water towards the meteoric waterline, captures stream water, the weighted mean average for regional meteoric waters. Similar regression of fossilized small mammal tissues would also capture local meteoric waters. Even in arid regions, small mammal fossils are a suitable proxy for climate reconstructions.

In the Great Basin, snowmelt overwhelmingly contributes to local precipitation, plant production, and stream flows. Snowmelt supports riparian and upland plants, and small mammals. Rattlesnakes prey primarily on small mammals, indirectly depending on snow melt for survival and reproduction. Climate models and rattlesnake emergence strongly indicate an earlier onset of spring and reduced ratio of snow to rain. Declining snowpack will have major impacts on biodiversity and management such as riparian vegetation, native plant restoration, trophic interactions, and ecological goods and services.

Keywords: stable isotopes, δ13C, δD, δ^{18}O, Crotalus lutosus, Snake Range, Great Basin National Park

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CHAPTER 1: Why is small mammal diversity higher in riparian areas than in uplands?

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Abstract

Riparian areas are valued in arid regions for supporting wildlife diversity. We examined relationships between small mammal diversity and riparian areas and mechanisms facilitating higher small mammal diversity in riparian areas. Riparian areas were identifiable from uplands by higher plant cover and supported higher small mammal abundance. Small mammal abundance was related to plant cover and decreased away from riparian habitat. Riparian and upland habitats supported different species, contributing to higher gamma diversity via species turnover between habitats. Differences in plant $\delta^{13}C$ between riparian and upland habitats were used to track assimilation of riparian resources by small mammals. Voles and shrews derived significant portions of their carbon from riparian vegetation. Sagebrush voles and woodrat hair was relatively low in $\delta^{13}C$, likely the result of assimilating forbs and annual grasses in upland habitat. Deer and harvest mice were abundant in riparian habitat but assimilated little riparian vegetation indicating that the riparian corridor provided resources other than food. In addition to food resources, plant cover likely provided protection from predators and a moderate microclimate. To our knowledge this is first use of $\delta^{13}C$ to trace riparian resources into a vertebrate community and show $\delta^{13}C$ as a good proxy for riparian vegetation assimilation.

Keywords: Small mammal, Riparian, Phreatophyte, Carbon Isotope

Introduction

Riparian areas are terrestrial habitats adjacent to aquatic ecosystems. Riparian areas are greatly influenced by their proximity to water and the primary controlling factor for riparian areas is the availability of water from in-stream or groundwater sources (Stromberg et al. 1996). In arid regions, riparian corridors are well developed along streams and form narrow, linear contrasts of dense, highly productive vegetation against the sparsely vegetated precipitation dependent upland matrix. In water limited environments, riparian areas are scarce and constitute less than 1% of most arid landscapes (Patten 1998).

Riparian resources, such as food, vegetative cover, and water, are often unavailable in the xeric, precipitation dependent upland matrix. Despite their low areal extent, riparian areas have a strong influence on wildlife diversity (Gregory et al. 1991). High plant biomass available in riparian areas is an abundant high quality food source for herbivores (Case and Kauffman 1997) and also provides protection to wildlife from predators (Peles and Barrett 1996). High plant cover in riparian areas moderates the riparian climate, increases shade, decreases solar insolation, lowers temperatures and increases humidity (Naiman and Decamps 1997).

Small mammals are ecosystem engineers in arid areas. Seed caching by small mammals enhances plant germination (McAdoo et al. 1983), burrowing aerates soils (Huntly and Inouye 1988), cycles nutrients (Sirotnak and Huntly 2000), and maintains early seral stage plant communities (Kitchen and Jorgensen 1999). As the prey base for many predators, small mammals are an important trophic link in food webs (Glaudas et al. 2008).

Small mammal diversity is often higher in riparian habitat than in uplands. For example, higher small mammal richness (Falck et al. 2003), abundance (Macdonald et al. 2006), evenness (Oaten and Larsen 2008), and increased turnover (Soykan and Sabo 2009) are found in riparian habitats across a range of geographic areas, spatial scales, and time spans. Riparian habitats exhibit a high level of structural and compositional diversity relative to uplands (Gregory et al. 1991) and higher small mammal diversity is often attributed to increased vegetative complexity (Bateman and Ostoja 2012). Alternatively, lack of diversity differences are attributed to a lack of heterogeneity between habitats (Macdonald et al. 2006).

Habitat heterogeneity in of itself cannot provide a mechanistic explanation for trends in small mammal diversity. Although the link between riparian areas and small mammal diversity is pervasive, causal mechanisms are not yet established. Habitat heterogeneity suggests several testable hypotheses related to resource availability, such as forage, cover, and microclimate. Increased resource availability in riparian areas and the general pattern of higher small mammal diversity in the riparian corridor lead us to a series of questions meant to clarify mechanisms responsible for higher small mammal diversity in riparian habitat. Our questions are followed with a series of predictions.

(1) Is small mammal diversity related to the availability of riparian habitat or proximity to streams? The relationship between small mammal diversity and riparian habitat is widespread and general. We expect higher abundance, richness and evenness in riparian habitat and high turnover between upland and riparian habitats. Higher diversity indices may result from differential availability in resources such as food, cover, and microclimate in riparian habitat. In arid regions, differences between riparian and upland habitats should maximize habitat heterogeneity, potentially maximizing contrasts in small mammal diversity.

(2) Do riparian and upland vegetation differ in stable isotope composition? If so, can stable isotopes be used to trace riparian resources? Phreatophytic vegetation in the Great Basin occur where groundwater is available and the presence of phreatophytes is a defining characteristic of riparian areas (Bren 1993). At higher water availabilities, plants are more efficient at discriminating against the heavier ^{13}C isotope (Farquhar et al. 1989). Therefore we expect that riparian vegetation will be lower than upland vegetation in carbon isotope ratios due to greater availability of soil moisture and groundwater near streams. If riparian and upland vegetation differ, stable carbon isotopes can be used to trace feeding and assimilation of riparian food sources by small mammals.

(3) Do small mammal isotope ratios suggest a diet of riparian vegetation? Stable isotopes can quantify the direct assimilation of food into the tissues of consumers (Phillips 2012). Given a difference between riparian and upland plants, small mammal consumers assimilating riparian vegetation should be distinct relative to species assimilating upland vegetation. Assimilation of vegetation may occur directly by consumption of vegetation or secondarily by consumption of primary consumers such as insects.

(4) What proportion of riparian vegetation is assimilated by the small mammal community? The proportion of riparian vegetation assimilated should be related to habitat use. Species and individuals with access to riparian resources should assimilate a higher proportion of riparian carbon than those lacking access, i.e., upland species.

Materials and Methods

Study Area – The South Snake Range encompasses Great Basin National Park (N – 38.98°, W – 114.30°; 31,201 hectares) and is located in east central Nevada in the Great Basin desert. Elevations in the South Snake range vary from 1,621 m in the town of Baker to over 3,982 m at the summit of Wheeler Peak. The climate is cool and arid and varies dramatically with elevation. In Garrison, Utah (elevation - 1609 m) mean annual precipitation is 19 cm and mean annual temperature is 10°C (Western Regional Climate Center, unpublished data). At the Lehman Caves Visitor Center, Nevada (elevation – 2832 m) annual precipitation is 33 cm and the mean annual temperature is 9°C (Western Regional Climate Center, unpublished data). Although there are no weather stations on Wheeler Peak, mean annual precipitation is estimated between 76 and 89 cm (Western Regional Climate Center, unpublished data). Ten perennial streams originate at high elevations in the South Snake Range and are recharged primarily by groundwater and snowmelt.

Study Design - Three watersheds (Lehman, Snake Creeks, and Strawberry Creek) were sampled with four transects per watershed. Transects were randomly located within the watersheds using a stratified sampling design. Transects were oriented perpendicular to streams and extended through the riparian corridor, across the stream, and approximately 450 meters into the uplands. Total transect length was approximately 520 m. Within a watershed the average distance between transects was 651 meters (sd = 143m). Watersheds were separated by approximately 7 km and all streams were first order.

Riparian and Upland Habitat Delineation - To quantitatively delineate riparian and upland habitats, we measured plant and ground cover using a line-point intercept method (Herrick et al. 2005b). To avoid measuring trampled vegetation, sampling points were offset from transects by

5-10 meters. At each sampling point (31 per transect), an observer tossed a pin flag to their left or right, with the direction determined by coin flip. The first azimuth for the pin drop was randomly chosen by spinning a compass. The other sampling points were 90°, 180°, and 270° relative to the first point for a total of four samples at each sampling point. The observer then stood at the pin flag location, closed their eyes and lowered the pin flag. Pin flag contacts were recorded as bare soil, rock (rock > 10 cm), litter (any organic matter in contact with the soil), herbaceous vegetation (grasses or forbs), shrub (woody vegetation < 3m in height), or tree (woody vegetation > 3 meters in height). The numbers of hits were tallied for each location (0, 1, 2, 3, or 4) and the total cover values calculated. Cover values were summed across sampling points and converted to percentages. Cover values were additive and could exceed 100% for total cover.

Plant Isotopes – Plant samples were collected along transects in August 2007 - 2009. Samples were oven dried at 50°C, ground in a Wiley Mill, and analyzed for stable carbon isotope ratios. Plant species and distance from streams were recorded for each sample.

Stable Isotope Analysis – Carbon isotopes ($\delta^{13}C$) were analyzed with Brigham Young University's Elemental Analyzer (EA) interfaced to a Delta V Advantage Isotope Ratio Mass Spectrometer (IRMS). Isotope results are presented relative to international standards in conventional delta (δ) notation as per mil (‰): $\delta_{sample} = R_{sample}\text{-}R_{standard}/R_{standard} \text{ X } 10^3$, where R is the ratio of the heavy isotope to the light isotope. Data are reported relative to Vienna Peedee belemnite marine limestone (VPDB) and were normalized against standards for accuracy using linear regression and checked for precision against duplicate samples. Concentration data was unavailable as the instrument was not calibrated for quantitative analysis. When duplicate samples were analyzed, the mean value was reported. Mean reproducibility for duplicate samples was 0.31‰ ± 0.29 (n=51) for $\delta^{13}C$. Analytical precision was 0.04‰, determined by measurement of internal standards over several years.

Riparian and Upland Climate – To monitor temperature and humidity differences between riparian and upland habitats, we installed a total of ten data loggers, five in each habitat (HOBO U23 Pro v2 Temperature/Relative Humidity Data Logger -U23-001). Locations for the data loggers were chosen randomly by habitat. Data loggers were placed approximately 1 foot off the ground in the shade of a tree or shrub and collected data hourly from 1 July - 30 September. Data was averaged each hour across habitats. To compare climactic stability between habitats, we used the daily temperature and humidity ranges, minimum and maximum values per habitat.

Small mammal sampling – Small mammals were sampled annually during July and August from 2007 – 2009 on the twelve transects as described above (*Study Design*). Transects were sampled for twelve nights in 2007 and eight nights in 2008 and 2009. Each transect consisted of 31 traps. Within the riparian habitat, traps were spaced approximately 10 m apart. In the uplands, traps were spaced on average 21m apart. Seventy-eight traps were placed within the riparian habitat (27%) and 294 in the upland habitat (73%).

At each trap station a single Sherman live trap (SFAL; 5 x 6 x 23 cm; LFA – 8 x 9 x 23 cm; or XLF; 15 – 10 x 11 x 38 cm) was set and baited with sunflower and milo seed between 17:00 - 20:00 hrs. Traps were checked between 05:00 - 10:00 hrs. Small mammals were ear tagged, identified to species, visually assessed for sex, weighed, hair sample collected, and released upon their initial capture. Recaptured individuals were weighed and assessed for ear tag number, species, and sex. We used abundance, evenness, and species richness as response variables of alpha (α) diversity.

Small Mammal $\delta^{13}C$ Analysis – Hair samples, approximately 3 cm^2 in area, were collected dorsally with scissors, immediately anterior to the base of the tail. Hair was sonicated in deionized water for 30 minutes, lipid extracted with petroleum ether for 30 minutes, and subsamples of approximately 0.75 mg measured with a microbalance in tin cups. Samples were analyzed for $\delta^{13}C$ as described above (*Stable Isotope Analysis*). Hair was analyzed since it is metabolically inert, preserving the isotopic information of the consumer at the time it was synthesized.

$\delta^{13}C$ is often used as a tracer of carbon sources within a food web (Karasov and Martinez del Rio 2007). Carbon isotope values vary distinctly between plants of different photosynthetic paths. Although C_3 plants are lower in $\delta^{13}C$ than C_4 and CAM by about 10 ‰, there are very few C_4 or CAM plants in our system. The differences we observe in $\delta^{13}C$ will be between C_3 plants. In water stressed C_3 plants, stomata close to minimize water loss. Stomatal closure reduces the intracellular partial pressure of CO_2 and subsequently reduces discrimination against the ^{13}C isotope during photosynthesis. Conversely, at higher water availabilities, partial pressure approaches ambient pressure, maximizing discrimination rates and leading to lower $\delta^{13}C$ (Karasov and Martinez del Rio 2007). In riparian areas, plants can photosynthesize with open stomata, resulting in depleted carbon values relative to uplands. The low values of $\delta^{13}C$ in riparian areas are indicative of groundwater availability and phreatophytic vegetation which are ultimately what we are interested in tracking .

Mixing Models – Mixing models are used to characterize the dietary composition of consumers (Phillips 2012). We used one tracer ($\delta^{13}C$), two source Bayesian mixing models to characterize the proportions of riparian and upland vegetation assimilated into the tissues of small mammals using Stable Isotope Analysis in Program R (SIAR; Parnell et al. 2010). Mixing models require isotope values for the mixtures ($\delta^{13}C$ values small mammal hair), source values (means and standard deviations of $\delta^{13}C$), and a trophic enrichment factor (TEF). The choice of TEF is the most sensitive parameter in a mixing model (Caut et al. 2009).

Caut et al. (2009) found that TEFs are directly related to the isotopic composition of a consumer's diet and recommended using Diet Dependent Discrimination Factors (DDDF) to determine a specific TEF for a given consumer-source system. Using the equation recommended by Caut et al. (2009) for mammal hair (TEF = -0.474 ($\delta^{13}C$) – 9.064) and the mean value for vegetation $\delta^{13}C$ on our study site (- 26.1‰) gave us a TEF of 3.31‰. We used 3.31‰. for TEF and a standard deviation of 0.1‰ taken from feeding trials with deer mice (*Peromyscus maniculatus)* (Miller et al. 2008a), the most abundant species in our study. We did not include concentration dependence in the models and priors were set as flat.

To increase sample sizes we included $\delta^{13}C$ values for several individuals that were captured opportunistically. These samples were only used in the mixing models and consisted of ten voles, three woodrats, eight canyon mice, 25 pocket mice, 39 piñon mice, 69 harvest mice, four shrews, and five cliff chipmunk. All samples were collected in similar habitat, immediately adjacent, and during the same month as the sampling transects. For species groups with large enough samples ($n \geq 10$ individuals per habitat) $\delta^{13}C$ values of individuals that occurred in both riparian and upland habitats were included. This allowed us to examine shifts in diet relative to the availability of riparian vegetation.

Statistical analysis – Abundance was the minimum number of small mammals known alive (MNKA) per trap station. Species richness was the number of species per habitat by transect. Trapping effort and hence the number of captures varied by habitat, so we rarefied samples by the median number of captures in the riparian habitat for comparisons of richness and evenness (Magurran 2004). Our evenness metric was the inverse of Simpsons index (SI) calculated as: SI = $1/[\sum(n_i*(n_i -1)/N(N-1)]$; where n_i = the number of individuals of the *ith* species; and N = the total number of individuals (Magurran 2004). As SI decreases, community evenness also decreases.

Singletons were excluded from analyses of δ^{13}C, stream distance, and habitat but were included in calculations of species richness, evenness, and abundance. To simplify analyses and increase sample sizes, voles (*Microtus longicaudus and M. montanus)*, chipmunks (*Tamias dorsalis, T. umbrinus, and T. minimus*), and shrews (*Sorex vagrans and S. merriami*) were combined for analyses of stream distance and δ^{13}C.

Habitat, stream distance and species were fixed effects. Sampling was conducted along transects in three watersheds, over three years. To account for a lack of independence among locations and years, we used generalized linear mixed models with year, watershed, and transect as random effects, using the package glmmADMB (Skaug et al. 2014) implemented in the statistical environment R. Models of plant isotope data included only watershed as a random effect, due to lack of convergence when year and transect were included. Since plant cover data were collected in a single year (2009), random effects included only watershed and transect. When model selection was required, we used likelihood ratio tests to select the most parsimonious models (Zuur et al. 2009).

Plant cover, small mammal abundance, and richness were counts. As count data were overdispersed, a negative binomial distribution and log link function were used. Small mammal abundances were zero inflated, a common issue with ecological count data (Zuur et al. 2009). To account for this we included a zero inflation term in the model for small mammal abundance. To validate model fit, we plotted residuals versus fitted values, residuals versus covariates, and examined histograms of residuals for normality.

In linear regression models, with multiple groups as explanatory variables, one group, the reference group, provides a baseline to compare the other groups. In experiments, the reference group is usually the control, which provides an estimate of the effect size of the experimental manipulations. In observational studies, the choice of the reference group is arbitrary. We chose deer mice, the numerically dominant species as the reference group. The intercept given in the tables represents the mean value for deer mice and the coefficients for the other groups are the differences from the reference group (i.e. the difference from the intercept).

Stable isotope and distance data approximated normal distributions and were modeled with a Gaussian distribution and identity link function. Student's t-tests were used to examine differences in temperature, humidity, and temperature and humidity ranges between riparian and upland habitats. All p-values were two tailed and assumed unequal variances between samples. An F-test was used to compare variances between $\delta^{13}C$ of riparian and upland plants. We used Bayesian change point analyses to detect changes in plant cover and small mammal abundance as a function of stream distance. The change point in vegetation cover was used to delineate upland and riparian habitats. Linear regression was used to correlate plant cover and small mammal abundance. All statistical analyses were done with Program R (R Core Team 2014).

This work was conducted according to the guidelines of Brigham Young University's Institutional Animal Care and Use Committee, IACUC project code # 07-0301, scientific research permits from Great Basin National Park (GRBA-2007-SCI-0002) and Nevada

Department of Wildlife (S35631), and the American Society of Mammalogists Guidelines (Sikes et al. 2011).

Results

Riparian and Upland Habitat Delineation –Plant cover declined as a function of increasing stream distance by 0.85 log odds per hundred meters (z = -7.26; $P < 0.001$; Figure 1). The Bayesian change point analysis indicated a distinct change in cover occurred at 39 meters from the stream (64% probability of change). We interpreted this information as strong evidence of a change in habitat based on plant cover and delineated riparian habitat from 0 – 40 meters of streams and upland habitat as > 40 meters from streams.

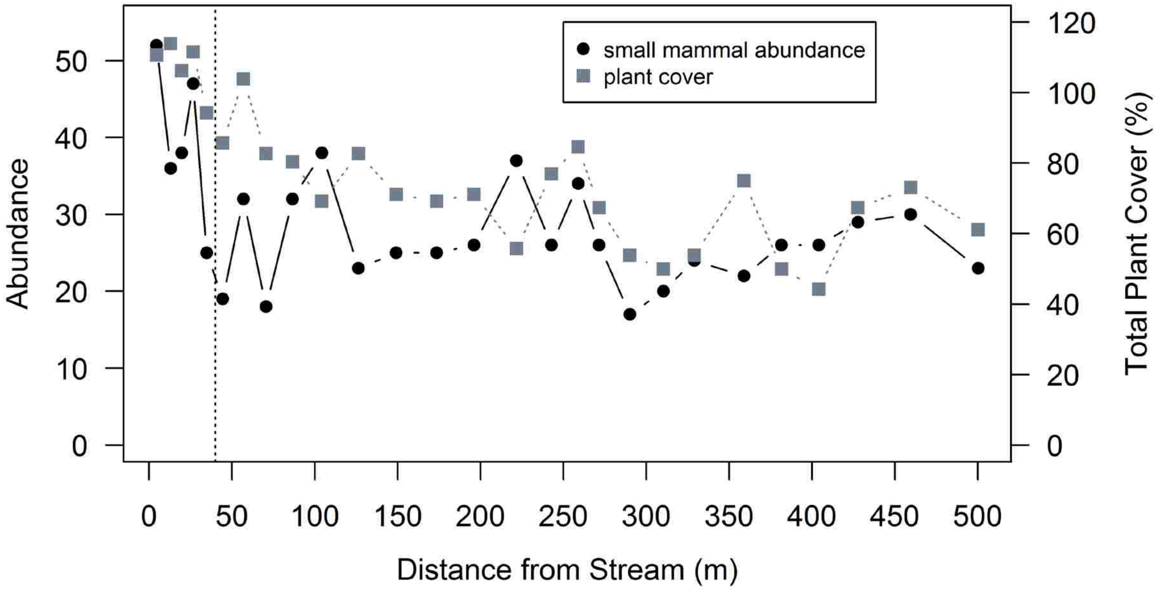

Figure 1. Relationships between stream distance, small mammal abundance, and plant cover. Vertical dotted line represents the change point between upland and riparian habitat (40 m). Total plant cover is the sum of tree, shrub, grass and forb cover and abundance is the minimum number known alive for each of 31 sampling locations for 12 transects in Great Basin National Park, Nevada, sampled over three years.

Mean total vegetation cover (1.63 log odds; z = 7.62; $P < 0.0001$), tree cover (2.45 log odds; z = 4.48; $P < 0.0001$), herbaceous cover (1.74 log odds; z = 5.31; $P < 0.0001$), and litter (1.41 log odds; z = 4.18, $P < 0.0001$) were higher in riparian than upland habitats. Bare soil (1.55 log odds, z = 3.47, $P < 0.001$) and rock cover (1.56 log odds; z = 2.09, $p < 0.001$) were higher in upland than riparian habitats. Habitats did not differ in shrub cover (z = -1.18, $P = 0.24$).

Riparian habitats were visually distinct even without statistical analysis of plant cover. Riparian areas were characterized by species such as narrowleaf cottonwood (*Populus anguistifolia*), quaking aspen (*P. tremuloides*), willow (*Salix spp.*), sedges (*Carex spp.*), Woods' rose (Rosa *woodsii)*, rushes (*Juncus spp.*), water birch (*Betula occidentalis*), Engelmann spruce (*Picea engelmannii*) and white fir (*Abies concolor*). Upland habitat was characterized by sparse, xeric vegetation such as basin big sagebrush (*Artemesia tridentata*), Mormon tea (*Ephedra viridis*), singleleaf piñon (*Pinus monophylla*), Utah juniper (*Juniperus osteosperma*), and various grass species. A wide variety of forb species occurred in both habitats.

Plant carbon isotopes – Stream distance and $\delta^{13}C$ were weakly related (0.744 ‰ increase in $\delta^{13}C$ per 100 meters; z = 4.47; $P < 0.001$; Figure 2). The riparian plant community was isotopically more negative (2.11‰; z = 6.2; $P < 0.0001$) and more variable in $\delta^{13}C$ (ratio of variances = 1.98; F = 1.98, numerator d.f. = 95, denominator d.f. = 89, $P < 0.001$) than plants in upland habitats (Figure 2). $\delta^{13}C$ values for riparian plants ranged from -31.5 to -21.4 and upland plants from -29.4- to -20.9. These ranges exclude an aquatic forb (-34.5‰) and a cactus sample (-12.4‰) collected from the riparian and uplands respectively. Analyses were conducted with and without these values and the statistical inferences were similar.

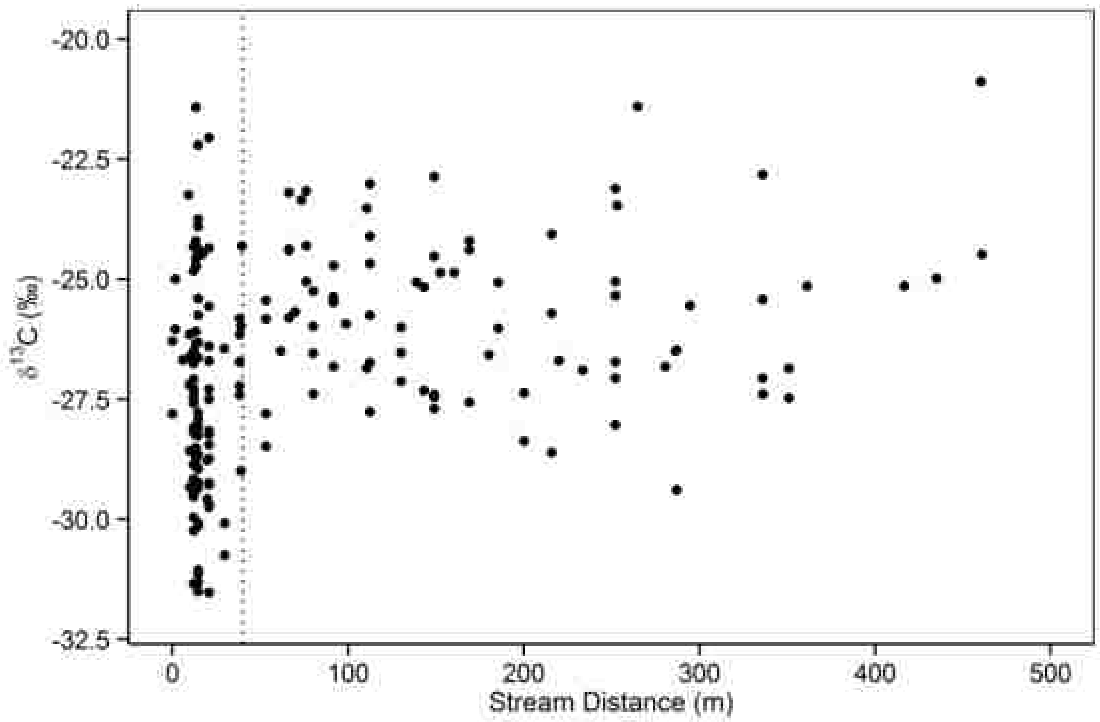

Figure 2. Relationship between δ13C and stream distance for plants in Great Basin National Park. Dotted line represents the delineation between riparian and upland habitats identified by a plant cover change point analysis (40 m).

We further explored plant δ^{13}C by aggregating plants into functional groups (tree, shrub, forb, and grass). Post-hoc Tukey tests indicated that there were no significant differences between trees, shrubs, forbs and grasses in riparian habitat ($P > 0.7$ for all comparisons; Figure 3). Riparian forbs were distinct from upland grasses, shrubs, and trees ($P < 0.05$) but did not differ from upland forbs-annual grasses and riparian plant groups. There were no other differences between upland plant groups (Figure 3).

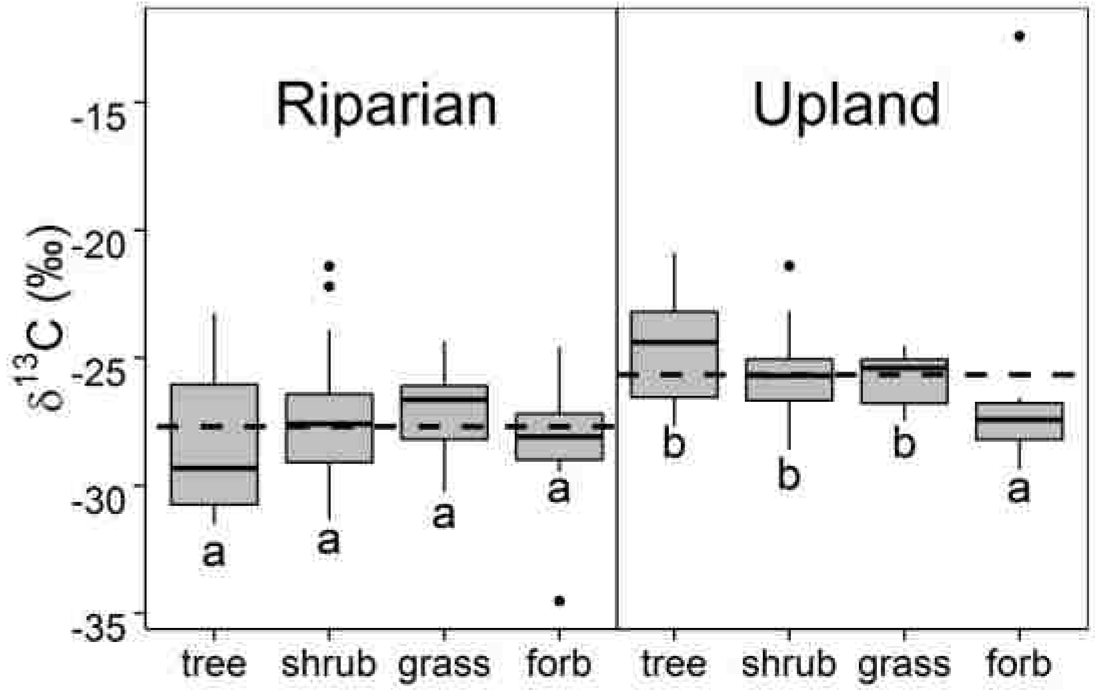

Figure 3. δ13C values for functional groups in riparian and upland habitats. The delineation between riparian and upland habitat was identified by a change point analysis for plant cover as 40 meters from stream. Mean values for the respective habitats are given by the horizontal dashed lines. Different letters above boxes indicate significant differences (Tukey HSD; $P < 0.05$).

We repeated the model selection process with three groups: riparian plants, upland forbs-annual grasses, and upland plants (trees, shrubs and perennial grasses). A three group classification was similar to eight functional groups (likelihood ratio test, $P = 0.354$) and did not differ from the two group riparian upland classification (likelihood ratio test, $P = 0.3149$).

Climate – Mean riparian temperature was cooler by 3.6 °C ($t = 4.94$, $df = 173$, $P < 0.001$) and mean humidity 16.2% higher ($t = 4.65$, $df = 181$, $P < 0.001$) than upland habitat. Riparian habitat had a wider humidity range by 8.7% ($t = 22.2$, $df = 4397$, $P = <0.001$) and a slightly narrower temperature range by 0.3°C ($t = -3.2$, $df = 3761$, $P = 0.001$) than upland habitat.

Small Mammal Diversity – In total 773 individuals comprising 16 species were captured over three years of sampling (Table 1). Total effort was 9,956 trap nights, trap success for unique individuals was 8%, and trap success including recaptures was 23%. Deer mice were by far the most abundant species in both habitats (Table 1).

Table 1. Small mammal captures (minimum number known alive) in riparian and upland habitats in Great Basin National Park, White Pine County, Nevada. Small mammal captures (minimum number known alive) in riparian and upland habitats in Great Basin National Park, White Pine County, Nevada. Mammals were sampled along 12 transects perpendicular to streams, annually in July and August from 2007-2009 for a total of 9,956 trap nights. Riparian habitat was located within 40 meters of streams.

Common name	Species	Riparian	Upland
deer mouse	*Peromyscus maniculatus*	120	374
piñon mouse	*Peromyscus truei*	2	74
western harvest mouse	*Reithrodontomys megalotis*	43	33
Great Basin pocket mouse	*Perognathus mollipilosus,*	5	24
cliff chipmunk	*Tamias dorsalis*	3	22
least chipmunk	*Tamias minimus*	6	12
montane vole	*Microtus montanus*	5	6
canyon mouse	*Peromyscus crinitus*	0	9
sagebrush vole	*Lemmiscus curtatus*	0	8
Uinta chipmunk	*Tamias umbrinus*	3	5
desert woodrat	*Neotoma lepida*	1	6
long-tailed vole	*Microtus longicaudus*	4	2
Merriam's shrew	*Sorex merriami*	1	1
vagrant shrew	*Sorex vagrans*	2	0
chisel-toothed kangaroo rat	*Dipodomys microps*	0	1
ermine	*Mustela erminea*	1	0

Species were separable based on capture distance from streams (Table 2). Western harvest mice, voles, and shrews were most strongly associated with riparian habitat. Although there was considerable overlap of individuals across habitats, all other species were considered upland (Figure 4). Canyon mice and piñon mice occurred furthest from streams and harvest mice, voles and shrews closest. Shrews, woodrats and sagebrush voles had the largest variation in capture distances due partially to their small sample sizes (four, seven, and eight, respectively). A group of five voles was captured approximately 200 meters from Strawberry Creek in a wet meadow (Figure 4). Although this area was not delineated as riparian habitat based on stream distance, wet meadows are supported by groundwater and likely provided riparian resources, such as food, cover and water, to this vole population.

Table 2. Results from generalized linear mixed model of stream distance (m) as a function of small mammal species. Random effects were year, watershed and transect. Deer mice were the reference group.

Variable	Estimate	Std. Error	z value	P value
Intercept (deer mice)	192.7	18.7	10.33	**<0.0001**
shrews (*Sorex* spp.)	-115.5	69.3	-1.67	0.1
Microtine voles	-58.4	43.5	-1.97	**0.05**
western harvest mouse	-57.8	13.4	-4.31	**<0.0001**
Great Basin pocket mouse	-5	25.6	-0.2	0.85
chipmunks (*Tamias* spp.)	18.7	16.6	1.13	0.26
desert woodrat	54.1	46.3	1.17	0.24
sagebrush vole	56.8	45.5	1.31	0.19
piñon mouse	79.4	15.1	5.28	**<0.0001**
canyon mouse	157.2	45.6	3.45	**0.0006**

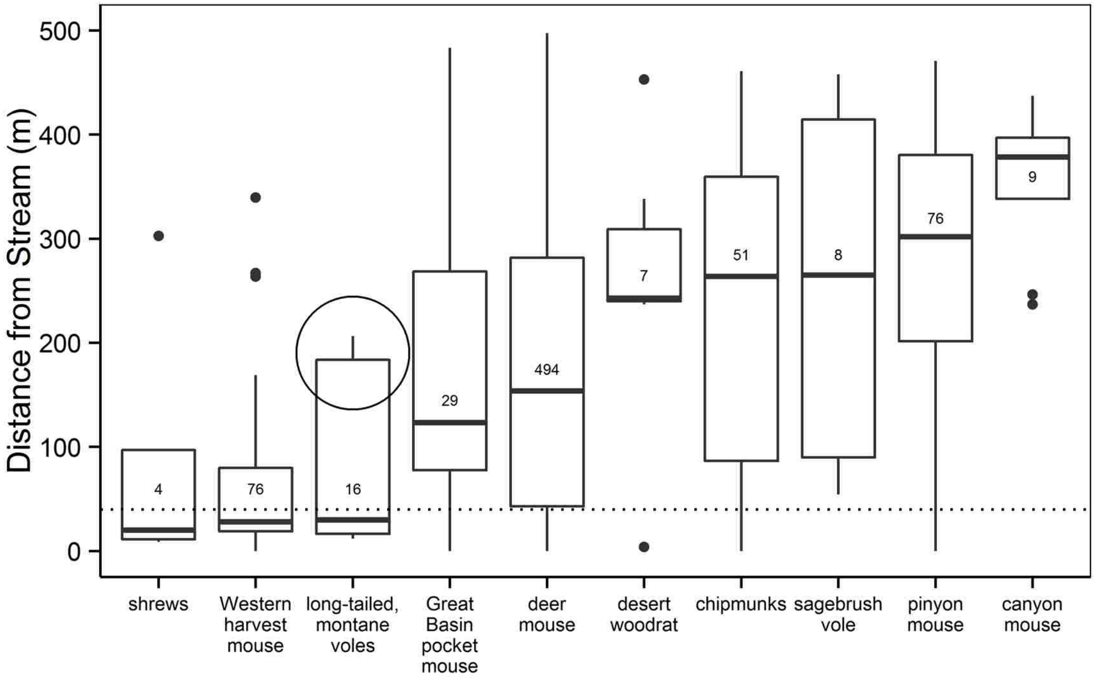

Figure 4. Boxplots of capture distances for small mammals. Dotted line represents the change point between riparian and upland habitats (40m). Samples sizes are given inside boxes. The circle highlights a group of voles captured away from a stream in a wet meadow supported by groundwater.

Small mammal abundance was correlated with stream distance (0.93 log odds per 100 meters, z = -2.495, $P = 0.013$; Figure 1) and total plant cover (abundance = 15.53 (total cover) + 8.961, $P = 0.004$; Figure 1). Small mammals were more abundant in riparian than upland habitat (1.32; z = 2.92; $P = 0.035$). Species richness (z = 0.68; $P = 0.5$) and evenness did not differ between habitats (z = 1.19; $P = 0.23$). Bray-Curtis similarity between riparian and upland habitat was 59%.

Small mammal stable carbon isotopes – Small mammals in riparian habitats were lower in $\delta^{13}C$ relative to uplands (0.70‰; z = 3.68, df = 235, $P < 0.001$). Small mammal $\delta^{13}C$ was weakly related to stream distance (0.15 increase in $\delta^{13}C$ per hundred meters increase in distance from stream; z = 2.74; $P = 0.0062$). Species provided a better explanation of the δ^{13}C values than stream distance or habitat (Figure 5; likelihood ratio test $P < 0.0001$).

Microtine voles and sagebrush voles were lowest and canyon mice highest in δ^{13}C. The difference in mean δ^{13}C between voles and canyon mice was 4.9‰. A linear model, with deer mice as the reference group indicated that *Microtus spp.* voles and sagebrush voles were relatively low in δ^{13}C, while piñon mice were relatively high (Table 3).

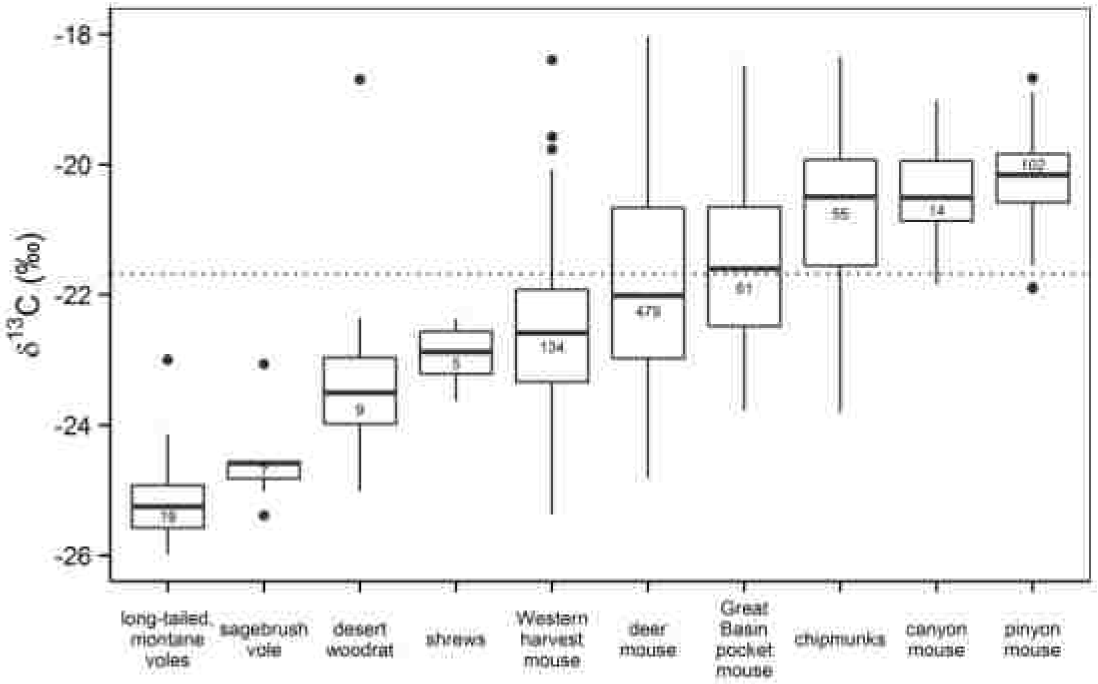

Figure 5. Boxplots of δ13C values for small mammals in Great Basin National Park. Samples sizes are given inside boxes. The dotted line is the median value for all individuals (-21.7‰).

Table 3 . Results from generalized linear mixed model of δ13C (‰) as a function of small mammal species. Random effects were year, watershed, and transect. Deer mice were the reference group.

Variable	Estimate	Std. Error	z value	*P* value
Intercept (deer mice)	-21.34	0.21	-100.13	**<0.0001**
Microtine voles	-3.6	0.62	-5.8	**<0.0001**
Sagebrush vole	-2.58	0.71	-3.65	**0.0003**
Desert woodrat	-1.89	0.77	-2.47	**0.014**
Shrews (*Sorex spp.*)	-0.86	1.82	-0.47	0.64
Western harvest mouse	-0.71	0.3	-2.32	**0.02**
Great Basin pocket mouse	-0.05	0.39	-0.12	0.91
Chipmunk (*Tamias spp.*)	0.36	0.31	1.17	0.24
Piñon mouse	0.93	0.3	3.13	**0.002**
Canyon mouse	1.19	0.8	1.5	0.135

Mixing Models – We used three iterations of mixing models to examine the assimilation of riparian δ^{13}C into the small mammal community. First, we grouped plants by habitat into upland and riparian groups to examine the assimilation of riparian δ^{13}C by species. A one tracer mixing model can only resolve two food sources and riparian and upland plant groups were preferred over plant functional groups as described above (*Plant carbon isotopes).* Arvicoline rodents (long-tailed, montane, and sagebrush voles) assimilated the highest proportion of riparian δ^{13}C, followed by woodrats, and shrews (Table 4). Conversely, several species were strongly linked to upland δ^{13}C. Deer mice, piñon mice, chipmunks, pocket mice, harvest mice and canyon mice almost exclusively assimilated upland carbon with the lower bound of riparian carbon use estimated at 0 (Table 4).

Table 4. Estimated proportion of δ13C derived from riparian sources and upper and lower 95% HDR*. Proportions were derived from a Bayesian mixing model using the R package SIAR (Parnell et al. 2010).

Species	Modal proportion Riparian $\delta^{13}C$	Mean proportion Riparian $\delta^{13}C$	Low 95% HDR Riparian $\delta^{13}C$	High 95% HDR Riparian $\delta^{13}C$
Microtine voles	0.96	0.88	0.73	1
Sagebrush vole	0.6	0.63	0.33	0.98
Desert woodrat	0.49	0.46	0.03	0.84
Shrews (*Sorex spp.*)	0.46	0.43	0.05	0.75
Canyon mouse	0.02	0.12	0	0.39
Great Basin pocket mouse	0.01	0.03	0	0.07
Western harvest mouse	0.01	0.06	0	0.16
Chipmunks (*Tamias spp.*)	0.01	0.03	0	0.09
Piñon mouse	0.01	0.01	0	0.04
Deer mouse	0	0.01	0	0.02

* HDR = high density region

Second, we divided upland plants into upland trees, shrubs and grasses and upland forbs and annual grasses. We used these two food sources to examine the assimilation of upland foods by upland associated species (pocket mice, chipmunks, sagebrush voles, woodrats, pinon mice, and canyon mice). Upland species varied in their assimilation of forbs and annual grasses (Table 5). Sagebrush voles and woodrats assimilated large proportions of forbs and annual grasses while canyon mice, deer mice, pocket mice, pinon mice and chipmunks assimilated very little.

Table 5. Estimated proportion of δ13C assimilated by upland small mammals from upland forbs and annual grasses and upper and lower 95% HDR*. Proportions were derived from a Bayesian mixing model using the R package SIAR (Parnell et al. 2010).

Species	Modal proportion upland forbs and annual grasses $\delta^{13}C$	Mean proportion upland forbs and annual grasses $\delta^{13}C$	Low 95% HDR upland forbs and annual grasses $\delta^{13}C$	High 95% HDR upland forbs and annual grasses $\delta^{13}C$
sagebrush vole	0.86	0.96	0.62	1.00
desert woodrat	0.45	0.49	0.05	0.81
canyon mouse	0.08	0.02	0.00	0.24
deer mouse	0.01	0.00	0.00	0.02
Great Basin pocket mouse	0.03	0.01	0.00	0.07
pinon mouse	0.01	0.00	0.00	0.03
chipmunks	0.02	0.01	0.00	0.06

Finally, deer mice, harvest mice, and chipmunks were captured in sufficient numbers to analyze their $\delta^{13}C$ as a function of habitat ($n \geq 10$ per habitat). Individuals with access to riparian food sources were expected to assimilate more riparian carbon than individuals from upland habitats. Although mixing models suggested subtle differences between species (Table 6), the 95% credible intervals for all species included zero for the proportion of riparian derived $\delta^{13}C$. For deer mice and chipmunks, the modes, means, and upper bounds were higher for individuals captured in riparian habitat than upland, suggesting greater assimilation of riparian food sources by individuals in riparian habitat (Table 6). This trend was not discernible for harvest mice. Regardless of the trend, the mean proportion of riparian vegetation assimilated was low (<20%) and suggests that the riparian corridor provided resources to these species groups primarily unrelated to food.

Table 6. Estimated proportion of δ13C derived from riparian sources for small mammal species captured in both upland and riparian habitats and upper and lower 95% HDR*. Proportions were derived from a Bayesian mixing model using the R package SIAR (Parnell et al. 2010).

Species	Modal proportion riparian $\delta^{13}C$	Mean proportion Riparian $\delta^{13}C$	Low 95% HDR Riparian $\delta^{13}C$	High 95% HDR Riparian $\delta^{13}C$
riparian deer mouse	0.08	0.09	0.00	0.19
upland deer mouse	0.00	0.02	0.00	0.05
riparian harvest mouse	0.03	0.13	0.00	0.36
upland harvest mouse	0.03	0.12	0.00	0.35
riparian chipmunk (*Tamias spp.*)	0.04	0.16	0.00	0.47
upland chipmunk (*Tamias spp.*)	0.02	0.07	0.00	0.17

Discussion

Small mammals were more abundant in riparian habitats than in uplands. Riparian and upland habitats also supported different species assemblies, contributing to higher gamma diversity via species turnover between habitats. Harvest mice, montane and long-tailed voles, and shrews were strongly linked to riparian habitat while other species, such as piñon and canyon mice, were associated with upland habitat. In our study, small mammal abundance was related to plant cover and decreased away from riparian habitat, but species richness and evenness did not differ between riparian and upland habitats. Although multiple studies have found higher measures of diversity in riparian habitat, the trend is far from universal. Doyle (1990) found higher richness and evenness over a three year study in Oregon. Lehmkuhl et al. (2008) found higher richness and abundance in riparian habitat in Washington, while Gomez and Anthony (1998) found higher abundance and species turnover but not higher richness in Oregon. Alternatively, other studies have shown no difference in abundance or richness between riparian and upland habitats (Laerm et al. 1997, Hanley and Barnard 1999).

These disparities in diversity between habitats may be related to sample design. Most studies comparing diversity have monitored small mammals for short time periods for a single season. Sullivan et al. (2014) sampled riparian and hedgerow habitats for seven years over different seasons and found seasonal variation in diversity patterns in diversity. Although our study occurred over three years, sampling was limited to the summer. During the winter, riparian habitat may lose value for food and cover, as plant production ends and deciduous trees lose their leaves. Similarly, climate data was also only collected during the summer and patterns in climate may change during the winter. Seasonal shifts in plant production and microclimate could alter the patterns in diversity we observed.

Hair reflects the isotopic composition of the mammal's body at the time it was grown (Miller et al. 2008a). Most small mammals molt is in the spring, several weeks to months before we sampled. Thus the information we used to infer diet was time lagged, and was representative of the animal's $\delta^{13}C$ composition at the time the hair was synthesized rather than the time of collection.

Trends of higher small mammal diversity in riparian habitat seems to be strongest where riparian habitat contrasts most with uplands, implicating heterogeneity as a proximal explanation (Maisonneuve and Rioux 2001). However, as heterogeneity is not in of itself a mechanism, we used $\delta^{13}C$ assimilation to separate species that relied on riparian vegetation for food versus species that did not. This goal presented several challenges primarily related to meeting the assumptions of the mixing models.

Mixing models are highly sensitive to trophic enrichment factors (TEF). For most mammal species, TEFs are unknown. The deer mouse is the only species in our community with an experimentally determined TEF (0.3‰; Miller et al. 2008a). It was immediately apparent that a TEF of 0.3‰ was too low in our system, given the much larger difference in means between plants and mammal hair measured in our system (4.7‰). Had we used 0.3‰ as TEF, the proportion of estimated riparian vegetation assimilated would have decreased by about 9%. We considered calculating a unique TEF for each species but for simplicity, we ultimately applied the TEF of 3.31‰ to the whole community.

We are not suggesting that small mammal carbon assimilation was entirely due to direct herbivory. Many of the species in our community are omnivores and assimilated carbon secondarily via insectivory. Although we did not have data on insects to include as a food source, the plants used in our mixing models form the base of the food web. Regardless of the trophic steps in carbon assimilation, we were interested in the assimilation of riparian carbon derived from plants which can be approximated using isotopic techniques as is commonly done in ecological studies (Karasov and Martinez del Rio 2007).

We collected a wide array of plant species from both upland and riparian habitats. Variation in $\delta^{13}C$ was higher in riparian plants than the upland plants and the lower range of upland plants overlapped with the upper range of riparian plants. Much of this overlap was due to upland forbs and annual grasses which were relatively low in $\delta^{13}C$. Mixing models cannot distinguish between sources that do not differ significantly, so grouping plants did not help resolve the issue of overlap. When overlapping food sources are encountered, it is recommended to combine groups, as we did with forbs and annual grasses in upland habitat.

Regardless of the differences between plant groups, single tracer isotope mixing models can only resolve two food sources (Phillips et al. 2014) and the model selection process supported an upland and riparian classification. In addition, using only two food sources does not allow fine scale characterizations of plant parts such as seeds versus leaves and insects. Since our fundamental goal was to quantify the importance of upland and riparian habitats via assimilation of riparian plants into the small mammal community, and not to assign specific food sources to different animal species, this limitation was not a problem. Measuring additional isotopes can increase the number of food groups that can be incorporated into the mixing models. In our case, nitrogen was measured but was uninformative in distinguishing between plant groups. It's possible that using additional tracer isotopes such as deuterium, oxygen, strontium, or sulfur could strengthen the accuracy and precision of the estimates of food assimilation and allow the resolution of additional food sources.

We did not include concentrations in the mixing models as our instrument was not calibrated for quantitative analysis. At the course scale of two food sources, it's unlikely that concentration data would have impacted on our results. Had we incorporated additional tracers and food groups, concentration data could have been important, as assimilated carbon tends to be routed from foods high in protein, such as insects rather than plants (Phillips et al. 2014).

Plant carbon isotope values were better explained by riparian and upland groupings than by functional groups. The difference between mean plant $\delta^{13}C$ between habitats was small (2‰) but highly significant. Mixing models can reliably distinguish between sources as small as 2‰, particularly when the standard deviations of the sources and mixtures are low and sample sizes are high ($n > 10$; Phillips and Gregg 2001). Differences in $\delta^{13}C$ of this magnitude have been used to infer landscape scale changes in vegetation. For example, a shift of <2‰ in the $\delta^{13}C$ of bat guano led to the inference that a monsoon had returned shifting vegetation from C_3 to C_4 on a landscape scale (Wurster et al. 2008). We have a strong a strong mechanistic explanation for lower plant $\delta^{13}C$ in the riparian corridor, strengthening our inferences. In water stressed C_3 plants, stomata close to minimize water loss. Stomatal closure reduces the intracellular partial pressure of CO_2 and subsequently reduces discrimination against the ^{13}C isotope during photosynthesis. Conversely, at higher water availabilities, partial pressure approaches ambient pressure, maximizing discrimination rates and leading to lower $\delta^{13}C$ (Karasov and Martinez del Rio 2007). In riparian areas, plants can photosynthesize with open stomata, resulting in lower carbon values relative to uplands.

Ultimately, mixing models allowed us to quantify the assimilation of riparian derived food sources into the small mammal community. Understanding the importance of riparian vegetation as a food source was a fundamental goal to clarify the mechanism allowing differences in small mammal diversity between riparian and upland habitats. In arid lands, many small mammal populations are limited by food availability (Beatley 1976) and small mammals are predominantly bottom-up controlled by resource availability (Meserve et al. 2003). Given the higher plant production of riparian habitat relative to uplands, we hypothesized that riparian plants were important food resources for small mammals.

Riparian plants contributed greatly to the carbon assimilation of voles (*Microtus spp.*) and shrews. Voles assimilated nearly all their carbon from riparian vegetation indicating a diet primarily of riparian vegetation. Similarly, shrews derived a large proportion of their carbon from riparian vegetation, secondarily by ingesting invertebrates. Shrews are obligate insectivores (Gillihan and Foresman 2004), while voles are strictly herbivorous (Sera and Early 2003). The assimilation of riparian derived carbon by these species demonstrates the importance of riparian food sources across multiple trophic levels in the small mammal community.

After riparian associated montane and long-tailed voles, sagebrush voles were lowest in $\delta^{13}C$, intimating the majority of their carbon was derived from riparian vegetation. However, it's unlikely that sagebrush voles fed on riparian plants. Sagebrush voles were strongly associated with uplands, are herbivorous (Carroll and Genoways 1980), and have small home ranges (<50 sq m; Mullican and Keller 1986). The second iteration of the mixing model showed that sagebrush voles likely fed on upland plants with low $\delta^{13}C$ (forbs and annual grasses), rather than riparian vegetation, an explanation consistent with its known feeding ecology (Carroll and Genoways 1980).

In spite of an association with upland habitat, woodrats also utilized a large proportion of food sources with low $\delta^{13}C$ values. The daily movements of woodrats regularly exceeds several hundred meters (Stones and Hayward 1968) and it is plausible that woodrats foraged in the riparian corridor. However, the relatively low $\delta^{13}C$ of upland forbs and annual grasses, can prove an alternative explanation for woodrat carbon.

Perhaps our most interesting results are for riparian associated small mammals that apparently did not assimilate riparian vegetation. Harvest mice were closely associated with streams and riparian habitat, yet were estimated to assimilate only 6% of their carbon from riparian vegetation. This did not vary as a function of habitat as animals closer to streams did not have lower $\delta^{13}C$ than individuals further from streams. Harvest mice are primarily granivorous but also feed on insects (Webster and Jones 1982). Riparian corridors were narrow (~80 m wide) and it is possible that harvest mice moved into the uplands to forage. Run-on subsidies from upland to riparian habitats are well documented (Nakano and Murakami 2001) and may have provided allochthonous food to harvest mice in riparian habitat in the form of seeds and insects. Alternatively, harvest mice may have fed on grass and shrub seeds within the riparian corridor which were higher in $\delta^{13}C$.

Harvest mice and deer mice were abundant in riparian habitat, assimilated very little riparian carbon, and likely relied on foods from outside the riparian corridor or selectively fed on foods with high carbon values in the corridor. Riparian food sources with low $\delta^{13}C$ values can therefore be excluded as a mechanism supporting harvest and deer mice in the riparian corridor. So what resources does the riparian corridor provide to deer and harvest mice?

Riparian habitat was clearly identifiable by higher plant cover than uplands. High plant cover moderated the riparian microclimate and provided two distinct habitats that were segregated by small mammals. Small mammals were also more abundant in riparian habitat and abundance closely tracked plant cover. Areas of high plant cover are often selected by small mammals as a mechanism to reduce predation (Manson et al. 1999). Alternatively a cool, humid microclimate important to some species of small mammals (Sera and Early 2003) is available in the riparian corridor. Even for species feeding on riparian foods, the protection and microclimate provided by riparian plant cover are likely to interact with forage. Our data did not allow us to distinguish between the effects of cover as protection from predators versus from microclimate.

To our knowledge this is first use of $\delta^{13}C$ to track the flow of riparian food sources into a vertebrate community. Although there were several issues related to meeting the assumptions of the mixing models, $\delta^{13}C$ is a suitable proxy for riparian vegetation assimilation. The utility of

$\delta^{13}C$ as a proxy for riparian vegetation is a novel way to track riparian resource use, particularly in more arid regions where the contrast between upland and riparian vegetation is stronger.

Conservation implications - Riparian areas are highly valued for their ability to support wildlife (Gregory et al. 1991). We found higher small mammal abundance in riparian habitats relative to uplands and turnover between riparian and upland habitats, trends consistent with other studies. Plant cover appeared to be an important mechanism facilitating high small mammal diversity in riparian areas. Plant cover provided resources to small mammals in the form of forage, protection from predators and a cool, humid microclimate.

Applications for domestic, industrial and agricultural groundwater pumping are increasing across the arid west. Proposed rates of groundwater pumping are predicted to lower water tables, kill phreatophytes, reduce plant cover and shift riparian plant communities towards xeric adapted vegetation (Deacon et al. 2007). Such changes to riparian vegetation would negatively impact small mammal diversity, reducing small mammal abundance and richness and decreasing overall gamma diversity. Small mammals can be keystone species, are important prey for predators, and serve critical roles in ecosystem function. Therefore, this change has the potential to cascade across trophic levels and indirectly impact other species within the Great Basin, changing extant plant and animal populations in the existing ecosystem where excessive groundwater pumping is permitted.

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CHAPTER 2: Effects of sagebrush restoration and conifer encroachment on Small Mammal Diversity in a Sagebrush Ecosystem

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Abstract

Conifer encroachment in sagebrush ecosystems reduces habitat heterogeneity, niche space, and resource availability, negatively affecting many wildlife populations. Sagebrush restoration is recommended as a management action to mitigate conifer encroachment and restore wildlife across millions of hectares in the Great Basin. In spite of this recommendation, the effects of conifer encroachment and sagebrush restoration are unknown for most wildlife species. Small non-volant mammals are keystone species, consumers, and prey, facilitating energy flow and ecological function. We assessed relationships between conifer encroachment and sagebrush restoration (conifer removal and seeding native plants) on small mammal communities over 11 years using a BACI design to assign causal relationships. Sagebrush habitat supported an additional small mammal species, twice the biomass, and nearly three times higher densities than conifer encroached habitat. Sagebrush restoration increased shrub cover (5%), decreased tree cover (26%) and density (43%) but failed to increase native herbaceous plant density. Restoration caused an increase in non-native, invasive annual cheatgrass (400%). Counter to prediction, small mammal diversity did not increase in response to sagebrush restoration but restoration maintained density in the face of conifer encroachment. Piñon mice (*Peromyscus truei*) are woodland specialists, the only species with higher densities in conifer encroached habitat, and were negatively affected by sagebrush restoration. The increase in cheatgrass resulting from sagebrush restoration treatments may not negatively impact small mammal diversity, provided cheatgrass density and cover does not progress to an annual grass monoculture and native vegetation is maintained. The consequences of conifer encroachment, a press impact, far outweigh the pulse impact of sagebrush restoration, a pulse impact, on small mammal diversity. Given the ecological roles of small mammals, maintenance of small mammal density is a desirable outcome for sagebrush restoration.

Key words: sagebrush, conifer removal, small mammal, SECR, density, BACI

Highlights

- Conifer encroachment into sagebrush habitat has dramatically reduced small mammal abundance and biomass.
- Sagebrush restoration increased shrub cover and annual grass density but did not increase native herbaceous plant densities.
- Sagebrush restoration had few effects on small mammal diversity.
- Sagebrush restoration reduced the density of the woodland specialist piñon mouse.
- Sagebrush restoration maintained small mammal densities in the face of conifer encroachment.

Introduction

In the last 130 years, late successional conifer woodlands have increased ten-fold in the Great Basin (Miller and Tausch 2001). “Conifer encroachment” describes a successional process of increasing conifer cover and density in sagebrush ecosystems. Historically, this process was regulated by periodic natural disturbances, such as high intensity fire (Miller et al. 2005, Tausch et al. 2009). In recent decades, human induced factors, such as fire exclusion (Gruell et al. 1994, Keane et al. 2002), increased atmospheric carbon dioxide concentration, increased winter precipitation, warmer temperatures (Rapp 2004), and selective herbivory by livestock (Miller et al. 1994) have interacted to increase the rate and scale of conifer encroachment. Like the causes, the effects of conifer encroachment on wildlife are complex.

In conifer dominated woodlands, the majority of plant biomass is sequestered as unpalatable cellulose or lignin, which is unavailable to most animals as food. Pine nuts and juniper berries are high in energy and protein but conifer mast is produced in erratic and unpredictable resource pulses (White et al. 1999, Felicetti et al. 2003). Shrub, grass, and forb production show less inter-annual variation than conifer mast, produce more palatable seeds and forage, and support higher insect diversity than woodlands, providing a more reliable food source to wildlife than conifer mast (Miller 2008, McIver and Macke 2014). Overall conifer encroachment in sagebrush ecosystems reduces habitat heterogeneity, niche space, and resource availability, negatively affecting many wildlife populations (Miller et al. 2005, Hanser and Knick 2011).

Small, non-volant mammals (hereafter small mammals) are ecosystem engineers and play important roles in sagebrush ecosystems. Seed caching enhances plant germination of plants such as such as bitterbrush (Purshia tridentata (Pursh) DC.; Hormay 1943, Young and Clements 2002), Mormon tea (Ephedra viridis Coville; Everett et al. 1978, Hollander et al. 2010), and Indian rice grass (Achnatherum hymenoides (Roem. & Schult.) Barkworth; McAdoo et al. 1983). Small mammals also scatter hoard pine nuts, juniper berries, and cheatgrass (*Bromus tectorum* L.) seed resulting in the establishment and dispersal of conifers and annual grasses in sagebrush habitat (Chambers et al. 1999, Young and Clements 2009). Although plant germination is enhanced by scatter hoarding, small mammal herbivory can also result in significant mortality of seeds and newly established plants (Clements and Young 1996), both decreasing the establishment of desirable native plants and increasing the prevalence of conifers and invasive annual grasses. Burrowing by small mammals aerates soils (Huntly and Inouye 1988), cycles nutrients (Sirotnak and Huntly 2000), and maintains early seral state plant communities (Kitchen and Jorgensen 1999) . As the prey base for many predators, small mammals are an important trophic link in food webs (Bekoff 1977, Glaudas et al. 2008).

In spite of their roles as keystone species, the effects of conifer encroachment on small mammals has received minimal attention relative to other wildlife. In a comparison of recent and historic small mammal communities, Rickart et al. (2008) attributed shifts in species composition to increasing coniferous woodlands. Changes in species composition included a decrease in sagebrush specialists, Great Basin pocket mice (*Perognathus mollpilosus)* and least chipmunks (*Tamius minimus)* and an increase in woodland specialists, piñon mice *(Peromyscus truei)* and cliff chipmunks (*Tamias dorsalis)*. Sagebrush restoration and conifer removal were suggested as a means to restore small mammal diversity in conifer encroached ecosystems (Rickart et al. 2008). Conversely, Rodhouse et al. (2010) noted the potential for sagebrush restoration and conifer removal to negatively impact piñon mice and cliff chipmunks.

Conifer removal is the primary restoration tool in conifer encroached, sagebrush ecosystems. Great Basin coniferous woodlands are dominated by two species: Singleleaf piñon pine (*Pinus monophylla* Torr. & Frém.) and Utah juniper (*Juniperus osteosperma* (Torr.) Little) and methods of conifer removal include chaining in high density conifer stands, lop and scatter of low density conifers, mastication using machinery, prescribed fire, and hand cutting with chainsaws (Bombaci and Pejchar 2016). To increase shrubs and herbaceous plants, conifer removal projects often incorporate seeding into management actions (Weltz et al. 2014).

We evaluated the relationships between conifer encroachment, sagebrush restoration, and small mammal diversity in a sagebrush ecosystem. We hypothesized that conifer encroachment has negatively impacted small mammal diversity and that sagebrush restoration can mitigate this loss of diversity. We made four predictions about the effects of conifer encroachment and sagebrush restoration on small mammal diversity: (1) Small mammal diversity has been reduced due to conifer encroachment; (2) Native shrub cover and herbaceous plant density will increase in response to sagebrush restoration; (3) Sagebrush restoration will increase small mammal abundance, richness, biomass, and evenness; and (4) Small mammal community responses to sagebrush restoration will be species-specific. Sagebrush specialists will increase in response to sagebrush restoration and woodland specialists will decrease in abundance.

Methods

Study Site – The study site was located in Great Basin National Park, South Snake Range, White Pine County, Nevada, USA (N – 38.98°, W –114.30°; Fig. 1). Elevations in the South Snake Range vary from 1,621 m in the town of Baker to 3,982 m at the summit of Wheeler Peak. The climate is cool and arid and varies with elevation. The elevation of the study site is 2,832 m, annual precipitation 33 cm, and the mean annual temperature is 9°C (Western Regional Climate Center, unpubl. data for Lehman Caves). The frost free period ranges from 60 – 90 days.

Sagebrush Restoration - Treatment goals were to reduce conifer cover from pre - treatment levels of 20 - 30% to less than 10% cover. Quantitative outcomes for shrubs and herbaceous vegetation were not defined but generally the goal was to increase native shrubs and native herbaceous vegetation, without increasing invasive annual grasses. Singleleaf piñon and Utah juniper trees were cut with chainsaws on 32 ha in 2004, 2006, and 2007. Conifer slash was disposed of through a combination of pile burning, chipping, and fuel wood disposal. To promote the restoration of shrub and herbaceous vegetation, a native seed mix consisting of mountain big sagebrush, Sandberg bluegrass (*Poa secunda* J. Presl), bluebunch wheatgrass, basin wildrye (*Leymus cinereus* (Scribn. & Merr.) Á. Löve), squirreltail (*Elymus elymoides* (Raf.) Swezey), Lewis flax (*Linum lewisii* Pursh), and Indian rice grass was broadcast on the conifer removal units with belly spreaders at approximately 9 kg of pure live seed per ha.

Study Design – Prior to sagebrush restoration treatments, habitats were stratified into two habitat types: sagebrush or conifer encroached. Stratification was based on visual assessment and pre-treatment Global Positioning System mapping of habitat patches. Twenty-four vegetation transects were randomly located; twelve in sagebrush habitat and twelve in conifer encroached habitat, conditional on a minimum separation of 50 m (Fig. 1). Five small mammal trapping grids were randomly chosen from conifer encroached habitat. Sagebrush habitat was limited, so the five sagebrush grids were located remotely using a Global Information System to maximize grid fit (Fig. 1). Although vegetation transects were not co-located exactly with trapping grids, seven grids were intersected by vegetation transects. The mean distance between vegetation transects and small mammal grids was 6.4 m (range = 0 - 36 m). Given this close proximity, we consider vegetation transects strongly linked to and representative of small mammal grids (Fig. 1).

Our study was set up as a Before - After - Control – Impact (BACI) design, a common, quasi-experimental study design widely used to compare environmental conditions before and after human disturbance (de Lucas et al. 2005). The BACI design predicts different patterns of change for impact sites relative to reference sites following a disturbance. Hereafter we use the terms “impact” and “treatment” interchangeably and use “reference” synonymously with “control”. A statistically significant interaction between time relative to treatment and treatment (Underwood 1992) strongly infers a causal relationship between impact and effect (Block et al. 2001). Reference sites should be closely matched to the impact sites. However, the absolute similarly between impact and the reference sites is less important than the trajectory of the sites relative to each other, with respect to treatments (Underwood 1994).

Four small mammal grids and nine vegetation plots served as impact sites. All impact sites were in sagebrush habitat where the impact consisted of conifer removal and seeding native vegetation (see *Sagebrush Restoration* above). Six small mammal grids and fifteen vegetation transects served as untreated, reference sites. Of these reference sites, one small mammal grid and three vegetation transects were in sagebrush habitat and five grids and twelve transects were in conifer encroached habitat. Habitat was considered a fixed effect, so that treated sagebrush sites were still considered sagebrush habitat following treatments.

Vegetation Sampling - Each vegetation transect was sampled before and after sagebrush restoration treatments in June of 2004, 2010, and 2014. Pre- treatment cover was assessed using a line intercept method (Bonham 1989). A major weakness of the line intercept method was that annual grass cover was poorly sampled. To better capture annual grass cover, we adjusted our methodology from a line intercept to a line – point intercept (Herrick et al. 2005a). We ran seven comparative transects in 2010 and found tree and shrub cover strongly correlated (r = 0.993 and 0.944 respectively) between methods while herbaceous cover was not (r = 0.675). Given these strong correlations between methods for tree and shrub cover, cover was used to assess treatment effects on shrubs, density on herbaceous vegetation, and both cover and density to address treatment effects on trees. Herbaceous plant density was measured in four quadrats per transect (35 cm x 35 cm). Quadrats, combined by transect for analysis, were oriented on the east side of transects every 10 meters, sampling a total area of 0.5 m^2 per transect. Tree density was sampled on larger plots (2 x 100 m), one plot per transect (Herrick et al. 2005a). All trees with stems wholly or partially within the plot were tallied.

Small Mammal Sampling – Small mammals were sampled with Sherman live traps arranged in a grid configuration. Grids were sampled each July from 2004 to 2014. Each grid consisted of 49 Sherman live traps (SFAL; 5 x 6 x 23 cm or LFA – 8 x 9 x 23 cm) separated by 15 meters, in a seven by seven pattern, sampling an area of approximately one ha. Individual trap locations were relocated with a GPS (±1 m). Traps were locked open and pre-baited for three to four days prior to sampling, then re-baited and set. Bait consisted of a mixture of millet and sunflower seeds. Traps were set each evening between 17:00 - 20:00, checked each morning between 05:00 - 10:00, and shut during the day. Trapping sessions consisted of four consecutive nights of trapping. Trapping was interrupted on two occasions for one night but resumed the following day. Captured small mammals were ear tagged, identified to species, visually assessed for sex, weighed, and released. Recaptured individuals were weighed and assessed for ear tag number, species, and sex, then released. After accounting for sprung traps, trap effort consisted of 20,920 trap nights. Ten species and 2,066 individuals were captured over the eleven years of sampling (Table 1). Small mammal densities fluctuated widely across years in both impact and reference grids (Fig. 2). Small mammal sampling was conducted according to the guidelines of Brigham Young University's Institutional Animal Care and Use Committee, project code # 07-0301, scientific research permits from Great Basin National Park (GRBA-2007-SCI-0002) and Nevada Department of Wildlife (S35631), and the American Society of Mammalogists Guidelines (Sikes et al. 2011).

Data Analysis (Vegetation) – To quantify pre-treatment differences in mean tree, shrub, and herbaceous cover between sagebrush and conifer encroached transects, we used Student's t-tests with unequal variances and f-tests to examine differences in variability. We examined the response of vegetation to conifer removal, using a BACI design (as described above) implemented in a generalized linear mixed model framework. For vegetation analyses, time was binned into two categories: pre- or post- treatment. Tree and shrub cover and herbaceous and tree density were treated as fixed effects in separate models. Cover was modeled with a negative binomial distribution and density with a Poisson distribution, both using log links. Site was incorporated into models as a random effect. Chi - square tests were used to test for differences in observed versus expected herbaceous density and percent composition of annual grasses between treated and untreated sites, pre- and post- treatment.

Data Analysis (Small Mammals) – We assessed the effects of habitat and sagebrush restoration treatments on small mammal communities using the BACI design described above. Species richness was the number of species per grid by year. Our evenness metric was the inverse of Simpsons index (SI) calculated as: $SI = 1/[\sum(n_i * (n_i - 1)/N(N-1)]$; where n_i = the number of individuals of the i^{th} species; and N = the total number of individuals (Magurran 2004). As SI decreases, community evenness also decreases. Total biomass was the sum of the mean weights of all individuals captured per grid by year.

Total density and density of individual species (deer mice, piñon mice, cliff chipmunks, voles, Great Basin pocket mice, and western harvest mice) were used as metrics of small mammal abundances. Spatially explicit capture recapture (SECR) models relate the spatial relationships of traps (detectors) and the movement of animals between traps through a combination of a state model and an observation model. The state model describes the distribution of the animal home ranges on the landscape. The observation model (spatial detection model) relates the probability of detecting an individual at a particular detector to the distance of the detector to a central point in each animal's home range. The distribution of home range centers is treated as a homogenous Poisson point process. Buffer width was set at 150 m. The detection function describes the decline in detection probability with distance from the home range center using a half-normal detection function. Detector types were single, as traps were generally capable of catching only one animal. Full likelihood was used to fit all models. Detection was modeled as a function of distance between the trap and the individual's latent activity center.

We generally ran eight candidate SECR models to calculate density. Each year was treated as a session and each grid analyzed separately by species. Density was always fit as a function of session (year). Detection (g0) and movement (σ) were modeled as :(1) constant detection probability across occasions and detectors; (2) learned response affecting detection; (3) trap response to time; (4) trap response with a time trend; (5) trap response model-transient; (6) site learned response; (7) site transient response; (8) heterogeneity model, finite mixture model, with 2 latent classes. All SECR models were computed in the R package secr (Efford 2015).

Generally the heterogeneity model (8) was highly favored by Akaike's Information Criterion, corrected for small sample size (AIC_c) when enough animals were captured to support the model structure (Δ AIC_c <2) (Burnham and Anderson 2002). Otherwise the null model was preferred. When there was competing weight of evidence, we used model averaging to calculate mean estimates of density (individuals ha^{-1}), by AIC_c model weight. When there was a clear top model (Δ AIC_c <2), it was used to estimate density. The year specific density estimates by sampling grid, were incorporated as response variables into the mixed models.

We used generalized linear mixed models to assess the effects of sagebrush restoration and habitat on small mammal diversity (species richness, total biomass, evenness, total density, and individual species density). Habitat (sagebrush or conifer encroached) and sagebrush restoration effects (interaction between treatment and time) were the primary independent variables. Time was defined in years from treatment or binned into pre- or post- treatment (Hewitt et al. 2001, Morrison et al. 2006). For most dependent variables we compared five models: (1) treatment versus time (pre-, post-) + habitat; (2) treatment versus time (year relative to treatment) + habitat; (3) habitat only; (4) treatment versus time (pre- post-); and (5) null model. Site and year were included as additive random effects in models. Richness and evenness were modeled using a Gaussian distribution and identity link function. A negative binomial distribution was used to model biomass and a Poisson distribution to model density, both using log link functions.

We used zero inflated models to analyze the effect of sagebrush restoration and habitat on piñon mouse, cliff chipmunk, vole, pocket mouse, and western harvest mouse densities. Long - tailed and montane vole densities were combined for analysis. The proportion of grids with no captures for these species ranged from 35 - 88%. Models for piñon mice, cliff chipmunks, voles, pocket mice, and harvest mice could support time only as pre-, post- treatment in the treatment time interaction. To allow model convergence, random effects for piñon mice only included year and random effects were excluded from models for cliff chipmunks, voles, pocket mice, and harvest mice.

To validate model fit, we plotted residuals versus fitted values, residuals versus covariates, and examined histograms of residuals for normality. We also compared models with treatment and habitat effects to null models using Akaike Information Criterion (AIC) to guide model selection (Burnham and Anderson 2002). Models differing by less than 2 AIC units were considered equivalent. Alpha (α) was set at 0.05. Effect sizes are given following statistical results, calculated from highest ranked model coefficients, model averaging, or mean differences between groups. Analyses were done with Program R (R Core Team 2015), generalized linear mixed models in the R package glmmADMB (Skaug et al. 2014), and model averaging with the R package 'MuMIn' (Barton 2017).

Results

Vegetation – Prior to sagebrush restoration, transects classified as sagebrush habitat had higher herbaceous (t = 4.20, d.f. = 13.1, *P* = 0.001; 5.3%) and shrub cover (t = 5.75, d.f. = 11.25,

$P = 0.0001$; 13.4%) than conifer encroached transects (Fig. 3). Total plant cover did not differ between habitats ($t = 1.03$, d.f. = 15.3, $P = 0.32$). Conifer encroached habitat was higher in tree cover ($t = 2.69$, d.f. = 16.89, $P = 0.015$; 13%) and had lower variance in herbaceous (ratio of variances = 0.09), shrub (ratio of variances = 0.01), and tree cover (ratio of variances = 0.29) than sagebrush habitat ($P < 0.05$ for all tests). Tree density was higher in conifer encroached relative to sagebrush habitat by a factor of two ($t = 4.80$, d.f. = 18, $P < 0.0001$; 7975 versus 4,071 trees ha^{-1}). Shrub cover best separated sagebrush from conifer encroached transects. All conifer encroached transects had < 2.6% shrub cover and all sagebrush transects > 2.6% shrub cover. Singleleaf pinyon was the dominant tree, accounting for 84% of tree cover and 93% of tree density. Utah juniper was less abundant and comprised 15% of tree cover and 5% of tree density. Curleaf mountain mahogany (*Cercocarpus ledifolius* Nutt.), aspen (*Populus tremuloides* Michx.), and chokecherry (*Prunus virginiana* L.) also occurred on transects but were rarely sampled.

Sagebrush restoration reduced tree cover from 28.7% to 2.2%, while tree cover was unchanged on untreated plots ($P < 0.0001$). Tree density was reduced from 4,194 to 1,805 trees ha^{-1} on treated plots while increasing from 7,120 to 7,374 trees ha^{-1} on untreated plots ($P < 0.0001$). Sagebrush restoration increased shrub cover from 13.1% to 18.6% on treated plots while shrub cover decreased slightly on untreated plots from 4.2% to 3.7% ($P = 0.0123$). Herbaceous plant density increased by 146% on treated plots and was unchanged on untreated plots ($P < 0.0001$). The increase in herbaceous density was driven by cheatgrass which increased four-fold on treated plots (Fig. 4). As a proportion of herbaceous density, cheatgrass density nearly doubled, increasing from 42% to 81% on treated plots, while decreasing from 66% to 42% on untreated plots. When cheatgrass was removed from the model, the increase in herbaceous density due to conifer removal was not statistically significant ($P = 0.20$). Cheatgrass also increased in percent composition on treated plots. Following sagebrush restoration treatments, cheatgrass density was higher than expected on treated plots, while non-cheatgrass herbaceous density was less than expected (Fig. 4; $\chi^2 = 619$, $P < 0.0001$). Total cheatgrass cover on post - treated transects ranged from 7 - 59% ($\bar{x} = 33 \pm 15\%$).

Small Mammal Diversity – Sagebrush restoration did not affect total biomass, (year, $P = 0.357$; pre-, post-, $P = 0.22$), richness (year, $P > 0.274$; pre-, post-, $P = 0.470$), or evenness (year, $P > 0.260$; pre-, post, $P = 0.69$). When time was binned into years relative to treatment, the treatment effect was significant at eight years post treatment ($P > 0.024$). When time was binned into pre- or post- treatment, sagebrush restoration maintained density on treated grids, while density dropped on untreated grids ($P = 0.0097$; Fig. 5). Model comparisons supported habitat - only models for richness and biomass indicating that treatment effects can be discarded in favor of the simpler, habitat only models (Table 2). Habitat had large effects on richness, biomass, and density ($P < 0.001$; Table 4). Sagebrush habitat supported an additional species, 2.3 times more biomass, and 2.7 times the number of individuals than conifer encroached grids (Table 3). Habitats did not differ in evenness ($P = 0.21$).

Species specific effects – Deer mice were the most abundant species in both habitats, making up 77% of captures (Table 1). The effects of sagebrush restoration on deer mice mirrored total density, where restoration treatments maintained density on treated grids and density fell on untreated grids (years 1 & 8, $P < 0.0238$; pre- post -treatment, $P = 0.0519$). Deer mice were 3.8 times more abundant in sagebrush than in conifer encroached habitat ($P < 0.0001$). Piñon mouse density was significantly reduced by sagebrush restoration treatments while density increased on untreated sites (pre- post- treatment; $P = 0.0036$; Fig 6). Piñon mouse density was

5.9 times higher on conifer encroached than sagebrush habitat (*P* = 0.00531). There were no treatment effects (*P* = 0.350) on cliff chipmunk density. Cliff chipmunks were more abundant (1.6 times) in sagebrush than conifer encroached habitat (*P* = 0.02621). Vole densities (*Microtus* sp.) were unaffected by conifer removal (*P* = 0.612) and were higher in sagebrush habitat by a factor of 22 (*P* = 0.0042). Great Basin pocket mouse density was not affected by conifer removal (*P* = 0.1136). Pocket mouse density was higher on sagebrush than conifer encroached grids by a factor of 16 (*P* = 0.0246). Western harvest mice occurred only in sagebrush habitat and we were unable to model habitat effects. Harvest mice increased in density in sagebrush habitat from 2004 - 2014 (*P* = 0.0028) and there was no effect of sagebrush restoration (*P* = 0.9973). We could not test for habitat or treatment effects for sagebrush vole density but we note that the only observations of sagebrush voles occurred on a sagebrush grid following conifer removal.

Discussion

Sagebrush restoration is recommended on millions of hectares across the Great Basin (Wisdom et al. 2002). As the scale and rate of these projects increase, understanding how sagebrush restoration affects wildlife communities is a major research need (Knick et al. 2014, Bombaci and Pejchar 2016). Small mammals are excellent models for assessing the effects of conifer encroachment and restoration. With their small home ranges, small mammals are closely tied to local changes in resource availability (Stephens et al. 2017). Additionally, small mammal communities include keystone species; habitat specialists and generalists; a diverse guild of feeding ecologies; and are both consumers and prey. Thus, small mammal community response is a window into ecosystem function, a fundamental goal of land management and restoration. This study is the first to assess the relationships between conifer encroachment and sagebrush restoration (conifer removal and seeding) on small mammal communities using a BACI design to assign causal relationships and random effects to increase inferential scope.

Large-scale ecological experiments, such as this study, are difficult to implement but are critical to address management and conservation questions (Soanes et al. 2018). Our study, like all studies has limitations. In spite of these limitations, the management questions we address should not go untested. We used the strongest possible methods and study design, given the constraints of management and habitat on the study site (Soanes et al. 2018). However, it is important to acknowledge the limitations of this study.

Due to limited sagebrush habitat, our study did not capture the entire successional range of sagebrush ecosystems. Conifer encroachment occurs on a continuum of increasing tree cover and density described with three woodland phases (Tausch et al. 2009). Conifers occur at low cover and density in Phase I woodlands, with shrubs and herbaceous vegetation dominating the understory. In contrast, Phase III woodlands have high conifer cover and density, with little shrub or understory vegetation. Phase II woodlands are co-dominated by conifers and shrubs and provide biological and structural attributes of both woodland and sagebrush habitats (Tausch et al. 2009). We considered framing of our results into woodland phases but ultimately used our *a priori* habitat stratification, as the woodland phase paradigm did not exist at the onset of our study. Retrospectively, our conifer encroached habitat was similar to Phase III woodlands and sagebrush habitat similar to Phase II woodlands. We recommend that inferences of our results be limited to sagebrush restoration in Phase II woodlands, using similar restoration methods (i.e. cutting conifers with chainsaws and seeding with native plant species).

Limited sagebrush habitat also affected our choice of reference sites. We struggled to find even the single reference patch of sagebrush habitat. All other reference sites were located in conifer encroached habitat, while all treated sites were located in sagebrush habitat, leading to an unbalanced study design. Fortunately BACI designs are flexible with respect to reference sites. Inherent in all BACI studies is the assumption that reference and impact sites are on similar temporal trajectories before treatments. When treatment effects alter this trajectory, they are manifested in the time treatment interaction.

Conifer encroachment and small mammal diversity – Differences in small mammal richness, biomass and density between habitats were large and dramatic (Table 3) and support the prediction that conifer encroachment has reduced small mammal diversity. Comparison of sagebrush and conifer encroached habitats can be viewed as a space for time substitution. Several lines of evidence support the hypothesis that our study site was historically more open and sagebrush dominated, and that conifer density and cover have increased over the last century (sensu Tausch et al. 2009). Soils are in the Badena series, a mollisol with glacial outwash parent material (USDA Natural Resources Conservation Service 2009). Characterized by a mollic epipedon, mollisols develop in the absence of conifers, primarily from organic matter derived from grasses and shrubs (USDA Natural Resources Conservation Service 2009). Additionally, historic photos of the study site document lower tree densities and higher shrub cover than currently occur (Appendix 1). We also regularly observed shrub skeletons under conifers, further indication of recent conifer encroachment (Appendix 2; Austin 1999, Miller et al. 2008b, Tausch et al. 2009) . Assuming an increase in tree density and cover over the past century, small mammal diversity has been lost from formerly open sagebrush habitat as a result of conifer encroachment.

Similar negative relationships between conifer encroachment and small mammal diversity were also found in northern Nevada sagebrush ecosystems. Coincident with regional woodland expansion, small mammal communities declined by 50% in abundance, biomass, and energy use between 1920 and 2008 (Rowe et al. 2011). We found three - fold lower density and two - fold lower small mammal biomass in conifer encroached habitat relative to sagebrush habitat, results consistent with the Rowe et al. (2011) historic comparison.

Although these arguments are correlative, direct observation and establishment of a true causal relationship between conifer encroachment and small mammal diversity is unlikely. Over 100 years are required for the development of woodlands similar to the conifer encroached habitat we studied (Tausch et al. 2009). Given limitations of funding for long term monitoring; correlative relationships, space for time substitutions, and historic comparisons provide the strongest possible evidence of negative effects of conifer encroachment on small mammal communities.

If conifer encroachment causes a loss of small mammal diversity, what mechanisms drive the process? Small mammal abundance and biomass reflect resource availability (Rowe et al. 2011). Conifer encroachment has resulted in the severe reduction of native understory shrubs and herbaceous vegetation, structural complexity and variability, plant productivity, habitat heterogeneity and an overall reduction of resource and niche space availability to the small mammal community.

Sagebrush restoration and vegetation –Sagebrush restoration increased shrub cover, decreased tree cover and density but failed to increase native herbaceous plant density. Restoration treatments also caused an increase in the non-native, annual cheatgrass (Fig. 4).

Cheatgrass can have negative effects on small mammal diversity. Small mammals were six times less abundant in cheatgrass habitat than sagebrush in Utah (Ostoja and Schupp 2009). Loss of small mammal diversity was directly related to the length of time since conversion from sagebrush to annual grassland, indicating a loss of diversity over time. Small mammal abundance and diversity declined with increasing cheatgrass cover (Freeman et al. 2014). Declining diversity was attributed to both indirect (i.e. changing fire frequencies and loss of shrub cover) and direct effects (i.e. educed forage quality and loss of the interstitial spaces between shrubs). Small mammal diversity did not respond to experimental supplementation with cheatgrass seed, as small mammals preferred native grass seeds over cheatgrass seed (Lucero et al. 2015).

Despite the increase in cheatgrass associated with sagebrush restoration, there were no negative effects on small mammal diversity in our study. Cover values of cheatgrass on our treated sites were modest (33%) compared to studies linking reduced small mammal diversity and cheatgrass (monoculture and 90% standing biomass ; Ostoja and Schupp 2009, 47-100% cover; Freeman et al. 2014). Native shrubs and herbaceous plants were also maintained on our treated sites. Thus, an increase in cheatgrass resulting from sagebrush restoration may not negatively impact small mammal diversity, provided cheatgrass density and cover does not progress to an annual grass monoculture.

Sagebrush restoration and small mammal communities – Contrary to prediction, small mammal diversity did not increase in response to sagebrush restoration. With the exception of total density, treatments did not affect diversity. Sagebrush restoration maintained small mammal densities in the face of conifer encroachment. In contrast to the “pulse” impact of restoration, the slow conversion of sagebrush habitat to conifer encroached habitat, is a “press” impact with a negative, and presumably slow effect on small mammal communities (see Underwood 1994 for definitions of press and pulse impacts). Restoration resets succession and reduces tree cover, increasing shrub cover and herbaceous plants. In untreated sites, shrub cover continued to be lost to conifer encroachment, as tree cover increased. Restoration delayed conversion of sagebrush habitat to conifer encroached habitat, effectively maintaining small mammal densities.

Species specific effects – Piñon mice showed a strong and negative response to sagebrush restoration. We anticipated this response, as piñon mice are true woodland obligates (Hoffmeister 1981, Rodhouse et al. 2010). Piñon mice were also the only species more abundant in conifer encroached habitat than sagebrush (by a factor of seven). These habitat preferences are consistent with historically expanding populations of piñon mice in response to woodland expansion (Rickart et al. 2008).

Counter to expectation, cliff chipmunks, also associated with conifer woodlands (Rodhouse et al. 2010), were not affected by conifer removal and were slightly more abundant in sagebrush habitat. We initially speculated that the larger cliff chipmunks had correspondingly larger home ranges than piñon mice and dispersed into treated sites from the conifer encroached matrix. However, the two species have similar home range sizes of approximately 1 ha (Hoffmeister 1981; this study, Hart 1992). Our methods restricted captures of diurnal species, such as cliff chipmunks, which may have influenced our results. Assessment of treatment effects on diurnal species will require daytime sampling.

Due to low capture rates, large annual fluctuations in density, and unbalanced occurrence across habitats and treatments, species - specific effects of sagebrush restoration and habitat on density were difficult to model for most species. This is a common theme in conservation biology; species of management concern are generally uncommon, habitat specialists, seldom captured in sufficient numbers to make strong, statistically valid inferences of treatment effects. We found no treatment effects for voles, pocket mice, or harvest mice. Voles and pocket mice were much more abundant in sagebrush than conifer encroached habitat. Harvest mice and sagebrush voles include annual grasses in their range of habitat preferences and our study found those species only on treated sites, post- sagebrush restoration. Future studies should test the hypothesis that some small mammal species may increase in density as a result of sagebrush restoration and increased annual grasses.

Additional work should focus on functional diversity as well as measures of aggregate diversity and attempt to model restoration effects on rarer species, particularly sagebrush specialists. Future questions should be addressed across the successional range of conifer encroachment in sagebrush ecosystems and replicated regionally.

Management implications – The negative consequences of conifer encroachment on small mammals far outweigh the impacts of sagebrush restoration. Given the role of small mammals as keystone species, consumers and prey species, maintenance of small mammal density is a desirable ecological outcome. Unless woodland specialists are of management concern, sagebrush restoration is an important tool for maintenance of small mammal diversity in the face of conifer encroachment. Moderate increases in cheatgrass as a result of sagebrush restoration, may not negatively affect small mammal communities, provided native shrubs and herbaceous plants are maintained and cheatgrass cover values are low.

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Tables

Table 7. Small mammal captures by species for sagebrush and conifer encroached habitats in Great Basin National Park, White Pine County Nevada. Small mammals were sampled from 2004 - 2014 for a total of 20,920 trap nights in ten, one hectare grids.

Common name	Species	Sagebrush	Conifer Encroached
Deer mouse	*Peromyscus maniculatus*	1228	369
Western harvest mouse	*Reithrodontomys megalotis*	144	0
Cliff chipmunk	*Tamias dorsalis*	75	80
Piñon mouse	*Peromyscus truei*	22	103
Montane vole	*Microtus montanus*	8	0
Long-tailed vole	*Microtus longicaudus*	14	1
Great Basin pocket mouse	*Perognathus mollipilosus*	13	1
Sagebrush vole	*Lemmiscus curtatus*	5	0
Uinta chipmunk	*Tamias umbrinus*	1	1
Least chipmunk	*Tamias minimus*	1	0

Table 8. Model comparisons of sagebrush restoration and habitat effects on small mammal diversity in Great Basin National Park.

	model	df	AIC
richness	treatment*time + habitat	8	288.96
	treatment*year + habitat	24	297.046
	habitat	5	283.95
	treatment*time	7	290.406
	null	4	292.056
total biomass	treatment*year + habitat	24	1442.65
	treatment*time + habitat	8	1423.098
	habitat	5	1418.948
	treatment*time	7	1432.136
	null	4	1433.926
evenness	treatment*time + habitat	8	226.706
	treatment*year + habitat	24	248.714
	habitat	5	221.678
	treatment*time	7	224.706
	null	4	221.15
total density	treatment*time + habitat	7	687.786
	treatment*year + habitat	23	685.892
	habitat	4	688.934
	treatment*time	6	688.976
	null	3	694.218

Table 9. Metrics of small mammal diversity for sagebrush and conifer encroached habitats in Great Basin National Park. Sites were sampled annually from 2004 - 2014. * indicates significant differences (P < 0.01).f small mammal diversity for sagebrush and conifer encroached habitats in Great Basin National Park. Sites were sampled annually from 2004 - 2014. * indicates significant differences (*P* < 0.01).

	sagebrush	encroached
Richness*	2.5 ± 9.0	1.7 ± 12.4
Evenness	1.52 ± 0.65	1.41 ± 0.70
Biomass (g)*	447.8 ± 347.0	187.6 ± 213.1
Density (ind./ ha)*	27.5 ± 23.3	10.1 ± 12.9

Figures

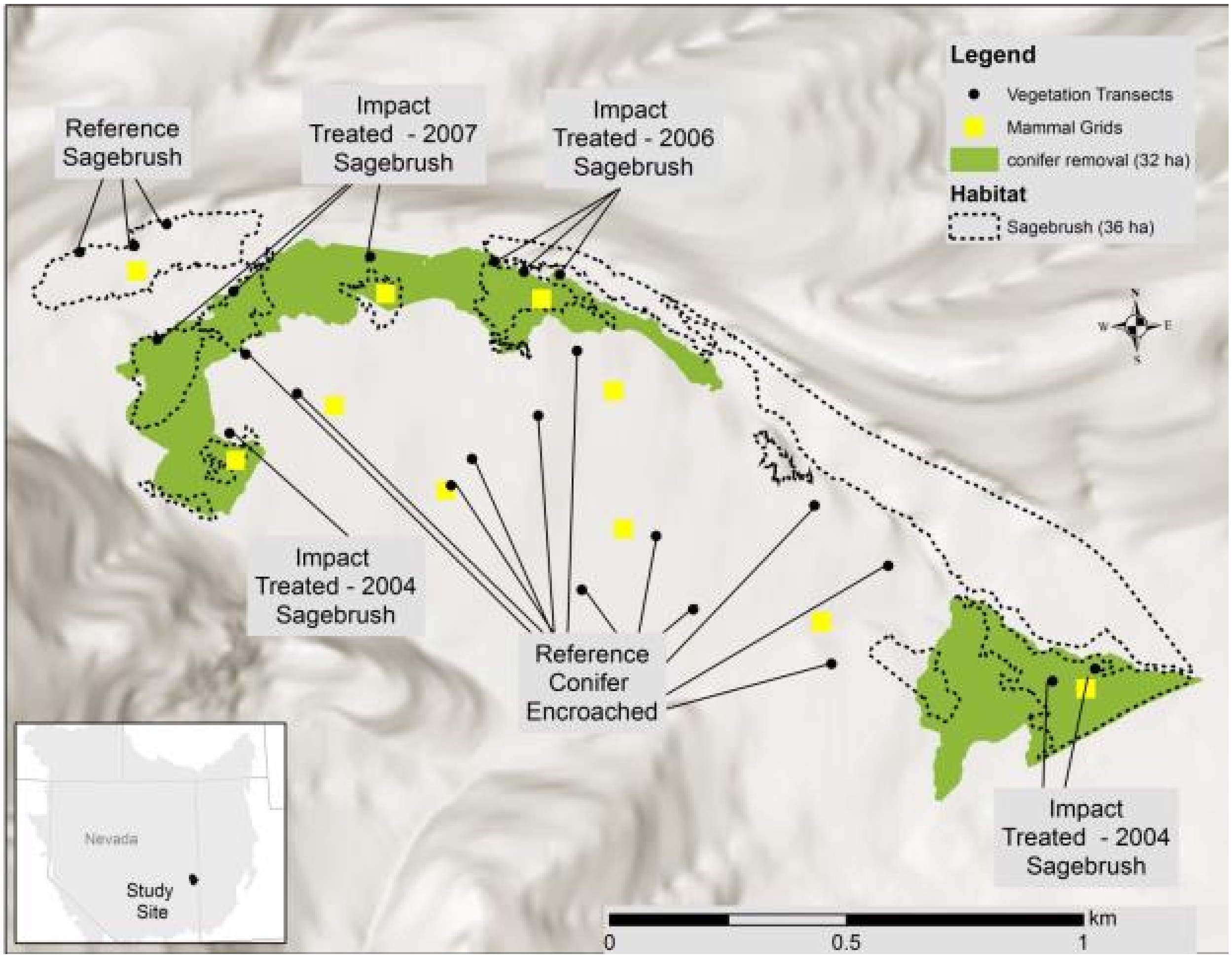


Figure 6. Study site map, showing sagebrush habitat, vegetation transects, small mammal grids, and areas of sagebrush restoration. The majority of the site was conifer encroached habitat (not shown; 161 ha). Inset map shows the study site in the context of the larger Great Basin desert (gray shading).

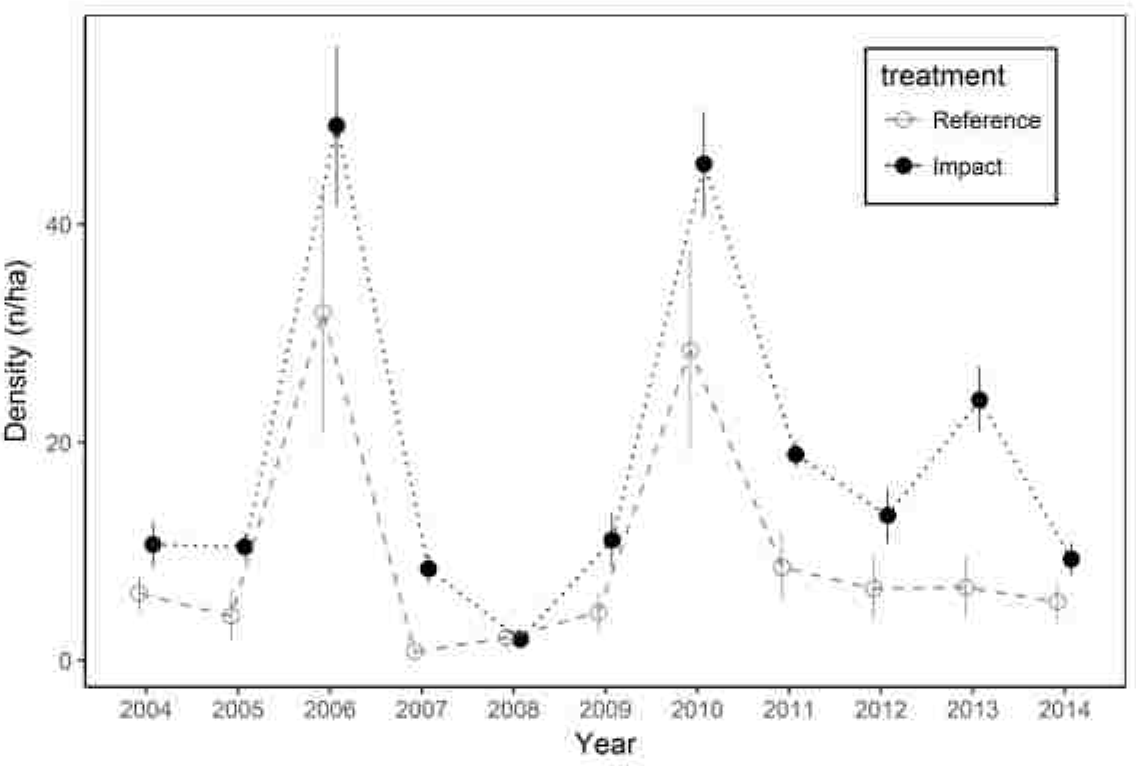


Figure 7. Annual small mammal densities ($\bar{x} \pm$ SE) in July for reference and impact grids in Great Basin National Park, White Pine County, Nevada.

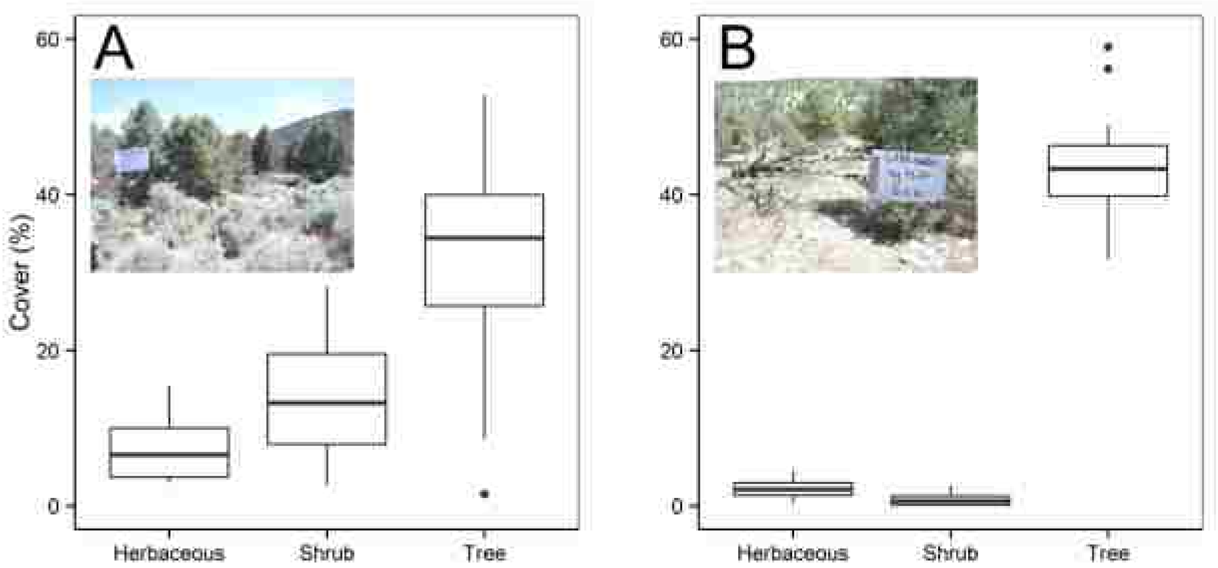


Figure 8. Prior to sagebrush restoration, sagebrush transects (A) were higher in herbaceous and shrub cover and lower in tree cover than conifer encroached transects. Conifer encroached transects (B) showed little variation in herbaceous and shrub cover and shrub cover was < 2.6% for all transects.

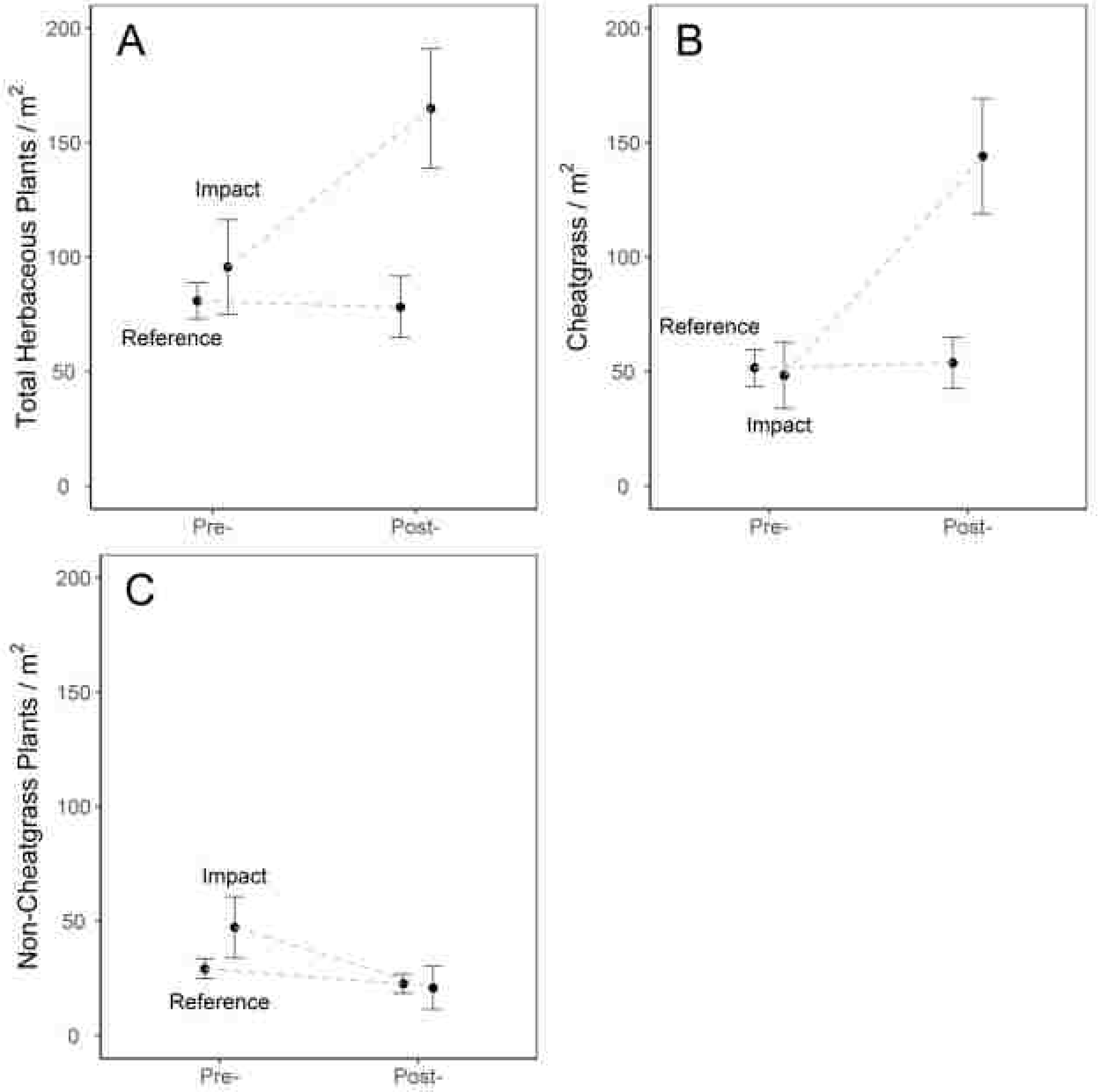


Figure 9. Restoration treatments in sagebrush habitat caused an increase in (A) total herbaceous plant density, driven by a proportional increase in (B) cheatgrass density on treated plots. (C) Non – cheatgrass herbaceous density was not significantly affected by sagebrush restoration. Values are means and standard errors.

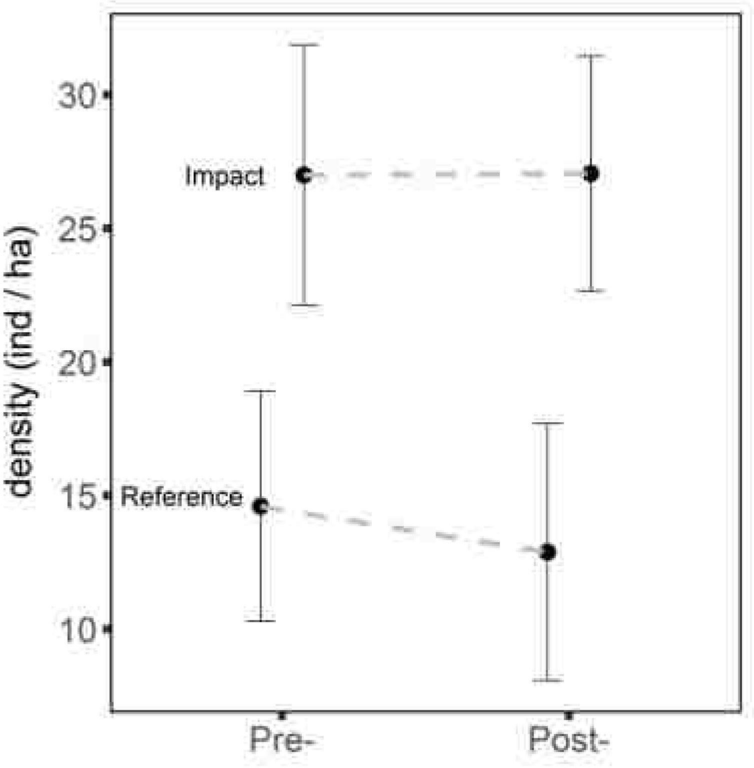


Figure 10. Total density of small mammals for impact and reference grids pre- and post- sagebrush restoration. Restoration maintained density on treated grids while density fell on untreated grids (*P* = 0.0097).

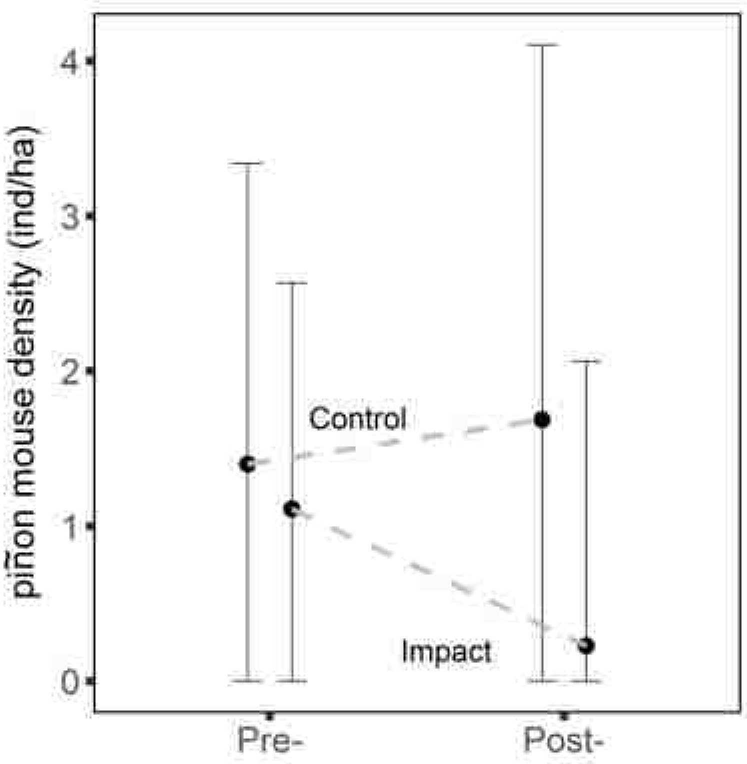
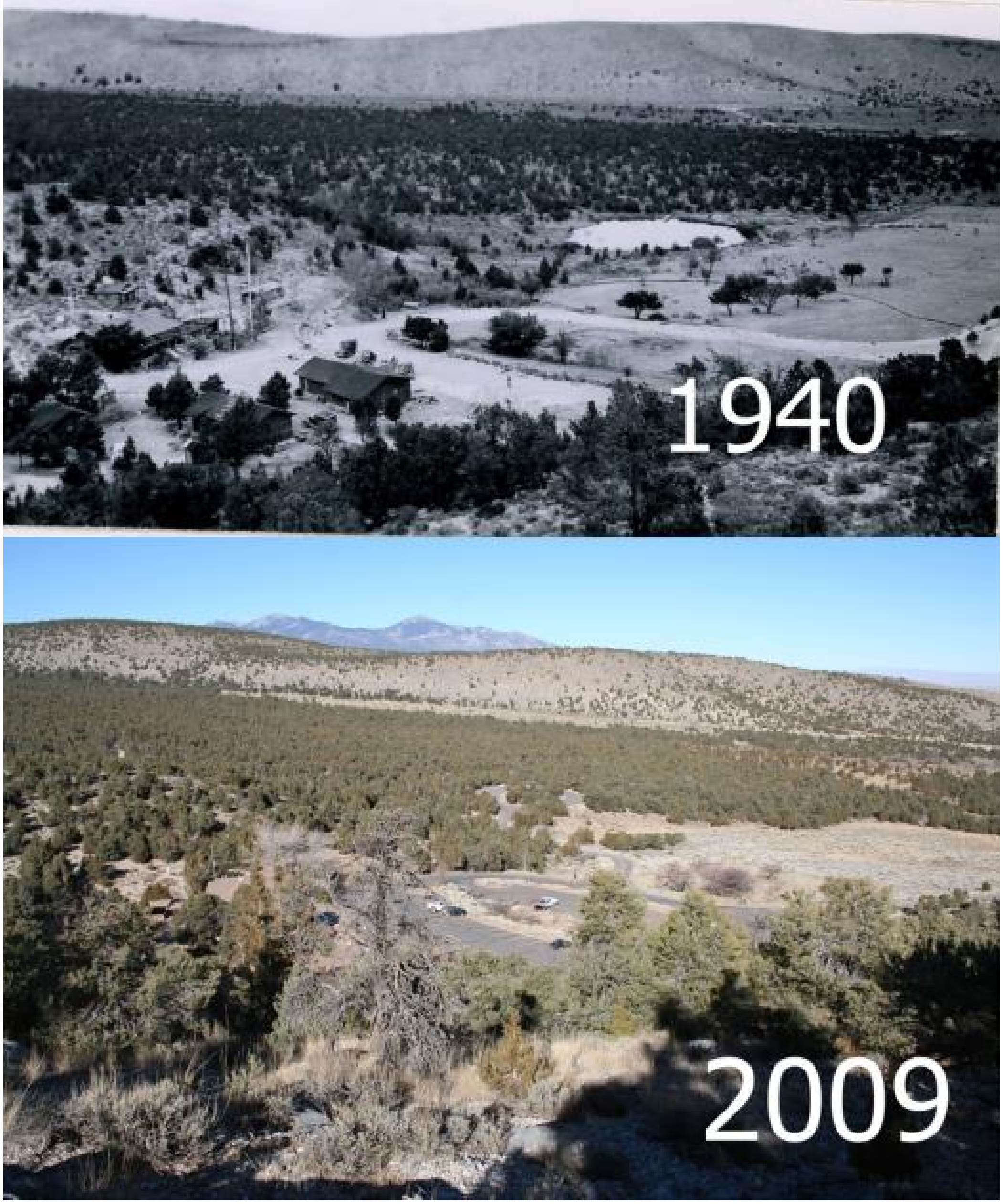


Figure 11. Total density of piñon mice for impact and reference grids before and after sagebrush restoration. Restoration decreased density on treated grids while density increased on untreated grids (*P* = 0.0036).

Chapter 2 Appendices

Appendix 1. Conifers have increased in density and aerial extent on the study site (Great Basin National Park, White Pine County, Nevada) from 1940 to 2009. This trend has occurred across the Great Basin where conifer encroachment is estimated to comprise up to 90% of all piñon juniper woodlands (Miller and Taush 2001).



Appendix 2. Shrub skeletons under conifers suggest relatively recent establishment of conifers into shrublands (Taush et al. 2009). Singleleaf pinyon (*Pinus monophylla*) requires a nurse plant to provide the proper microclimate for establishment. Pinyon seed germinates under the shrub (often cached by a small mammal) and over time overtops the nurse plant, eventually killing that shrub via competition for light, water and nutrients.

CHAPTER 3: Population growth (ג), recruitment, and harvest potential of four Great Basin rattlesnake (*Crotalus lutosus*) populations

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Abstract

Population growth (λ) is a direct measure of fitness necessary for science based wildlife management. Population growth rates of “uncharismatic”, cryptic species such as snakes have been particularly difficult to obtain. Interest is growing in the non-consumptive value of rattlesnakes for ecological services, recreational viewing, and photography. The current lack of population growth rates, abundance data, and population projections, are limiting the development of effective management, conservation and recovery goals for rattlesnakes. We used a long-term dataset and capture mark recapture models to quantify survival, recruitment, population growth (λ), and abundance in four populations of Great Basin Rattlesnakes (*Crotalus lutosus*). Based on estimates of population growth rates, survival, recruitment, and abundance, elasticity analyses were conducted, sustainable annual harvest rates calculated, and management implications discussed. Mean annual survival was estimated from the highest ranked model at 0.81. Apparent survival differed by age class, with YOY survival significantly lower (0.32) than juvenile (0.78) and adult survival (0.80). Temporal variation in survival was strongly supported, while variation in survival by size, sex, or location received very little support. Annual recruitment across the study was estimated at 0.123. Temporal variation in recruitment ranged from 0.01 - 0.33. Mean population growth, a derived parameter, was estimated at 1.00, indicating a stable population across the study. Estimated population growth by site varied from 0.93 - 1.08. Population growth was less than one for two sites indicating declining populations. Estimates of adult females per site in 2017 ranged from 9 - 35. One site warrants close monitoring as it seems likely bound for extinction (population growth = 0.93). Individuals from all sites lived well past average life expectancy. The oldest individuals were at least 17 years old. Survival overwhelmingly contributed to the value of population growth relative to recruitment (84%

versus 21%). The allowable adult female mortality rate was 0.103. Site specific estimates of allowable harvest of adult females per population ranged from 1 - 7 per site or seven across all sites.

Introduction

Snakes are a highly secretive clade of reptiles, important in ecosystem function, biomedical research, commercial trade, and the pet industry. Many snake species are imperiled, and worldwide snake populations are declining (Gibbons et al. 2000, Reading et al. 2010). In spite of declining populations, population growth rates of “uncharismatic”, cryptic species such as snakes have been particularly difficult to obtain (Griffiths and Dos Santos 2012). In most cases, the underlying causes of decline are unknown (Winne et al. 2007, Lukoschek et al. 2013). Other declines are hypothesized as resulting from habitat loss, over harvest, and human persecution (Webb et al. 2002, Reading et al. 2010). The recent emergence of disease (Allender et al. 2015, Burbrink et al. 2017) as a driver of snake population declines has increased both the need and urgency for robust estimates of population growth to assess the severity of declines; determine trigger points for management intervention; allow delivery of interventions to appropriate age, stage and sex classes; quantify the effectiveness of management actions; and project population viability.

Management of rattlesnakes is an emerging field in wildlife conservation. Human persecution in conjunction with low fecundity, late reproduction and slow growth rates have contributed to declining rattlesnake populations across North America (Brown 1993, Rudolph and Burgdorf 1997, Holycross and Douglas 2007, Chiucchi and Gibbs 2010, Clark et al. 2011, Fill et al. 2015). Many rattlesnake species aggregate in large groups for hibernation, gestation, and parturition, leaving large segments of the population, particularly reproductive females (Brown 1993), vulnerable to harvest and fear-based killing. Rattlesnakes often have large home ranges and suffer significant road mortality during seasonal migrations (Shepard et al. 2008, Jochimsen et al. 2014). Additionally, the high fidelity of rattlesnakes to their home ranges and hibernacula and subsequent low emigration rates, makes the *in situ* establishment of new populations or re-establishment of extirpated populations unlikely (Nowak et al. 2002, Walker et al. 2009).

Rattlesnake management varies greatly across North America. In several states, rattlesnakes are commercially harvested at “round-ups” with no restrictions on take (Campbell et al. 1989). In other states, rattlesnakes are strictly protected from take and managed as endangered or threatened species (Rubio 1998). Some states allow limited harvest, while still other states prohibit take or have eliminated “round-ups” in an attempt to recover declining populations (Means 2009, Feldner et al. 2016). Interest is growing in the non-consumptive value of rattlesnakes for ecological services (e.g. small mammal, disease control, and seed dispersal), recreational viewing, and photography (Reiserer et al. 2018). To our knowledge, no rattlesnake harvests are based on population growth, demography, or harvest rates, nor have management plans explicitly incorporated ecological services or recreational opportunities into management strategies. The current lack of population growth rates, abundance data, and population projections, are limiting the development of effective management, conservation and recovery goals for rattlesnakes.

Great Basin rattlesnakes (GBR; *Crotalus lutosus*) are excellent models for studies of population growth in snakes. The species overwinters in communal, ancestral hibernacula to survive the long, harsh winters of the cold desert, showing high fidelity to their hibernacula. Philopatry is advantageous for long-term, capture mark recapture (CMR) studies, minimizing the influence of immigration and emigration, increasing recapture rates and allowing estimates of apparent survival to approximate true survival. Due to their isolated, remote distribution, Great Basin rattlesnakes remain abundant in many areas and populations may approach carrying capacity (Hamilton and Conrad 2008). We used a long-term dataset (2001-2017) and CMR models to quantify survival, recruitment, population growth (λ), and abundance in four populations. Based on estimates of population growth rates, survival, recruitment, and abundance, elasticity analyses were conducted, sustainable annual harvest rates calculated, and management implications discussed.

Methods

Study Site – Great Basin Rattlesnakes were captured at four communal hibernacula in the Central Basin and Range ecoregion (White Pine County, Nevada and Millard County, Utah; Fig. 12). Surveys were conducted during spring emergence (March, April, and May) from 2001 - 2017. Regional topography was dominated by north to south trending mountain ranges and valleys. All hibernacula were closely associated with large limestone outcrops and ledges with talus, boulders, and cobbles.

Snake Capture, Survey Effort, and Processing – Rattlesnakes were captured during diurnal visual encounter surveys at communal hibernacula using snake tongs or hooks. Capture Mark Recapture (CMR) was initiated at sites B, C, and D in 2001. Site A was discovered in 2004 and CMR initiated in 2005 (Fig. 12). Beginning in 2007, number of annual surveys and survey time at each site was recorded. Total search effort was defined as the search minutes (time spent surveying and capturing rattlesnakes), multiplied by the number of surveyors. Surveys focused on known hibernating crevices, with limited time spent examining areas in the vicinity of the hibernacula for dispersing and basking snakes, and additional potential hibernating crevices.

Upon capture, snakes were placed in cloth bags or coolers and processed in a laboratory. During processing, snakes were restrained in clear plastic tubes (Foster 2012). From 2001 -

2007, snakes were marked using ventral scale clipping (Brown and Parker 1976). Beginning in 2008, all snakes were marked with Passive Integrated Transponder (PIT) tags (Plummer and Tucker 2012), injected subcutaneously on the snake's right side, approximately 10 – 18 cm caudad to the vent. Ventral scale clips remained identifiable in 2015. Snakes with existing ventral scale scars were PIT tagged and the PIT tag number replaced the ventral scale clip in databases. Passive Integrated Tags were 12 or 8 mm long, with smaller tags used for marking young of year and juvenile snakes (Model Numbers - BIOMARK FDX-B HPT12 BIOMARK FDX-B MINIHPT8; http://www.biomark.com/). All snakes were electronically scanned for PIT tags and visually examined for the presence of ventral scale clips. Snout to vent length (SVL) and tail length (TL) were measured in a squeeze box to the nearest millimeter (Quinn and Jones 1974, Foster 2012). Mass was measured using Pesola spring scales (± 2 – 5 g) or an electronic balance (± 0.1 g) with scales tared to account for snake bag mass. Sex was determined by probing for the presence of hemipenes (Reed and Tucker 2012). Snakes were returned to their exact capture location within 24 hours of capture except during extreme weather. When sub-freezing temperatures and snow were forecast, snakes were occasionally held in the laboratory for up to 72 hours until weather conditions were suitable for their release. Upon release snakes usually retreated into the hibernating crevices or under large rocks.

We defined three age classes: Young of year (YOY), juveniles, and adults. Young of year, born in late August or early September prior to spring surveys, were identifiable by the presence of a natal button and occasionally one additional rattle segment, small size, and gray coloration, had survived a single overwintering season. Glaudas et al. (2009) found that no GBR less than 50 cm and all snakes greater than 70 cm were sexually mature, so we classified juveniles as < 50 cm SVL and adults as snakes > 50 cm SVL.

A body condition index (BCI) was created using a linear model of mass versus SVL on a log scale. To determine how heavy a snake was relative to its length, the residual value for each individual was divided by the predicted value, giving a percentage of the snake's mass relative to its predicted mass (Coates et al. 2009, Jenkins et al. 2009, Rose and Todd 2017). Since snakes at hibernacula have not fed since fall ingress (6 months), BCI was not affected by food intake, but other variables such as reproductive condition may have influenced BCI.

*Permits and IACUC – S*ampling was conducted according to the guidelines of Brigham Young University's Institutional Animal Care and Use Committee, project code # 07-0301, scientific research permits from Great Basin National Park (GRBA-2007-SCI-0002), Nevada Department of Wildlife (S35631), Utah Department of Wildlife Certificate of Registration (#1COLL6355) and American Society of Ichthyologists and Herpetologists Guidelines for Use of Live Amphibians and Reptiles in Field and Laboratory Research (Beaupre et al. 2004).

Statistical analyses – For detecting differences in total captures by year, sex and site, we used generalized linear models under a Poisson distribution. Generalized linear mixed models, with individuals as random effects, were used to quantify differences between sexes and sites in SVL, mass, and BCI. Mass and SVL were natural log transformed prior to all analyses. Data presented are means plus or minus standard errors. Confidence intervals were used to assess statistical significance and parameter effect sizes, with α set at 0.05. All statistical analyses were conducted in Program R (R Core Team 2015). General linear mixed effects models were implemented with the R package "nlme" (Pinheiro J. et al. 2015).

Demographic Modeling – Cormack-Jolly- Seber (CJS) models, with individual capture histories and annual delineation of time periods, were used to estimate apparent survival (Φ) and recapture probability (*p*) from 2001-2017. Apparent survival is defined as the probability that an individual survives or does not emigrate from the study area between sampling periods. Thus, Φ confounds true survival with emigration (Sandercock 2006, Mazerolle et al. 2007). Apparent survival estimates encompass the intervals between annual spring emergence surveys at communal hibernacula. Each sampling period during emergence was followed by an active season, fall ingress, and an overwintering period. The active season is typically from April - September with overwintering from October - March (B. Hamilton unpublished data). Following spring emergence, most snakes dispersed from hibernacula to forage, shed, mate and give birth. In late summer to early fall, snakes return to hibernacula for overwintering. Thus, annual Φ includes mortality and emigration which could have occurred during either the active season or the overwintering period. Great Basin rattlesnakes show high fidelity to hibernacula and while emigration and immigration are likely very low, they cannot be eliminated as contributing to Φ. Recapture probability (*p*), the probability that a marked animal is recaptured, given that it survived, was estimated during the spring emergence sampling periods.

Cormack-Jolly-Seber models make several assumptions: (1) Marked individuals are homogeneous in their survival and detection probabilities (e.g. no individual heterogeneity); (2) all emigration is permanent; (3) samples are instantaneous, and animals are released immediately after sampling; (4) marks are not lost, and all marks are correctly read; (5) fates of individuals are independent from fates of any other animals (Nichols 2005, Mazerolle et al. 2007).

We used reverse time modeling (Pradel and Jolly-Seber (JS) models) to quantify Φ, λ, recruitment (*f*), and abundance. These models use slightly different parameterizations of the underlying population processes than CJS models, reversing capture histories to derive information about both entering and exiting the population (Nichols 2016), with population growth driven by additions and losses (births, deaths, immigration and emigration). Pradel models estimate realized λ as the relative contributions of Φ (process of remaining in the population) and recruitment (*f;* the per capita recruitment rate) by relating the two through a seniority parameter (ϒ; the probability an individual alive at time $_i$ was also alive and in the population at time $_{i-1}$). At its most basic formulation, abundance can be determined by dividing the number of captures by the detection probability (Abundance=$N_{captures}/p$; (Mazerolle et al. 2007). Jolly-Seber models, implemented in POPAN, the program for analysis of open population, mark-recapture data, estimate four parameters, Φ, *p*, pent, and N. Φ and *p* are defined identically to CJS and Pradel models. Pent, the net probability of individuals entering the population via births and immigration is similar to *f* in Pradel models. N, a derived parameter, is the estimate of abundance (Schwarz and Arnason 1996, Arnason and Schwarz 2002).

In addition to the assumptions of CJS models, reverse time models require two additional assumptions. First, the area of the study site must remain constant (Pradel 1996). As one site was added in year 5, we subset the data to include only the years that all sites were sampled (2005-2017). The second assumption is that capture probabilities do not differ between marked and unmarked individuals in the population (Nichols 2005). This assumption allows the numbers of unmarked individuals to be estimated in POPAN models, giving an abundance estimate for each group by time period. Newly captured animals are assumed to have the same capture probability as marked animals and represent a random sample of all unmarked animals in the population.

We first optimized CJS models for *p* using Akaike Information Criterion, corrected for small sample size (AIC_c), to guide model selection (Burnham and Anderson 2002). Akaike Information Criterion, is a balance of model fit and complexity, and provides a relative measure of model quality, given the model set and data. Using an intercept only parameter for Φ, we tested 25 models for p. We considered site, sex, and age class as groups and incorporated body condition and SVL on initial capture as individual covariates. Additional model parameters included time (delineated annually as a factor), Time (linear trend), age (time since initial capture), Age (linear trend of the time since initial capture), and time since marking (tsm, time from each capture event considered as a factor). We then used the top weighted model parameters for p and considered 22 models of Φ. Model parameters for Φ included sex, site, and age class as groups, with SVL and BCI as individual covariates. Other parameters included time (delineated annually as a factor from 2001 - 2017), Time (linear trend from 2001 - 2017), age (time since initial capture), and Age (linear trend of the time since initial capture). We tested the most parameterized CJS model for goodness of fit in the program RELEASE (tests 2 and 3) and found no evidence for lack of fit ($\chi^2_{77} = 74.7$, $P = 1.00$). Reverse time models have additional parameters than CJS models, which limited the complexity of our model set. We incorporated the highest weighted model parameters from the CJS analysis for p into Pradel and JS models and selected from five models. The location - year additive model was highly favored for both Pradel and JS models (15 times the model support).

A clear top model (Δ AIC$_c$ <2) emerged for each model type and was used for inference (Burnham and Anderson 2002). Variance components using the highest weighted model were used to calculate means and standard errors for model parameters by year, location, sex, and age class (White et al. 2001). In calculating means and standard errors, parameter estimates of the first and last years were excluded as these parameters are often inestimable. In addition to excluding first and last years for mean parameter estimates for Pradel and JS models, we excluded an estimate of Φ from 2009 of 0.999 with confidence intervals spanning zero to one. We calculated the geometric mean of λ and used the delta method to calculate variance.

Using the most robust estimates of Φ, f, and λ, we conducted a simple elasticity analysis to rank the relative importance of survival and recruitment to overall and hibernacula specific population growth (Nichols et al. 2000). Cormack-Jolly-Seber, Pradel, and Jolly-Seber models were implemented in the program MARK (White and Burnham 1999) via Program R (R Core Team 2015) with the package RMark (Laake 2013).

To differentiate sex ratios from 1:1, we used chi - square tests to compare observed versus expected frequencies of counts (Wilson and Hardy 2002). Count frequencies were raw captures and abundance estimates were calculated from POPAN. Based on the mean CJS estimates of Φ, we calculated the average life expectancy (ALE) as: $1/-\ln(\Phi)$ and the median life expectancy (MLE) as: $\ln(0.5)/\ln(\Phi)$ by sex and site (Robeck et al. 2015).

To calculate the number of females that could be lost to harvest, we used the equation $H = 1- \Phi \leq f * \Phi$ where H is the harvest rate, f is recruitment, and Φ apparent survival. This equation, which requires adult female harvest to be less than the product of f and Φ, balances harvest with λ to determine harvest levels that will maintain a self-sustaining population (i.e. $\lambda \geq 1$) (Skalski et al. 2005; p. 344). Harvest rates (H) were multiplied by the 2017 abundance estimates to determine number of adult females available for harvest and allowable annual take.

Results

Site visits and sampling effort were documented from 2007 - 2017. Mean annual visits per site was 10.5 ± 0.22. Annual sampling effort ranged from 11 - 54 hours. From 2001 – 2017, we captured 472 individuals, 966 times (175 females and 297 males; Table 10). Annual captures ranged from 18 - 86 ($\bar{x} = 57 \pm 4.7$) and varied by site ($P < 0.009$), and sex ($P < 0.0001$). Total captures increased over the study by 2.6% per year ($P = 0.0007$). Snake length was strongly related to mass ($\log_e$ mass (g) = 3.01 * $\log_e$ SVL (cm) - 7.2, $P < 0.0001$, $R^2 = 0.8977$; Fig. 13). Mean SVL was 57.9 ± 0.61 cm and mean mass was 175.5.8 ± 4.7g. Males were significantly longer (5.7 cm; $P < 0.0001$), heavier (61.2 g; $P < 0.00001$), and in better body condition than females ($P = 0.0189$).

Mortality - Eleven individuals were found dead during the study. Necropsies identified the likely causes of death as: hyperthermia (n = 1), apparent rock fall (n = 1), and human caused (n = 9). Human caused deaths included decapitation (n = 7) and vehicle strikes (n = 2). We were able to read the ventral clips or PIT tags on six of the eleven individuals found dead. Of the nine observed mortalities where sex was determined, three were females (Fig. 14).

CJS models - Five individuals with unresolvable data entry errors in their ventral scale clip or missing SVL were removed from the dataset, leaving 467 individuals and 969 captures for the CJS analysis. The top ranked model for recapture probability (*p*) carried 69% of the model weight (2.2 times the model weight of the next most supported model) and supported additive effects of location and sex (Table 11). Mean recapture probability was 0.29 ± 0.017. Recapture probability varied by site and was significantly higher for males (0.37 ± 0.06) than females (0.22 ± 0.06). Although significantly better than the null model (Δ $AIC_c = 2.953$), time since marking effects on *p* were not significant. Age as a linear trend indicated an increasing probability of recapture with time. Overall our results for recapture probability (*p*) are equivocal and provided mixed support for a behavioral aversion to capture by GBR (AIC_c or confidence intervals).

The top model for Φ included additive effects of age class and time (96% of the model weight; Table 12). Mean Φ was estimated from the highest ranked model at 0.81 ± 0.01.

Apparent survival differed by age class, with YOY survival significantly lower (0.32 ± 0.02) than juvenile (0.78 ± 0.02) and adult survival (0.80 ± 0.02). Temporal variation in survival was strongly supported (Fig. 15; Table 12). Variation in survival by BCI, SVL, sex, or location received very little support (Table 12).

Reverse time Models - To meet the assumption of constant study site area, we subset the data to include only years of sampling common to all sites (2005 - 2017), leaving 387 individuals and 781 total captures for analysis. Based on the CJS model selection, *p* was modeled additively as a function of sex and location. Survival, recruitment, and pent were modeled additively by location and time. Abundance was modeled by site, year, sex, and age class. These models received 94% and 100% of the model weights for both Pradel and JS models, respectively.

Estimates of mean Φ and *p* under the Pradel and JS models were slightly higher than the CJS estimates (Table 13). Annual recruitment (*f*) across the study was estimated at 0.123 ± 0.014. Temporal variation in *f* ranged from 0.01 - 0.33 (Fig. 16). Mean λ, a derived parameter, was estimated at 1.00 ± 0.02, indicating a stable population across the study. Estimated λ by site varied from 0.93 - 1.08, with $\lambda < 1$ for two sites indicating declining populations (Table 10). Estimates of adult females per site in 2017 ranged from 9 - 35 individuals (Table 10; Fig. 17). Hibernaculum D warrants close monitoring as it seems likely bound for extinction ($\lambda = 0.93$; Fig. 17).

Sex Ratios – Males were captured in higher numbers than females suggesting a male biased sex ratio across survey locations ($\chi^2 = 31.5$; $P < 0.0001$). Using the JS abundance estimates, the male biased sex ratio held for adults ($\chi^2 = 14.5$; $P < 0.001$) but did not differ from unity for juveniles ($\chi^2 = 1.4$; $P = 0.2373$) or YOY ($\chi^2 = 1.4$; $P = 0.2413$). Although more males were captured than females at all sites (Table 10), male biased sex ratios were confirmed at two sites using the JS estimates of abundance (A and B; $P < 0.001$).

Life Expectancy - Using the mean estimate of Φ from the CJS models (0.81), ALE was 4.7 and MLE was 3.3 years, respectively. Average life expectancy for YOY snakes was 0.87, juveniles 4.0, and adults 4.4 years. Individuals were documented from all sites that lived well past average life expectancy (Table 10). The oldest individuals were at least 17 years old but were certainly older, as they were initially captured as adults. Based on recapture intervals, the mean age of the oldest 10% was 10.2 and the mean age of the oldest 25% was 7.6 years, respectively. Using the location specific estimates of Φ from the Pradel model, average age varied by site from 2.9 - 6.6 years (Table 10).

Elasticity/sensitivity analysis – Survival overwhelmingly contributed to the value of lambda relative to recruitment, 84% versus 21% across sites (Fig. 16). Site specific elasticity of survival ranged from 0.74 - 0.88 (Table 10).

Estimates of allowable anthropogenic mortality – Using a mean *f* of 0.123, mean adult Φ of 0.835, the allowable adult female mortality rate was 0.103. Site specific estimates of allowable harvest of adult females per population ranged from 1 - 7 per site or seven across all sites (Table 10).

Discussion

Population growth is a direct measure of fitness and the most critical demographic parameter for science based wildlife management (Sibly and Hone 2002). In principle, realized population growth is calculated simply as the quotient of successive population estimates (N_{t+1} / N_t). In practice, estimating population growth is more challenging, and requires long term datasets, particularly for species with low detectability (Dorcas and Wilson 2009). Reverse time, state space models hold great potential to estimate λ, which can be further partitioned into component survival, recruitment, emigration, and immigration, while accounting for imperfect recapture probability (Nichols 2016).

Many long - term, capture mark recapture datasets on rattlesnakes are suitable for reverse time modeling. Estimating population growth and recruitment, in addition to survival, would yield valuable information for rattlesnake conservation and management, particularly in assessing management effects on population growth, the extent and magnitude of population declines, success or failure of translocations, and the influence of rattlesnakes on ecological services, such as rodent control, disease spread, and seed dispersal. In this study, a long term dataset was used to quantify realized λ, recruitment, survival, and abundance in four populations. To our knowledge, this is the first study to estimate recruitment and population growth (λ) in rattlesnakes using reverse time, state space modeling.

Spatial variation in demographic traits is commonly observed in rattlesnakes (Beaupre 1995, Hileman et al. 2017, Jenkins et al. 2017). In our study, spatial variation was strongly supported by reverse time models. Using the most parsimonious Pradel model, site specific estimates of Φ ranged from 0.71 - 0.86, recruitment from 0.11 - 0.26, and λ from 0.93 - 1.08. As a consequence of spatial variation, mean λ was >1 for two sites and <1 for two other sites. Examining the abundance estimates and confidence intervals for lambda suggested a growing population at site C, stable populations at sites A and B, and a declining population at site D (Fig. 17, Table 10).

In contrast to reverse time models, the most robust estimate of Φ from the highest ranked CJS model did not support spatial variation. This disparity may be due to the longer time series (16 versus 11 years), greater sample size (467 vs. 387 individuals), fewer parameter estimates, or differing model assumptions of CJS and reverse time models. Reverse time models estimate survival for both marked and unmarked individuals, while CJS models condition estimates on only marked individuals (Nichols 2005). Differences in mean estimates between model types were relatively small (Table 13).

Abundance showed strong spatial variation, a reflection of site specific variation in λ. Adult female abundance ranged from 9 – 35 per site in 2017 (Table 10). While the minimum viable population concept has been challenged for long lived species (Shoemaker et al. 2013), quasi-extinction occurs when a population drops below 20 reproductive females (White 2000). Populations with less than twenty reproductive females are considered critically endangered and prone to extinction due to demographic and environmental stochasticity, genetic drift, and Allee effects (Skalski et al. 2005). Three of our four populations were comprised of < 20 adult females for the duration of our study and only one site exceeded twenty adult females in 2017 (Fig. 17).

Small populations raise questions about the scale of management and the appropriateness of harvest. Are populations isolated, critically endangered and facing imminent extirpation in geographic locations where they previously thrived? Or are the individual populations demographically connected, interacting parts of a larger metapopulation? Defining the scale and connectedness of rattlesnake populations is a critical management objective, as the two interpretations have very different conservation and management implications.

Great Basin rattlesnake populations can be viewed as a network of interconnected nodes. Hibernacula form the central and most important nodes. Snakes disperse from the hibernacula, aggregate at smaller nodes for mating, gestation, parturition, feeding, digestion, and ecdysis; then collapse back to the hibernacula for overwintering. Newly born rattlesnakes, likely follow their mother via scent trailing from birthing rookeries to hibernacula (Brown and Frances 1983). Emigration and immigration between hibernacula are apparently rare, likely a selective consequence of the severe, harsh, long winters of the Great Basin.

Quantifying the extent and magnitude of emigration and immigration is critical to define the connectedness of hibernacula and the scale of management. Genetic studies could quantify the degree of isolation and interbreeding between hibernacula, but are unable to quantify the demographic parameters of immigration and emigration, which are the defining parameters for demographic interconnectedness and determining the scale of management. On the one hand, each population could be viewed as critically endangered (<20 adult females). However, on the other hand, if the population is viewed as a whole (78 adult females), then it would be considered robust, with a surplus available for harvest.

Our study is missing data on an entire age class of rattlesnakes: neonates from parturition (late August early September) to their first emergence from hibernation as YOY. Unlike some rattlesnake species, which are highly detectible during gestation and parturition (Brown 1993), gravid GBR and neonates are difficult to locate (Feldner et al. 2016). Our sampling, limited to annual spring surveys, also constrained our ability to find neonates and gravid females. Neonates and YOY are presumably more vulnerable to predation than adults (i.e., predation by ophiophagous *Masticophis taeniatus* that occur at all sites), starvation (there is some evidence that feeding can help neonates and YOY survive the first winter) and exposure (i.e., choosing a poor overwinter site vulnerable to temperature extremes). Age class was a critical variable in describing survival and recruitment, and inclusion of the neonatal age class is important for more complete life table matrix approaches and in determining site specific fecundity.

Age class structure was strongly supported in the CJS models, with adults and juveniles surviving at significantly higher rates than YOY snakes. While we urge cautious interpretation of the exact parameter values of Φ for YOY due to small sample size (26 individuals), overall age class effects were strongly supported by AIC_c , a large effect size, and estimates were similar to other populations of GBR (Jenkins et al. 2017). Age class effects in our study are consistent with general survival patterns in snakes, where adults tend to survive at the highest rates, neonates and YOY the lowest, and juveniles at intermediate rates (Pike et al. 2008).

There are few published estimates of population growth for rattlesnakes. In a northern Utah population of GBR, projected λ was 0.947 and this population declined to extinction by 1980 (Parker and Brown 1974, Parker and Plummer 1987, Parker and Brown 2016). In Idaho, populations of GBR have been reported to vary spatially in λ, with projected site specific λ ranging from 0.92 - 1.01 (Jenkins et al. 2017). In these studies, λ was calculated as projected population growth, using the dominant eigenvalue from life tables. In our study, λ was estimated as realized, rather than projected population growth. Although calculated differently, our estimates of λ are consistent with projected λ from these other studies.

Temporal variation was strongly reflected in all parameters and model types. Temporal variation is at least partially a reflection of demographic response to climate variability. Rattlesnakes in arid regions are limited by prey availability (Nowak et al. 2015). Increased precipitation increases primary production leading to increases in prey availability (primarily small mammals for GBR; Beatley 1976, Glaudas et al. 2008). For capital breeders such as GBR, increased prey intake is correlated with fecundity (Bonnet et al. 2001), and is expected to increase reproduction, recruitment, abundance, and population growth (Nowak et al. 2008).

While often strongly correlated with reproduction and recruitment (Taylor et al. 2005), rattlesnake survival is also influenced by climate. Female survival of timber rattlesnakes was significantly reduced during years of low prey availability (Olson et al. 2015). Reduced survival was due to increased movement and prey searching, which led to increased mortality. As ectotherms, adult rattlesnakes are well equipped for low prey availability, can survive an entire year without feeding, and are very unlikely to starve. However, neonate, YOY and juvenile survival in contrast may be more sensitive to climate mediated prey availability, and subject to starvation (Jenkins et al. 2017), thus showing more annual variation in survival than adults (Kissner and Weatherhead 2005).

Mean annual Φ in our study was similar to published estimates for GBR. Survival estimates for GBR in Idaho ranged from 0.29 - 0.47 for neonates, 0.69 - 0.70 for juveniles, and 0.75 - 0.84 for adults (Jenkins et al. 2017). In a northern Utah population of GBR, mean annual survival ranged from 0.75 - 0.84 (Woodbury 1951, Parker and Plummer 1987, Parker and Brown 2016). In the closely related *Crotalus oreganus,* annual survival declined from 0.82 to 0.55 for adults, potentially due to a handling effect and accidental mortality by researchers over the nine year study (Diller and Wallace 2002). As in a recent Idaho study, we found no support for a similar linear decrease in survival (Jenkins et al. 2017).

Due to sampling only during spring emergence, we were unable to partition Φ into overwinter and active season components. Most mortality (18% versus 4%) in a northern Utah population of GBR was found to occur during the active season (Parker and Brown 1974). However, reports of up to 34% winter mortality in this population were likely incorrect (Hirth 1966, Parker and Brown 2016). Causes of active season mortality for GBR include vehicle strikes, predation (badgers, spotted skunks, raptors, kingsnakes, desert striped whipsnakes), hyperthermia, hypothermia, and rock fall (Feldner et al. 2016).

Humans caused most mortality in our study. Of the 11 active season mortalities we observed, two were vehicle strikes and seven were decapitation (Fig. 3). As CMR models confound mortality sources, our survival estimates include an unknown proportion of anthropogenic mortality, reflected in spatial and temporal variation. Future work with radio telemetry, known fate and joint models are recommended to explicitly partition mortality into constituent components of natural, anthropogenic, active season, and overwintering mortality.

Elasticity analyses confirmed the disproportionate influence of adult survival over recruitment in driving population growth overall. However, geographic variation in elasticity indicated that the relative influence of survival on λ differed by site. For example, λ was >1 for sites C and B, but these sites differed by 13% in elasticities, reflecting spatial variation in the relative influence of recruitment. This suggests that that some sites are “slower”, depending more on survival for population growth, while other sites are “faster” and more dependent on recruitment and reproduction. This “live fast die young” life history strategy has been observed in other species of snakes (Miller et al. 2011) and has important management implications. Faster sites could support higher rates of harvest and in the context of metapopulation models, would be expected to be source populations.

Most populations in this study could support additional harvest of adult females and harvest rates varied as a function of λ and population size. Reptile response to harvest (i.e. density dependence, additive and compensatory mortality) is not well understood. At rattlesnake round-ups, harvest rates are high but may be sustainable (Fitzgerald and Painter 2000), although there is limited evidence of demographic impacts (Means 2009). High harvest rates of a tropical python were also sustainable (Shine et al. 1999). Harvested turtle populations increased rates of juvenile growth and reached sexual maturity at smaller sizes than non-harvested populations, demonstrating genetic control of growth rates and age of first reproduction under selection pressure (Spencer and Janzen 2010). Under selection pressure, elasticity analyses shifedt away from adult survival towards fecundity. In other words, species can adjust to stressors including harvest. Growth rates can adapt to mortality patterns, and are not necessarily passive responses to resource limitation and temperature. In principle, reptile populations respond to harvest similarly to other taxa such as birds, mammals and fish. However our harvest recommendations do not incorporate spatial and temporal variation in demographic rates. Spatial and temporal variation increase demographic stochasticity and require harvest rates to be adjusted downward to accommodate this stochasticity.

Management Implications – Like most rattlesnake species, GBR have experienced local declines and extirpations, primarily due to human persecution (Hall 1929, Parker and Brown 1974). Deliberate killing by humans caused most mortality in our study. In spite of the observed anthropogenic mortality, most sites could support additional, limited harvest of adult females. Spatial and temporal variation increase demographic stochasticity and require harvest rates to be adjusted downward to accommodate this stochasticity. We recommend using lowest harvest rates to minimize population declines and impacts to ecological services provided by rattlesnakes. Use of the lower end estimates spreads risk across populations, allows populations to grow during years of high recruitment, and minimizes negative effects during years of low recruitment. Requiring some geographic separation between collected animals could also be used to minimize risks.

How do our recommended harvest levels compare with existing regulations? The distribution of GBR includes six states (Nevada, Utah, Idaho, Oregon, California, and Arizona). Legal take for these states ranges from zero to four snakes per year, per person. The critical piece of information we are missing is harvest rate. We recommend reporting of reptile collection, similar to the Hunter Information Program and angler surveys. We also recommend more liberal harvest for males and minimal harvest for females.

Higher harvest rates may be possible, if GBR show density dependent response to harvest. Several reptile species and some snakes show evidence of increasing their demographic rates under different conditions. Optimal harvest models, rely on density dependent response to harvest and operate at one-half of carrying capacity (K) to maximize population growth and provide the maximum economic yield and sustained yield of individuals for harvest (Skalski et al. 2005). Under this scenario, by definition, ecological goods and services are reduced by half relative to a population at carrying capacity (K). Rarely are populations harvested at such optimal harvest rates, partially to buffer against declines and to allow recreation and ecological services. Since rattlesnakes are increasingly valued for recreational viewing opportunities and ecological services, such as top down control of rodent populations and decreased disease prevalence, less than optimal harvest rates are recommended.

Many wildlife management agencies are attempting to recover depleted or extirpated rattlesnake populations through habitat management, translocation, or protection from harvest and indiscriminate killing (Walker et al. 2009). Elasticity analyses provide valuable information for adaptive management and rattlesnake recovery. Results of our elasticity analyses suggest that maintaining or enhancing adult survival is most important to management GBR. However, adult survival may be at its maximum for many populations of GBR. Therefore recruitment may be more responsive to management in populations where recovery and enhanced λ is the goal. Rattlesnakes are capital breeders and increased resource availability and enhanced habitat and prey availability could increase recruitment, fecundity, and reproduction. These goals may be more achievable than increasing survival. To our knowledge few studies of rattlesnake recovery have measured enhanced recruitment. Some potential means to increase recruitment are manipulation of habitat features such as basking sites and hibernacula (i.e., daylighting), manipulation of seral stage (i.e., prescribed fire, logging, mechanical thinning), and connection of landscapes via corridors (Shoemaker et al. 2009).

Defining the scale of populations for management is critical, as is evident from this study that indicated the size of some of our populations is concerning. While our results cannot eliminate the possibility that populations of GBR are part of a larger metapopulation, initial interpretation of demographic parameters does not support a hypothesis of interacting populations via immigration and emigration. Instead, our results support independently acting GBR populations with minimal emigration or immigration between hibernacula, as indicated by spatial variation in lambda, recruitment, survival and abundance. We also recommend more liberal harvest for males and minimal harvest for females.

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Tables

Table 10. Summary of variables for Great Basin rattlesnakes at four hibernacula in in eastern Nevada and western Utah. Data were collected between 2001 and 2017.

Variable	Sex	Site A	Site B	Site C	Site D
search time (hrs)		54	54	43	68
total surveys		80	80	96	80
total captures	F	50	130	76	64
	M	160	282	119	85
individuals captured	F	30	54	56	35
	M	80	102	72	43
mean SVL (cm)	F	54 ± 1.5	58 ± 1.6	57 ± 1.7	56 ± 1.2
	M	61 ± 1.5	65 ± 1.6	64 ± 1.7	62 ± 1.2
mean mass (g)	F	139 ± 12	168 ± 13	178 ± 14	149 ± 15
	M	206 ± 12	235 ± 13	245 ± 14	217 ± 15
mean body condition	F	-0.02 ± 0.03	-0.05 ± 0.03	0.03 ± 0.03	-0.06 ± 0.03
	M	0.02 ± 0.03	-0.005 ± 12	0.08 ± 0.03	-0.02 ± 0.03
lambda (λ)		0.97 ± 0.03	1.03 ± 0.04	1.08 ± 0.04	0.93 ± 0.03
total adults (> 50cm)	F	36 ± 7	36 ± 4	75 ± 15	28 ± 6
2017 adults (>50 cm)	F	18	16	35	9
sex ratio (POPAN)		1.7	1.7	0.96	1.1
sex ratio (raw captures)		2.7	1.9	1.3	1.2
POPAN estimates	F	67	58	107	41
	M	112	98	103	45
Average Life Expectancy		2.92	6.63	3.32	3.64
oldest observed snakes	F	10	17	14	14
	M	12	16	13	12
Φ (Pradel)		0.71 ± 0.02	0.86 ± 0.008	0.74 ± 0.02	0.76 ± 0.02
f		0.18 ± 0.02	0.12 ± 0.01	0.26 ± 0.02	0.11 ± 0.01
elasticity $_{\Phi}$		0.80	0.88	0.74	0.87
allowable Harvest rate (H)	F	0.1278	0.1032	0.1924	0.0836
allowable harvest (H x 2017 abundance estimates)	F	3	2	7	1

Table 11. Model results for CJS models of recapture probability (p). Φ was modeled as intercept only.

p	parameters (n)	AIC$_c$	ΔAICc	weight	Deviance
Site + Sex	6	2213.88	0.00	0.69	1541.02
Site * Sex	9	2215.45	1.57	0.31	1536.47
Site + SVL	6	2231.43	17.55	0.00	2219.33
Site	5	2236.36	22.48	0.00	1565.52
Site + BCI	6	2237.88	24.00	0.00	2225.78
BCI * Site	9	2243.09	29.21	0.00	2224.87
Age + Sex	4	2255.16	41.28	0.00	1586.35
Sex + time	18	2258.40	44.52	0.00	1560.80
age class + time	19	2260.86	46.98	0.00	1561.17
Sex + SVL	4	2265.97	52.09	0.00	2257.92
Sex * SVL	5	2267.22	53.34	0.00	2257.15
time since marking + Sex	4	2267.52	53.64	0.00	2259.47
Sex	3	2268.82	54.93	0.00	1602.02
BCI + Sex	4	2270.36	56.48	0.00	2262.31
BCI * Sex	5	2272.33	58.45	0.00	2262.26
age class	4	2272.78	58.90	0.00	1603.97
Age	3	2274.41	60.53	0.00	1607.62
time	17	2276.55	62.67	0.00	1581.04
time * Sex	33	2279.13	65.25	0.00	1549.57
SVL	3	2281.51	67.63	0.00	2275.48
Time	3	2283.52	69.63	0.00	1616.72
time since marking	3	2284.84	70.96	0.00	2278.81
null	2	2287.79	73.91	0.00	1623.01
BCI	3	2288.95	75.07	0.00	2282.92
age	17	2290.94	77.06	0.00	1595.43

Table 12. Model table for CJS models of apparent survival (Φ). p was modeled as Location +sex.

Φ	parameters (n)	AIC_c	ΔAICc	weight	Deviance
age class + time	23	2185.15	0.00	0.96	1477.02
time	21	2194.18	9.03	0.01	1490.28
Site + Sex + time + SVL	26	2194.30	9.15	0.01	2140.56
Site + time + SVL	25	2194.43	9.29	0.01	2142.83
Site + time	24	2194.82	9.67	0.01	1484.58
Site + Sex + time	25	2195.40	10.25	0.01	1483.03
age class	8	2204.75	19.60	0.00	1527.81
Site + age class	11	2208.49	23.34	0.00	1525.41
null	6	2213.88	28.73	0.00	1541.02
Sex	7	2214.57	29.43	0.00	1539.67
Sex*SVL	8	2215.13	29.99	0.00	2198.96
SVL	7	2215.23	30.09	0.00	2201.10
Sex + SVL	8	2215.71	30.57	0.00	2199.54
BCI	7	2215.89	30.75	0.00	2201.76
Site	9	2217.22	32.08	0.00	1538.24
Site + Sex	10	2218.32	33.17	0.00	1537.29
Site + SVL	10	2218.71	33.57	0.00	2198.44
Sex*SVL + Site	11	2219.03	33.88	0.00	2196.71
Site + Sex + SVL	11	2219.59	34.44	0.00	2197.27
time*Sex	37	2219.64	34.49	0.00	1481.36
Site*Sex	14	2224.86	39.71	0.00	1535.58
age class*time	54	2225.67	40.53	0.00	1449.31

Table 13. Comparison of model parameters for CJS, Pradel and JS estimates of Φ and p. Estimates were derived from variance components of top weighted models and represent the most robust estimates over the study.

	Φ	*p*
CJS	0.81 ± 0.02	0.28 ± 0.02
Pradel	0.84 ± 0.014	0.31 ± 0.012
JS	0.85 ± 0.02	0.304 ± 0.042

Figures

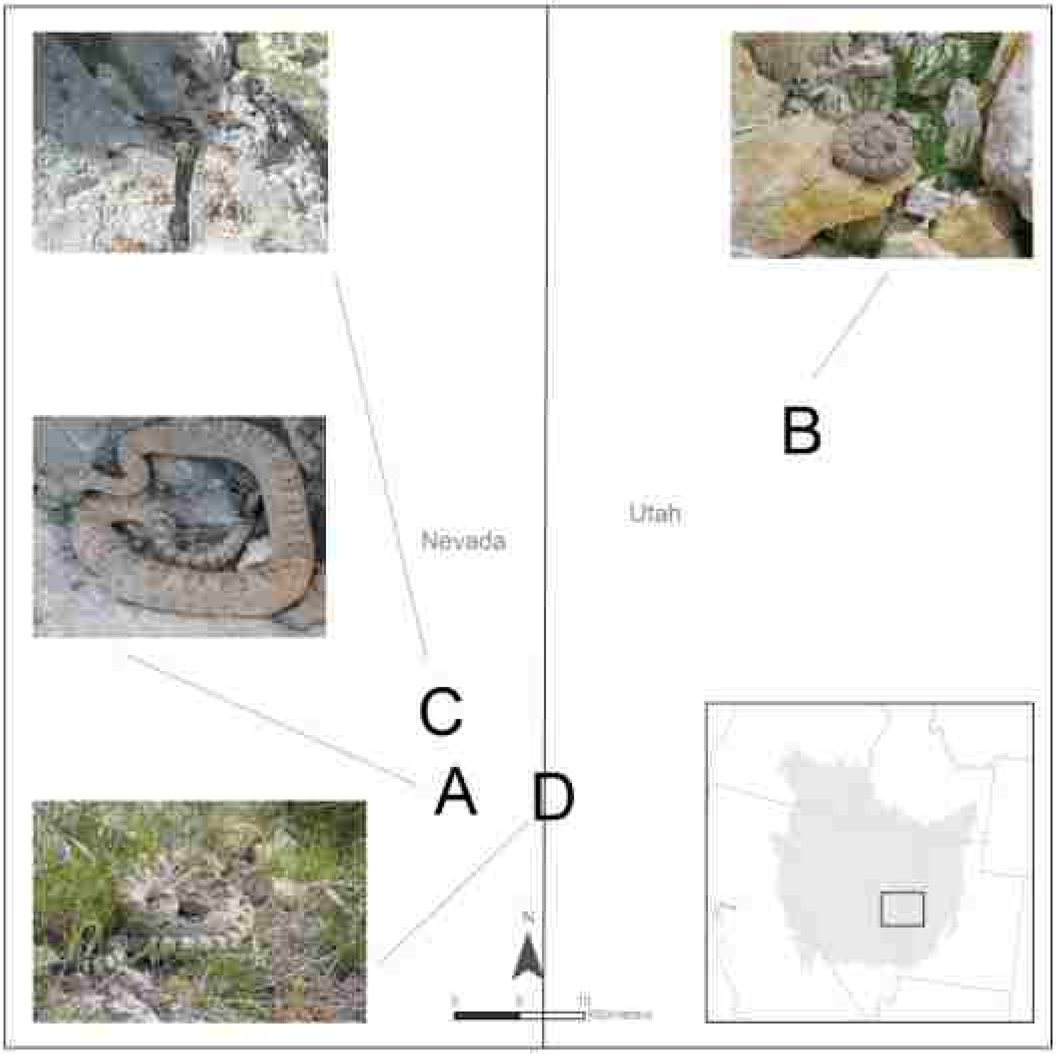

Figure 12. Study site with hibernacula locations designated by letters corresponding to text and Table 10. Photographs show a representative individual for each hibernaculum. Inset map shading shows the Great Basin ecoregion relative to the study site.

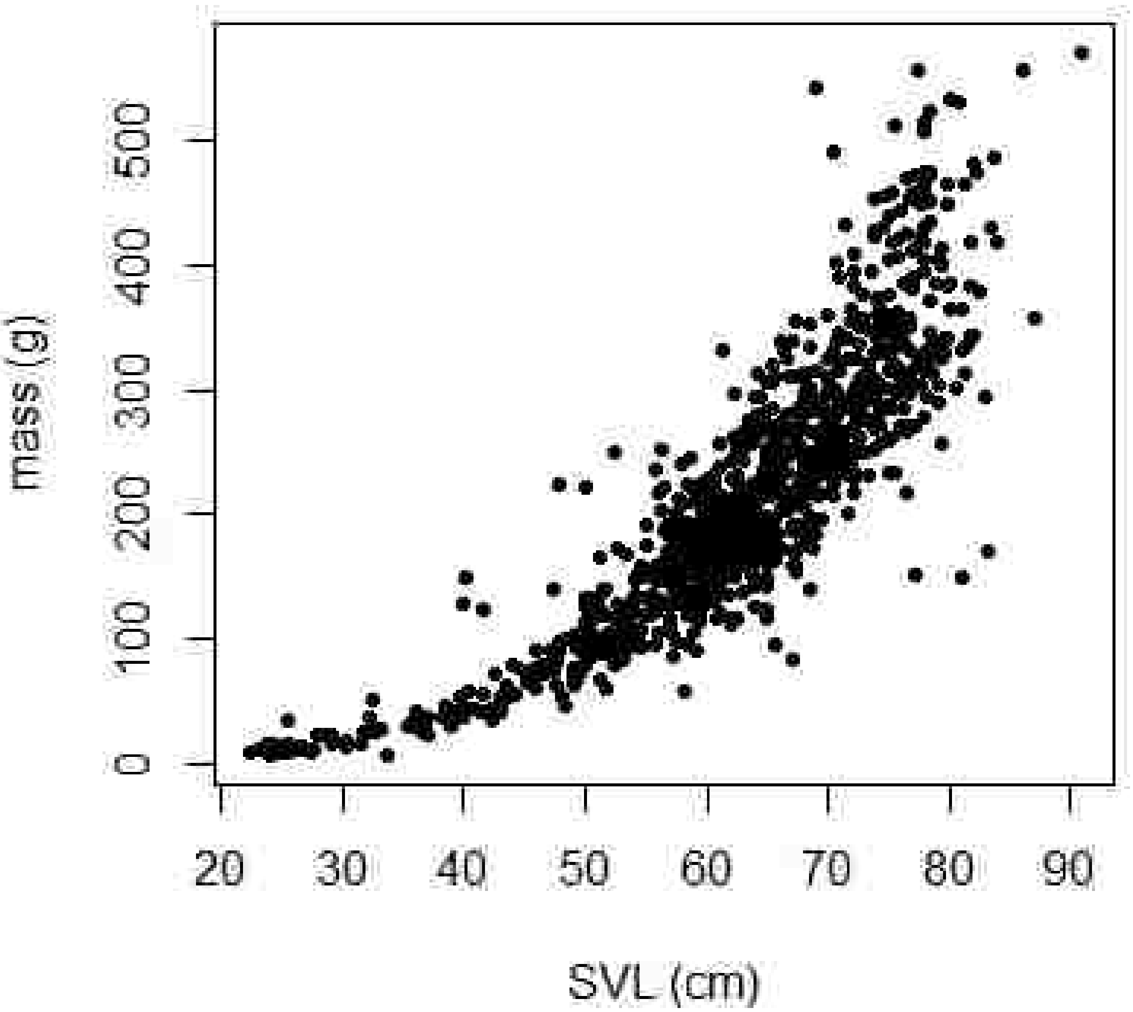

Figure 13. Relationship between mass and SVL for GBR at four communal hibernacula in eastern Nevada and western Utah. Data consisted of 933 measurements of 463 individuals captured between 2001 and 2017.

Figure 14. Three GBR found decapitated and skinned at communal hibernaculum in 2014. Note the presence of ova indicating reproductive female.

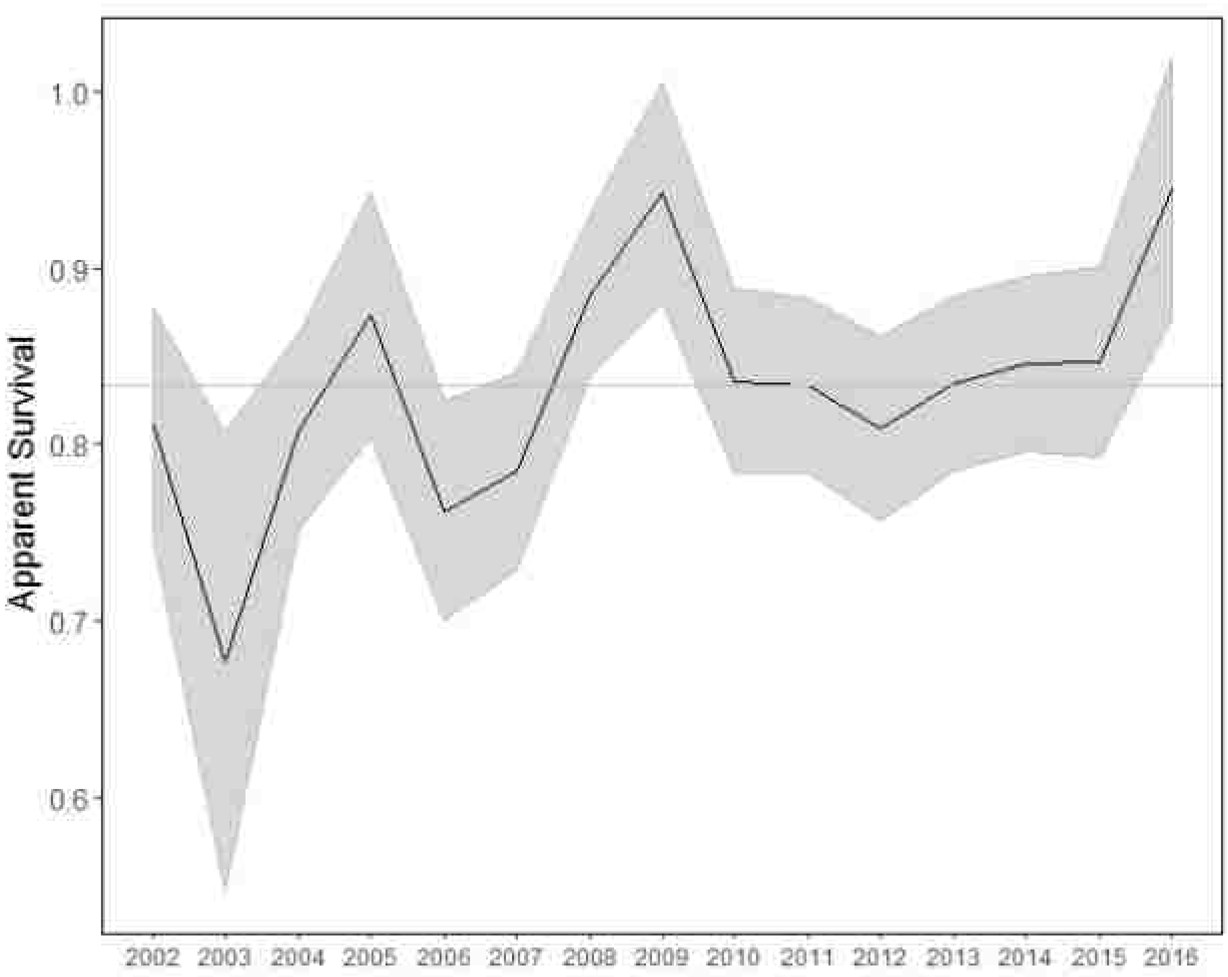

Figure 15. Adult (> 50 cm SVL) annual apparent survival (Φ) estimates of GBR in eastern Nevada and western Utah. Survival estimates and standard errors were calculated using variance components from top ranked CJS model. Solid black line is the annual mean and the shaded gray area the standard error. Gray horizontal line is the mean across all years.

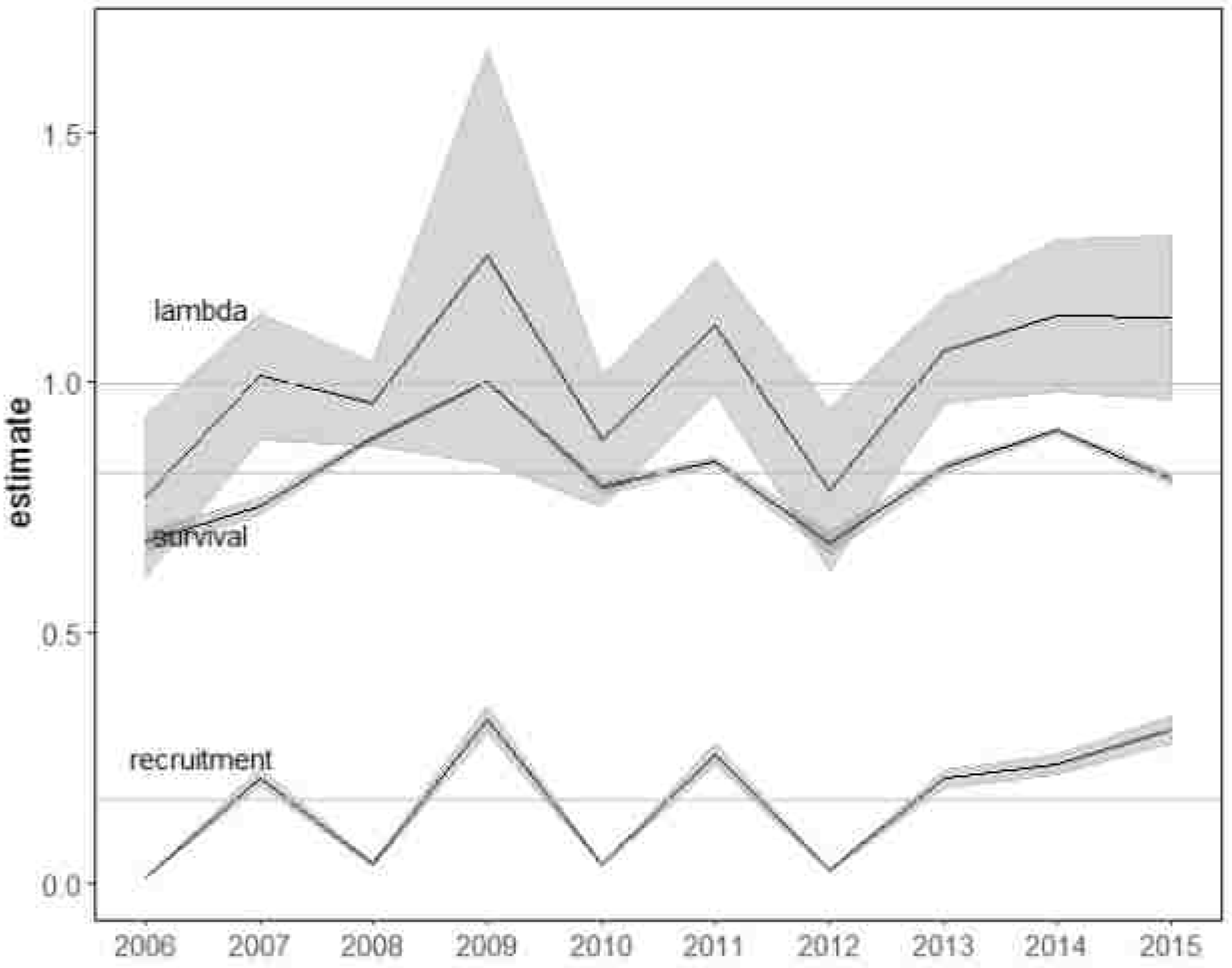

Figure 16. Recruitment (f), apparent survival (Φ), and realized population growth (λ) estimates for adult GBR (> 50 cm SVL) at four communal hibernacula in eastern Nevada and western Utah. Solid black lines are annual means, shaded gray areas standard errors, and horizontal gray lines mean values across years.

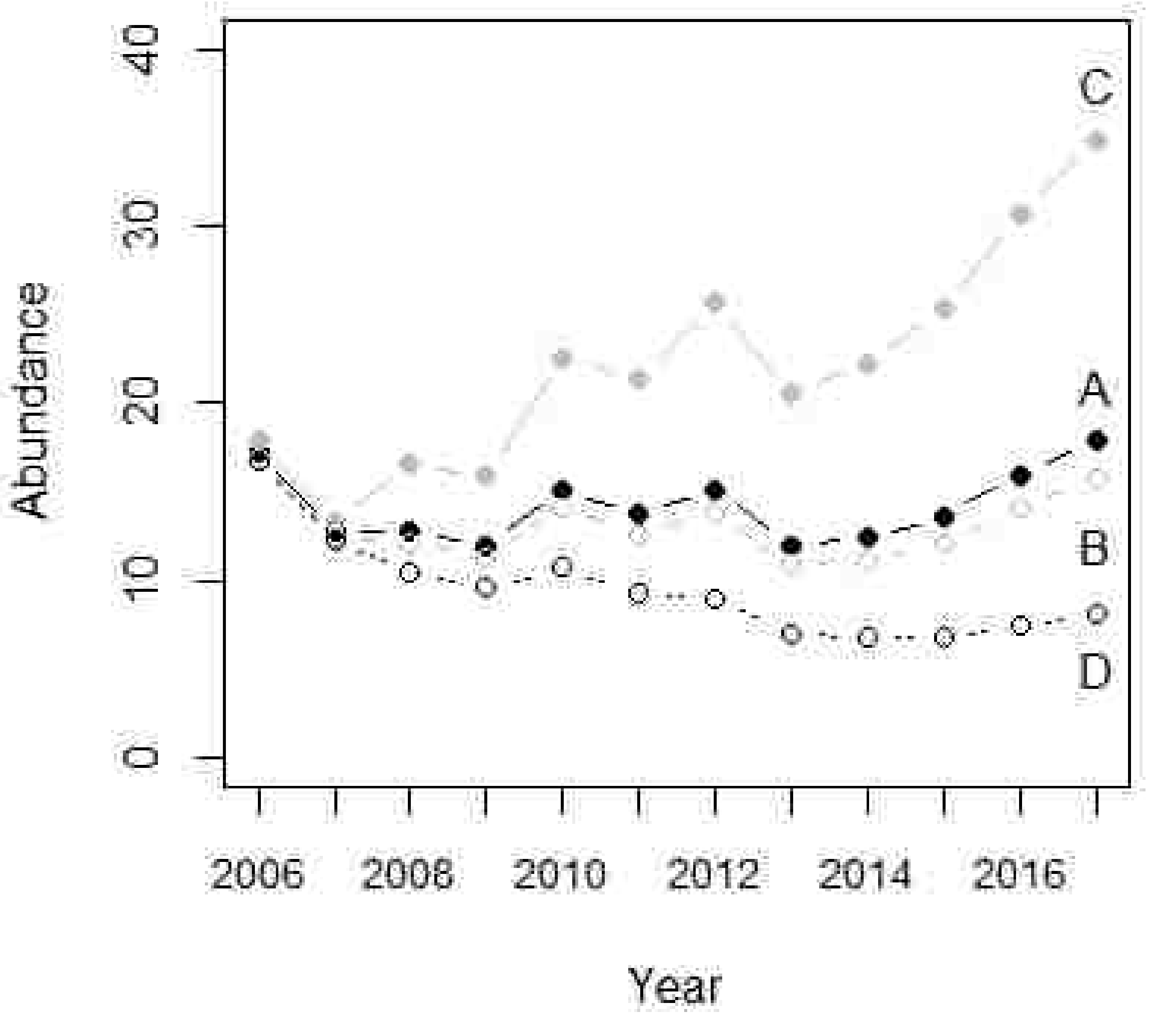

Figure 17. Annual estimates of adult (> 50 cm SVL) female abundance for four communal hibernacula of GBR in eastern Nevada and western Utah.

CHAPTER 4: Does small mammal body water represent local meteoric waters?

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Abstract

Fossilized animal tissues are often used as proxies of ancient climates, with stable isotope ratios of C, H, O, and N used to characterize climate based on variations found in these preserved plant and animal remains. The pathway from climate to fossil is a complex series of events, whereby local meteoric waters, representative of climatic conditions, are incorporated into an animal's body water that was utilized for tissue formation, and these retained isotopic signatures in fossilized tissues provide relevant information from the time of formation. Herein we use a dataset with meteoric, stream, evaporative and small mammal body waters to describe the relationship between small mammal body water, stream water, and local meteoric waters. We show that small mammal body water in an arid region is linearly related to meteoric waters. This suggests that extinct and extant small mammal fossils are appropriate for spatial and temporal climate reconstructions. This information has value for climate reconstruction, habitat use, conservation biology, and water resource management, all of which are of particular concern to the arid region of Western United States where this study was conducted in the Great Basin.

Introduction

Stable isotope ratios of fossilized animal tissues are often used as proxies of ancient climates. The pathway from climate to fossil is a complex series of events, whereby local meteoric waters, representative of climatic conditions, are incorporated into an animal's body water, utilized for tissue formation, that retain isotopic signatures from the time of formation in fossilized tissues. Until recently, fossil-based climate reconstructions generally relied on larger animal fossils (Bryant and Froelich 1995, Grimes et al. 2008), but with the utilization of isotopic techniques, much smaller animal and plant tissues have contributed to the climatic information base.

Large home ranges and long-life spans integrate the variation of meteoric waters over large spatial and temporal scales, reducing the effects of seasonal variation, localized climate effects, and habitat selection. Larger tissues are more resistant to chemical changes during diagenesis and provide adequate mass of fossil material for isotope extraction. The relatively constant body temperatures (37°C) of larger mammals supports continuous physiological reactions and fractionation between tissue formation and substrates (Ciner et al. 2016). Many large mammals are obligate drinkers, directly consuming meteoric waters, which reduces fractionation with different trophic levels (Levin et al. 2006). These factors led to the recommendation for larger animal tissues to be used for climate recreation (Bryant and Froelich 1995). However, in many geological strata larger animal tissues may not be available, and their value may preclude their use in consumptive isotope analyses. This has led to interest in using small mammals (<1kg) for fossil- based climate reconstruction (Grimes et al. 2008).

Small mammals are readily availability in the fossil record, particularly from the Quaternary period (D'Angela and Longinelli 1990) that includes strata lacking large mammal fossils. The ready availability of small mammal fossils may allow for more consumptive use for isotope analysis and climate reconstruction from a wider range of localities. Animal tissues reflect the isotope composition at the time of their synthesis, and the shorter life spans and smaller home ranges of small mammals captures a wider range of climate variability relative to large mammals, increasing temporal and spatial resolution of climate reconstruction. Small mammal communities often have high species richness, high functional diversity, and use of a variety of microhabitats. These community level traits capture a greater range of phylogenic groups, habitats, and physiological diversity, relative to larger taxa.

However, a number of factors related to water utilization complicate climate reconstruction from fossilized small mammal tissue remains. Small mammals include a smaller proportion of drinking water in their overall oxygen intake, and many species do not drink, relying instead on free water in food sources such as seeds. Many arid habitat small mammals are fossorial, remaining in cool burrows during daytime, and being nocturnally active to help diminish evaporative water losses. Strategies for water conservation in such small mammals include extra-long renal loops of Henle to highly concentrate urine by countercurrent exchange, dehydration of feces prior to defecation, condensation of respiratory moisture in nasal passages, and reliance on metabolic water derived from very dry food sources.   In addition, changes in body temperature during hibernation and torpor in small mammals could alter the temperature dependent physiological reactions, varying fractionation factors between substrates and tissues. Small body sizes leave tissues more susceptible to diagenesis, potentially altering the isotopic composition of fossils and washing away climate signals. The high degree of variation in small mammal tissue has been suggested to preclude their use as a useful proxy of climate. Ultimately incorporating a variety of sizes, time intervals, physiologies, and habitats is important to obtain independent lines of evidence for corroboration of climate reconstruction and to provide different scales of spatial and temporal resolution, and seasonal variation.

Herein we use a dataset with meteoric, stream, evaporative and small mammal body waters to describe the relationship between small mammal body water, stream water, and local meteoric waters. We hypothesized that the relationship between small mammal body water in an arid region would be linearly related to meteoric waters, and if true, small mammal fossils would be an appropriate proxy for climate reconstruction.

Materials and Methods

Study Area – The South Snake Range includes Great Basin National Park (GBNP; N – 38.98°, W –114.30°; 31,201 hectares) and is located in east central Nevada in the Central Basin and Range ecoregion (Fig. 18). Elevations vary from 1,621m in the town of Baker, NV, to 3,982m at the summit of Wheeler Peak. The climate is cool and arid and varies dramatically with elevation. In Garrison, UT (elevation - 1609 m) mean annual precipitation is 19 cm and mean annual temperature is 10°C (Western Regional Climate Center, unpubl. data). At the Lehman Caves Visitor Center located in GBNP (elevation – 2832 m) annual precipitation is 33 cm and the mean annual temperature is 9°C (Western Regional Climate Center, unpubl. data). Although there are no long-term weather stations below Wheeler Peak, mean annual precipitation is estimated between 76 and 89 cm (Western Regional Climate Center, unpubl. data). Although most precipitation falls as snow, summer convection generates thunderstorms which may contribute significantly to local precipitation (Acheampong 1992). Ten perennial streams originate at high elevations (Prudic et al. 2015) from snowmelt and become increasingly influenced by groundwater as they descend (Elliot et al. 2006). The mammal community is diverse, consisting of >50 species representing seven orders. Small mammals utilize virtually all available habitats from valley floor salt desert, mesic riparian meadows and streams, coniferous forest, and ascending to barren alpine mountaintops (Rickart et al. 2008). Small mammal tissues are abundant in the local fossil record and many of these fossilized species are extant today (Grayson 1987;2011).

Data collection –Stream samples were collected directly from Lehman, Snake, and Strawberry creeks (n=163; Fig. 18; elevation range = 1627 – 3044m). Precipitation samples representing meteoric waters were collected from four sites (elevation range = 1627 – 3098m). Snow was collected directly from the ground and melted prior to isotope analysis. Rain was collected from building and gutter run-off through screened funnels to minimize debris accumulation, placed in glass jars, with a layer of mineral oil added to prevent evaporation. Most samples of meteoric waters were from single precipitation events (n = 165). Other samples were the aggregate of several precipitation events collected over multiple days (n = 29). Precipitation samples were decanted into amber glass vials with conical lids, sealed with parafilm, and stored in a dark cabinet at room temperature prior to isotopic analysis.

Approximately ten liters of water collected from Lehman Creek was used for an evaporative water experiment sensu (Craig et al. 1963). Water was left in two open containers, and permitted to evaporate at room temperature (20°C). Samples were collected from the unevaporated water at 0, 10, 16, 19, 23, and 46 days from experiment initiation (n = 22). Relative humidity, the primary control of evaporation rate, was not recorded but likely approximated outdoor conditions during the experiment (range = 7% - 53%, mean 30%; https://www.wunderground.com/history/; accessed 2 March 2018).

Small mammals were sampled annually during July and August from 2007 – 2009. This was considered the period of maximum water stress due to high temperatures, low relative humidity, and high aridity. Small mammals were sampled along transects and opportunistically to increase sample sizes. At each trap station, a single Sherman live trap (SFAL; 5 x 6 x 23 cm; LFA – 8 x 9 x 23 cm; or XLF; 15 – 10 x 11 x 38 cm) was set and baited with sunflower and milo seed between 17:00 - 20:00 hrs. Traps were checked between 05:00 - 10:00 hrs. All small mammals used in this study were in the Order Rodentia. Families within Rodentia included: Heteromyidae, Cricetidae, and Sciuridae. The Cricetidae was broken into two sub-families: Arvicolinae and Neotominae.

Small mammals were anesthetized using isoflurane inhalant, restrained by the nape of the neck, thumb pressure applied to the external jugular vein caudal to the mandible, and the upper eyelid elevated to obtain a blood sample from the retro-orbital sinus. A micro-hematocrit capillary tube was inserted into the medial canthus of the eye at a 30° - 45° angle. The tube was rotated into the retro-orbital sinus and approximately 0.1 mL blood collected by capillary action into the tube. After the blood sample was collected, pressure was applied to the orbital region with gauze until clotting was achieved, and a small amount of antibiotic ophthalmic ointment (bacitracin-neomycin-polymixin) was applied to the medial canthus of the eye (Timm 1979, Suckow et al. 2001). Capillary tubes were sealed with critoseal in the field and flame sealed in the laboratory.

Water from blood samples was extracted cryogenically prior to isotopic analysis (Ehleringer et al. 2000). Blood water is generally considered representative of body water in small mammals, and hereafter we refer to blood and body water as equivalent (Longinelli 1984). Small mammal sampling was conducted according to the guidelines of Brigham Young University's Institutional Animal Care and Use Committee, project code # 07-0301, scientific research permits from Great

Basin National Park (GRBA-2007-SCI-0002) and Nevada Department of Wildlife (S35631), and the American Society of Mammalogists Guidelines (Sikes et al. 2011).

Stable isotope results are presented relative to international standards in conventional δ notation as ‰: $\delta_{sample} = R_{sample}\text{-}R_{standard}/R_{standard}$ X 1000, where R is the ratio of the heavy isotope to the light isotope. Data are reported as the ratio of heavy to light isotopes (^{18}O:^{16}O; ^{2}H:^{1}H) normalized to the Vienna Standard Mean Ocean Water (VSMOW)/Standard Light Antarctic Precipitation (SLAP) scale (Coplen 1988, Nelson 2000, Nelson and Dettman 2001). $\delta^{18}O_{VSMOW}$ and δD_{VSMOW} are hereafter referred to as $\delta^{18}O$ and δD.

Stable isotope ratios of water samples (δD, $\delta^{18}O$) were analyzed at Brigham Young University, Department of Geology, Provo, Utah. Samples (n = 188) were initially analyzed with a Finnigan Delta Plus (Bremen, Germany) isotope ratio mass spectrometer interfaced to a Gasbench (Finnigan, Bremen, Germany) with methods similar to Anderson et al. (2006). For this study, the reproducibility of our internal standard was 0.5‰ for δD and 0.2‰ for $\delta^{18}O$.

Analyses of the remaining precipitation and stream samples (n = 141) and all body water samples (n = 334) were completed using a Los Gatos Research Liquid Water Isotope Analyzer (LWIA-24d), which analyzes $\delta^{18}O$ and δD simultaneously, with a precision of 0.2‰ and 0.6‰, respectively. Batch sample set-up used the procedure outlined in Nelson (2000) and Nelson and Dettman (2001). Memory correction was addressed by rejecting the first four injections of each sample. The remaining four injections of each isotope run were drift corrected (procedure used in Nelson and Dettman 2001) using in-house standards. The in-house standards (calibrated by VSMOW and SLAP) have isotopic values within the range of our data, thus reducing the influence of memory. The final isotopic composition of a sample was determined by taking the average of the drift corrected injections (Williams 2013).

To build internal consistency and ensure direct comparability between instruments, samples were run in batches with calibrated lab standards. Data and equipment were checked for precision by running duplicates of samples and standards, and normalized against standards for accuracy using linear regression. Samples that fell off the meteoric waterline suggested large analytical errors and were removed from the dataset prior to statistical analyses ($n = 1$ for precipitation and $n = 4$ for stream samples).

Statistical analyses – Ordinary least squares (OLS) linear regression was used to model δD versus $\delta^{18}O$ for meteoric waters and build a local meteoric water line (LMWL). The LMWL was then compared to the global meteoric water line (GMWL; Craig 1961). Model selection using Akaike Information Criteria corrected (AIC_c) for small sample size was used to compare models of single versus separate slopes and intercepts for precipitation type (rain and snow), a proxy for seasonal differences in winter versus summer precipitation patterns. Similarly, OLS regression was used to calculate line of best fit for the evaporated water δD versus $\delta^{18}O$. This evaporation line served as a model of un-encumbered evaporation (Craig et al. 1963), representative of the theoretical maximum for evaporation.

δD and $\delta^{18}O$ of small mammal body water was modeled with OLS regression. Slopes and intercepts were compared to the LMWL and evaporative water line. To examine taxonomic differences in body waters, we used AIC_c to select between models with species or phylogenic group as covariates. To increase samples sizes, voles (*Microtus montanus* and *M. longicaudatus)* were grouped into "*Microtus sp.*" and chipmunks (*Tamias dorsalis*, *T. minimus*, and *T.*

umbrinus) into "*Tamias sp*." for species level analyses. Phylogenetic groups included: Heteromyidae, Sciuridae, and Cricetidae, with Cricetidae broken into two sub-families of Arvicolinae and Neotominae. All statistical analyses were conducted in Program R (R Core Team 2015). Confidence intervals were used to assess statistical significance and parameter effect sizes, with α set at 0.05. Values presented are means ± standard errors.

Results

The LMWL differed from the GMWL in slope and intercept (Fig. 19). Model comparison indicated that separate slopes and intercepts for snow and rain better explained meteoric waters than a single slope and intercept (Table 14; Fig. 20). Spatial and temporal differences in stream water δD were highly significant ($P < 0.001$), but effect sizes were small (1 - 3‰). There were no temporal or spatial differences in stream water $\delta^{18}O$ ($P > 0.12$). Relative to meteoric waters, stream samples grouped tightly and showed minimal variation ($\overline{x}_{\delta D} = 110.8 \pm 2.0$; $\overline{x}_{\delta 18O} = 15.1 \pm 0.5$; n= 163; Fig. 19). The evaporative water line was described by the linear model $\delta D = 4.0(\pm 0.02) * \delta^{18}O - 53.2(\pm 0.30)$ ($r^2 = 0.99$; Fig. 19).

The overall regression line for small mammal body water fell between the local meteoric and the evaporation lines ($\delta D = 4.6\ (\pm 0.21) * \delta^{18}O - 40.1(\pm 0.58)$, $r^2 = 0.58$; Fig. 21). This envelope captured 90% (301 of 334) of body water samples (Fig. 21). Heteromyids tended to fall below the evaporative line (Fig. 22 & 23). The mean and standard error for chisel-toothed kangaroo rat body water fell below the evaporative water line (Fig. 23). Small mammal species differed significantly in their isotopic composition (Table 15; Fig.23). Model selection supported the additive model for species, with significantly different intercepts but a common slope (Table 16).

Extending the linear regression equation for small mammal body water towards the meteoric waterline, showed that the regression line and 95% CI intersected stream waters, the mean weighted estimate of local meteoric waters. All species ultimately intersected the mean value of the streams, suggesting that small mammals, as well as streams integrated precipitation variability.

Discussion

While stable carbon and nitrogen isotopes from small mammal fossils are often used to recreate ancient environmental conditions (Terry et al. 2017, Terry 2018), the use of stable hydrogen and oxygen isotopes in climate reconstruction has generally been limited to larger mammals. This limited use has been based on a variety of reasons, but one of the most prominent is that small mammal tissues are not representative of local meteoric waters (Jeffrey et al. 2015, Smiley et al. 2016). Given homogenous fractionation factors (D'Angela and Longinelli 1990), tissues are a linear and direct reflection of body water. Therefore, if it can be shown that body waters linearly reflect meteoric waters, it follows that fossil-based climate reconstructions using isotopic signatures from small mammals is appropriate.

Deviations between local and global meteoric water lines are useful to explain patterns of local temperature, precipitation, and aridity. The shallower slope of our LMWL is due largely to the influence of warm season precipitation and re-evaporation of falling water droplets from convective storms falling in an arid atmosphere with the subsequent enrichment of those water droplets. The deuterium excess factor for local meteoric waters is significantly lower than the global deuterium excess factor. This is likely a result of differing source conditions for the vapor in combination with rain-out effects due to continentality, elevation and distance to coast (Dansgaard effects) (Dansgaard 1964).

Model fit for meteoric waters was substantially better with separate slopes and intercepts for snow and rain. Seasonal variation in isotope composition of meteoric waters is common in the southwest (Sharp 2007), and isotopic differences between snow and rain are consistent with two distinct sources of precipitation. The Pacific Ocean is the dominant source for snow and winter precipitation in the Western United States, while summer rain is derived from the Gulf of Mexico and Gulf of California (rain-monsoonal, convective precipitation) (Houghton et al. 1975). Winter precipitation, dominated by snow, was depleted in oxygen and deuterium relative to rain which fell in the summer. Deuterium excess factors also differed between snow and rain, indicating differences in the sources of the vapor.

Local surface waters often are direct reflections of the mass balance of precipitation and they integrate precipitation patterns (Dutton et al. 2005). The compact grouping of stream samples collected over several years from multiple streams, demonstrated the utility of local stream water as integrators of the highly variable precipitation regime. Local precipitation is dominated by snowfall, cold precipitation from the Pacific Ocean, in terms of volume. In contrast, warm season precipitation, derived from the Gulf of Mexico, contributes very little to stream flows as most warm season precipitation is lost to the atmosphere via evapotranspiration. The slope of the LMWL shows this water deficit and is indicative of evaporation of falling rain.

Our data definitively show that small mammals are not drinking stream water, even during periods of environmentally high water stress and high aridity. This includes species such as voles, with high water requirements living right beside streams (Hamilton et al. 2015). The half-life for small mammal body water is ~1.5 days (Longinelli 1984, D'Angela and Longinelli 1990, Podlesak et al. 2008). If small mammals had drunk from streams within a few days, body water would have tracked stream water much more closely. Apparently, all small mammals in our system meet their water needs through food consumption.

Small mammal species differed significantly the isotopic composition of their body water. Canyon mice and piñon mice live in extremely arid habitats (Hoffmeister 1981, Johnson and Armstrong 1987) but lack the water conservation measures utilized by heteromyids (MacMillen and Garland 1989). In contrast, voles (*Microtus sp*) have high water demands and live right next to or very near streams. Although there is no evidence that voles were directly drinking stream water, the water they got from their food is less enriched in water isotopes than other species. This is likely a result of their feeding on vegetation in riparian areas (Hamilton et al. 2015) where groundwater is available. This leads to lower isotope values and less enrichment of the leaf water.

Heteromyids, famed for their water conservation strategies (French 1993), were lowest in slope and most depleted in isotopes. *D. microps* was the only species to fall below the evaporation line, the theoretical minimum for body water. This was likely a function of its capture location, as all *D. microps* were captured at our lowest elevation site. Therefore, the stream waters may not be representative of the local meteoric waters of their capture location.

The low slope of small mammal body water suggests consumption of highly evaporated water sources. Species with higher slopes for their body water may indicate consumption of less evaporated water sources, i.e. free water in food (insects or plants), or directly drinking. The slope of leaf derived seed moisture approximates the evaporative water line.

The overall regression line for small mammal body water fell between the local meteoric and the evaporation lines. These lines represent the theoretical minimum (evaporation) and maximum (LMWL) for small mammal body water. Extending the linear regression equation for small mammal body water towards the meteoric waterline, showed that the regression line, and 95% CI intersected stream waters, the mean weighted estimate of local meteoric waters. This suggests that regression of small mammal body water found in tissues and fossils would capture local meteoric waters in small mammal communities. The distance from the line is also a useful proxy of aridity, at least in the cricetids (Levin et al. 2006). Although this relationship needs to be tested in other systems, we suggest that this regression line will be a robust way to determine local meteoric water composition using fossilized rodent tissues. The results of this study provides additional tools for climate reconstruction and evaluation of habitat use, as well as conservation biology and water resource management, all of which are of particular concern to arid regions in the West such as the Great Basin.

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Table 14. Model selection results of δD versus δ18 for local meteoric waters. Precipitation type was rain or snow. Precipitation type was rain or snow.

δD	parameters (n)	AIC_c	ΔAICc	weight
δ18O *precipitation type	5	1208.09	0.00	1.00
δ18O: precipitation type	4	1225.32	17.23	0.00
δ18O	3	1227.50	19.42	0.00
δ18O + precipitation type	4	1229.59	21.50	0.00
null	2	1786.64	578.56	0.00

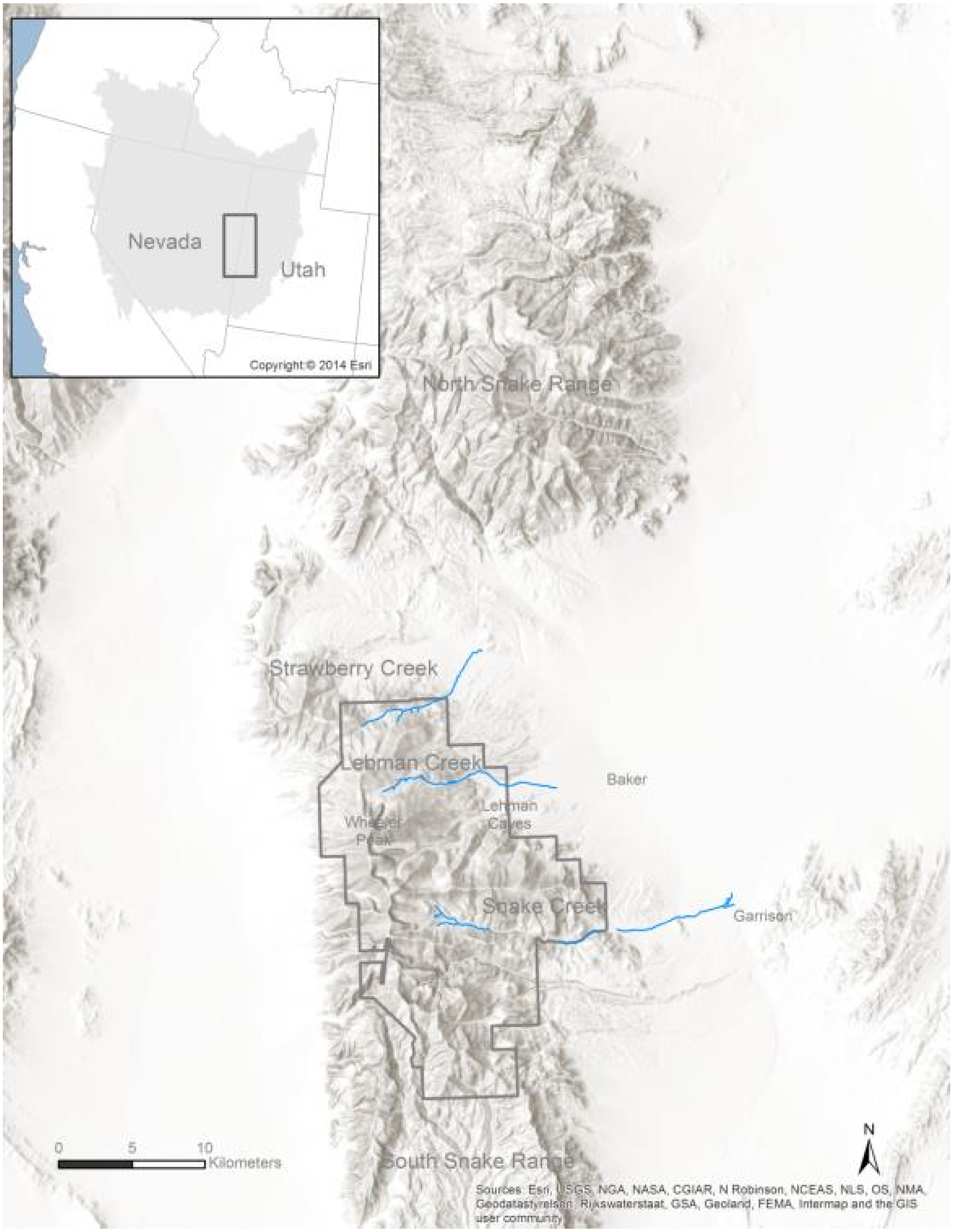
Table 15. Means, standard errors, and sample sizes for small mammal body water by species.

Family	Phylogenetic group	Scientific Name	Common Name	δD	$\delta^{18}O$	n
Cricetidae	Arvicolinae	*Microtus longicaudatus*	Long-tailed Vole	-38.68 ± 11.44	-1.67 ± 4.18	4
		Microtus montanus	Montane Vole	-55.8 ± 6.1	-2.97 ± 1.11	4
Heteromyidae	Heteromyidae	*Dipodomys microps*	Chisel-toothed kangaroo rat	-55.92 ± 11.68	1.04 ± 2.61	7
		Perognathus mollipilosus	Great Basin pocket mouse	-51.26 ± 12.92	-0.43 ± 2.76	27
Cricetidae	Neotominae	*Peromyscus crinitus*	Canyon mouse	-23.24 ± 8.07	1.99 ± 1.68	8
		Peromyscus maniculatus	Deer mouse	-40.91 ± 14.12	-0.26 ± 2.29	156
		Peromyscus truei	Piñon mouse	-24.76 ± 14.31	2.22 ± 2.77	50
		Reithrodontomys megalotis	Western Harvest Mouse	-41.51 ± 16.01	-0.55 ± 2.14	51
Sciuridae	Sciuridae	*Tamias dorsalis*	Cliff Chipmunk	-37.94 ± 16.69	0.62 ± 3.59	13
		Tamias minimus	Least chipmunk	-38.9 ± 13.34	1.71 ± 3.04	8
		Tamias umbrinus	Uinta chipmunk	-45.21 ± 16.85	-0.2 ± 3.68	6

Table 16. Model selection table for small mammal body waters (δD versus δ18O).

δD	parameters (n)	AIC_c	ΔAICc	weight
δ 18O+species	10	2458.12	0.00	0.92
δ 18O*species	17	2463.411	5.29	0.07
δ 18O*family group	9	2466.418	8.30	0.01
δ 18O:species	10	2517.946	59.83	0.00
δ 18O	3	2522.153	64.03	0.00
null	2	2807.016	348.90	0.00

Figures



Sources: Esri, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

Figure 18. Study site of the Snake Range showing sampled streams and geographic points of interest. Shading in the inset map shows the central Basin and Range ecoregion.

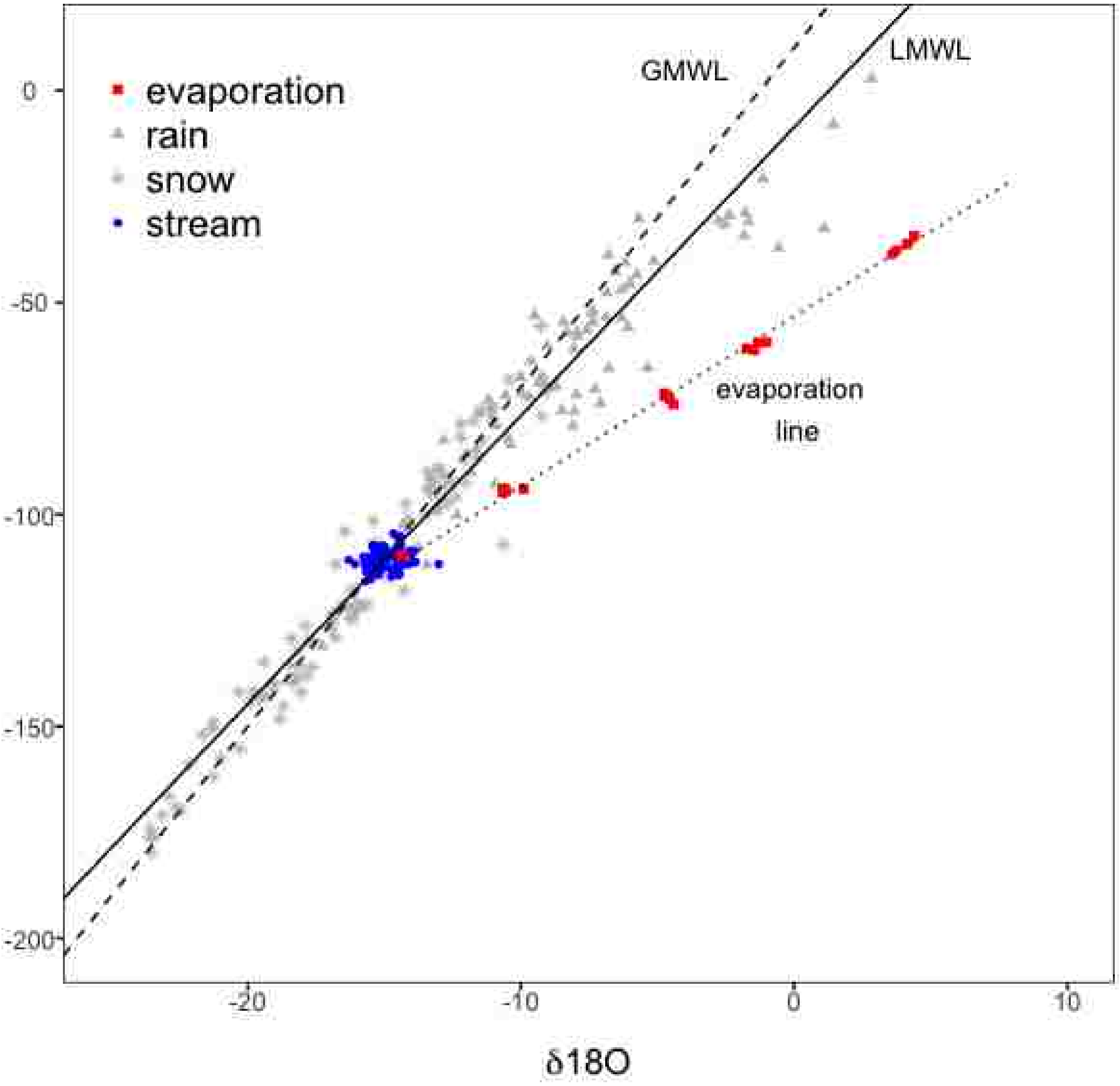


Figure 19. δD and δ18O values for mkMeteoric waters (rain and snow), stream, and evaporative waters of the Snake Range. The LMWL (δD=6.8 (± 0.11)*δ^{18}O-8.7(±1.5); $r^2 = 0.96$) differed significantly from the GMWL (δD=8*δ^{18}O+10) in slope and intercept.

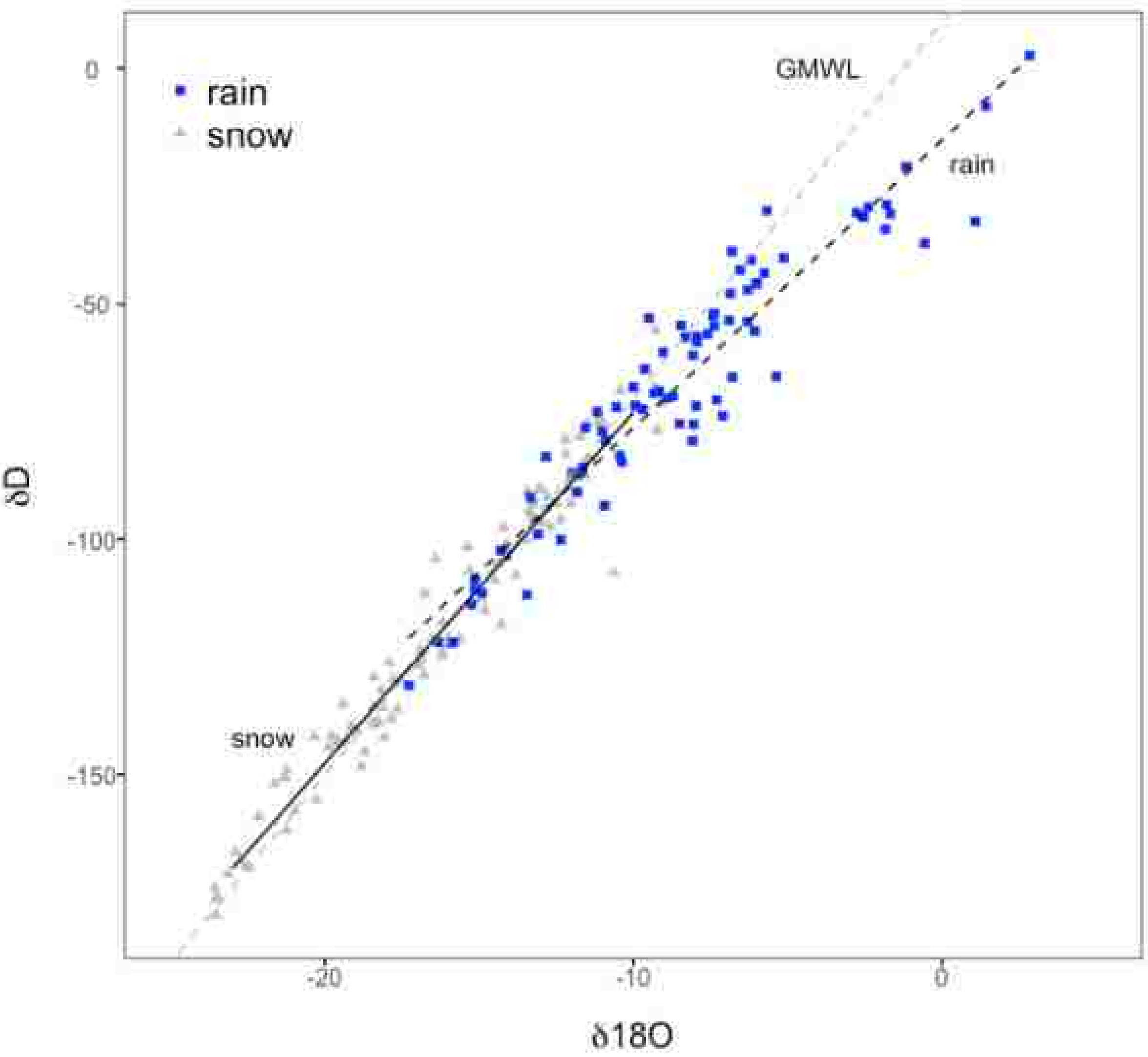


Figure 20. Stable isotope δD and δ18O composition of meteoric waters of the Snake Range. Rain (δD=6.1(±0.24)*δ^{18}O - 6.1(±2.3); $r^2 = 0.96$) and snow δD=7.5 (±0.17)*δ^{18}O+2.3(±2.8); $r^2 = 0.96$) differed significantly from the GMWL (δD=8*δ^{18}O+10) in slopes and intercepts.

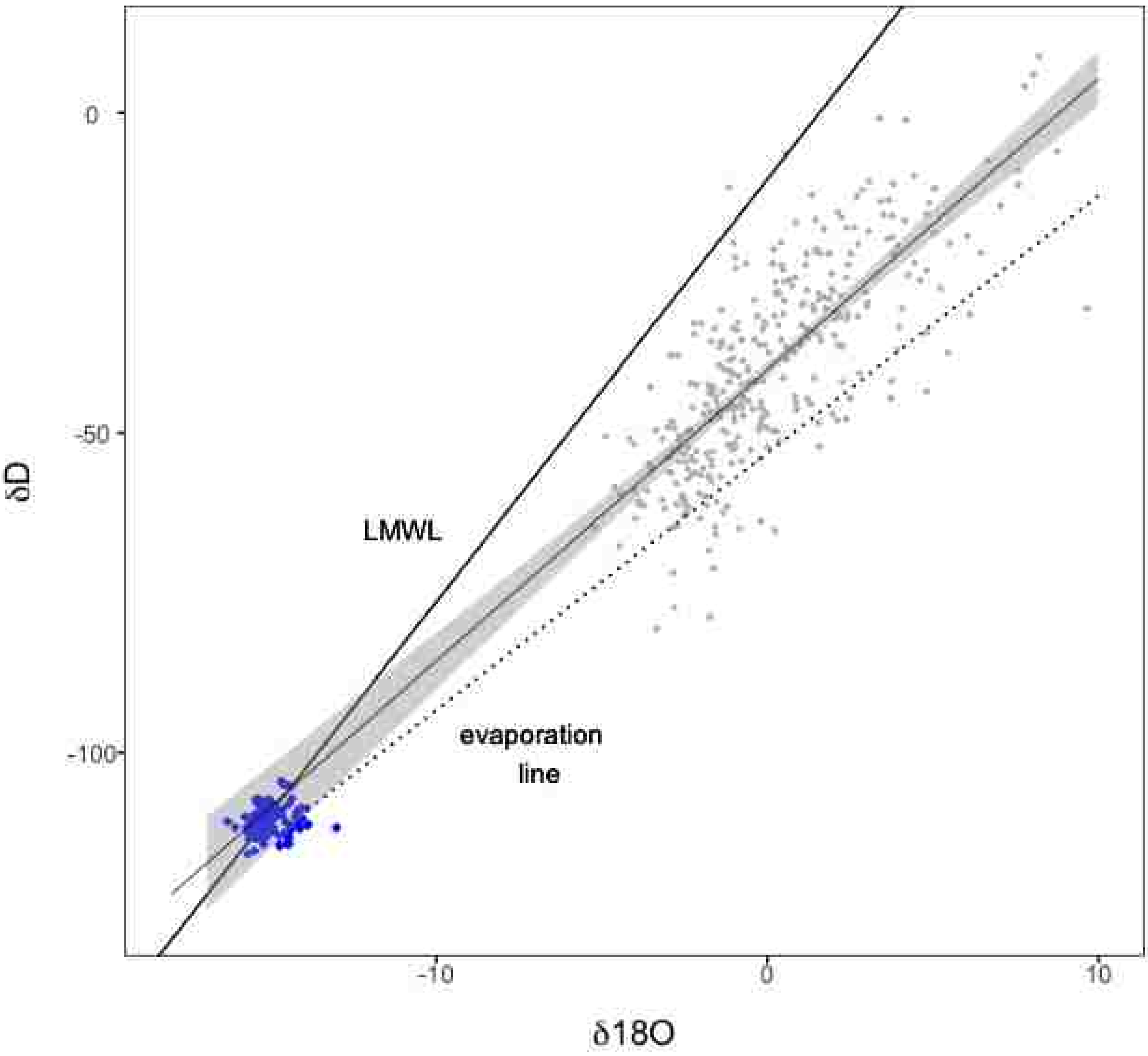


Figure 21. Small mammal body water (gray points), regression line (δD = 4.6 (±0.21)* δ18O - 40.1(±0.58), r2 = 0.58), and 95% confidence interval relative to local meteoric water line (LMWL) and evaporation line for δD and δ18O values. Note that the intersection of the small mammal confidence interval (gray shading) with stream water (blue points).

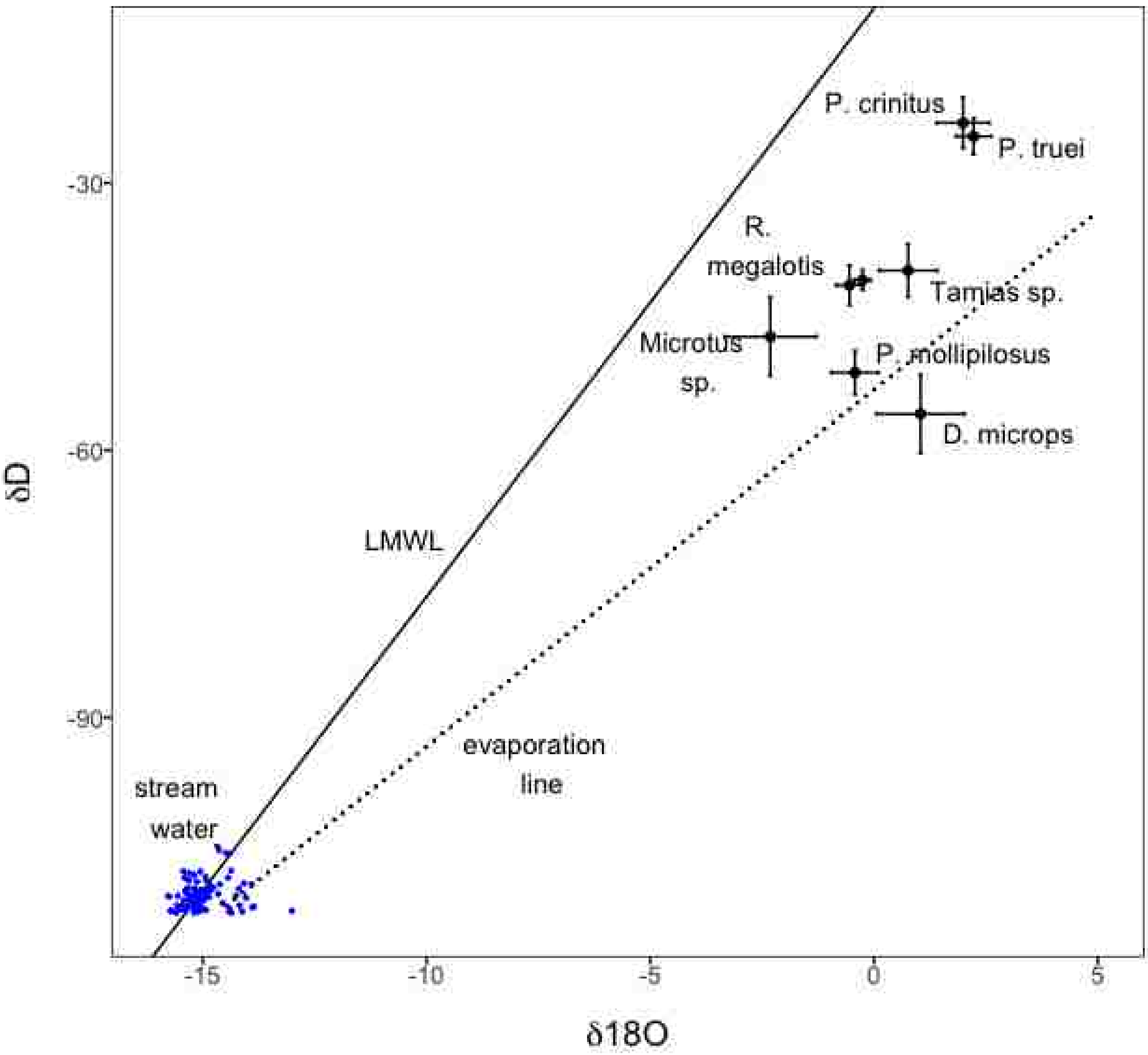


Figure 22. δD and δ18O values for small mammal body water (means and standard error), stream water, local meteoric water line (LMWL) and evaporation line.

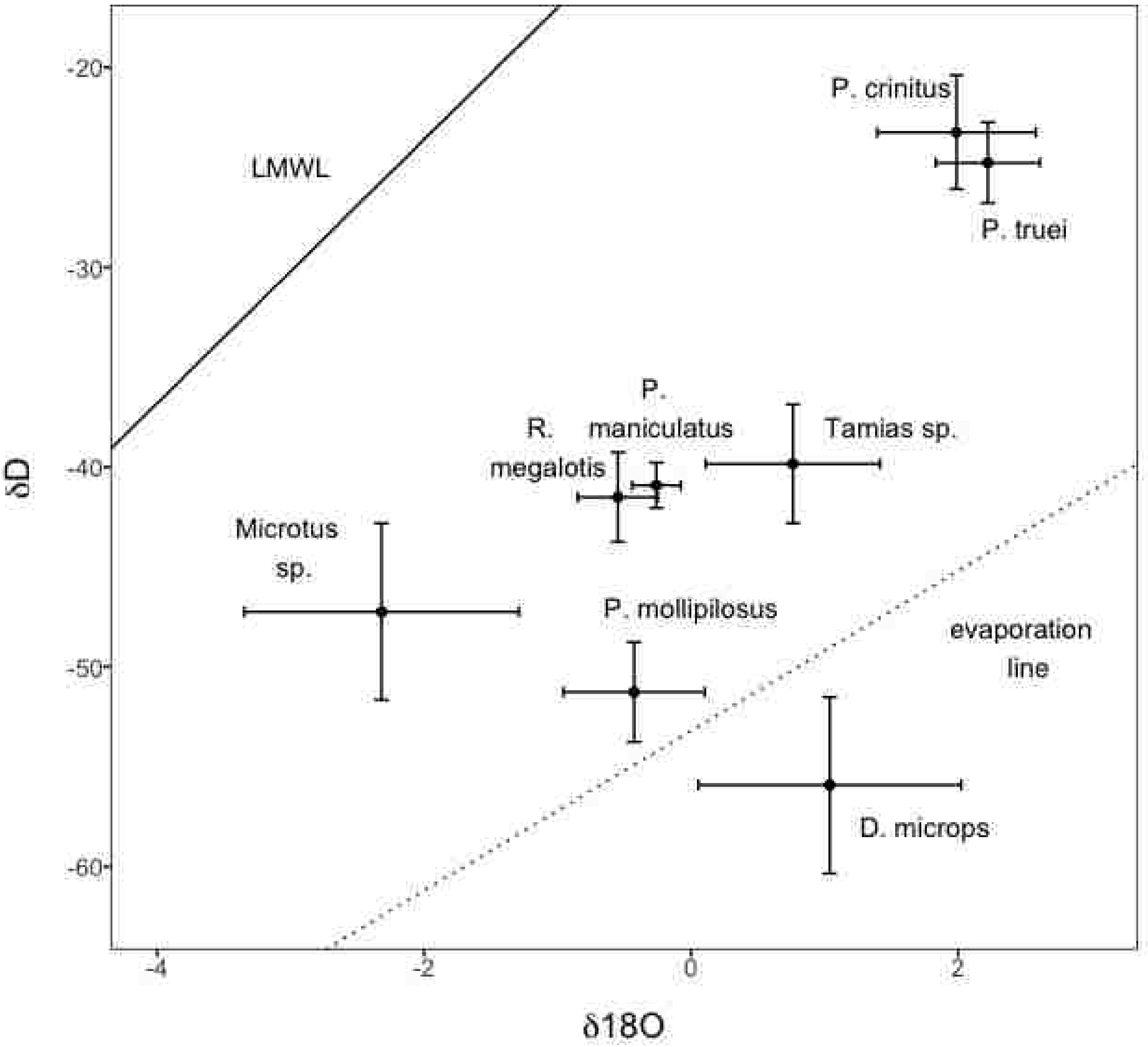


Figure 23. Means and standard errors of small mammal body water δD and δ18O values constrained by local meteoric water line (LMWL) and the evaporation line.

APPENDICES

Appendix 3. Stable isotope values (δ13C and δ15N) for small mammal hair samples in the South Snake Range. Isotopes were analyzed with Brigham Young University's Elemental Analyzer (EA) interfaced to a Delta V Advantage Isotope Ratio Mass Spectrometer (IRMS). Isotope results are presented relative to international standards in conventional delta (δ) notation as per mil (‰): $\delta_{sample} = R_{sample}-R_{standard}/R_{standard}$ X 1000, where R is the ratio of the heavy isotope to the light isotope. Data are reported relative to Vienna Peedee belemnite marine limestone (VPDB) and were normalized against standards for accuracy using linear regression and checked for precision against duplicate samples. Concentration data was unavailable as the instrument was not calibrated for quantitative analysis. When duplicate samples were analyzed, the mean value was reported. Mean reproducibility for duplicate samples was 0.31‰ ± 0.29 (n=51) for δ^{13}C and 0.69‰ ± 0.61 (n=53) for δ^{15}N. Analytical precision was 0.04‰, determined by measurement of internal standards over several years.

Hair samples, approximately 3 cm^2 in area, were collected dorsally with scissors, immediately anterior to the base of the tail. Hair was sonicated in deionized water for 30 minutes, lipid extracted with petroleum ether for 30 minutes, and subsamples of approximately 0.75 mg measured with a microbalance in tin cups. Samples were analyzed for δ^{13}C as described above. Hair was analyzed since it is metabolically inert, preserving the isotopic information of the consumer at the time it was synthesized.

CommonName	ScientificName	TrapDate	δ^{15}N	. δ^{13}C	Latitude	Longitude
Canyon mouse	Peromyscus crinitus	8/12/2008	5.589429	-19.01218	38.918633	-114.151246
Canyon mouse	Peromyscus crinitus	8/4/2009	5.628068	-19.84752	38.918409	-114.150574
Canyon mouse	Peromyscus crinitus	8/7/2009	5.404638	-20.77095	38.918894	-114.151519
Canyon mouse	Peromyscus crinitus	8/11/2009	5.77965	-20.85419	38.91858	-114.151099
Canyon mouse	Peromyscus crinitus	8/12/2009	6.226756	-20.2406	38.917716	-114.18692
Canyon mouse	Peromyscus crinitus	8/14/2009	4.98237	-21.65989	38.917638	-114.187038
Canyon mouse	Peromyscus crinitus	8/14/2009	5.722623	-21.29444	38.918894	-114.151519
Canyon mouse	Peromyscus crinitus	8/14/2009	5.730021	-20.63313	38.918633	-114.151246
Canyon mouse	Peromyscus crinitus	8/14/2009	8.514155	-19.02117	38.917589	-114.177426
Canyon mouse	Peromyscus crinitus	8/17/2009	7.414429	-21.83987	38.917585	-114.186958
Canyon mouse	Peromyscus crinitus	8/18/2009	6.316402	-19.69272	38.91692	-114.184205
Canyon mouse	Peromyscus crinitus	8/18/2009	6.665567	-20.87383	38.917946	-114.186769
Canyon mouse	Peromyscus crinitus	8/18/2009	7.03085	-20.37974	38.917015	-114.184254

Canyon mouse	Peromyscus crinitus	8/19/2009	8.391215	-20.27637	38.917222	-114.186643
Chisel toothed kangaroo rat	Dipodomys microps	7/10/2008	10.76738	-22.60728	39.016637	-114.125125
Chisel toothed kangaroo rat	Dipodomys microps	7/29/2008	9.869862	-23.24658	39.017517	-114.126044
Chisel toothed kangaroo rat	Dipodomys microps	7/29/2008	10.23706	-18.89168	38.91682	-114.147184
Chisel toothed kangaroo rat	Dipodomys microps	7/29/2008	10.72812	-22.73392	39.017295	-114.127343
Chisel toothed kangaroo rat	Dipodomys microps	7/29/2008	11.31353	-18.17602	39.016411	-114.127679
Chisel toothed kangaroo rat	Dipodomys microps	7/29/2008	11.54827	-21.11793	39.016173	-114.127681
Chisel toothed kangaroo rat	Dipodomys microps	7/29/2008	13.37432	-15.51457	39.015122	-114.127211
Chisel toothed kangaroo rat	Dipodomys microps	7/31/2008	9.143003	-21.56022	39.019136	-114.125212
Chisel toothed kangaroo rat	Dipodomys microps	8/1/2008	8.433622	-22.70871	39.019239	-114.12663
Chisel toothed kangaroo rat	Dipodomys microps	8/1/2008	10.61966	-21.5416	39.015458	-114.127424
Chisel toothed kangaroo rat	Dipodomys microps	8/9/2008	9.307497	-20.57362	39.019986	-114.126851
Chisel toothed kangaroo rat	Dipodomys microps	8/10/2008	8.846754	-22.35811	39.017989	-114.126279
Cliff chipmunk	Tamias dorsalis	7/24/2007	4.131142	-20.07121	38.916763	-114.147092
Cliff chipmunk	Tamias dorsalis	7/25/2007	7.335638	-19.14367	38.911589	-114.170243
Cliff chipmunk	Tamias dorsalis	7/26/2007	2.497477	-20.4862	38.913712	-114.151231
Cliff chipmunk	Tamias dorsalis	7/26/2007	2.835491	-19.9892	38.918205	-114.15047
Cliff chipmunk	Tamias dorsalis	7/26/2007	5.012509	-19.62026	38.908953	-114.17217

Cliff chipmunk	Tamias dorsalis	7/26/2007	5.75312	-19.98402	38.91108	-114.170645
Cliff chipmunk	Tamias dorsalis	7/27/2007	3.351979	-19.83431	38.918434	-114.150888
Cliff chipmunk	Tamias dorsalis	7/27/2007	5.681742	-20.49437	38.916763	-114.147092
Cliff chipmunk	Tamias dorsalis	7/27/2007	6.497558	-20.11036	38.909117	-114.171956
Cliff chipmunk	Tamias dorsalis	7/27/2007	7.860433	-21.9768	38.91108	-114.170645
Cliff chipmunk	Tamias dorsalis	8/2/2007	6.831959	-21.16147	39.007732	-114.210774
Cliff chipmunk	Tamias dorsalis	8/2/2007	7.121418	-19.43801	39.013651	-114.208086
Cliff chipmunk	Tamias dorsalis	8/3/2007	7.567846	-20.69775	39.008047	-114.210841
Cliff chipmunk	Tamias dorsalis	8/6/2007	4.797777	-19.02101	38.910011	-114.171197
Cliff chipmunk	Tamias dorsalis	8/7/2007	3.642112	-20.09272	38.90839	-114.172815
Cliff chipmunk	Tamias dorsalis	8/8/2007	3.190272	-19.90687	38.918434	-114.150888
Cliff chipmunk	Tamias dorsalis	8/8/2007	6.788893	-20.11129	38.90839	-114.172815
Cliff chipmunk	Tamias dorsalis	8/14/2007	7.817019	-20.50766	39.013131	-114.207947
Cliff chipmunk	Tamias dorsalis	8/20/2007	7.010795	-21.10893	38.910465	-114.15439
Cliff chipmunk	Tamias dorsalis	9/15/2007	6.302531	-21.39873	38.912347	-114.152069
Cliff chipmunk	Tamias dorsalis	9/27/2007	9.223185	-20.40932	39.053964	-114.305938
Cliff chipmunk	Tamias dorsalis	7/17/2008	7.818263	-21.53396	39.014864	-114.233124
Cliff chipmunk	Tamias dorsalis	7/22/2008	7.119725	-21.19447	39.011434	-114.218454
Cliff chipmunk	Tamias dorsalis	7/30/2008	4.547975	-19.85295	38.915288	-114.156144
Cliff chipmunk	Tamias dorsalis	8/13/2008	4.994979	-20.0222	38.917485	-114.148914
Cliff chipmunk	Tamias dorsalis	8/13/2009	7.463215	-20.08438	38.914995	-114.153839
Cliff chipmunk	Tamias dorsalis	8/13/2009	8.824683	-19.56995	38.917224	-114.148384
Cliff chipmunk	Tamias dorsalis	8/14/2009	2.601758	-20.08033	38.91521	-114.155707
Deer Mouse	Peromyscus maniculatus	7/3/2007	5.431065	-19.79698	39.054578	-114.310925
Deer Mouse	Peromyscus	7/3/2007	5.541576	-21.63192	39.055874	-114.312602

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/6/2007	5.688433	-23.45827	39.053313	-114.318017
Deer Mouse	Peromyscus maniculatus	7/23/2007	3.11329	-19.37627	39.054275	-114.311532
Deer Mouse	Peromyscus maniculatus	7/23/2007	3.310184	-19.14516	38.911153	-114.15485
Deer Mouse	Peromyscus maniculatus	7/23/2007	4.218329	-18.78347	39.053303	-114.321806
Deer Mouse	Peromyscus maniculatus	7/23/2007	5.09411	-19.43256	39.051895	-114.321567
Deer Mouse	Peromyscus maniculatus	7/23/2007	5.827343	-21.90464	39.058725	-114.304957
Deer Mouse	Peromyscus maniculatus	7/23/2007	5.919246	-19.72411	39.051904	-114.317128
Deer Mouse	Peromyscus maniculatus	7/23/2007	5.959238	-21.15924	39.053893	-114.311306
Deer Mouse	Peromyscus maniculatus	7/23/2007	6.289233	-20.58086	39.052912	-114.317973
Deer Mouse	Peromyscus maniculatus	7/23/2007	6.655453	-21.68773	39.054515	-114.305846
Deer Mouse	Peromyscus maniculatus	7/23/2007	7.25463	-22.08261	39.052779	-114.31107
Deer Mouse	Peromyscus maniculatus	7/23/2007	7.788719	-23.21497	39.054464	-114.305891
Deer Mouse	Peromyscus maniculatus	7/23/2007	8.231389		39.056731	-114.305552
Deer Mouse	Peromyscus maniculatus	7/23/2007	9.849708	-22.78562	39.048777	-114.320435
Deer Mouse	Peromyscus maniculatus	7/24/2007	2.210964	-19.32342	39.053091	-114.311085
Deer Mouse	Peromyscus	7/24/2007	2.301823	-19.48723	39.054665	-114.311692

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/24/2007	2.315779	-19.36611	39.049331	-114.320617
Deer Mouse	Peromyscus maniculatus	7/24/2007	5.039329	-20.21177	39.054178	-114.30586
Deer Mouse	Peromyscus maniculatus	7/24/2007	5.041098	-20.40557	39.055321	-114.311887
Deer Mouse	Peromyscus maniculatus	7/24/2007	6.066541	-22.46427	39.054178	-114.311491
Deer Mouse	Peromyscus maniculatus	7/24/2007	6.149096	-22.88754	39.053195	-114.318275
Deer Mouse	Peromyscus maniculatus	7/24/2007	6.95962	-21.79044	39.054869	-114.311788
Deer Mouse	Peromyscus maniculatus	7/24/2007	7.336	-22.70264	39.054826	-114.319125
Deer Mouse	Peromyscus maniculatus	7/24/2007	8.049054	-21.85385	38.91234	-114.170127
Deer Mouse	Peromyscus maniculatus	7/24/2007	8.375583	-23.6636	39.054637	-114.319021
Deer Mouse	Peromyscus maniculatus	7/24/2007	9.334505	-22.28886	38.912486	-114.170027
Deer Mouse	Peromyscus maniculatus	7/24/2007	13.50886	-18.53565	39.052717	-114.321765
Deer Mouse	Peromyscus maniculatus	7/25/2007	2.555312	-18.26791	39.049625	-114.320731
Deer Mouse	Peromyscus maniculatus	7/25/2007	5.638949	-22.329	39.056494	-114.305539
Deer Mouse	Peromyscus maniculatus	7/25/2007	5.846717		39.05214	-114.321545
Deer Mouse	Peromyscus maniculatus	7/25/2007	6.318932	-20.38647	39.056731	-114.305552
Deer Mouse	Peromyscus	7/25/2007	6.358659	-23.2028	39.052532	-114.317746

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/25/2007	6.413696	-19.23632	39.050421	-114.321103
Deer Mouse	Peromyscus maniculatus	7/25/2007	7.268475	-20.86156	39.054178	-114.311491
Deer Mouse	Peromyscus maniculatus	7/25/2007	7.956552	-20.39439	39.057944	-114.304809
Deer Mouse	Peromyscus maniculatus	7/25/2007	8.598454	-20.09922	39.051554	-114.321522
Deer Mouse	Peromyscus maniculatus	7/26/2007	3.340458	-18.40729	38.910307	-114.155001
Deer Mouse	Peromyscus maniculatus	7/26/2007	5.825227	1.566963	39.057298	-114.30531
Deer Mouse	Peromyscus maniculatus	7/26/2007	6.125348	-21.64494	38.909841	-114.155257
Deer Mouse	Peromyscus maniculatus	7/26/2007	6.375701	-22.7208	39.054607	-114.305879
Deer Mouse	Peromyscus maniculatus	7/26/2007	6.4286	-19.12897	39.054178	-114.311491
Deer Mouse	Peromyscus maniculatus	7/26/2007	6.888957	-18.94715	39.058725	-114.304957
Deer Mouse	Peromyscus maniculatus	7/26/2007	6.915029	-21.66542	38.913621	-114.151065
Deer Mouse	Peromyscus maniculatus	7/27/2007	3.956293	-20.71635	38.912058	-114.154444
Deer Mouse	Peromyscus maniculatus	7/27/2007	4.019666	-18.46014	39.053887	-114.31869
Deer Mouse	Peromyscus maniculatus	7/27/2007	4.641039	-18.92245	39.052891	-114.321822
Deer Mouse	Peromyscus maniculatus	7/27/2007	7.317701	-19.86289	39.05695	-114.312503
Deer Mouse	Peromyscus	7/27/2007	7.421598	-24.22563	38.916557	-114.146926

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/27/2007	7.468301	-22.81572	39.052541	-114.310859
Deer Mouse	Peromyscus maniculatus	7/27/2007	7.950426	-22.89495	38.912486	-114.170027
Deer Mouse	Peromyscus maniculatus	7/27/2007	7.99128	-23.15491	39.049625	-114.320731
Deer Mouse	Peromyscus maniculatus	7/27/2007	9.107326	-18.36322	39.058725	-114.304957
Deer Mouse	Peromyscus maniculatus	7/27/2007	9.681539	-23.17364	39.049331	-114.320617
Deer Mouse	Peromyscus maniculatus	7/30/2007	4.726203	-20.24612	39.010148	-114.20773
Deer Mouse	Peromyscus maniculatus	7/30/2007	6.001304	-19.16836	39.052541	-114.310859
Deer Mouse	Peromyscus maniculatus	7/30/2007	6.15968	-19.03778	39.057417	-114.305201
Deer Mouse	Peromyscus maniculatus	7/30/2007	6.213954	-22.63106	39.052532	-114.317746
Deer Mouse	Peromyscus maniculatus	7/30/2007	6.250714	-23.14744	39.053339	-114.31832
Deer Mouse	Peromyscus maniculatus	7/30/2007	7.704267	-21.77897	39.054464	-114.305891
Deer Mouse	Peromyscus maniculatus	7/30/2007	7.853255	-20.31333	39.013774	-114.217146
Deer Mouse	Peromyscus maniculatus	7/30/2007	7.940288	-22.85335	39.050421	-114.321103
Deer Mouse	Peromyscus maniculatus	7/30/2007	9.055474	-21.25484	39.010632	-114.212106
Deer Mouse	Peromyscus maniculatus	7/30/2007	9.816546	-21.04663	39.054496	-114.318945
Deer Mouse	Peromyscus	7/31/2007	4.794353	-20.25657	39.057577	-114.305064

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/31/2007	5.542695	-20.26321	39.057049	-114.305427
Deer Mouse	Peromyscus maniculatus	7/31/2007	6.033731	-22.99771	39.052532	-114.317746
Deer Mouse	Peromyscus maniculatus	7/31/2007	6.949969	-19.45851	39.007863	-114.208132
Deer Mouse	Peromyscus maniculatus	7/31/2007	7.016982	-23.88788	39.051651	-114.316765
Deer Mouse	Peromyscus maniculatus	7/31/2007	7.655642	-22.46418	39.009811	-114.207815
Deer Mouse	Peromyscus maniculatus	7/31/2007	8.122044	-15.51319	39.013645	-114.217253
Deer Mouse	Peromyscus maniculatus	8/1/2007	4.199529	-21.30902	39.052226	-114.317439
Deer Mouse	Peromyscus maniculatus	8/1/2007	5.046119	-20.20792	39.049477	-114.320724
Deer Mouse	Peromyscus maniculatus	8/1/2007	5.801732	-18.04411	39.054067	-114.318852
Deer Mouse	Peromyscus maniculatus	8/1/2007	5.869576	-22.46878	39.050778	-114.321354
Deer Mouse	Peromyscus maniculatus	8/1/2007	8.049977	-23.06426	39.056569	-114.312338
Deer Mouse	Peromyscus maniculatus	8/1/2007	8.429586	-23.36597	39.049819	-114.320713
Deer Mouse	Peromyscus maniculatus	8/1/2007	9.016294	-22.53845	39.048777	-114.320435
Deer Mouse	Peromyscus maniculatus	8/1/2007	10.32491	-19.73893	39.010969	-114.207835
Deer Mouse	Peromyscus maniculatus	8/2/2007	3.651279	-18.83706	39.051747	-114.316963
Deer Mouse	Peromyscus	8/2/2007	4.26131	-19.41039	39.013447	-114.208057

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/2/2007	5.365653	-18.08295	39.052732	-114.317872
Deer Mouse	Peromyscus maniculatus	8/2/2007	5.5697	-21.86077	39.009845	-114.20839
Deer Mouse	Peromyscus maniculatus	8/2/2007	6.244352	-23.13735	39.053195	-114.318275
Deer Mouse	Peromyscus maniculatus	8/2/2007	6.956653	-22.88863	39.054869	-114.311788
Deer Mouse	Peromyscus maniculatus	8/2/2007	7.811214	-20.45383	39.048777	-114.320435
Deer Mouse	Peromyscus maniculatus	8/3/2007	3.073616	-18.71913	39.054178	-114.30586
Deer Mouse	Peromyscus maniculatus	8/3/2007	4.001608	-18.63306	39.053091	-114.311085
Deer Mouse	Peromyscus maniculatus	8/3/2007	5.491014	-18.97704	39.052564	-114.311087
Deer Mouse	Peromyscus maniculatus	8/3/2007	5.608016		39.056731	-114.305552
Deer Mouse	Peromyscus maniculatus	8/3/2007	6.168527	-22.25986	39.050942	-114.321376
Deer Mouse	Peromyscus maniculatus	8/3/2007	6.790471	-21.50628	39.050778	-114.321354
Deer Mouse	Peromyscus maniculatus	8/3/2007	15.41855	-18.03365	39.008773	-114.210927
Deer Mouse	Peromyscus maniculatus	8/3/2007	15.72279	-22.43633	39.010969	-114.207835
Deer Mouse	Peromyscus maniculatus	8/6/2007	2.696723	-18.26405	39.048817	-114.320384
Deer Mouse	Peromyscus maniculatus	8/6/2007	3.676346	-20.19344	39.058725	-114.304957
Deer Mouse	Peromyscus	8/6/2007	4.338544	-20.12602	38.911839	-114.170315

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/6/2007	4.589989	-22.80148	38.916676	-114.147088
Deer Mouse	Peromyscus maniculatus	8/6/2007	6.226941	-22.21712	39.057577	-114.305064
Deer Mouse	Peromyscus maniculatus	8/6/2007	6.672361	-22.19897	38.913621	-114.151065
Deer Mouse	Peromyscus maniculatus	8/6/2007	6.704282	-23.40187	39.048777	-114.320435
Deer Mouse	Peromyscus maniculatus	8/6/2007	6.768259	-17.67635	39.05547	-114.305637
Deer Mouse	Peromyscus maniculatus	8/6/2007	7.34172	-22.99161	38.91246	-114.154496
Deer Mouse	Peromyscus maniculatus	8/6/2007	7.570232	-21.38687	38.916557	-114.146926
Deer Mouse	Peromyscus maniculatus	8/6/2007	7.674776	-21.18302	39.055237	-114.305646
Deer Mouse	Peromyscus maniculatus	8/6/2007	7.856948	-20.50161	39.052043	-114.317286
Deer Mouse	Peromyscus maniculatus	8/6/2007	7.873387	-23.02151	39.048985	-114.320576
Deer Mouse	Peromyscus maniculatus	8/6/2007	8.162746	-23.47395	38.912408	-114.15452
Deer Mouse	Peromyscus maniculatus	8/7/2007	5.762853	-22.32215	39.054515	-114.305846
Deer Mouse	Peromyscus maniculatus	8/7/2007	6.073178	-23.0763	39.050687	-114.316079
Deer Mouse	Peromyscus maniculatus	8/7/2007	6.0803	-21.06575	39.05547	-114.305637
Deer Mouse	Peromyscus maniculatus	8/7/2007	8.241613	-23.54461	38.91264	-114.154516
Deer Mouse	Peromyscus	8/7/2007	8.834249	-18.67997	39.054826	-114.319125

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/7/2007	14.66708	-19.45014	39.053191	-114.311141
Deer Mouse	Peromyscus maniculatus	8/8/2007	4.960542	-19.13184	38.912486	-114.170027
Deer Mouse	Peromyscus maniculatus	8/8/2007	5.008144	-21.08538	39.052528	-114.311007
Deer Mouse	Peromyscus maniculatus	8/8/2007	6.054899	-21.68101	39.054117	-114.305816
Deer Mouse	Peromyscus maniculatus	8/8/2007	7.023332	-20.34576	39.050564	-114.316118
Deer Mouse	Peromyscus maniculatus	8/8/2007	7.670056	-21.46156	38.916571	-114.147006
Deer Mouse	Peromyscus maniculatus	8/8/2007	7.92104	-23.23726	39.050564	-114.316118
Deer Mouse	Peromyscus maniculatus	8/8/2007	12.05517	-20.55394	39.052528	-114.311007
Deer Mouse	Peromyscus maniculatus	8/9/2007	2.863488	-18.63004	38.911726	-114.170322
Deer Mouse	Peromyscus maniculatus	8/9/2007	3.518895	-20.40898	39.054117	-114.305816
Deer Mouse	Peromyscus maniculatus	8/9/2007	4.663643	-22.52815	39.050564	-114.316118
Deer Mouse	Peromyscus maniculatus	8/9/2007	5.877617	-22.05628	39.048777	-114.320435
Deer Mouse	Peromyscus maniculatus	8/9/2007	6.307323	-22.74469	39.050564	-114.316118
Deer Mouse	Peromyscus maniculatus	8/9/2007	6.317717	-20.57188	39.050564	-114.316118
Deer Mouse	Peromyscus maniculatus	8/9/2007	6.569228	-21.24452	38.911839	-114.170315
Deer Mouse	Peromyscus	8/9/2007	7.77476	-22.12693	38.916572	-114.147038

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/9/2007	8.950405	-20.50206	38.911589	-114.170243
Deer Mouse	Peromyscus maniculatus	8/13/2007	2.720969	-19.66814	38.909085	-114.155459
Deer Mouse	Peromyscus maniculatus	8/13/2007	3.634116	-19.32957	39.008834	-114.208363
Deer Mouse	Peromyscus maniculatus	8/13/2007	9.150383	-15.08395	39.009699	-114.211384
Deer Mouse	Peromyscus maniculatus	8/13/2007	12.36304	-21.81038	39.010632	-114.212106
Deer Mouse	Peromyscus maniculatus	8/14/2007	5.857907	-21.76052	39.013815	-114.20821
Deer Mouse	Peromyscus maniculatus	8/14/2007	7.350114	-18.35095	39.015996	-114.21414
Deer Mouse	Peromyscus maniculatus	8/14/2007	7.369939	-18.99457	39.013658	-114.217261
Deer Mouse	Peromyscus maniculatus	8/15/2007	4.05017	-18.88906	39.016087	-114.21391
Deer Mouse	Peromyscus maniculatus	8/15/2007	5.001499	-20.42264	38.908553	-114.15588
Deer Mouse	Peromyscus maniculatus	8/15/2007	6.129109	-20.52615	39.010632	-114.212106
Deer Mouse	Peromyscus maniculatus	8/15/2007	7.443843	-19.78213	38.908309	-114.172969
Deer Mouse	Peromyscus maniculatus	8/17/2007	2.965191	-19.19747	39.008705	-114.208323
Deer Mouse	Peromyscus maniculatus	8/17/2007	4.119596	-19.81437	39.01252	-114.207877
Deer Mouse	Peromyscus maniculatus	8/17/2007	4.134395	-18.92039	39.014178	-114.216586
Deer Mouse	Peromyscus	8/20/2007	2.549327	-19.54434	38.912058	-114.171154

	maniculatus					
Deer Mouse	Peromyscus maniculatus	9/15/2007	4.462923	-21.45864	38.916365	-114.148421
Deer Mouse	Peromyscus maniculatus	7/9/2008	8.070706	-23.65638	38.985392	-114.24233
Deer Mouse	Peromyscus maniculatus	7/9/2008	10.82504	-22.80489	38.985646	-114.242539
Deer Mouse	Peromyscus maniculatus	7/9/2008	18.02942	-20.53205	38.985794	-114.241861
Deer Mouse	Peromyscus maniculatus	7/10/2008	3.423158	-20.83985	38.985309	-114.242463
Deer Mouse	Peromyscus maniculatus	7/10/2008	8.366796	-21.12993	38.98566	-114.242408
Deer Mouse	Peromyscus maniculatus	7/17/2008	8.50798	-21.58602	39.012774	-114.222882
Deer Mouse	Peromyscus maniculatus	7/22/2008	8.908291	-22.30099	39.0147	-114.235706
Deer Mouse	Peromyscus maniculatus	7/22/2008	10.32663	-23.57387	39.015245	-114.235858
Deer Mouse	Peromyscus maniculatus	7/24/2008	7.128616	-18.70006	39.018022	-114.225367
Deer Mouse	Peromyscus maniculatus	7/29/2008	3.684852	-19.04034	39.052043	-114.317286
Deer Mouse	Peromyscus maniculatus	7/29/2008	5.76174	-21.86469	39.051591	-114.316726
Deer Mouse	Peromyscus maniculatus	7/29/2008	5.843341	-21.35463	39.052717	-114.321765
Deer Mouse	Peromyscus maniculatus	7/29/2008	6.350817	-12.39955	39.051184	-114.316484
Deer Mouse	Peromyscus maniculatus	7/29/2008	6.543014	-21.63499	39.050564	-114.316118
Deer Mouse	Peromyscus	7/29/2008	6.847888	-22.56936	39.049081	-114.320587

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/29/2008	6.905053	-22.51547	39.056372	-114.312269
Deer Mouse	Peromyscus maniculatus	7/29/2008	7.011168	-23.64141	39.054067	-114.318852
Deer Mouse	Peromyscus maniculatus	7/29/2008	7.577346	-21.76118	39.054637	-114.319021
Deer Mouse	Peromyscus maniculatus	7/29/2008	7.710788	-23.76705	39.050752	-114.316329
Deer Mouse	Peromyscus maniculatus	7/29/2008	7.993147	-19.90433	39.048985	-114.320576
Deer Mouse	Peromyscus maniculatus	7/29/2008	8.080671	-8.434958	39.055237	-114.305646
Deer Mouse	Peromyscus maniculatus	7/29/2008	8.221401	-21.55542	39.049331	-114.320617
Deer Mouse	Peromyscus maniculatus	7/29/2008	8.755997	-23.20236	39.053191	-114.311141
Deer Mouse	Peromyscus maniculatus	7/29/2008	9.238149	-20.44393	39.049819	-114.320713
Deer Mouse	Peromyscus maniculatus	7/29/2008	9.454083	-15.57411	39.051186	-114.32143
Deer Mouse	Peromyscus maniculatus	7/29/2008	9.678638	-23.23531	39.049625	-114.320731
Deer Mouse	Peromyscus maniculatus	7/29/2008	10.51467	-21.32415	39.051742	-114.321555
Deer Mouse	Peromyscus maniculatus	7/29/2008	11.55579	-20.2866	39.051368	-114.321462
Deer Mouse	Peromyscus maniculatus	7/29/2008	11.80575	-22.36213	39.053028	-114.318107
Deer Mouse	Peromyscus maniculatus	7/29/2008	12.25719	-19.71502	38.98813	-114.233999
Deer Mouse	Peromyscus	7/30/2008	5.990788	-22.56516	39.054178	-114.311491

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/30/2008	6.20267	-24.01291	39.053339	-114.31832
Deer Mouse	Peromyscus maniculatus	7/30/2008	6.678833	-23.55072	39.050421	-114.321103
Deer Mouse	Peromyscus maniculatus	7/30/2008	6.929727	-23.27307	39.054496	-114.318945
Deer Mouse	Peromyscus maniculatus	7/30/2008	6.96845	-23.42023	39.052043	-114.317286
Deer Mouse	Peromyscus maniculatus	7/30/2008	7.014351	-20.99481	39.053191	-114.311141
Deer Mouse	Peromyscus maniculatus	7/30/2008	7.038036	-23.85289	39.05214	-114.321545
Deer Mouse	Peromyscus maniculatus	7/30/2008	7.275137	-23.25671	39.054498	-114.311607
Deer Mouse	Peromyscus maniculatus	7/30/2008	7.372669	-23.31783	39.052717	-114.321765
Deer Mouse	Peromyscus maniculatus	7/30/2008	7.527963	-21.83811	39.054117	-114.305816
Deer Mouse	Peromyscus maniculatus	7/30/2008	7.647682	-21.68333	39.056372	-114.312269
Deer Mouse	Peromyscus maniculatus	7/30/2008	12.76257	-21.87793	39.049819	-114.320713
Deer Mouse	Peromyscus maniculatus	7/31/2008	5.945303	-20.54358	39.054498	-114.311607
Deer Mouse	Peromyscus maniculatus	7/31/2008	6.243168	-21.42321	39.051747	-114.316963
Deer Mouse	Peromyscus maniculatus	7/31/2008	6.252213	-22.48842	39.055993	-114.312119
Deer Mouse	Peromyscus maniculatus	7/31/2008	6.480426	-23.13285	39.050752	-114.316329
Deer Mouse	Peromyscus	7/31/2008	6.601099	-23.56428	38.989409	-114.242871

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/31/2008	6.641206	-22.69814	39.05547	-114.305637
Deer Mouse	Peromyscus maniculatus	7/31/2008	6.657741	-22.07103	39.049331	-114.320617
Deer Mouse	Peromyscus maniculatus	7/31/2008	6.709913	-22.83285	39.050687	-114.316079
Deer Mouse	Peromyscus maniculatus	7/31/2008	7.150203	-23.83399	39.050687	-114.316079
Deer Mouse	Peromyscus maniculatus	7/31/2008	7.384599	-23.70187	39.054826	-114.319125
Deer Mouse	Peromyscus maniculatus	7/31/2008	8.448318	-22.96217	39.055237	-114.305646
Deer Mouse	Peromyscus maniculatus	7/31/2008	8.904156	-22.31624	38.989557	-114.242782
Deer Mouse	Peromyscus maniculatus	7/31/2008	8.910631	-22.59504	39.054637	-114.319021
Deer Mouse	Peromyscus maniculatus	7/31/2008	9.441525	-22.29943	39.055824	-114.312069
Deer Mouse	Peromyscus maniculatus	7/31/2008	10.06215	-22.37975	39.056731	-114.305552
Deer Mouse	Peromyscus maniculatus	8/1/2008	5.450714	-23.64665	39.056859	-114.305468
Deer Mouse	Peromyscus maniculatus	8/1/2008	5.763676	-24.26136	39.051651	-114.316765
Deer Mouse	Peromyscus maniculatus	8/1/2008	5.841183	-21.52927	39.054498	-114.311607
Deer Mouse	Peromyscus maniculatus	8/1/2008	6.02358	-21.39987	39.056808	-114.312382
Deer Mouse	Peromyscus maniculatus	8/1/2008	6.301451	-22.14692	39.054158	-114.30592
Deer Mouse	Peromyscus	8/1/2008	6.461649	-22.85382	39.050778	-114.321354

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/1/2008	6.606332	-23.26789	39.052043	-114.317286
Deer Mouse	Peromyscus maniculatus	8/1/2008	7.559925	-23.3815	38.989681	-114.241197
Deer Mouse	Peromyscus maniculatus	8/1/2008	7.75548	-23.25804	39.051061	-114.316488
Deer Mouse	Peromyscus maniculatus	8/1/2008	8.065269	-23.33422	39.05344	-114.321907
Deer Mouse	Peromyscus maniculatus	8/1/2008	8.590919	-21.91266	39.05552	-114.311997
Deer Mouse	Peromyscus maniculatus	8/1/2008	9.040707	-22.48374	39.049331	-114.320617
Deer Mouse	Peromyscus maniculatus	8/1/2008	9.232201	-22.01742	38.988829	-114.241537
Deer Mouse	Peromyscus maniculatus	8/1/2008	10.54573	-22.07843	39.05567	-114.305632
Deer Mouse	Peromyscus maniculatus	8/5/2008	5.500296	-22.83588	39.058544	-114.304879
Deer Mouse	Peromyscus maniculatus	8/5/2008	5.51998	-22.45955	39.056731	-114.305552
Deer Mouse	Peromyscus maniculatus	8/5/2008	6.062654	-22.42048	39.055655	-114.312074
Deer Mouse	Peromyscus maniculatus	8/5/2008	6.417315	-23.30533	39.050752	-114.316329
Deer Mouse	Peromyscus maniculatus	8/5/2008	6.742388	-22.59738	39.054464	-114.305891
Deer Mouse	Peromyscus maniculatus	8/5/2008	6.831954	-19.65971	39.055824	-114.312069
Deer Mouse	Peromyscus maniculatus	8/5/2008	6.946212	-21.58067	39.055007	-114.305717
Deer Mouse	Peromyscus	8/5/2008	7.111516	-22.61887	39.05567	-114.305632

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/6/2008	6.90915	-22.05542	39.054495	-114.305904
Deer Mouse	Peromyscus maniculatus	8/6/2008	7.304327	-23.41821	39.054665	-114.311692
Deer Mouse	Peromyscus maniculatus	8/6/2008	7.677773	-23.07137	39.057298	-114.30531
Deer Mouse	Peromyscus maniculatus	8/6/2008	7.698795	-22.16725	39.052779	-114.31107
Deer Mouse	Peromyscus maniculatus	8/6/2008	7.922637	-22.46467	39.052656	-114.311078
Deer Mouse	Peromyscus maniculatus	8/6/2008	14.52691	-20.82357	39.049625	-114.320731
Deer Mouse	Peromyscus maniculatus	8/7/2008	5.467587	-23.02528	39.052528	-114.311007
Deer Mouse	Peromyscus maniculatus	8/7/2008	5.695996	-21.02692	39.052557	-114.310938
Deer Mouse	Peromyscus maniculatus	8/7/2008	6.621496	-20.84354	39.051651	-114.316765
Deer Mouse	Peromyscus maniculatus	8/7/2008	6.761649	-21.98637	39.053887	-114.31869
Deer Mouse	Peromyscus maniculatus	8/7/2008	6.83936	-22.45202	39.051554	-114.321522
Deer Mouse	Peromyscus maniculatus	8/7/2008	6.87949	-22.53416	39.055007	-114.305717
Deer Mouse	Peromyscus maniculatus	8/7/2008	7.019208	-21.9559	39.051203	-114.316566
Deer Mouse	Peromyscus maniculatus	8/7/2008	7.269059	-21.30833	39.050898	-114.316378
Deer Mouse	Peromyscus maniculatus	8/7/2008	7.406561	-22.36754	39.054067	-114.318852
Deer Mouse	Peromyscus	8/7/2008	9.254037	-23.50681	39.049625	-114.320731

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/7/2008	9.477923	-22.84785	39.050942	-114.321376
Deer Mouse	Peromyscus maniculatus	8/8/2008	5.369075	-21.77266	39.056279	-114.305663
Deer Mouse	Peromyscus maniculatus	8/8/2008	8.968228	-23.18613	39.051742	-114.321555
Deer Mouse	Peromyscus maniculatus	8/8/2008	10.05963	-23.02171	39.049819	-114.320713
Deer Mouse	Peromyscus maniculatus	8/8/2008	11.1166	-21.50028	39.054665	-114.311692
Deer Mouse	Peromyscus maniculatus	8/8/2008	12.7316	-19.50708	39.016256	-114.21378
Deer Mouse	Peromyscus maniculatus	8/12/2008	4.858569	-21.80721	39.013833	-114.217019
Deer Mouse	Peromyscus maniculatus	8/12/2008	6.367867	-20.31201	39.009941	-114.208302
Deer Mouse	Peromyscus maniculatus	8/13/2008	5.268342	-23.2505	39.010376	-114.211929
Deer Mouse	Peromyscus maniculatus	8/14/2008	5.724621	-21.19576	39.009684	-114.208376
Deer Mouse	Peromyscus maniculatus	8/14/2008	10.6112	-19.8554	39.016724	-114.212554
Deer Mouse	Peromyscus maniculatus	8/15/2008	10.84362	-20.14411	39.016724	-114.212554
Deer Mouse	Peromyscus maniculatus	6/29/2009	2.522504	-20.91462	38.973594	-114.174286
Deer Mouse	Peromyscus maniculatus	6/29/2009	3.712159	-21.51057	38.931771	-114.253005
Deer Mouse	Peromyscus maniculatus	6/29/2009	3.877195	-22.09187	38.931337	-114.251954
Deer Mouse	Peromyscus	6/29/2009	3.935	-22.62284	38.928145	-114.253258

	maniculatus					
Deer Mouse	Peromyscus maniculatus	6/29/2009	3.95487		38.928978	-114.252843
Deer Mouse	Peromyscus maniculatus	6/29/2009	4.035203	-20.44239	38.93101	-114.253588
Deer Mouse	Peromyscus maniculatus	6/29/2009	4.103164	-22.02541	38.931582	-114.254477
Deer Mouse	Peromyscus maniculatus	6/29/2009	4.184634	-22.31277	38.928022	-114.253122
Deer Mouse	Peromyscus maniculatus	6/29/2009	4.510698	-21.91317	38.931537	-114.254789
Deer Mouse	Peromyscus maniculatus	6/29/2009	4.53055	-22.02851	38.929046	-114.251936
Deer Mouse	Peromyscus maniculatus	6/29/2009	4.874671	-23.05545	38.931876	-114.252159
Deer Mouse	Peromyscus maniculatus	6/29/2009	5.076767	-22.34691	38.931328	-114.252381
Deer Mouse	Peromyscus maniculatus	6/29/2009	5.669504	-22.93354	38.931674	-114.253807
Deer Mouse	Peromyscus maniculatus	6/29/2009	6.369238	-24.2486	38.926009	-114.251494
Deer Mouse	Peromyscus maniculatus	6/29/2009	6.781523	-20.34307	38.930941	-114.254043
Deer Mouse	Peromyscus maniculatus	6/29/2009	7.936696	-22.51286	38.926288	-114.251821
Deer Mouse	Peromyscus maniculatus	6/29/2009	8.618976	-20.74178	38.931387	-114.251887
Deer Mouse	Peromyscus maniculatus	6/29/2009	9.034719	-19.32896	38.926843	-114.252201
Deer Mouse	Peromyscus maniculatus	6/29/2009	14.08166	-19.93061	38.925876	-114.251372
Deer Mouse	Peromyscus	6/29/2009	15.00143	-22.30763	38.926192	-114.251781

	maniculatus					
Deer Mouse	Peromyscus maniculatus	6/30/2009	2.445863		38.930212	-114.25314
Deer Mouse	Peromyscus maniculatus	6/30/2009	3.623403	-19.96024	38.931094	-114.253257
Deer Mouse	Peromyscus maniculatus	6/30/2009	4.096731	-23.03534	38.93101	-114.253588
Deer Mouse	Peromyscus maniculatus	6/30/2009	4.415537	-21.97796	38.931387	-114.251887
Deer Mouse	Peromyscus maniculatus	6/30/2009	4.730724	-22.19155	38.928022	-114.253122
Deer Mouse	Peromyscus maniculatus	6/30/2009	5.190753	-22.45777	38.929189	-114.252628
Deer Mouse	Peromyscus maniculatus	6/30/2009	5.200636	-23.38283	38.931648	-114.254112
Deer Mouse	Peromyscus maniculatus	6/30/2009	10.89917		38.930339	-114.253194
Deer Mouse	Peromyscus maniculatus	6/30/2009	11.79061	-16.28567	38.930987	-114.253719
Deer Mouse	Peromyscus maniculatus	6/30/2009	14.07449	-22.66096	38.926742	-114.252129
Deer Mouse	Peromyscus maniculatus	6/30/2009	15.55597	-20.72894	38.929099	-114.252862
Deer Mouse	Peromyscus maniculatus	7/7/2009	5.455639	-22.513	39.015834	-114.230338
Deer Mouse	Peromyscus maniculatus	7/7/2009	6.158982	-23.36618	39.015956	-114.223346
Deer Mouse	Peromyscus maniculatus	7/7/2009	6.954136	-24.31481	39.017786	-114.228322
Deer Mouse	Peromyscus maniculatus	7/7/2009	7.52672	-23.72156	39.018216	-114.229344
Deer Mouse	Peromyscus	7/7/2009	7.862639	-22.97287	39.015564	-114.230348

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/7/2009	7.958867	-22.33977	39.015687	-114.229824
Deer Mouse	Peromyscus maniculatus	7/7/2009	8.03861	-22.26207	39.017402	-114.229203
Deer Mouse	Peromyscus maniculatus	7/7/2009	14.54356	-21.20628	39.018204	-114.228825
Deer Mouse	Peromyscus maniculatus	7/8/2009		-21.91707	39.010277	-114.211883
Deer Mouse	Peromyscus maniculatus	7/9/2009	8.779296	-21.52828	39.017529	-114.228851
Deer Mouse	Peromyscus maniculatus	7/10/2009	5.540692	-23.38499	39.016239	-114.223855
Deer Mouse	Peromyscus maniculatus	7/10/2009	7.062969	-23.75126	39.01793	-114.228662
Deer Mouse	Peromyscus maniculatus	7/10/2009	8.866697	-21.70874	39.015286	-114.230013
Deer Mouse	Peromyscus maniculatus	7/14/2009	2.225418		39.018506	-114.234703
Deer Mouse	Peromyscus maniculatus	7/14/2009	3.118928	-20.49139	39.01457	-114.235884
Deer Mouse	Peromyscus maniculatus	7/14/2009	4.19278		39.017978	-114.235243
Deer Mouse	Peromyscus maniculatus	7/14/2009	5.201476	-18.46204	39.014983	-114.232427
Deer Mouse	Peromyscus maniculatus	7/14/2009	5.390497	-24.53131	39.01511	-114.232075
Deer Mouse	Peromyscus maniculatus	7/14/2009	6.533578		39.01797	-114.234897
Deer Mouse	Peromyscus maniculatus	7/14/2009	6.743886	-22.17369	39.015371	-114.235506
Deer Mouse	Peromyscus	7/14/2009	7.022095	-24.44235	39.014831	-114.235527

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/14/2009	7.242485	-23.797	39.014852	-114.232605
Deer Mouse	Peromyscus maniculatus	7/14/2009	7.24572	-20.11474	39.014594	-114.233135
Deer Mouse	Peromyscus maniculatus	7/14/2009	7.301951	-20.80453	39.014705	-114.235879
Deer Mouse	Peromyscus maniculatus	7/14/2009	7.530365	-20.48849	39.014447	-114.232621
Deer Mouse	Peromyscus maniculatus	7/14/2009	7.688969	-21.11105	39.017887	-114.225373
Deer Mouse	Peromyscus maniculatus	7/14/2009	8.01551	-21.45829	39.01497	-114.235695
Deer Mouse	Peromyscus maniculatus	7/14/2009	8.055199	-21.91707	39.018096	-114.234546
Deer Mouse	Peromyscus maniculatus	7/14/2009	8.165052	-22.5676	39.018006	-114.224675
Deer Mouse	Peromyscus maniculatus	7/14/2009	8.29496	-22.60353	39.01801	-114.224848
Deer Mouse	Peromyscus maniculatus	7/14/2009	8.571669	-22.16259	39.018375	-114.234881
Deer Mouse	Peromyscus maniculatus	7/14/2009	8.71078	-22.97287	39.014844	-114.232259
Deer Mouse	Peromyscus maniculatus	7/14/2009	8.753251	-22.82113	39.01459	-114.232962
Deer Mouse	Peromyscus maniculatus	7/14/2009	9.041514	-23.35647	39.014979	-114.232254
Deer Mouse	Peromyscus maniculatus	7/14/2009	9.152582	-23.25566	39.014856	-114.232778
Deer Mouse	Peromyscus maniculatus	7/14/2009	9.199817	-22.44934	39.014991	-114.232773
Deer Mouse	Peromyscus	7/14/2009	9.371428		39.013897	-114.228035

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/14/2009	11.4755	-17.19189	39.017192	-114.224534
Deer Mouse	Peromyscus maniculatus	7/14/2009	11.54382	-20.81552	39.014975	-114.232081
Deer Mouse	Peromyscus maniculatus	7/14/2009	12.05029	-21.71352	39.017879	-114.225027
Deer Mouse	Peromyscus maniculatus	7/14/2009	12.41302	-19.90386	39.014289	-114.2275
Deer Mouse	Peromyscus maniculatus	7/14/2009	15.74155	-19.51379	39.014713	-114.232437
Deer Mouse	Peromyscus maniculatus	7/15/2009	3.471582	-20.68009	39.018022	-114.225367
Deer Mouse	Peromyscus maniculatus	7/15/2009	4.898304		39.014416	-114.227148
Deer Mouse	Peromyscus maniculatus	7/15/2009	6.08334	-23.70574	39.014565	-114.235711
Deer Mouse	Peromyscus maniculatus	7/15/2009	6.176854	-24.07295	39.014692	-114.23536
Deer Mouse	Peromyscus maniculatus	7/15/2009	8.006024	-22.65188	39.017605	-114.224864
Deer Mouse	Peromyscus maniculatus	7/15/2009	8.826157	-22.78087	39.018027	-114.225541
Deer Mouse	Peromyscus maniculatus	7/15/2009	9.538644	-13.0815	39.014594	-114.233135
Deer Mouse	Peromyscus maniculatus	7/15/2009	11.74729	-20.08358	39.015101	-114.235517
Deer Mouse	Peromyscus maniculatus	7/15/2009		-23.28486	39.018096	-114.234546
Deer Mouse	Peromyscus maniculatus	7/16/2009	3.170752	-21.29882	39.017601	-114.224691
Deer Mouse	Peromyscus	7/16/2009	4.474832	-22.25094	39.014823	-114.235181

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/16/2009	5.543094		39.013623	-114.227872
Deer Mouse	Peromyscus maniculatus	7/16/2009	6.244307	-23.73885	39.014451	-114.232794
Deer Mouse	Peromyscus maniculatus	7/16/2009	6.798706		39.018109	-114.235065
Deer Mouse	Peromyscus maniculatus	7/16/2009	8.513515	-19.37038	39.01459	-114.232962
Deer Mouse	Peromyscus maniculatus	7/16/2009	13.24831	-18.04121	39.018006	-114.224675
Deer Mouse	Peromyscus maniculatus	7/16/2009	15.09602	-20.44055	39.018092	-114.234373
Deer Mouse	Peromyscus maniculatus	7/17/2009	8.602629	-17.64172	39.01878	-114.234865
Deer Mouse	Peromyscus maniculatus	7/22/2009	4.004792	-19.28861	38.895404	-114.297327
Deer Mouse	Peromyscus maniculatus	7/22/2009	5.721931	-21.96815	38.895871	-114.297084
Deer Mouse	Peromyscus maniculatus	7/22/2009	6.335593	-21.68345	38.895067	-114.297471
Deer Mouse	Peromyscus maniculatus	7/22/2009	6.821742	-21.18184	38.903502	-114.298556
Deer Mouse	Peromyscus maniculatus	7/22/2009	7.127464	-21.98959	38.901508	-114.298501
Deer Mouse	Peromyscus maniculatus	7/22/2009	7.241657	-21.11948	38.903562	-114.29882
Deer Mouse	Peromyscus maniculatus	7/22/2009	7.841468	-21.63048	38.896132	-114.29779
Deer Mouse	Peromyscus maniculatus	7/22/2009	9.409947	-22.14712	38.900923	-114.29847
Deer Mouse	Peromyscus	7/22/2009	10.46062	-20.60982	38.903642	-114.301139

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/22/2009	13.08168	-22.87355	38.895302	-114.297397
Deer Mouse	Peromyscus maniculatus	7/23/2009	4.068048	-23.24379	38.901579	-114.310903
Deer Mouse	Peromyscus maniculatus	7/23/2009	4.489845	-23.14757	38.901532	-114.310685
Deer Mouse	Peromyscus maniculatus	7/23/2009	5.047338	-20.56356	38.903901	-114.300811
Deer Mouse	Peromyscus maniculatus	7/23/2009	5.384356	-24.51484	38.90152	-114.312507
Deer Mouse	Peromyscus maniculatus	7/23/2009	5.688867	-22.25923	38.903686	-114.299137
Deer Mouse	Peromyscus maniculatus	7/23/2009	6.335593	-21.68345	38.895067	-114.297471
Deer Mouse	Peromyscus maniculatus	7/23/2009	6.543757	-20.66054	38.900923	-114.29847
Deer Mouse	Peromyscus maniculatus	7/23/2009	7.388513	-21.79835	38.903839	-114.300006
Deer Mouse	Peromyscus maniculatus	7/23/2009	7.725823	-23.15288	38.901528	-114.312681
Deer Mouse	Peromyscus maniculatus	7/23/2009	7.920444	-20.89533	38.902264	-114.29943
Deer Mouse	Peromyscus maniculatus	7/23/2009	8.071594	-20.66689	38.90407	-114.301811
Deer Mouse	Peromyscus maniculatus	7/23/2009	10.87854	-15.45982	38.901508	-114.298501
Deer Mouse	Peromyscus maniculatus	7/23/2009	10.99522	-21.78685	38.897453	-114.29847
Deer Mouse	Peromyscus maniculatus	7/23/2009	11.78649	-14.69937	38.901435	-114.31034
Deer Mouse	Peromyscus	7/23/2009	13.18626	-16.61616	38.901969	-114.311303

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/23/2009	13.44171	-13.49372	38.903807	-114.29985
Deer Mouse	Peromyscus maniculatus	7/28/2009	2.845794	-20.69105	39.00911	-114.20843
Deer Mouse	Peromyscus maniculatus	7/28/2009	5.946046	-20.63223	39.013833	-114.217019
Deer Mouse	Peromyscus maniculatus	7/28/2009	6.341934	-23.21594	39.054275	-114.311532
Deer Mouse	Peromyscus maniculatus	7/28/2009	6.765488	-23.45213	39.008834	-114.208363
Deer Mouse	Peromyscus maniculatus	7/28/2009	6.987907	-23.10901	39.055007	-114.305717
Deer Mouse	Peromyscus maniculatus	7/28/2009	7.109257	-24.8067	39.052226	-114.317439
Deer Mouse	Peromyscus maniculatus	7/28/2009	7.261218	-23.32278	39.054902	-114.305788
Deer Mouse	Peromyscus maniculatus	7/28/2009	7.361796	-20.25119	39.050421	-114.321103
Deer Mouse	Peromyscus maniculatus	7/28/2009	7.578455	-24.33389	39.054826	-114.319125
Deer Mouse	Peromyscus maniculatus	7/28/2009	7.65523	-20.40533	39.010109	-114.211751
Deer Mouse	Peromyscus maniculatus	7/28/2009	8.734522	-20.76097	39.0533	-114.311149
Deer Mouse	Peromyscus maniculatus	7/28/2009	11.45353	-18.15061	39.049331	-114.320617
Deer Mouse	Peromyscus maniculatus	7/28/2009	16.01757	-20.81604	39.050942	-114.321376
Deer Mouse	Peromyscus maniculatus	7/29/2009	4.730245	-23.2098	39.056279	-114.305663
Deer Mouse	Peromyscus	7/29/2009	4.988762	-22.05662	39.054826	-114.319125

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/29/2009	5.093316	-22.11444	39.052532	-114.317746
Deer Mouse	Peromyscus maniculatus	7/29/2009	5.118934	-22.61574	39.013658	-114.217261
Deer Mouse	Peromyscus maniculatus	7/29/2009	5.274631	-22.94602	39.055321	-114.311887
Deer Mouse	Peromyscus maniculatus	7/29/2009	5.285462	-20.57718	39.056494	-114.305539
Deer Mouse	Peromyscus maniculatus	7/29/2009	5.393534	-20.17489	39.016364	-114.213593
Deer Mouse	Peromyscus maniculatus	7/29/2009	7.288868	-22.46966	39.013711	-114.217171
Deer Mouse	Peromyscus maniculatus	7/29/2009	7.36303	-24.2436	39.049477	-114.320724
Deer Mouse	Peromyscus maniculatus	7/29/2009	9.660072	-20.93785	39.050421	-114.321103
Deer Mouse	Peromyscus maniculatus	7/29/2009	9.702632	-22.85829	39.052355	-114.321616
Deer Mouse	Peromyscus maniculatus	7/29/2009	9.824532	-23.04788	39.050011	-114.320752
Deer Mouse	Peromyscus maniculatus	7/29/2009	10.58867	-21.48914	39.053518	-114.311125
Deer Mouse	Peromyscus maniculatus	7/29/2009	12.59123	-16.77919	39.048817	-114.320384
Deer Mouse	Peromyscus maniculatus	7/29/2009	13.92462	-14.68497	39.050568	-114.32128
Deer Mouse	Peromyscus maniculatus	7/29/2009	14.14054	-21.17379	39.056808	-114.312382
Deer Mouse	Peromyscus maniculatus	7/29/2009	16.368	-20.85721	39.048985	-114.320576
Deer Mouse	Peromyscus	7/30/2009	5.590631	-23.0882	39.052528	-114.311007

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/30/2009	5.949105	-23.70104	39.052732	-114.317872
Deer Mouse	Peromyscus maniculatus	7/30/2009	6.159264	-24.48144	39.051742	-114.321555
Deer Mouse	Peromyscus maniculatus	7/30/2009	6.305565	-22.77139	39.054178	-114.311491
Deer Mouse	Peromyscus maniculatus	7/30/2009	6.678054	-22.81628	39.056859	-114.305468
Deer Mouse	Peromyscus maniculatus	7/30/2009	6.746047	-21.80844	39.053709	-114.318613
Deer Mouse	Peromyscus maniculatus	7/30/2009	6.90772	-23.08263	39.054869	-114.311788
Deer Mouse	Peromyscus maniculatus	7/30/2009	7.062393	-18.76577	39.051184	-114.316484
Deer Mouse	Peromyscus maniculatus	7/30/2009	7.085843	-23.15024	39.05567	-114.305632
Deer Mouse	Peromyscus maniculatus	7/30/2009	7.126411	-23.57727	39.052891	-114.321822
Deer Mouse	Peromyscus maniculatus	7/30/2009	7.363677	-24.67574	39.052351	-114.317671
Deer Mouse	Peromyscus maniculatus	7/30/2009	7.861477	-21.50355	39.01252	-114.207877
Deer Mouse	Peromyscus maniculatus	7/30/2009	8.300966	-22.78551	39.053303	-114.321806
Deer Mouse	Peromyscus maniculatus	7/30/2009	9.076003	-14.0581	39.055655	-114.312074
Deer Mouse	Peromyscus maniculatus	7/30/2009	9.137079	-22.47246	39.009956	-114.207703
Deer Mouse	Peromyscus maniculatus	7/30/2009	9.737962	-20.93773	39.054275	-114.311532
Deer Mouse	Peromyscus	7/30/2009	13.27817	-21.5707	39.051895	-114.321567

	maniculatus					
Deer Mouse	Peromyscus maniculatus	7/31/2009	5.349288	-23.99654	39.054498	-114.311607
Deer Mouse	Peromyscus maniculatus	7/31/2009	5.426697	-23.12633	39.054607	-114.305879
Deer Mouse	Peromyscus maniculatus	7/31/2009	6.529838	-23.10788	39.052891	-114.321822
Deer Mouse	Peromyscus maniculatus	7/31/2009	6.666411	-23.17734	39.057577	-114.305064
Deer Mouse	Peromyscus maniculatus	7/31/2009	6.965151	-23.23529	39.058544	-114.304879
Deer Mouse	Peromyscus maniculatus	7/31/2009	7.054292	-23.62412	39.052732	-114.317872
Deer Mouse	Peromyscus maniculatus	7/31/2009	7.401154	-19.78622	39.049625	-114.320731
Deer Mouse	Peromyscus maniculatus	7/31/2009	8.219979	-22.81872	39.054902	-114.305788
Deer Mouse	Peromyscus maniculatus	8/4/2009	5.177035	-22.54911	39.054713	-114.305751
Deer Mouse	Peromyscus maniculatus	8/4/2009	6.077963	-21.77498	38.912486	-114.170027
Deer Mouse	Peromyscus maniculatus	8/4/2009	6.342219	-23.14182	39.052732	-114.317872
Deer Mouse	Peromyscus maniculatus	8/4/2009	6.818532	-18.55555	39.049819	-114.320713
Deer Mouse	Peromyscus maniculatus	8/4/2009	7.050134	-23.33208	39.053339	-114.31832
Deer Mouse	Peromyscus maniculatus	8/4/2009	7.315026	-22.42593	39.052506	-114.321747
Deer Mouse	Peromyscus maniculatus	8/4/2009	7.617436	-24.19721	39.054826	-114.319125
Deer Mouse	Peromyscus	8/4/2009	8.425421	-23.83762	39.050666	-114.315845

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/5/2009	2.988821	-21.0507	39.052351	-114.317671
Deer Mouse	Peromyscus maniculatus	8/5/2009	3.674285	-21.8933	38.912408	-114.15452
Deer Mouse	Peromyscus maniculatus	8/5/2009	5.570894	-23.42722	39.054018	-114.311386
Deer Mouse	Peromyscus maniculatus	8/5/2009	5.6068	-23.59723	39.051591	-114.316726
Deer Mouse	Peromyscus maniculatus	8/5/2009	6.049414	-23.27401	39.049819	-114.320713
Deer Mouse	Peromyscus maniculatus	8/5/2009	6.300363	-18.56861	39.050752	-114.316329
Deer Mouse	Peromyscus maniculatus	8/5/2009	6.693333	-19.18651	39.051061	-114.316488
Deer Mouse	Peromyscus maniculatus	8/5/2009	7.248136	-23.69792	39.050568	-114.32128
Deer Mouse	Peromyscus maniculatus	8/5/2009	11.11341	-22.26993	39.054495	-114.305904
Deer Mouse	Peromyscus maniculatus	8/6/2009	2.196607	-20.54056	38.912415	-114.170061
Deer Mouse	Peromyscus maniculatus	8/6/2009	4.884455	-21.65427	38.91246	-114.154496
Deer Mouse	Peromyscus maniculatus	8/6/2009	6.824336	-23.11217	39.054495	-114.305904
Deer Mouse	Peromyscus maniculatus	8/6/2009	6.855862	-21.57037	39.058544	-114.304879
Deer Mouse	Peromyscus maniculatus	8/6/2009	7.554384	-23.92333	39.049819	-114.320713
Deer Mouse	Peromyscus maniculatus	8/6/2009	7.623765	-24.24738	39.054283	-114.318892
Deer Mouse	Peromyscus	8/7/2009	6.289787	-23.75053	38.913712	-114.151231

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/7/2009	6.331103	-23.74708	38.913744	-114.151134
Deer Mouse	Peromyscus maniculatus	8/7/2009	7.28651	-21.34509	38.91521	-114.155707
Deer Mouse	Peromyscus maniculatus	8/7/2009	8.484558	-22.21197	39.049331	-114.320617
Deer Mouse	Peromyscus maniculatus	8/7/2009	12.38992	-18.51079	39.051904	-114.317128
Deer Mouse	Peromyscus maniculatus	8/7/2009	14.9156	-22.02258	39.053518	-114.311125
Deer Mouse	Peromyscus maniculatus	8/11/2009	4.185209	-22.04187	38.909841	-114.155257
Deer Mouse	Peromyscus maniculatus	8/12/2009	4.054001	-21.34208	38.912825	-114.183204
Deer Mouse	Peromyscus maniculatus	8/12/2009	4.363652	-24.2963	38.914433	-114.186438
Deer Mouse	Peromyscus maniculatus	8/12/2009	4.677144	-19.1982	38.914799	-114.185913
Deer Mouse	Peromyscus maniculatus	8/12/2009	5.226477	-23.03419	38.914856	-114.186813
Deer Mouse	Peromyscus maniculatus	8/12/2009	6.435994	-22.77984	39.016724	-114.212554
Deer Mouse	Peromyscus maniculatus	8/12/2009	7.476995	-21.22147	38.914292	-114.18668
Deer Mouse	Peromyscus maniculatus	8/12/2009	9.732738	-23.01946	39.009941	-114.208302
Deer Mouse	Peromyscus maniculatus	8/12/2009	10.65492	-21.5084	39.008871	-114.211025
Deer Mouse	Peromyscus maniculatus	8/13/2009	4.508913	-22.97123	38.911256	-114.170477
Deer Mouse	Peromyscus	8/13/2009	5.86363	-22.70851	38.913124	-114.187905

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/13/2009	6.403151	-21.14775	38.911472	-114.170356
Deer Mouse	Peromyscus maniculatus	8/13/2009	6.410499	-22.50186	38.913761	-114.187385
Deer Mouse	Peromyscus maniculatus	8/13/2009	6.833513	-21.32864	38.912546	-114.188784
Deer Mouse	Peromyscus maniculatus	8/13/2009	8.886282	-21.90605	38.914904	-114.18675
Deer Mouse	Peromyscus maniculatus	8/14/2009	4.502208	-22.42847	38.918467	-114.185376
Deer Mouse	Peromyscus maniculatus	8/14/2009	4.633996	-21.20403	38.913712	-114.151231
Deer Mouse	Peromyscus maniculatus	8/14/2009	4.804887	-19.94896	39.006894	-114.207694
Deer Mouse	Peromyscus maniculatus	8/14/2009	5.312154	-22.1119	38.913761	-114.187385
Deer Mouse	Peromyscus maniculatus	8/14/2009	6.021315	-24.38952	38.913678	-114.151142
Deer Mouse	Peromyscus maniculatus	8/14/2009	8.136458	-23.19547	38.913103	-114.177826
Deer Mouse	Peromyscus maniculatus	8/14/2009	8.470115	-21.90977	39.011486	-114.207797
Deer Mouse	Peromyscus maniculatus	8/17/2009	4.101567	-20.84795	38.917098	-114.186824
Deer Mouse	Peromyscus maniculatus	8/17/2009	4.726219	-21.57655	38.914799	-114.185913
Deer Mouse	Peromyscus maniculatus	8/17/2009	5.689785	-23.31503	38.913931	-114.187189
Deer Mouse	Peromyscus maniculatus	8/17/2009	6.907645	-22.06073	38.911811	-114.189601
Deer Mouse	Peromyscus	8/17/2009	6.996802	-21.49035	38.912733	-114.183099

	maniculatus					
Deer Mouse	Peromyscus maniculatus	8/17/2009	7.136867	-20.88727	38.914433	-114.186438
Deer Mouse	Peromyscus maniculatus	8/17/2009	7.36514	-22.2451	38.914856	-114.186813
Deer Mouse	Peromyscus maniculatus	8/18/2009	5.885243	-21.65117	38.916699	-114.186834
Deer Mouse	Peromyscus maniculatus	8/18/2009	7.213492	-21.41547	38.912319	-114.18889
Deer Mouse	Peromyscus maniculatus	8/19/2009	4.415086	-22.21346	38.914433	-114.186438
Deer Mouse	Peromyscus maniculatus	8/19/2009	4.519195	-21.68712	38.913761	-114.187385
Deer Mouse	Peromyscus maniculatus	8/19/2009	7.550138	-22.38319	38.91482	-114.18609
Deer Mouse	Peromyscus maniculatus	8/19/2009	9.517506	-22.0119	38.913103	-114.177826
Deer Mouse	Peromyscus maniculatus	8/20/2009	4.982955	-22.7272	38.915874	-114.17712
Deer Mouse	Peromyscus maniculatus	8/20/2009	5.657098	-23.38588	38.915037	-114.186671
Desert woodrat	Neotoma lepida	7/25/2007	4.368113	-23.88956	38.915154	-114.153951
Desert woodrat	Neotoma lepida	8/2/2007	8.758889	-22.36009	39.015161	-114.215133
Desert woodrat	Neotoma lepida	8/6/2007	3.148909	-23.98166	38.919087	-114.151654
Desert woodrat	Neotoma lepida	8/8/2007	3.373109	-23.3075	38.918409	-114.150574
Desert woodrat	Neotoma lepida	8/17/2007	8.916844	-18.69199	39.015466	-114.214875
Desert woodrat	Neotoma lepida	8/14/2009	3.00336	-25.01767	38.912415	-114.169771
Desert woodrat	Neotoma lepida	8/18/2009	3.545521	-22.96411	38.914971	-114.183207
Desert woodrat	Neotoma lepida	8/18/2009	3.933317	-23.50078	38.916623	-114.18383
Desert woodrat	Neotoma lepida	8/20/2009	2.097643	-24.21508	38.917015	-114.184254

Ermine	Mustela erminea	8/7/2007	10.24282	-22.79973	39.054117	-114.305816
Great Basin pocket mouse	Perognathus parvus	7/6/2007	7.002164	-17.73744	39.053014	-114.313735
Great Basin pocket mouse	Perognathus parvus	7/23/2007	4.127044	-23.78102	39.057944	-114.304809
Great Basin pocket mouse	Perognathus parvus	7/24/2007	2.359441	-21.99071	39.051747	-114.316963
Great Basin pocket mouse	Perognathus parvus	7/27/2007	2.916244	-22.03497	39.055993	-114.312119
Great Basin pocket mouse	Perognathus parvus	8/8/2007	4.23989	-22.13313	39.048777	-114.320435
Great Basin pocket mouse	Perognathus parvus	8/10/2007	3.036206	-21.06274	39.052528	-114.311007
Great Basin pocket mouse	Perognathus parvus	8/14/2007	5.961035	-20.8048	39.014152	-114.21677
Great Basin pocket mouse	Perognathus parvus	8/15/2007	4.94746	-22.61455	38.911294	-114.154833
Great Basin pocket mouse	Perognathus parvus	8/15/2007	6.072864	-20.65442	39.015616	-114.214696
Great Basin pocket mouse	Perognathus parvus	8/17/2007	5.376476	-22.51743	38.911147	-114.153621
Great Basin pocket mouse	Perognathus parvus	8/20/2007	2.118193	-22.85578	38.914012	-114.151583
Great Basin pocket mouse	Perognathus parvus	8/24/2007	7.416842	-21.6183	39.015253	-114.209817
Great Basin pocket mouse	Perognathus parvus	8/24/2007	8.239291	-20.1563	39.015057	-114.21327
Great Basin pocket mouse	Perognathus parvus	8/27/2007	8.62256	-19.78976	39.016249	-114.209405
Great Basin pocket mouse	Perognathus parvus	9/5/2007	4.821399	-22.50176	38.919265	-114.142124
Great Basin	Perognathus parvus	9/14/2007	4.876297	-22.46939	38.919294	-114.140793

pocket mouse						
Great Basin pocket mouse	Perognathus parvus	7/8/2008	7.369168	-20.29197	39.00948	-114.212434
Great Basin pocket mouse	Perognathus parvus	7/9/2008	7.804378	-19.57659	39.010155	-114.212407
Great Basin pocket mouse	Perognathus parvus	7/9/2008	8.117269	-21.5036	39.018121	-114.127892
Great Basin pocket mouse	Perognathus parvus	7/10/2008	9.214171	-21.76491	39.016172	-114.12483
Great Basin pocket mouse	Perognathus parvus	7/10/2008	10.06252	-21.11348	39.015864	-114.127087
Great Basin pocket mouse	Perognathus parvus	7/29/2008	5.5487	-18.91378	39.05552	-114.311997
Great Basin pocket mouse	Perognathus parvus	7/29/2008	8.685892	-20.52056	39.019239	-114.12663
Great Basin pocket mouse	Perognathus parvus	7/30/2008	2.784213	-22.87304	39.049625	-114.320731
Great Basin pocket mouse	Perognathus parvus	7/30/2008	3.19064	-21.90457	39.054713	-114.305751
Great Basin pocket mouse	Perognathus parvus	7/31/2008	6.13537	-21.19625	39.054607	-114.305879
Great Basin pocket mouse	Perognathus parvus	7/31/2008	6.946492	-23.06575	39.019663	-114.125659
Great Basin pocket mouse	Perognathus parvus	7/31/2008	8.321561	-22.61855	39.017929	-114.124599
Great Basin pocket mouse	Perognathus parvus	8/7/2008	5.259533	-21.5371	39.016364	-114.213593
Great Basin pocket mouse	Perognathus parvus	8/7/2008	7.093138	-16.95373	39.016724	-114.212554
Great Basin pocket mouse	Perognathus parvus	8/8/2008	2.143262	-18.47848	39.056569	-114.312338
Great Basin	Perognathus parvus	8/8/2008	4.961128	-21.796	39.008871	-114.211025

pocket mouse						
Great Basin pocket mouse	Perognathus parvus	8/8/2008	6.807967	-20.74358	39.010632	-114.212106
Great Basin pocket mouse	Perognathus parvus	8/9/2008	2.74	-21.6	39.019851	-114.126767
Great Basin pocket mouse	Perognathus parvus	8/10/2008	6.417541	-23.14618	39.019851	-114.126767
Great Basin pocket mouse	Perognathus parvus	8/10/2008	8.00491	-23.31932	39.016411	-114.127679
Great Basin pocket mouse	Perognathus parvus	8/10/2008	8.565632	-21.58122	39.019078	-114.126607
Great Basin pocket mouse	Perognathus parvus	8/10/2008	8.848112	-22.56111	39.016868	-114.127737
Great Basin pocket mouse	Perognathus parvus	8/10/2008	10.60069	-21.96264	39.01756	-114.127756
Great Basin pocket mouse	Perognathus parvus	8/12/2008	9.628309	-22.12232	39.009563	-114.211344
Great Basin pocket mouse	Perognathus parvus	8/15/2008	6.283645	-22.64579	39.010606	-114.212121
Great Basin pocket mouse	Perognathus parvus	6/29/2009	1.624219	-20.30257	38.931341	-114.25221
Great Basin pocket mouse	Perognathus parvus	6/29/2009	2.263272	-20.28279	38.973817	-114.175538
Great Basin pocket mouse	Perognathus parvus	6/29/2009	2.578384	-20.72666	38.974242	-114.175336
Great Basin pocket mouse	Perognathus parvus	6/29/2009	2.884246	-20.4757	38.976398	-114.179802
Great Basin pocket mouse	Perognathus parvus	6/29/2009	2.934419	-23.15083	38.975676	-114.179578
Great Basin pocket mouse	Perognathus parvus	6/29/2009	3.18353	-21.71495	38.973871	-114.17575
Great Basin	Perognathus parvus	6/30/2009	1.705765	-21.25303	38.931845	-114.25244

pocket mouse						
Great Basin pocket mouse	Perognathus parvus	6/30/2009	2.484287	-20.66278	38.973594	-114.174286
Great Basin pocket mouse	Perognathus parvus	6/30/2009	2.514721	-20.4175	38.974451	-114.176411
Great Basin pocket mouse	Perognathus parvus	6/30/2009	2.798041	-20.38943	38.97419	-114.174706
Great Basin pocket mouse	Perognathus parvus	6/30/2009	2.967623	-22.83319	38.974023	-114.176589
Great Basin pocket mouse	Perognathus parvus	6/30/2009	3.023427	-20.63768	38.976191	-114.178973
Great Basin pocket mouse	Perognathus parvus	6/30/2009	3.466425	-22.51349	38.973817	-114.175538
Great Basin pocket mouse	Perognathus parvus	7/9/2009	6.573711		39.009463	-114.211742
Great Basin pocket mouse	Perognathus parvus	7/17/2009	2.684899	-20.70821	39.017208	-114.225226
Great Basin pocket mouse	Perognathus parvus	7/30/2009	10.00277	-21.00115	39.014238	-114.216533
Great Basin pocket mouse	Perognathus parvus	7/31/2009	4.557361	-21.91613	39.01493	-114.215504
Great Basin pocket mouse	Perognathus parvus	8/4/2009	2.742311	-21.6044	39.058092	-114.304731
Great Basin pocket mouse	Perognathus parvus	8/13/2009	6.332572	-22.43801	39.007315	-114.207845
Great Basin pocket mouse	Perognathus parvus	8/14/2009	3.70011	-21.02956	38.911589	-114.170243
Great Basin pocket mouse	Perognathus parvus	8/20/2009	6.369412	-19.53469	38.915887	-114.183548
Least chipmunk	Tamias minimus	7/31/2007	5.251141	-23.25952	39.052912	-114.317973
Least chipmunk	Tamias minimus	7/31/2007	5.773133	-21.56551	39.053718	-114.311203

Least chipmunk	Tamias minimus	8/1/2007	5.997909	-23.47193	39.054496	-114.318945
Least chipmunk	Tamias minimus	8/9/2007	4.108156	-21.82041	39.050564	-114.316118
Least chipmunk	Tamias minimus	8/9/2007	5.408543	-22.3379	39.052541	-114.310859
Least chipmunk	Tamias minimus	8/9/2007	5.562809	-21.73538	39.048777	-114.320435
Least chipmunk	Tamias minimus	8/5/2008	3.735557	-20.7444	39.054275	-114.311532
Least chipmunk	Tamias minimus	8/5/2008	4.973225	-20.65793	39.056372	-114.312269
Least chipmunk	Tamias minimus	8/7/2008	5.207436	-21.04865	39.052528	-114.311007
Least chipmunk	Tamias minimus	8/7/2008	5.66742	-20.92537	39.055051	-114.311844
Least chipmunk	Tamias minimus	7/28/2009	2.728128	-23.7498	39.057298	-114.30531
Least chipmunk	Tamias minimus	8/5/2009	4.253778	-23.12909	39.052891	-114.321822
Long-tailed vole	Microtus longicaudus	7/29/2009	7.898753	-24.91628	39.048828	-114.320417
Long-tailed vole	Microtus longicaudus	7/30/2009	5.956785	-25.35329	39.050564	-114.316118
Long-tailed vole	Microtus longicaudus	7/30/2009	6.6024	-25.63694	39.048817	-114.320384
Long-tailed vole	Microtus longicaudus	7/31/2009	5.419102	-24.1359	39.055237	-114.305646
Montane vole	Microtus montanus	8/3/2007	7.208757	-25.11004	39.048817	-114.320384
Montane vole	Microtus montanus	8/15/2007	8.945706	-24.74035	39.009956	-114.207703
Montane vole	Microtus montanus	8/16/2007	8.338357	-25.57217	39.009941	-114.208302
Montane vole	Microtus montanus	8/17/2007	8.742361	-26.867	39.009921	-114.207706
Montane vole	Microtus montanus	9/25/2007	4.460239	-24.95633	39.052582	-114.301443
Montane vole	Microtus montanus	6/30/2009	4.800835	-25.58395	38.92929	-114.252853
Montane vole	Microtus montanus	7/16/2009	5.962918	-26.89171	39.015236	-114.235512
Montane vole	Microtus montanus	7/16/2009	5.995502	-26.2796	39.014819	-114.235008
Montane vole	Microtus montanus	7/16/2009	6.98103	-26.02515	39.015245	-114.235858
Montane vole	Microtus montanus	7/16/2009	7.276179	-25.72821	39.01538	-114.235853
Montane vole	Microtus montanus	7/16/2009	8.805496	-26.12714	39.014561	-114.235538

Montane vole	Microtus montanus	7/17/2009	6.725508	-25.2749	39.01524	-114.235685
Montane vole	Microtus montanus	7/17/2009	6.895323	-25.22458	39.014819	-114.235008
Montane vole	Microtus montanus	7/17/2009	7.861409	-25.98158	39.015245	-114.235858
Montane vole	Microtus montanus	7/28/2009	7.169354	-22.99572	39.053893	-114.311306
Pinon mouse	Peromyscus truei	7/23/2007	5.95735	-21.9061	38.91858	-114.151099
Pinon mouse	Peromyscus truei	7/23/2007	6.561548	-21.32696	38.918633	-114.151246
Pinon mouse	Peromyscus truei	7/23/2007	6.973312	-19.59247	38.914957	-114.154702
Pinon mouse	Peromyscus truei	7/23/2007	7.06084	-20.23782	38.918051	-114.149858
Pinon mouse	Peromyscus truei	7/23/2007	8.583228	-20.62187	38.917425	-114.148677
Pinon mouse	Peromyscus truei	7/23/2007	8.823957	-20.14091	38.917485	-114.148914
Pinon mouse	Peromyscus truei	7/23/2007	9.758331	-21.19611	38.911256	-114.170477
Pinon mouse	Peromyscus truei	7/23/2007	10.00111	-20.37656	38.914995	-114.153839
Pinon mouse	Peromyscus truei	7/24/2007	6.575315	-20.27304	38.919087	-114.151654
Pinon mouse	Peromyscus truei	7/24/2007	7.29205	-20.15164	38.908201	-114.15596
Pinon mouse	Peromyscus truei	7/24/2007	8.182445	-19.9579	38.915439	-114.156338
Pinon mouse	Peromyscus truei	7/24/2007	8.281064	-19.7906	38.917158	-114.148098
Pinon mouse	Peromyscus truei	7/24/2007	9.241467	-20.21401	38.913608	-114.151119
Pinon mouse	Peromyscus truei	7/24/2007	9.829157	-21.10833	38.914573	-114.152722
Pinon mouse	Peromyscus truei	7/25/2007	5.411223	-20.20847	38.908309	-114.172969
Pinon mouse	Peromyscus truei	7/25/2007	6.188697	-20.4427	38.908765	-114.17258
Pinon mouse	Peromyscus truei	7/25/2007	7.478952	-20.11267	38.918256	-114.150043
Pinon mouse	Peromyscus truei	7/25/2007	7.962119	-19.14661	38.91508	-114.153848
Pinon mouse	Peromyscus truei	7/26/2007	5.888425	-20.13612	38.915252	-114.155891
Pinon mouse	Peromyscus truei	7/26/2007	6.026938	-19.55046	38.909501	-114.171532
Pinon mouse	Peromyscus truei	7/27/2007	5.460006	-19.59065	38.910529	-114.170912

Pinon mouse	Peromyscus truei	7/27/2007	7.579588	-20.01988	38.91508	-114.153848
Pinon mouse	Peromyscus truei	7/30/2007	9.183097	-20.79794	39.016364	-114.213593
Pinon mouse	Peromyscus truei	7/30/2007	9.412885	-19.87131	39.005424	-114.207662
Pinon mouse	Peromyscus truei	7/30/2007	11.16561	-20.15681	39.016087	-114.21391
Pinon mouse	Peromyscus truei	7/31/2007	8.93712	-19.91736	39.005424	-114.207662
Pinon mouse	Peromyscus truei	8/2/2007	10.39337	-20.65535	39.016441	-114.213388
Pinon mouse	Peromyscus truei	8/3/2007	6.055733	-19.0529	39.01493	-114.215504
Pinon mouse	Peromyscus truei	8/3/2007	9.245373	-19.98719	39.005424	-114.207662
Pinon mouse	Peromyscus truei	8/6/2007	7.444396	-19.95428	38.909609	-114.171434
Pinon mouse	Peromyscus truei	8/6/2007	7.883557	-19.69661	38.915182	-114.154967
Pinon mouse	Peromyscus truei	8/7/2007	7.339345	-20.1685	38.917485	-114.148914
Pinon mouse	Peromyscus truei	8/7/2007	8.225114	-20.14958	38.914995	-114.153839
Pinon mouse	Peromyscus truei	8/7/2007	9.812535	-20.7932	38.914573	-114.152722
Pinon mouse	Peromyscus truei	8/9/2007	7.687095	-20.15511	38.918205	-114.15047
Pinon mouse	Peromyscus truei	8/9/2007	7.882725	-20.44933	38.91108	-114.170645
Pinon mouse	Peromyscus truei	8/13/2007	5.151894	-19.13808	39.007506	-114.207925
Pinon mouse	Peromyscus truei	8/13/2007	7.267223	-19.26365	38.908838	-114.172461
Pinon mouse	Peromyscus truei	8/13/2007	7.716421	-21.54971	38.908378	-114.15598
Pinon mouse	Peromyscus truei	8/13/2007	9.146537	-19.47388	39.006265	-114.210655
Pinon mouse	Peromyscus truei	8/13/2007	9.236796	-20.30684	39.006087	-114.210666
Pinon mouse	Peromyscus truei	8/14/2007	5.238907	-18.67319	39.007506	-114.207925
Pinon mouse	Peromyscus truei	8/15/2007	8.631691	-20.23569	38.914995	-114.153839
Pinon mouse	Peromyscus truei	8/23/2007	8.858677	-19.35583	39.015383	-114.209951
Pinon mouse	Peromyscus truei	8/23/2007	9.149601	-20.44639	39.014697	-114.213103
Pinon mouse	Peromyscus truei	8/23/2007	9.753953	-20.08349	39.015273	-114.211523

Pinon mouse	Peromyscus truei	8/23/2007	10.01521	-20.7614	39.015223	-114.210869
Pinon mouse	Peromyscus truei	8/23/2007	10.67696	-20.46778	39.016833	-114.210364
Pinon mouse	Peromyscus truei	8/23/2007	10.6839	-20.21205	39.01568	-114.208525
Pinon mouse	Peromyscus truei	8/23/2007	12.11039	-20.01074	39.015437	-114.208075
Pinon mouse	Peromyscus truei	8/27/2007	5.15073	-20.30186	39.013876	-114.208627
Pinon mouse	Peromyscus truei	8/27/2007	9.829611	-20.09029	39.015057	-114.21327
Pinon mouse	Peromyscus truei	8/30/2007	10.71702	-20.94484	39.015057	-114.21327
Pinon mouse	Peromyscus truei	7/30/2008	8.608435	-19.10158	38.91234	-114.170127
Pinon mouse	Peromyscus truei	8/6/2008	10.00347	-19.43406	39.014178	-114.20822
Pinon mouse	Peromyscus truei	8/8/2008	11.52258	-19.24791	39.016724	-114.212554
Pinon mouse	Peromyscus truei	8/13/2008	7.439003	-20.38243	38.91508	-114.153848
Pinon mouse	Peromyscus truei	7/8/2009	8.884962	-20.82833	39.01569	-114.22353
Pinon mouse	Peromyscus truei	7/14/2009	10.93606	-20.47964	39.011172	-114.218811
Pinon mouse	Peromyscus truei	7/28/2009	8.546821	-21.89214	39.008597	-114.208426
Pinon mouse	Peromyscus truei	7/28/2009	9.877074	-19.28981	39.015161	-114.215133
Pinon mouse	Peromyscus truei	7/28/2009	10.05008	-19.97731	39.014821	-114.215617
Pinon mouse	Peromyscus truei	7/28/2009	10.8329	-19.82887	39.016087	-114.21391
Pinon mouse	Peromyscus truei	7/28/2009	11.16896	-20.51381	39.015616	-114.214696
Pinon mouse	Peromyscus truei	7/31/2009	11.00513	-18.88929	39.015616	-114.214696
Pinon mouse	Peromyscus truei	8/4/2009	6.983578	-20.71881	38.915142	-114.155224
Pinon mouse	Peromyscus truei	8/4/2009	9.104695	-19.74962	38.914702	-114.152913
Pinon mouse	Peromyscus truei	8/5/2009	8.744775	-21.13142	38.915035	-114.154468
Pinon mouse	Peromyscus truei	8/7/2009	8.227821	-20.73751	38.908309	-114.172969
Pinon mouse	Peromyscus truei	8/12/2009	5.689861	-20.43146	38.908953	-114.17217
Pinon mouse	Peromyscus truei	8/12/2009	7.765323	-20.7535	38.912086	-114.189455

Pinon mouse	Peromyscus truei	8/12/2009	9.097131	-21.1501	38.908624	-114.172792
Pinon mouse	Peromyscus truei	8/12/2009	9.098841	-20.1593	38.917222	-114.186643
Pinon mouse	Peromyscus truei	8/13/2009	7.839333	-19.82451	38.913568	-114.187536
Pinon mouse	Peromyscus truei	8/13/2009	7.853324	-20.21408	38.917638	-114.187038
Pinon mouse	Peromyscus truei	8/13/2009	7.858396	-19.59668	38.918209	-114.186506
Pinon mouse	Peromyscus truei	8/13/2009	8.672278	-19.95134	38.917485	-114.148914
Pinon mouse	Peromyscus truei	8/13/2009	8.7294	-19.1579	38.915776	-114.186662
Pinon mouse	Peromyscus truei	8/13/2009	9.487106	-20.44374	38.915541	-114.186588
Pinon mouse	Peromyscus truei	8/14/2009	7.609963	-19.64674	38.916091	-114.186735
Pinon mouse	Peromyscus truei	8/14/2009	8.010694	-21.02521	38.909501	-114.171532
Pinon mouse	Peromyscus truei	8/14/2009	8.106653	-20.95362	38.90839	-114.172815
Pinon mouse	Peromyscus truei	8/14/2009	12.08597	-20.8199	39.014544	-114.216013
Pinon mouse	Peromyscus truei	8/17/2009	6.9173	-21.19068	38.911596	-114.189805
Pinon mouse	Peromyscus truei	8/17/2009	6.991948	-20.1615	38.912748	-114.18825
Pinon mouse	Peromyscus truei	8/17/2009	7.383984	-19.98922	38.914456	-114.183172
Pinon mouse	Peromyscus truei	8/17/2009	7.676281	-20.27116	38.916822	-114.177272
Pinon mouse	Peromyscus truei	8/17/2009	8.102639	-20.60753	38.913836	-114.182913
Pinon mouse	Peromyscus truei	8/17/2009	8.159084	-19.61884	38.915874	-114.17712
Pinon mouse	Peromyscus truei	8/17/2009	8.737803	-20.13561	38.917133	-114.177295
Pinon mouse	Peromyscus truei	8/17/2009	9.152223	-20.61852	38.918289	-114.186208
Pinon mouse	Peromyscus truei	8/17/2009	9.311037	-19.9781	38.915547	-114.183342
Pinon mouse	Peromyscus truei	8/17/2009	9.342648	-19.90582	38.914457	-114.177433
Pinon mouse	Peromyscus truei	8/17/2009	9.762077	-20.00658	38.916335	-114.186663
Pinon mouse	Peromyscus truei	8/18/2009	7.467709	-20.19222	38.915547	-114.183342
Pinon mouse	Peromyscus truei	8/18/2009	7.53154	-20.39214	38.916761	-114.183964

Pinon mouse	Peromyscus truei	8/18/2009	8.181903	-21.02111	38.912748	-114.18825
Pinon mouse	Peromyscus truei	8/18/2009	8.186094	-19.93849	38.918467	-114.185376
Pinon mouse	Peromyscus truei	8/18/2009	8.253662	-19.40256	38.915694	-114.183438
Pinon mouse	Peromyscus truei	8/18/2009	8.83609	-20.19908	38.916091	-114.186735
Pinon mouse	Peromyscus truei	8/19/2009	8.071068	-21.08056	38.915349	-114.183289
Pinon mouse	Peromyscus truei	8/19/2009	9.154716	-19.7488	38.91132	-114.190026
sagebrush vole	Lemmiscus curtatus	7/31/2008	5.064013	-24.62531	39.057298	-114.30531
sagebrush vole	Lemmiscus curtatus	7/29/2009	7.399413	-23.06217	39.054713	-114.305751
sagebrush vole	Lemmiscus curtatus	7/30/2009	3.244785	-24.5412	39.054464	-114.305891
sagebrush vole	Lemmiscus curtatus	7/30/2009	4.0602	-25.01876	39.056372	-114.312269
sagebrush vole	Lemmiscus curtatus	7/30/2009	4.216303	-24.57949	39.055824	-114.312069
sagebrush vole	Lemmiscus curtatus	7/30/2009	5.543403	-24.58146	39.054902	-114.305788
sagebrush vole	Lemmiscus curtatus	7/31/2009	5.202004	-25.38463	39.056372	-114.312269
Uinta chipmunk	Tamias umbrinus	7/26/2007	3.196771	-22.89935	39.052506	-114.321747
Uinta chipmunk	Tamias umbrinus	7/26/2007	5.360356	-23.79742	39.052912	-114.317973
Uinta chipmunk	Tamias umbrinus	7/26/2007	6.871234	-18.7848	39.050752	-114.316329
Uinta chipmunk	Tamias umbrinus	7/27/2007	5.551934	-22.28217	39.054902	-114.305788
Uinta chipmunk	Tamias umbrinus	7/27/2007	7.293907	-21.3523	39.050752	-114.316329
Uinta chipmunk	Tamias umbrinus	7/31/2007	4.667814	-19.75031	39.054181	-114.305839
Uinta chipmunk	Tamias umbrinus	8/14/2007	7.007234	-20.02896	39.006666	-114.210618
Uinta chipmunk	Tamias umbrinus	7/30/2008	4.791104	-21.71902	39.055321	-114.311887
Uinta chipmunk	Tamias umbrinus	7/22/2009	4.932795	-19.8782	38.901644	-114.300668
Uinta chipmunk	Tamias umbrinus	7/23/2009	5.122986	-19.59842	38.896373	-114.29707
Uinta chipmunk	Tamias umbrinus	7/23/2009	6.301351	-18.57334	38.903903	-114.301088
Uinta chipmunk	Tamias umbrinus	7/23/2009	6.721156	-20.66058	38.903502	-114.298556

Uinta chipmunk	Tamias umbrinus	7/23/2009	6.940385	-22.0672	38.903903	-114.301088
Uinta chipmunk	Tamias umbrinus	7/23/2009	8.093259	-17.70733	38.903642	-114.301139
Uinta chipmunk	Tamias umbrinus	7/23/2009	8.856613	-18.35106	38.903959	-114.301589
Unknown shrew	Sorex ssp.	7/29/2009	7.195693	-22.88084	39.048774	-114.320402
Vagrant shrew	Sorex vagrans	7/14/2009	12.14205	-22.57029	39.015236	-114.235512
Vagrant shrew	Sorex vagrans	7/15/2009	12.07572	-22.37323	39.015236	-114.235512
Vagrant shrew	Sorex vagrans	7/15/2009	12.38977	-23.20951	39.014815	-114.234835
Vagrant shrew	Sorex vagrans	7/16/2009	11.37427	-23.63013	39.01497	-114.235695
Western Harvest mouse	Reithrodontomys megalotis	7/24/2007	11.39949	-16.32971	38.913826	-114.151403
Western Harvest mouse	Reithrodontomys megalotis	7/24/2007	16.03374	-20.32857	38.910483	-114.154998
Western Harvest mouse	Reithrodontomys megalotis	7/25/2007	10.91136	-21.38771	38.916727	-114.147276
Western Harvest mouse	Reithrodontomys megalotis	7/26/2007	5.24521	-23.57458	38.912566	-114.154501
Western Harvest mouse	Reithrodontomys megalotis	7/26/2007	7.170893	-23.0897	38.910666	-114.154952
Western Harvest mouse	Reithrodontomys megalotis	7/26/2007	7.291045	-22.34373	38.911726	-114.170322
Western Harvest mouse	Reithrodontomys megalotis	7/27/2007	10.98034	-16.42208	38.913826	-114.151403
Western Harvest mouse	Reithrodontomys megalotis	7/30/2007	9.64456	-21.73253	39.010311	-114.211868
Western Harvest mouse	Reithrodontomys megalotis	7/30/2007	15.93761	-17.92097	39.009826	-114.211409
Western Harvest mouse	Reithrodontomys megalotis	7/31/2007	7.507497	-22.15205	39.009826	-114.211409
Western Harvest mouse	Reithrodontomys megalotis	7/31/2007	9.344599	-20.48134	39.009941	-114.208302

Western Harvest mouse	Reithrodontomys megalotis	8/1/2007	7.652794	-23.40121	39.009844	-114.20776
Western Harvest mouse	Reithrodontomys megalotis	8/1/2007	9.202818	-21.23135	39.010606	-114.212121
Western Harvest mouse	Reithrodontomys megalotis	8/2/2007	7.35817	-22.79912	39.009844	-114.20776
Western Harvest mouse	Reithrodontomys megalotis	8/2/2007	7.755902	-21.52554	39.010441	-114.21198
Western Harvest mouse	Reithrodontomys megalotis	8/2/2007	8.003236	-21.91636	39.010311	-114.211868
Western Harvest mouse	Reithrodontomys megalotis	8/2/2007	9.516879	-20.06931	39.010494	-114.21207
Western Harvest mouse	Reithrodontomys megalotis	8/2/2007	13.08798	-14.71638	39.013902	-114.216995
Western Harvest mouse	Reithrodontomys megalotis	8/3/2007	8.444846	-23.58735	39.009844	-114.20776
Western Harvest mouse	Reithrodontomys megalotis	8/3/2007	8.782774	-23.81059	39.01038	-114.207719
Western Harvest mouse	Reithrodontomys megalotis	8/3/2007	12.60945	-21.9781	39.013711	-114.217171
Western Harvest mouse	Reithrodontomys megalotis	8/6/2007	6.400612	-22.77939	38.913821	-114.151304
Western Harvest mouse	Reithrodontomys megalotis	8/6/2007	8.378827	-24.75126	38.912026	-114.170263
Western Harvest mouse	Reithrodontomys megalotis	8/8/2007	10.809	-23.55245	38.912026	-114.170263
Western Harvest mouse	Reithrodontomys megalotis	8/13/2007	6.757509	-23.33441	39.010606	-114.212121
Western Harvest mouse	Reithrodontomys megalotis	8/13/2007	7.668467	-22.50601	39.01386	-114.216997
Western Harvest mouse	Reithrodontomys megalotis	8/13/2007	9.614763	-23.52107	39.010376	-114.211929

Western Harvest mouse	Reithrodontomys megalotis	8/14/2007	6.573447	-23.01991	39.010441	-114.21198
Western Harvest mouse	Reithrodontomys megalotis	8/14/2007	8.224658	-23.33835	39.009921	-114.207706
Western Harvest mouse	Reithrodontomys megalotis	8/14/2007	8.550153	-21.54971	39.014371	-114.21634
Western Harvest mouse	Reithrodontomys megalotis	8/14/2007	8.916844	-23.37984	38.912227	-114.170053
Western Harvest mouse	Reithrodontomys megalotis	8/14/2007	9.119482	-22.98394	39.010846	-114.207861
Western Harvest mouse	Reithrodontomys megalotis	8/14/2007	10.03587	-17.80671	39.010636	-114.207773
Western Harvest mouse	Reithrodontomys megalotis	8/15/2007	11.11589	-18.39612	38.911726	-114.170322
Western Harvest mouse	Reithrodontomys megalotis	8/16/2007	7.637898	-23.6688	39.009936	-114.211519
Western Harvest mouse	Reithrodontomys megalotis	8/16/2007	9.741608	-14.03722	39.010148	-114.20773
Western Harvest mouse	Reithrodontomys megalotis	8/17/2007	6.876788	-22.82275	38.911049	-114.155301
Western Harvest mouse	Reithrodontomys megalotis	8/17/2007	8.200566	-22.38647	39.01386	-114.216997
Western Harvest mouse	Reithrodontomys megalotis	8/20/2007	6.75453	-23.53625	38.911933	-114.16921
Western Harvest mouse	Reithrodontomys megalotis	8/20/2007	7.755427	-21.8875	38.911826	-114.169909
Western Harvest mouse	Reithrodontomys megalotis	8/20/2007	8.460095	-22.46418	38.911957	-114.169745
Western Harvest mouse	Reithrodontomys megalotis	8/20/2007	12.43441	-13.73027	38.911757	-114.153982
Western Harvest mouse	Reithrodontomys megalotis	8/20/2007	12.85701	-14.07712	38.912778	-114.153345

Western Harvest mouse	Reithrodontomys megalotis	8/21/2007	6.709939	-23.00217	39.010441	-114.21198
Western Harvest mouse	Reithrodontomys megalotis	8/22/2007	7.451891	-23.51393	39.010148	-114.20773
Western Harvest mouse	Reithrodontomys megalotis	8/22/2007	8.736819	-21.4183	39.014371	-114.21634
Western Harvest mouse	Reithrodontomys megalotis	9/5/2007	5.543489	-22.16655	38.916841	-114.147125
Western Harvest mouse	Reithrodontomys megalotis	9/5/2007	8.229057	-22.18014	38.912676	-114.153052
Western Harvest mouse	Reithrodontomys megalotis	9/5/2007	13.12322	-13.32294	38.91253	-114.153563
Western Harvest mouse	Reithrodontomys megalotis	9/14/2007	10.75392	-17.44327	38.916594	-114.147844
Western Harvest mouse	Reithrodontomys megalotis	9/15/2007	4.177976	-22.25784	38.919304	-114.141289
Western Harvest mouse	Reithrodontomys megalotis	9/15/2007	6.956799	-23.61922	38.916841	-114.147125
Western Harvest mouse	Reithrodontomys megalotis	9/15/2007	15.43771	-19.7643	38.91663	-114.147773
Western Harvest mouse	Reithrodontomys megalotis	9/17/2007	5.472713	-23.29096	38.912676	-114.153052
Western Harvest mouse	Reithrodontomys megalotis	9/17/2007	8.641868	-23.58039	38.919278	-114.14178
Western Harvest mouse	Reithrodontomys megalotis	7/10/2008	7.122537	-21.97534	39.010277	-114.211883
Western Harvest mouse	Reithrodontomys megalotis	7/10/2008	14.26373	-23.03823	38.985688	-114.242361
Western Harvest mouse	Reithrodontomys megalotis	7/22/2008	7.316547	-23.09794	39.015097	-114.235344
Western Harvest mouse	Reithrodontomys megalotis	7/22/2008	7.591642	-20.65686	39.014958	-114.235176

Western Harvest mouse	Reithrodontomys megalotis	7/22/2008	10.16681	-21.93619	39.014561	-114.235538
Western Harvest mouse	Reithrodontomys megalotis	7/23/2008	7.014209	-22.37709	39.01497	-114.235695
Western Harvest mouse	Reithrodontomys megalotis	7/23/2008	7.045799	-21.34574	39.01538	-114.235853
Western Harvest mouse	Reithrodontomys megalotis	7/23/2008	7.686996	-22.48047	39.015085	-114.234825
Western Harvest mouse	Reithrodontomys megalotis	7/23/2008	9.005654	-24.2748	39.014954	-114.235003
Western Harvest mouse	Reithrodontomys megalotis	7/23/2008	9.858953	-17.81025	39.015376	-114.23568
Western Harvest mouse	Reithrodontomys megalotis	7/23/2008	15.14434	-19.57619	39.014688	-114.235187
Western Harvest mouse	Reithrodontomys megalotis	7/25/2008	7.014515	-21.62515	39.018212	-114.229171
Western Harvest mouse	Reithrodontomys megalotis	7/25/2008	10.11037	-23.48333	39.01495	-114.23483
Western Harvest mouse	Reithrodontomys megalotis	7/29/2008	6.56179	-21.67585	38.987932	-114.234953
Western Harvest mouse	Reithrodontomys megalotis	7/29/2008	6.875304	-22.48338	38.987801	-114.234522
Western Harvest mouse	Reithrodontomys megalotis	7/29/2008	10.68173	-16.52209	38.989752	-114.239984
Western Harvest mouse	Reithrodontomys megalotis	7/29/2008	11.27466	-22.31629	38.988014	-114.234169
Western Harvest mouse	Reithrodontomys megalotis	7/30/2008	8.978569	-22.83743	39.057944	-114.304809
Western Harvest mouse	Reithrodontomys megalotis	7/31/2008	10.2774	-23.03716	38.987645	-114.234948
Western Harvest mouse	Reithrodontomys megalotis	8/7/2008	6.954321	-22.06366	39.055321	-114.311887

Western Harvest mouse	Reithrodontomys megalotis	8/11/2008	10.48529	-20.14262	39.009248	-114.208068
Western Harvest mouse	Reithrodontomys megalotis	8/12/2008	9.370545	-22.24941	39.01386	-114.216997
Western Harvest mouse	Reithrodontomys megalotis	8/14/2008	14.44861	-13.40333	39.010441	-114.21198
Western Harvest mouse	Reithrodontomys megalotis	8/15/2008	9.593279	-22.15486	39.013902	-114.216995
Western Harvest mouse	Reithrodontomys megalotis	6/29/2009	4.021378	-20.77659	38.92705	-114.252399
Western Harvest mouse	Reithrodontomys megalotis	6/29/2009	5.900367		38.929632	-114.25291
Western Harvest mouse	Reithrodontomys megalotis	7/7/2009	5.911493	-23.92129	39.010277	-114.211883
Western Harvest mouse	Reithrodontomys megalotis	7/7/2009	6.815225		39.010146	-114.212061
Western Harvest mouse	Reithrodontomys megalotis	7/7/2009	10.39337		39.01015	-114.212234
Western Harvest mouse	Reithrodontomys megalotis	7/7/2009	14.54944	-13.59337	39.009999	-114.211547
Western Harvest mouse	Reithrodontomys megalotis	7/7/2009	15.37309	-20.95285	39.01002	-114.212413
Western Harvest mouse	Reithrodontomys megalotis	7/7/2009		7.917441	39.010003	-114.21172
Western Harvest mouse	Reithrodontomys megalotis	7/8/2009	8.648567		39.01029	-114.212402
Western Harvest mouse	Reithrodontomys megalotis	7/9/2009	8.615382		39.010007	-114.211894
Western Harvest mouse	Reithrodontomys megalotis	7/10/2009	8.151535		39.010146	-114.212061
Western Harvest mouse	Reithrodontomys megalotis	7/10/2009	8.357903		39.00988	-114.212245

Western Harvest mouse	Reithrodontomys megalotis	7/10/2009	16.51032	-21.96345	39.018208	-114.228998
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	6.774583	-22.13097	39.014954	-114.235003
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	7.156515	-23.75668	39.018022	-114.225367
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	7.188242	-22.67395	39.01495	-114.23483
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	7.469927	-23.21339	39.017216	-114.225572
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	7.57451	-21.33738	39.014565	-114.235711
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	8.946975	-20.23561	39.01511	-114.235863
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	9.056599	-22.25101	39.014975	-114.235868
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	9.060865	-23.83436	39.017744	-114.225032
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	9.165768	-23.53756	39.01522	-114.234819
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	9.477197		39.018771	-114.234519
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	9.754325	-23.61497	39.015105	-114.23569
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	10.69708	-22.79523	39.014987	-114.2326
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	11.5676	-22.14667	39.01511	-114.235863
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	14.00212	-21.38352	39.015228	-114.235166
Western Harvest mouse	Reithrodontomys megalotis	7/14/2009	16.64309	-21.8401	39.015355	-114.234814

Western Harvest mouse	Reithrodontomys megalotis	7/15/2009	4.336063	-22.61991	39.014549	-114.235019
Western Harvest mouse	Reithrodontomys megalotis	7/15/2009	6.860239	-23.23477	39.015224	-114.234993
Western Harvest mouse	Reithrodontomys megalotis	7/15/2009	7.381094	-23.50113	39.017757	-114.225551
Western Harvest mouse	Reithrodontomys megalotis	7/15/2009	7.455273	-25.37074	39.015359	-114.234987
Western Harvest mouse	Reithrodontomys megalotis	7/15/2009	7.659437	-22.96491	39.017478	-114.225216
Western Harvest mouse	Reithrodontomys megalotis	7/15/2009	7.912169	-23.60502	39.017752	-114.225378
Western Harvest mouse	Reithrodontomys megalotis	7/15/2009	8.327295	-23.5389	39.015228	-114.235166
Western Harvest mouse	Reithrodontomys megalotis	7/15/2009	10.09395	-22.51679	39.017466	-114.224696
Western Harvest mouse	Reithrodontomys megalotis	7/16/2009	6.04485	-22.7343	39.014549	-114.235019
Western Harvest mouse	Reithrodontomys megalotis	7/16/2009	6.557123	-23.4353	39.014835	-114.235701
Western Harvest mouse	Reithrodontomys megalotis	7/16/2009	8.440258	-24.73502	39.014975	-114.235868
Western Harvest mouse	Reithrodontomys megalotis	7/16/2009	11.31624	-21.62267	39.015376	-114.23568
Western Harvest mouse	Reithrodontomys megalotis	7/17/2009	8.085524	-22.78581	39.014975	-114.235868
Western Harvest mouse	Reithrodontomys megalotis	7/17/2009	8.771535	-22.5125	39.018002	-114.224502
Western Harvest mouse	Reithrodontomys megalotis	7/28/2009	8.118321	-22.58848	39.009603	-114.208396
Western Harvest mouse	Reithrodontomys megalotis	7/28/2009	9.120495	-21.57544	39.057417	-114.305201

Western Harvest mouse	Reithrodontomys megalotis	7/29/2009	7.748631	-22.07226	39.010311	-114.211868
Western Harvest mouse	Reithrodontomys megalotis	7/29/2009	8.419847	-20.41395	39.009684	-114.208376
Western Harvest mouse	Reithrodontomys megalotis	7/30/2009	7.161363	-22.57433	39.009489	-114.208393
Western Harvest mouse	Reithrodontomys megalotis	7/30/2009	8.396425	-22.90271	39.01386	-114.216997
Western Harvest mouse	Reithrodontomys megalotis	7/31/2009	7.18478	-22.4268	39.009241	-114.208388
Western Harvest mouse	Reithrodontomys megalotis	8/7/2009	12.08962	-23.23622	38.914293	-114.152658
Western Harvest mouse	Reithrodontomys megalotis	8/11/2009	7.528391	-23.19751	39.009684	-114.208376
Western Harvest mouse	Reithrodontomys megalotis	8/11/2009	8.306778	-21.91967	39.010494	-114.21207
Western Harvest mouse	Reithrodontomys megalotis	8/12/2009	7.280671	-23.00835	39.009241	-114.208388
Western Harvest mouse	Reithrodontomys megalotis	8/12/2009	7.772744	-22.61923	38.914016	-114.151873
Western Harvest mouse	Reithrodontomys megalotis	8/13/2009	5.904346	-20.64693	39.009844	-114.20776
Western Harvest mouse	Reithrodontomys megalotis	8/13/2009	7.206144	-22.38298	39.009811	-114.207815
Western Harvest mouse	Reithrodontomys megalotis	8/13/2009	8.050644	-23.22077	39.009361	-114.208443
Western Harvest mouse	Reithrodontomys megalotis	8/14/2009	4.490341	-23.22515	39.010632	-114.212106
Western Harvest mouse	Reithrodontomys megalotis	8/14/2009	5.3115	-24.20431	39.010003	-114.211589
Western Harvest mouse	Reithrodontomys megalotis	8/19/2009	17.22048	-21.93422	38.914799	-114.185913

Western Harvest mouse	Reithrodontomys megalotis	9/12/2009	3.871708	-22.86184	39.015108	-114.130573
Western Harvest mouse	Reithrodontomys megalotis	9/12/2009	4.23158	-23.72155	39.016723	-114.129973
Western Harvest mouse	Reithrodontomys megalotis	9/13/2009	5.30753	-23.57489	39.01523	-114.130531
White tailed antelope squirrel	Ammospermophilus leucurus	7/10/2008	10.02705	-20.57584	39.016415	-114.125018
White tailed antelope squirrel	Ammospermophilus leucurus	7/31/2008	8.790761	-19.5302	39.017989	-114.126279
White tailed antelope squirrel	Ammospermophilus leucurus	7/31/2008	10.9125	-19.99984	39.020001	-114.126018
White tailed antelope squirrel	Ammospermophilus leucurus	7/31/2008	11.26039	-19.35009	39.018287	-114.124734

Appendix 4. Stable isotope values (δD and δ18O) for small mammal hair samples in the South Snake Range. Isotopes were analyzed with Cornell University's Stable Isotope Laboratory on a Temperature Conversion Elemental Analyzer (TC/EA) interfaced to a Thermo Delta V Isotope Ratio Mass Spectrometer (IRMS). Isotope results are presented relative to international standards in conventional delta (δ) notation as per mil (‰): δsample = R_{sample}-$R_{standard}$/$R_{standard}$ X 1000, where R is the ratio of the heavy isotope to the light isotope. When duplicate samples were analyzed, the mean value was reported.

Hair samples, approximately 3 cm^2 in area, were collected dorsally with scissors, immediately anterior to the base of the tail. Hair was sonicated in deionized water for 30 minutes, lipid extracted with petroleum ether for 30 minutes, and subsamples of approximately 0.5 mg were measured in silver cups (Costech – 5 X 9 mm). Hair was analyzed since it is metabolically inert, preserving the isotopic information of the consumer at the time it was synthesized.

CommonName	ScientificName	TrapDate	δD	δ^{18}O	Latitude	Longitude
Cliff chipmunk	Tamias dorsalis	15-Sep-07	-192.313	9.914	38.91235	-114.152
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-185.322	12.616	39.04963	-114.321
Deer Mouse	Peromyscus maniculatus	17-Aug-07	-177.936	17.389	39.01418	-114.217
Cliff chipmunk	Tamias dorsalis	27-Jul-07	-170.233	14.342	38.91843	-114.151
Montane vole	Microtus montanus	17-Aug-07	-166.722	16.663	39.00992	-114.208
Great Basin pocket mouse	Perognathus parvus	10-Jul-08	-163.1662		39.01617	-114.125
Montane vole	Microtus montanus	15-Aug-07	-162.0817	28.9285	39.00996	-114.208
Pinon mouse	Peromyscus truei	13-Aug-07	-158.535	9.959	39.00751	-114.208
Deer Mouse	Peromyscus maniculatus	31-Jul-07	-158.423	16.017	39.05758	-114.305
Cliff chipmunk	Tamias dorsalis	20-Aug-07	-157.684	11.325	38.91047	-114.154
Pinon mouse	Peromyscus truei	23-Aug-07	-156.917	12.158	39.01544	-114.208
Great Basin pocket mouse	Perognathus parvus	10-Aug-08	-156.5266		39.01756	-114.128
Great Basin pocket mouse	Perognathus parvus	09-Jul-08	-155.6976		39.01812	-114.128
Western	Reithrodontomys	17-Sep-07	-155.6237	24.0195	38.91928	-114.142

Harvest mouse	megalotis					
Deer Mouse	Peromyscus maniculatus	01-Aug-07	-155.5077	22.6735	39.01097	-114.208
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-153.804	10.532	39.05289	-114.322
Pinon mouse	Peromyscus truei	23-Aug-07	-153.665	17.383	39.01538	-114.21
Western Harvest mouse	Reithrodontomys megalotis	14-Aug-07	-153.3887	15.2945	38.91223	-114.17
Deer Mouse	Peromyscus maniculatus	03-Aug-07	-152.575	17	39.05078	-114.321
Cliff chipmunk	Tamias dorsalis	27-Jul-07	-152.005	12.78	38.90912	-114.172
Deer Mouse	Peromyscus maniculatus	03-Aug-07	-151.304	12.176	39.01097	-114.208
Deer Mouse	Peromyscus maniculatus	30-Jul-07	-149.751	14.983	39.0545	-114.319
Great Basin pocket mouse	Perognathus parvus	10-Aug-08	-148.4753		39.01687	-114.128
Deer Mouse	Peromyscus maniculatus	01-Aug-07	-147.35	8.316	39.05078	-114.321
Deer Mouse	Peromyscus maniculatus	25-Jul-07	-146.424	15.023	39.05418	-114.311
Great Basin pocket mouse	Perognathus parvus	31-Jul-08	-144.5497		39.01793	-114.125
Deer Mouse	Peromyscus maniculatus	24-Jul-07	-144.1517	21.9535	39.05464	-114.319
Cliff chipmunk	Tamias dorsalis	14-Aug-07	-142.3757	17.9155	39.01313	-114.208
Montane vole	Microtus montanus	16-Aug-07	-141.924	24.979	39.00994	-114.208
Great Basin pocket mouse	Perognathus parvus	09-Aug-08	-140.9476		39.01985	-114.127
Cliff chipmunk	Tamias dorsalis	27-Jul-07	-140.886	9.669	38.91676	-114.147

Western Harvest mouse	Reithrodontomys megalotis	16-Aug-07	-140.4677	23.7415	39.01015	-114.208
Deer Mouse	Peromyscus maniculatus	30-Jul-07	-140.378	16.781	39.01377	-114.217
Cliff chipmunk	Tamias dorsalis	26-Jul-07	-140.073	15.718	38.91371	-114.151
Great Basin pocket mouse	Perognathus parvus	15-Aug-08	-140.0537	8.773962	39.01061	-114.212
Western Harvest mouse	Reithrodontomys megalotis	20-Aug-07	-139.8097	18.8645	38.91183	-114.17
Western Harvest mouse	Reithrodontomys megalotis	30-Jul-07	-139.693	15.119	39.00983	-114.211
Least chipmunk	Tamias minimus	09-Aug-07	-139.414	13.89	39.05254	-114.311
Great Basin pocket mouse	Perognathus parvus	10-Jul-08	-139.3369		39.01586	-114.127
Great Basin pocket mouse	Perognathus parvus	08-Aug-08	-139.273	9.816983	39.00887	-114.211
Pinon mouse	Peromyscus truei	23-Aug-07	-138.481	17.776	39.01568	-114.209
Chisel toothed kangaroo rat	Dipodomys microps	10-Jul-08	-137.437		39.01664	-114.125
Western Harvest mouse	Reithrodontomys megalotis	14-Aug-07	-136.8767	20.5265	39.00992	-114.208
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-136.64	7.65	39.05254	-114.311
Deer Mouse	Peromyscus maniculatus	02-Aug-07	-134.533	15.812	39.01345	-114.208
Cliff chipmunk	Tamias dorsalis	08-Aug-07	-134.505	14.894	38.91843	-114.151
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-134.15	8.67	39.00936	-114.208
Western Harvest mouse	Reithrodontomys megalotis	02-Aug-07	-133.6577	17.7315	39.00984	-114.208
Great Basin	Perognathus parvus	07-Aug-08	-131.6167	10.65147	39.01636	-114.214

pocket mouse						
Desert woodrat	Neotoma lepida	17-Aug-07	-131.0847	15.6385	39.01547	-114.215
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-131.0066	9.400863	38.91682	-114.147
Great Basin pocket mouse	Perognathus parvus	07-Aug-08	-129.9392	8.050004	39.01672	-114.213
Western Harvest mouse	Reithrodontomys megalotis	21-Aug-07	-129.299	11.389	39.01044	-114.212
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-128.8238	8.095487	39.05524	-114.306
Great Basin pocket mouse	Perognathus parvus	30-Jul-08	-127.7036	10.37614	39.05471	-114.306
Pinon mouse	Peromyscus truei	02-Aug-07	-126.574	13.112	39.01644	-114.213
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-126.5573	10.32813	39.05272	-114.322
Pinon mouse	Peromyscus truei	27-Aug-07	-126.48	12.236	39.01388	-114.209
Pinon mouse	Peromyscus truei	25-Jul-07	-126.2687	19.5305	38.91508	-114.154
Deer Mouse	Peromyscus maniculatus	30-Jul-07	-125.816	7.973	39.01063	-114.212
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-125.8049		38.98968	-114.241
Deer Mouse	Peromyscus maniculatus	23-Jul-07	-125.576	10.776	38.91115	-114.155
Great Basin pocket mouse	Perognathus parvus	09-Jul-08	-125.5552		39.01016	-114.212
Great Basin pocket mouse	Perognathus parvus	23-Jul-07	-125.461	7.697	39.05794	-114.305
Western Harvest mouse	Reithrodontomys megalotis	31-Jul-07	-125.2147	15.7405	39.00983	-114.211
Deer Mouse	Peromyscus maniculatus	26-Jul-07	-124.13	13.956	39.05873	-114.305

Western Harvest mouse	Reithrodontomys megalotis	05-Sep-07	-123.873	13.292	38.91268	-114.153
Great Basin pocket mouse	Perognathus parvus	10-Aug-08	-123.4544		39.01908	-114.127
Deer Mouse	Peromyscus maniculatus	17-Aug-07	-123.4487	18.6975	39.00871	-114.208
Deer Mouse	Peromyscus maniculatus	24-Jul-07	-123.3917	21.4925	39.05532	-114.312
Western Harvest mouse	Reithrodontomys megalotis	26-Jul-07	-123.069	15.638	38.91067	-114.155
Great Basin pocket mouse	Perognathus parvus	12-Aug-08	-122.7782	9.202512	39.00956	-114.211
Western Harvest mouse	Reithrodontomys megalotis	23-Jul-08	-122.6664		39.01497	-114.236
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-122.57	12.9879	39.05524	-114.306
Pinon mouse	Peromyscus truei	23-Aug-07	-122.54	12.554	39.0147	-114.213
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-122.4638	12.69748	39.05464	-114.319
Western Harvest mouse	Reithrodontomys megalotis	15-Sep-07	-122.333	12.594	38.91684	-114.147
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-121.9325	13.19676	39.05253	-114.318
Great Basin pocket mouse	Perognathus parvus	10-Aug-07	-121.706	5.684	39.05253	-114.311
Pinon mouse	Peromyscus truei	23-Jul-07	-121.416	12.321	38.91863	-114.151
sagebrush vole	Lemmiscus curtatus	30-Jul-09	-121.12	15.03	39.0549	-114.306
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-121.0591	10.49128	39.0545	-114.312
Western Harvest mouse	Reithrodontomys megalotis	02-Aug-07	-120.9657	20.2425	39.01031	-114.212

Western Harvest mouse	Reithrodontomys megalotis	15-Sep-07	-120.9127	20.4155	38.9193	-114.141
Western Harvest mouse	Reithrodontomys megalotis	14-Sep-07	-120.5417	16.2455	38.91659	-114.148
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-120.4425	10.68163	39.04899	-114.321
Desert woodrat	Neotoma lepida	08-Aug-07	-120.3677	18.6865	38.91841	-114.151
Deer Mouse	Peromyscus maniculatus	09-Aug-07	-119.8227	18.5475	39.05056	-114.316
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-119.47	13.44803	39.05407	-114.319
Western Harvest mouse	Reithrodontomys megalotis	22-Jul-08	-119.2576		39.01456	-114.236
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-119.1346	13.76212	39.05599	-114.312
Western Harvest mouse	Reithrodontomys megalotis	02-Aug-07	-118.7567	19.9645	39.01044	-114.212
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-118.39	9.65	39.00996	-114.208
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-118.27	9.4	39.0545	-114.319
Great Basin pocket mouse	Perognathus parvus	10-Aug-08	-118.02		39.01985	-114.127
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-117.8776		39.01799	-114.126
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-117.84	7.38	39.05106	-114.316
Western Harvest mouse	Reithrodontomys megalotis	17-Sep-07	-117.44	21.078	38.91268	-114.153
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-117.3315		39.05854	-114.305
Great Basin	Perognathus parvus	27-Jul-07	-117.298	7.635	39.05599	-114.312

pocket mouse						
Western Harvest mouse	Reithrodontomys megalotis	20-Aug-07	-117.2167	18.8455	38.91196	-114.17
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-117.1666		39.05319	-114.311
Uinta chipmunk	Tamias umbrinus	27-Jul-07	-116.776	20.119	39.0549	-114.306
Pinon mouse	Peromyscus truei	13-Aug-07	-116.59	15.049	39.00609	-114.211
Least chipmunk	Tamias minimus	09-Aug-07	-116.51	16.371	39.04878	-114.32
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-116.4682		39.01752	-114.126
Western Harvest mouse	Reithrodontomys megalotis	23-Jul-08	-116.4016		39.01495	-114.235
Western Harvest mouse	Reithrodontomys megalotis	30-Jul-07	-116.2397	16.2255	39.01031	-114.212
Western Harvest mouse	Reithrodontomys megalotis	29-Jul-08	-116.1318		38.9878	-114.235
Chisel toothed kangaroo rat	Dipodomys microps	01-Aug-08	-116.081		39.01546	-114.127
Chisel toothed kangaroo rat	Dipodomys microps	09-Aug-08	-116.081		39.01557	-114.127
Deer Mouse	Peromyscus maniculatus	15-Aug-08	-115.682	11.05817	39.01672	-114.213
Pinon mouse	Peromyscus truei	07-Aug-07	-115.2807	20.1305	38.91749	-114.149
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-115.0877	13.49204	39.05278	-114.311
Great Basin pocket mouse	Perognathus parvus	10-Jul-08	-114.9518		39.01879	-114.127
Cliff chipmunk	Tamias dorsalis	17-Jul-08	-114.8674		39.01486	-114.233
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-114.7419	13.52605	39.05042	-114.321

Western Harvest mouse	Reithrodontomys megalotis	23-Jul-08	-114.4483		39.01509	-114.235
White tailed antelope squirrel	Ammospermophilus leucurus	31-Jul-08	-114.3016		39.01799	-114.126
Pinon mouse	Peromyscus truei	23-Aug-07	-113.9227	26.1055	39.01527	-114.212
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-113.903	7.187224	39.05483	-114.319
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-113.5617	9.895005	39.05069	-114.316
Least chipmunk	Tamias minimus	01-Aug-07	-113.535	14.903	39.0545	-114.319
Pinon mouse	Peromyscus truei	28-Jul-09	-113.3	12.83	39.0086	-114.208
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-113.1577	15.27956	39.04899	-114.321
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-112.9582	10.52457	39.05106	-114.316
Deer Mouse	Peromyscus maniculatus	07-Aug-07	-112.8677	24.5405	39.05069	-114.316
Western Harvest mouse	Reithrodontomys megalotis	10-Jul-08	-112.7995	10.58074	39.01028	-114.212
Western Harvest mouse	Reithrodontomys megalotis	03-Aug-07	-112.777	15.826	39.01038	-114.208
Desert woodrat	Neotoma lepida	06-Aug-07	-112.743	21.37	38.91909	-114.152
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-112.6312		39.01512	-114.127
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-112.57	8.39	39.05649	-114.306
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-112.4751		38.98956	-114.243
Deer Mouse	Peromyscus maniculatus	06-Aug-07	-112.124	12.522	38.91246	-114.154

Uinta chipmunk	Tamias umbrinus	31-Jul-07	-111.977	20.798	39.05418	-114.306
Great Basin pocket mouse	Perognathus parvus	30-Jul-08	-111.8367	10.18809	39.04963	-114.321
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-111.7217	8.540615	39.05673	-114.306
Chisel toothed kangaroo rat	Dipodomys microps	31-Jul-08	-111.6606		39.01914	-114.125
Deer Mouse	Peromyscus maniculatus	17-Aug-07	-111.1517	15.9185	39.01252	-114.208
Pinon mouse	Peromyscus truei	30-Jul-07	-111.111	13.371	39.01609	-114.214
Western Harvest mouse	Reithrodontomys megalotis	12-Aug-08	-111.0658	13.30806	39.01386	-114.217
Western Harvest mouse	Reithrodontomys megalotis	25-Jul-08	-111.0256		39.01495	-114.235
sagebrush vole	Lemmiscus curtatus	30-Jul-09	-110.99	10.82	39.05637	-114.312
Chisel toothed kangaroo rat	Dipodomys microps	10-Aug-08	-110.9281		39.01799	-114.126
Western Harvest mouse	Reithrodontomys megalotis	31-Jul-09	-110.92	13.28	39.00977	-114.208
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-110.8801	13.11293	39.04963	-114.321
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-110.8494		39.05501	-114.306
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-110.59	9.73	39.0532	-114.318
Pinon mouse	Peromyscus truei	23-Aug-07	-110.5157	18.7025	39.01683	-114.21
Great Basin pocket mouse	Perognathus parvus	14-Sep-07	-110.477	9.885	38.91929	-114.141
Long-tailed vole	Microtus longicaudus	30-Jul-09	-110.42	10.36	39.05056	-114.316
Great Basin pocket mouse	Perognathus parvus	29-Jul-08	-110.2562		39.01924	-114.127

Great Basin pocket mouse	Perognathus parvus	15-Aug-07	-110.239	9.074	38.91129	-114.155
Deer Mouse	Peromyscus maniculatus	14-Aug-09	-110.17	9.68	38.91368	-114.151
Great Basin pocket mouse	Perognathus parvus	20-Aug-07	-110.148	10.902	38.91401	-114.152
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-110.0015	8.518608	39.05175	-114.317
Great Basin pocket mouse	Perognathus parvus	30-Jul-09	-109.81	12.76	39.01424	-114.217
Great Basin pocket mouse	Perognathus parvus	17-Aug-07	-109.759	10.694	38.91115	-114.154
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-109.75	8.36	39.01063	-114.212
Long-tailed vole	Microtus longicaudus	30-Jul-09	-109.69	9.83	39.04882	-114.32
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-109.375	13.2727	39.05547	-114.306
Western Harvest mouse	Reithrodontomys megalotis	13-Aug-07	-109.374	14.696	39.01386	-114.217
Deer Mouse	Peromyscus maniculatus	08-Aug-08	-109.3358	11.08314	39.05467	-114.312
Chisel toothed kangaroo rat	Dipodomys microps	09-Aug-08	-108.8904		39.01999	-114.127
Western Harvest mouse	Reithrodontomys megalotis	23-Jul-08	-108.6985		39.01538	-114.236
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-108.66	7.92	39.00911	-114.208
Western Harvest mouse	Reithrodontomys megalotis	25-Jul-08	-108.4235		39.01821	-114.229
Great Basin pocket mouse	Perognathus parvus	08-Aug-08	-108.2632	11.00513	39.01063	-114.212
Deer Mouse	Peromyscus	28-Jul-09	-108.17	10.26	39.01383	-114.217

	maniculatus					
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-108.08	9.07	39.04963	-114.321
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-107.99	10.58	39.05251	-114.322
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-107.9647	13.62408	39.05319	-114.311
Pinon mouse	Peromyscus truei	24-Jul-07	-107.792	14.27	38.91457	-114.153
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-107.38	9.1	39.01366	-114.217
Deer Mouse	Peromyscus maniculatus	14-Aug-09	-106.75	11.66	39.01149	-114.208
Uinta chipmunk	Tamias umbrinus	26-Jul-07	-106.599	12.712	39.05075	-114.316
Great Basin pocket mouse	Perognathus parvus	08-Aug-07	-106.499	10.271	39.04878	-114.32
Pinon mouse	Peromyscus truei	09-Aug-07	-106.482	17.646	38.91108	-114.171
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-106.4771	10.61421	39.05118	-114.316
Montane vole	Microtus montanus	25-Sep-07	-106.4387	19.3155	39.05258	-114.301
Western Harvest mouse	Reithrodontomys megalotis	31-Jul-07	-106.3977	16.7005	39.00994	-114.208
sagebrush vole	Lemmiscus curtatus	31-Jul-08	-106.079	11.96728	39.0573	-114.305
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-106.0397		39.05075	-114.316
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-105.9611		38.98941	-114.243
Least chipmunk	Tamias minimus	31-Jul-07	-105.758	12.942	39.05372	-114.311
Long-tailed vole	Microtus longicaudus	29-Jul-09	-105.74	10.58	39.04883	-114.32
Cliff chipmunk	Tamias dorsalis	03-Aug-07	-105.4967	22.2195	39.00805	-114.211
Deer Mouse	Peromyscus	29-Jul-08	-105.3154	10.94896	39.05075	-114.316

	maniculatus					
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-105.2162	10.68475	39.05069	-114.316
Deer Mouse	Peromyscus maniculatus	12-Aug-08	-105.1675	13.0865	39.01383	-114.217
Great Basin pocket mouse	Perognathus parvus	31-Jul-08	-105.1201	11.05534	39.05461	-114.306
Least chipmunk	Tamias minimus	09-Aug-07	-105.0667	14.9255	39.05056	-114.316
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-104.7682		39.0545	-114.312
Deer Mouse	Peromyscus maniculatus	06-Aug-07	-104.3987	17.4865	39.04899	-114.321
Western Harvest mouse	Reithrodontomys megalotis	28-Jul-09	-104.38	11.09	39.00983	-114.211
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-104.32	11.23	39.05628	-114.306
Cliff chipmunk	Tamias dorsalis	30-Jul-08	-104.2127	12.61379	38.91529	-114.156
sagebrush vole	Lemmiscus curtatus	29-Jul-09	-104.2	12.68	39.05471	-114.306
White tailed antelope squirrel	Ammospermophilus leucurus	31-Jul-08	-103.6407		39.01829	-114.125
Cliff chipmunk	Tamias dorsalis	26-Jul-07	-103.619	12.171	38.90895	-114.172
Deer Mouse	Peromyscus maniculatus	08-Aug-08	-103.563	10.25724	39.04982	-114.321
Great Basin pocket mouse	Perognathus parvus	31-Jul-08	-103.4383		39.01966	-114.126
Deer Mouse	Peromyscus maniculatus	26-Jul-07	-103.391	12.426	38.91362	-114.151
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-103.2918	12.34271	39.05334	-114.318
Deer Mouse	Peromyscus	01-Aug-08	-103.2535	11.22252	39.05567	-114.306

	maniculatus					
Deer Mouse	Peromyscus maniculatus	24-Jul-07	-103.1027	24.7055	38.91249	-114.17
Deer Mouse	Peromyscus maniculatus	06-Aug-07	-102.96	9.563	38.91241	-114.155
Deer Mouse	Peromyscus maniculatus	06-Aug-09	-102.7	8.39	38.91242	-114.17
Western Harvest mouse	Reithrodontomys megalotis	22-Jul-08	-102.4266		39.01496	-114.235
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-102.4	8.92	39.05428	-114.319
Great Basin pocket mouse	Perognathus parvus	24-Jul-07	-102.322	7.133	39.05175	-114.317
Great Basin pocket mouse	Perognathus parvus	05-Sep-07	-102.066	11.002	38.91927	-114.142
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-101.7097	8.926867	39.05204	-114.317
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-101.6325	13.54206	39.0545	-114.319
Western Harvest mouse	Reithrodontomys megalotis	01-Aug-07	-101.572	15.182	39.00984	-114.208
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-101.04	10.25	39.01011	-114.212
Western Harvest mouse	Reithrodontomys megalotis	30-Jul-09	-101.01	12.59	39.00949	-114.208
Deer Mouse	Peromyscus maniculatus	10-Jul-08	-100.9286		38.98566	-114.242
Deer Mouse	Peromyscus maniculatus	09-Aug-07	-100.61	10.913	38.91173	-114.17
Deer Mouse	Peromyscus maniculatus	14-Aug-09	-100.54	11.01	39.01025	-114.212

White tailed antelope squirrel	Ammospermophilus leucurus	31-Jul-08	-100.4271		39.02	-114.126
Western Harvest mouse	Reithrodontomys megalotis	23-Jul-08	-100.396		39.01538	-114.236
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-100.37	11.61	39.04878	-114.32
Pinon mouse	Peromyscus truei	23-Jul-07	-100.332	12.967	38.91858	-114.151
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-100.3103	11.15737	39.04963	-114.321
Deer Mouse	Peromyscus maniculatus	02-Aug-07	-100.2347	28.4035	39.00985	-114.208
Great Basin pocket mouse	Perognathus parvus	08-Aug-08	-100.1952	11.85957	39.05657	-114.312
Deer Mouse	Peromyscus maniculatus	04-Aug-09	-100.17	9.2	38.91242	-114.17
Montane vole	Microtus montanus	07-Aug-09	-100.13	10.14	39.05608	-114.306
Deer Mouse	Peromyscus maniculatus	12-Aug-09	-99.83	11.02	39.00994	-114.208
Deer Mouse	Peromyscus maniculatus	12-Aug-09	-99.79	11.28	39.01672	-114.213
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-99.5	10.95	39.05303	-114.318
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-99.35653	12.76783	39.04933	-114.321
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-99.2831	13.69396	39.05407	-114.319
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-99.06364	13.82214	39.05056	-114.316
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-99.01	12.7	39.01371	-114.217
Deer Mouse	Peromyscus	29-Jul-08	-98.97351	11.97661	39.05174	-114.322

	maniculatus					
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-98.89458	19.56579	39.05094	-114.321
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-98.71186		39.05467	-114.312
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-98.53709	13.73453	39.05344	-114.322
Deer Mouse	Peromyscus maniculatus	06-Aug-07	-98.411	11.793	38.91362	-114.151
Western Harvest mouse	Reithrodontomys megalotis	17-Aug-07	-98.337	14.876	39.01386	-114.217
Pinon mouse	Peromyscus truei	30-Jul-07	-98.29867	25.0265	39.01636	-114.214
Cliff chipmunk	Tamias dorsalis	07-Aug-07	-98.21167	23.1975	38.90839	-114.173
Montane vole	Microtus montanus	04-Aug-09	-98.21	11.71	39.05595	-114.306
Deer Mouse	Peromyscus maniculatus	14-Aug-07	-98.19867	23.7565	39.016	-114.214
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-98.09983	11.89858	39.05214	-114.322
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-98.01266	24.1585	39.05389	-114.319
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-97.82112	11.12266	39.05075	-114.316
Deer Mouse	Peromyscus maniculatus	13-Aug-07	-97.777	6.86	39.01063	-114.212
Deer Mouse	Peromyscus maniculatus	08-Aug-08	-97.64172	13.56406	39.05628	-114.306
Western Harvest mouse	Reithrodontomys megalotis	06-Aug-07	-97.585	12.346	38.91203	-114.17
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-97.55	11.32	39.00883	-114.208
Deer Mouse	Peromyscus	05-Aug-08	-97.54438	15.14052	39.05446	-114.306

	maniculatus					
Pinon mouse	Peromyscus truei	07-Aug-07	-97.41367	18.1705	38.91457	-114.153
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-97.25	11.82	39.01252	-114.208
Cliff chipmunk	Tamias dorsalis	06-Aug-07	-97.147	12.012	38.91001	-114.171
Pinon mouse	Peromyscus truei	23-Jul-07	-97.03467	19.2375	38.91805	-114.15
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-96.864	13.30099	39.05673	-114.306
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-96.73	12.43	39.05001	-114.321
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-96.69714	13.66209	39.05165	-114.317
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-96.67	10.88	39.05289	-114.322
Pinon mouse	Peromyscus truei	24-Jul-07	-96.623	14.816	38.91544	-114.156
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-96.55402	14.46332	39.05681	-114.312
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-96.14922		38.98813	-114.234
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-96.02	10.93	38.91241	-114.155
Western Harvest mouse	Reithrodontomys megalotis	29-Jul-09	-96.02	13.55	39.0573	-114.305
Deer Mouse	Peromyscus maniculatus	08-Aug-07	-95.967	11.901	38.91249	-114.17
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-95.95288	10.49128	39.04963	-114.321
Deer Mouse	Peromyscus maniculatus	14-Aug-09	-95.95	11.88	38.91371	-114.151
Montane vole	Microtus montanus	04-Aug-09	-95.95	13.24	39.05608	-114.306

Deer Mouse	Peromyscus maniculatus	29-Jul-08	-95.79977	10.56409	39.05159	-114.317
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-95.75	9.02	38.91383	-114.151
Deer Mouse	Peromyscus maniculatus	06-Aug-09	-95.65	11.97	39.04982	-114.321
Western Harvest mouse	Reithrodontomys megalotis	25-Jul-07	-95.576	13.864	38.91673	-114.147
Least chipmunk	Tamias minimus	05-Aug-08	-95.47127		39.05637	-114.312
Western Harvest mouse	Reithrodontomys megalotis	15-Aug-08	-95.189	14.84023	39.0139	-114.217
Western Harvest mouse	Reithrodontomys megalotis	17-Aug-07	-94.94466	23.6215	38.91105	-114.155
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-94.91762	13.96233	39.0545	-114.312
Deer Mouse	Peromyscus maniculatus	13-Aug-09	-94.86	9.38	38.91362	-114.151
Western Harvest mouse	Reithrodontomys megalotis	06-Aug-09	-94.7	9.98	39.05501	-114.306
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-94.61	10.27	39.05686	-114.305
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-94.547	11.257	38.91249	-114.17
Deer Mouse	Peromyscus maniculatus	23-Jul-07	-94.536	15.63	39.05673	-114.306
Deer Mouse	Peromyscus maniculatus	03-Aug-07	-94.46667	17.9005	39.00877	-114.211
Unknown shrew	Sorex ssp.	29-Jul-09	-94.37	6.98	39.04877	-114.32
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-94.00333	16.06278	39.05155	-114.322
Pinon mouse	Peromyscus truei	30-Jul-08	-93.99016	13.11894	38.91234	-114.17

Deer Mouse	Peromyscus maniculatus	13-Aug-09	-93.87	12.73	38.91126	-114.17
sagebrush vole	Lemmiscus curtatus	30-Jul-09	-93.75	15.74	39.05794	-114.305
Least chipmunk	Tamias minimus	05-Aug-08	-93.58952		39.05428	-114.312
Desert woodrat	Neotoma lepida	25-Jul-07	-93.46067	24.9605	38.91515	-114.154
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-93.41	9.54	39.05487	-114.312
Deer Mouse	Peromyscus maniculatus	13-Aug-08	-93.40879	12.59971	39.01038	-114.212
Deer Mouse	Peromyscus maniculatus	31-Jul-09	-93.13	9.23	39.05402	-114.311
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-93.03817	12.94608	39.05416	-114.306
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-92.9614	12.75883	39.05272	-114.322
Pinon mouse	Peromyscus truei	23-Jul-07	-92.91866	26.3465	38.91126	-114.17
Deer Mouse	Peromyscus maniculatus	14-Aug-08	-92.8916	10.99056	39.01672	-114.213
White tailed antelope squirrel	Ammospermophilus leucurus	10-Jul-08	-92.80853		39.01642	-114.125
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-92.74928		39.0545	-114.306
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-92.73	11.3	39.00996	-114.208
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-92.50896	15.95075	39.05637	-114.312
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-92.21272	13.41202	39.05204	-114.317
Uinta chipmunk	Tamias umbrinus	26-Jul-07	-92.209	10.778	39.05291	-114.318
Deer Mouse	Peromyscus	28-Jul-09	-92.1	13.17	39.01626	-114.214

	maniculatus					
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-92.08755		39.01617	-114.128
Uinta chipmunk	Tamias umbrinus	27-Jul-07	-92.03867	22.2475	39.05075	-114.316
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-92.03332	14.35759	39.05686	-114.305
Deer Mouse	Peromyscus maniculatus	15-Aug-07	-91.897	19.072	39.01609	-114.214
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-91.79633	12.34486	39.05204	-114.317
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-91.72	11.95	39.05057	-114.321
sagebrush vole	Lemmiscus curtatus	30-Jul-09	-91.68	11.79	39.05446	-114.306
Long-tailed vole	Microtus longicaudus	30-Jul-09	-91.66	14.59	39.05428	-114.319
Uinta chipmunk	Tamias umbrinus	30-Jul-08	-91.53031	16.39488	39.05532	-114.312
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-91.45078		39.05418	-114.311
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-91.12	9.77	39.05794	-114.305
Canyon mouse	Peromyscus crinitus	11-Aug-09	-91.02	11.37	38.91858	-114.151
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-90.93851	13.62947	39.05253	-114.311
Deer Mouse	Peromyscus maniculatus	24-Jul-08	-90.93183		39.01802	-114.225
Pinon mouse	Peromyscus truei	06-Aug-07	-90.86166	18.1195	38.90961	-114.171
sagebrush vole	Lemmiscus curtatus	30-Jul-09	-90.82	16.16	39.05582	-114.312
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-90.73	11.83	39.05483	-114.319
Western Harvest mouse	Reithrodontomys megalotis	29-Jul-09	-90.7	12.06	39.01031	-114.212

Deer Mouse	Peromyscus maniculatus	05-Aug-08	-90.66981	13.97618	39.05567	-114.306
Deer Mouse	Peromyscus maniculatus	31-Jul-09	-90.66	12.78	39.05758	-114.305
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-90.583	9.373	38.91206	-114.154
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-90.5048	14.73725	39.05334	-114.318
Uinta chipmunk	Tamias umbrinus	26-Jul-07	-90.403	10.372	39.05251	-114.322
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-90.32184		38.98883	-114.242
Long-tailed vole	Microtus longicaudus	31-Jul-09	-90.24	13.62	39.05524	-114.306
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-90.16305	11.86431	39.05078	-114.321
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-90.03293	13.61608	39.0512	-114.317
Great Basin pocket mouse	Perognathus parvus	24-Aug-07	-89.908	11.109	39.01525	-114.21
Pinon mouse	Peromyscus truei	15-Aug-07	-89.86	6.128	38.915	-114.154
Western Harvest mouse	Reithrodontomys megalotis	13-Aug-09	-89.77	15.48	39.00984	-114.208
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-89.76388	9.812051	39.04982	-114.321
Pinon mouse	Peromyscus truei	13-Aug-08	-89.70976	15.40059	38.91508	-114.154
Western Harvest mouse	Reithrodontomys megalotis	05-Sep-07	-89.50967	13.6365	38.91253	-114.154
Deer Mouse	Peromyscus maniculatus	04-Aug-09	-89.43	11.16	39.05067	-114.316
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-89.4	9.84	39.05159	-114.317
Deer Mouse	Peromyscus	22-Jul-08	-89.3652		39.01525	-114.236

	maniculatus					
Western Harvest mouse	Reithrodontomys megalotis	07-Aug-08	-89.15309	12.92988	39.05532	-114.312
Deer Mouse	Peromyscus maniculatus	31-Jul-07	-88.748	16.568	39.00981	-114.208
Western Harvest mouse	Reithrodontomys megalotis	26-Jul-07	-88.664	18.216	38.91257	-114.155
Western Harvest mouse	Reithrodontomys megalotis	28-Jul-09	-88.62	13.68	39.0096	-114.208
Least chipmunk	Tamias minimus	31-Jul-07	-88.613	13.678	39.05291	-114.318
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-88.61	10.96	39.01636	-114.214
Great Basin pocket mouse	Perognathus parvus	27-Aug-07	-88.587	10.332	39.01625	-114.209
Deer Mouse	Peromyscus maniculatus	14-Aug-08	-88.17847	12.36047	39.00968	-114.208
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-87.94	9.42	39.05254	-114.311
Deer Mouse	Peromyscus maniculatus	07-Aug-09	-87.9	11.85	39.04933	-114.321
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-87.81	13.38	39.05566	-114.312
Chisel toothed kangaroo rat	Dipodomys microps	01-Aug-08	-87.78317		39.01924	-114.127
Great Basin pocket mouse	Perognathus parvus	31-Jul-09	-87.63	13.37	39.01493	-114.216
Deer Mouse	Peromyscus maniculatus	22-Jul-08	-87.61945		39.0147	-114.236
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-87.61	12.26	39.05139	-114.316
Western Harvest mouse	Reithrodontomys megalotis	13-Aug-09	-87.49	12.72	39.00981	-114.208

Western Harvest mouse	Reithrodontomys megalotis	29-Jul-08	-87.45047		38.98793	-114.235
Western Harvest mouse	Reithrodontomys megalotis	29-Jul-08	-87.35964		38.98975	-114.24
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-87.1	9.94	39.05352	-114.311
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-87.07746		39.01641	-114.128
Western Harvest mouse	Reithrodontomys megalotis	31-Jul-09	-86.97	16.02	39.00924	-114.208
Deer Mouse	Peromyscus maniculatus	04-Aug-09	-86.96	10.37	39.05389	-114.311
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-86.92122	12.50817	39.05637	-114.312
Deer Mouse	Peromyscus maniculatus	31-Jul-09	-86.89	13.91	39.05418	-114.306
Deer Mouse	Peromyscus maniculatus	31-Jul-09	-86.87	11.93	39.0519	-114.322
sagebrush vole	Lemmiscus curtatus	31-Jul-09	-86.78	13.61	39.05637	-114.312
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-86.6302	11.98809	39.04982	-114.321
Canyon mouse	Peromyscus crinitus	14-Aug-09	-86.49	13.36	38.91515	-114.154
Western Harvest mouse	Reithrodontomys megalotis	13-Aug-09	-86.48	16.46	39.00936	-114.208
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-86.471	12.184	38.91656	-114.147
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-86.39	13.94	39.05567	-114.306
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-86.27471	12.74429	39.05446	-114.306
Deer Mouse	Peromyscus maniculatus	31-Jul-09	-86.2	12.91	39.05371	-114.319

Western Harvest mouse	Reithrodontomys megalotis	30-Jul-09	-86.15	16.86	39.01386	-114.217
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-86.04	13.09	39.05428	-114.312
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-85.94459	9.618926	39.05256	-114.311
Deer Mouse	Peromyscus maniculatus	09-Aug-07	-85.878	11.894	39.05056	-114.316
Deer Mouse	Peromyscus maniculatus	11-Aug-09	-85.84	12.77	38.90984	-114.155
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-85.83746	11.11226	39.05464	-114.319
Deer Mouse	Peromyscus maniculatus	15-Aug-07	-85.81	13.648	38.90855	-114.156
Cliff chipmunk	Tamias dorsalis	02-Aug-07	-85.778	12.57	39.01365	-114.208
Deer Mouse	Peromyscus maniculatus	12-Aug-09	-85.72	14.77	39.0097	-114.211
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-85.32938	12.48875	39.05165	-114.317
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-85.32625	12.26061	39.04933	-114.321
Deer Mouse	Peromyscus maniculatus	17-Jul-08	-85.29953		39.01277	-114.223
Pinon mouse	Peromyscus truei	23-Jul-07	-85.243	8.535	38.91743	-114.149
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-85.17	14.9	39.05236	-114.322
Pinon mouse	Peromyscus truei	06-Aug-08	-84.98984	13.17995	39.01418	-114.208
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-84.73	10.45	39.05402	-114.311
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-84.5664	14.27727	39.05389	-114.319

Western Harvest mouse	Reithrodontomys megalotis	14-Aug-08	-84.54697	12.79214	39.01044	-114.212
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-84.44	12.74	39.05371	-114.319
Deer Mouse	Peromyscus maniculatus	07-Aug-09	-84.27	11.81	38.91374	-114.151
Western Harvest mouse	Reithrodontomys megalotis	06-Aug-07	-84.238	14.043	38.91382	-114.151
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-84.13472		39.05566	-114.312
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-83.97716	17.09208	39.05552	-114.312
Least chipmunk	Tamias minimus	07-Aug-08	-83.90777	16.52092	39.05253	-114.311
Cliff chipmunk	Tamias dorsalis	22-Jul-08	-83.89191		39.01143	-114.218
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-83.63	8.37	39.0519	-114.322
Deer Mouse	Peromyscus maniculatus	04-Aug-09	-83.57	9.75	39.05273	-114.318
Deer Mouse	Peromyscus maniculatus	04-Aug-09	-83.57	11.84	39.05251	-114.322
Deer Mouse	Peromyscus maniculatus	12-Aug-08	-83.54288	10.76226	39.00994	-114.208
Great Basin pocket mouse	Perognathus parvus	08-Jul-08	-83.52767		39.00948	-114.212
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-83.25146		39.0173	-114.127
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-83.24	12.95	39.05402	-114.311
Deer Mouse	Peromyscus maniculatus	31-Jul-09	-83.23	13.34	39.05273	-114.318
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-82.83	9.5	39.05566	-114.312

Western Harvest mouse	Reithrodontomys megalotis	23-Jul-08	-82.60555		39.01469	-114.235
Pinon mouse	Peromyscus truei	31-Jul-07	-82.56966	23.5615	39.00542	-114.208
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-82.55	11.94	39.05273	-114.318
Western Harvest mouse	Reithrodontomys megalotis	29-Jul-09	-81.93	12.32	39.00983	-114.211
Deer Mouse	Peromyscus maniculatus	06-Aug-07	-81.84367	26.8915	39.05204	-114.317
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-81.83	12.32	39.05686	-114.305
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-81.61	12.38	39.05253	-114.318
Deer Mouse	Peromyscus maniculatus	04-Aug-09	-81.56	10.72	38.91249	-114.17
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-81.38061	16.13581	39.04933	-114.321
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-81.2738	12.96377	39.05412	-114.306
Deer Mouse	Peromyscus maniculatus	13-Aug-07	-81.207	10.872	38.90909	-114.155
Cliff chipmunk	Tamias dorsalis	17-Jul-08	-81.12193		39.01445	-114.233
Cliff chipmunk	Tamias dorsalis	18-Jul-08	-81.12193		39.01473	-114.233
Great Basin pocket mouse	Perognathus parvus	04-Aug-09	-80.99	14.37	39.05809	-114.305
Deer Mouse	Peromyscus maniculatus	09-Jul-08	-80.65446		38.98565	-114.243
Western Harvest mouse	Reithrodontomys megalotis	14-Aug-09	-80.51	13.94	39.01063	-114.212
Desert woodrat	Neotoma lepida	14-Aug-09	-80.33	18.26	38.91242	-114.17
Deer Mouse	Peromyscus	04-Aug-09	-80.31	13.15	39.0519	-114.317

	maniculatus					
Deer Mouse	Peromyscus maniculatus	03-Aug-07	-80.245	13.217	39.05094	-114.321
Deer Mouse	Peromyscus maniculatus	04-Aug-09	-80.07	13.21	39.05235	-114.318
Deer Mouse	Peromyscus maniculatus	06-Aug-07	-79.951	11.063	38.91656	-114.147
Western Harvest mouse	Reithrodontomys megalotis	01-Aug-07	-79.824	13.037	39.01061	-114.212
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-79.35	12.71	39.05628	-114.306
Cliff chipmunk	Tamias dorsalis	23-Jul-08	-79.28221		39.01753	-114.229
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-79.26454		39.05501	-114.306
Cliff chipmunk	Tamias dorsalis	13-Aug-08	-79.20476	14.2671	38.91749	-114.149
Pinon mouse	Peromyscus truei	14-Aug-09	-79.17	12.11	39.01454	-114.216
Canyon mouse	Peromyscus crinitus	14-Aug-09	-79.11	13.36	38.91889	-114.152
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-78.87	12.92	39.05777	-114.305
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-78.77625	13.75012	39.05582	-114.312
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-78.56818	13.40202	39.0573	-114.305
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-78.31	10.85	39.0545	-114.312
Cliff chipmunk	Tamias dorsalis	27-Sep-07	-78.012	15.556	39.05396	-114.306
Pinon mouse	Peromyscus truei	12-Aug-09	-78	12.32	38.90862	-114.173
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-77.86	14.31	39.0545	-114.312
Deer Mouse	Peromyscus	05-Aug-09	-77.82	13.9	39.0545	-114.306

	maniculatus					
Western Harvest mouse	Reithrodontomys megalotis	26-Jul-07	-77.595	17.442	38.91173	-114.17
Deer Mouse	Peromyscus maniculatus	13-Aug-07	-77.531	6.761	39.00883	-114.208
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-77.30647	12.69781	39.05303	-114.318
Deer Mouse	Peromyscus maniculatus	13-Aug-09	-77.08	11.6	38.91147	-114.17
Deer Mouse	Peromyscus maniculatus	07-Aug-09	-76.98	13.79	38.91371	-114.151
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-76.92	12.52	39.05174	-114.322
Deer Mouse	Peromyscus maniculatus	09-Jul-08	-76.91141		38.98539	-114.242
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-76.88	12.48	39.05467	-114.312
Western Harvest mouse	Reithrodontomys megalotis	14-Aug-09	-76.81	17.42	39.01	-114.212
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-76.7	15.41	39.05075	-114.316
Deer Mouse	Peromyscus maniculatus	13-Aug-07	-76.67	8.003	39.0097	-114.211
Pinon mouse	Peromyscus truei	03-Aug-07	-76.431	10.974	39.01493	-114.216
Deer Mouse	Peromyscus maniculatus	26-Jul-07	-76.401	14.88	38.90984	-114.155
Western Harvest mouse	Reithrodontomys megalotis	13-Aug-09	-76.13	12.32	39.00983	-114.211
Deer Mouse	Peromyscus maniculatus	15-Aug-07	-75.555	10.851	38.90831	-114.173
Western Harvest mouse	Reithrodontomys megalotis	11-Aug-09	-75.52	14.69	39.01049	-114.212

Cliff chipmunk	Tamias dorsalis	27-Jul-07	-75.474	11.454	38.91108	-114.171
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-75.1511	10.98132	39.0509	-114.316
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-74.85	14.05	39.04882	-114.32
Deer Mouse	Peromyscus maniculatus	02-Aug-07	-74.847	10.791	39.04878	-114.32
Deer Mouse	Peromyscus maniculatus	31-Jul-07	-74.739	14.764	39.01365	-114.217
Deer Mouse	Peromyscus maniculatus	06-Aug-09	-74.69	13.89	39.05303	-114.318
Western Harvest mouse	Reithrodontomys megalotis	16-Aug-07	-74.612	13.856	39.00994	-114.212
Pinon mouse	Peromyscus truei	12-Aug-09	-74.3	12.14	38.90895	-114.172
Deer Mouse	Peromyscus maniculatus	12-Aug-09	-74.19	14.77	39.00887	-114.211
Deer Mouse	Peromyscus maniculatus	09-Aug-07	-74.164	18.977	38.91657	-114.147
Great Basin pocket mouse	Perognathus parvus	15-Aug-07	-73.515	11.03	39.01562	-114.215
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-73.42	11.15	39.05253	-114.311
Western Harvest mouse	Reithrodontomys megalotis	31-Jul-08	-73.15936		38.98765	-114.235
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-72.86079		39.05119	-114.321
Cliff chipmunk	Tamias dorsalis	26-Jul-07	-72.515	15.531	38.91108	-114.171
Great Basin pocket mouse	Perognathus parvus	14-Aug-07	-72.473	9.503	39.01415	-114.217
Deer Mouse	Peromyscus maniculatus	06-Aug-09	-72.07	11.42	39.05854	-114.305

Deer Mouse	Peromyscus maniculatus	26-Jul-07	-71.971	13.951	38.91031	-114.155
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-71.84	14.76	39.05235	-114.318
Deer Mouse	Peromyscus maniculatus	10-Jul-08	-71.78556		38.98531	-114.242
Deer Mouse	Peromyscus maniculatus	31-Jul-07	-71.608	13.692	39.00786	-114.208
Western Harvest mouse	Reithrodontomys megalotis	22-Aug-07	-71.028	15.777	39.01015	-114.208
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-70.94	15.95	39.05001	-114.321
Deer Mouse	Peromyscus maniculatus	30-Jul-07	-70.747	6.857	39.01015	-114.208
Deer Mouse	Peromyscus maniculatus	07-Aug-07	-70.687	14.278	38.91264	-114.155
Pinon mouse	Peromyscus truei	28-Jul-09	-70.51	13.44	39.01562	-114.215
Pinon mouse	Peromyscus truei	23-Jul-07	-70.182	21.475	38.91496	-114.155
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-69.90993	11.65939	39.05159	-114.317
Western Harvest mouse	Reithrodontomys megalotis	12-Aug-09	-69.85	11.66	39.00924	-114.208
Canyon mouse	Peromyscus crinitus	12-Aug-08	-69.5814	12.02362	38.91863	-114.151
Deer Mouse	Peromyscus maniculatus	30-Jul-09	-69.58	11.33	39.0519	-114.322
Montane vole	Microtus montanus	28-Jul-09	-69.44	17.11	39.05389	-114.311
Deer Mouse	Peromyscus maniculatus	09-Jul-08	-69.33575		38.98579	-114.242
Canyon mouse	Peromyscus crinitus	11-Aug-09	-69.25	14.18	38.91791	-114.15
Western Harvest mouse	Reithrodontomys megalotis	24-Jul-07	-69.237	4.854	38.91383	-114.151

Deer Mouse	Peromyscus maniculatus	07-Aug-09	-69.11	11.68	38.91521	-114.156
Western Harvest mouse	Reithrodontomys megalotis	28-Jul-09	-68.5	16.01	39.05742	-114.305
Western Harvest mouse	Reithrodontomys megalotis	11-Aug-08	-68.48894		39.00925	-114.208
Western Harvest mouse	Reithrodontomys megalotis	29-Jul-09	-68.35	10.92	39.00968	-114.208
Deer Mouse	Peromyscus maniculatus	07-Aug-09	-68.28	14.42	39.05214	-114.322
Western Harvest mouse	Reithrodontomys megalotis	12-Aug-09	-68.22	12.46	39.01437	-114.216
Pinon mouse	Peromyscus truei	28-Jul-09	-67.97	13.53	39.01609	-114.214
Canyon mouse	Peromyscus crinitus	14-Aug-09	-66.99	13.68	38.91863	-114.151
Pinon mouse	Peromyscus truei	31-Jul-09	-66.87	11.71	39.01562	-114.215
Deer Mouse	Peromyscus maniculatus	15-Aug-07	-66.353	8.016	39.01063	-114.212
Deer Mouse	Peromyscus maniculatus	08-Aug-08	-65.53178	17.68725	39.05174	-114.322
Great Basin pocket mouse	Perognathus parvus	10-Aug-08	-65.53178		39.01641	-114.128
Cliff chipmunk	Tamias dorsalis	08-Aug-07	-65.479	13.07	38.90839	-114.173
Pinon mouse	Peromyscus truei	23-Jul-07	-65.381	11.822	38.91749	-114.149
Desert woodrat	Neotoma lepida	02-Aug-07	-65.169	22.85	39.01516	-114.215
Cliff chipmunk	Tamias dorsalis	24-Jul-07	-64.935	11.066	38.91676	-114.147
Western Harvest mouse	Reithrodontomys megalotis	11-Aug-09	-64.8	11.51	39.00968	-114.208
Western Harvest mouse	Reithrodontomys megalotis	05-Sep-07	-64.661	16.982	38.91684	-114.147
Pinon mouse	Peromyscus truei	14-Aug-09	-64.55	13.57	39.01574	-114.214

Deer Mouse	Peromyscus maniculatus	31-Jul-08	-64.51786	8.447349	39.05582	-114.312
Pinon mouse	Peromyscus truei	25-Jul-07	-64.407	15.584	38.90877	-114.173
Cliff chipmunk	Tamias dorsalis	25-Jul-07	-64.198	11.06	38.91159	-114.17
Least chipmunk	Tamias minimus	05-Aug-09	-64.01	20.23	39.05289	-114.322
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-63.79522	12.12851	39.05137	-114.321
Western Harvest mouse	Reithrodontomys megalotis	12-Aug-09	-63.69	14.78	38.91402	-114.152
Canyon mouse	Peromyscus crinitus	04-Aug-09	-63.59	13.5	38.91841	-114.151
Pinon mouse	Peromyscus truei	25-Jul-07	-63.499	16.497	38.90831	-114.173
Pinon mouse	Peromyscus truei	13-Aug-07	-63.457	10.177	39.00627	-114.211
Pinon mouse	Peromyscus truei	14-Aug-09	-62.92	11.59	38.90839	-114.173
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-62.49	11.64	39.05319	-114.311
Pinon mouse	Peromyscus truei	28-Jul-09	-62.23	11.9	39.01516	-114.215
Cliff chipmunk	Tamias dorsalis	13-Aug-09	-62.02	17.05	38.915	-114.154
Deer Mouse	Peromyscus maniculatus	08-Aug-08	-61.86266	13.49504	39.01626	-114.214
Pinon mouse	Peromyscus truei	25-Jul-07	-61.696	16.829	38.91826	-114.15
Pinon mouse	Peromyscus truei	13-Aug-07	-61.65267	24.5525	38.90884	-114.172
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-61.13	15.08	39.05272	-114.322
Deer Mouse	Peromyscus maniculatus	07-Aug-09	-60.82	15.77	39.0519	-114.317
Canyon mouse	Peromyscus crinitus	04-Aug-09	-60.78	13.05	38.91843	-114.151
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-60.18	16.13	39.05461	-114.306
Great Basin	Perognathus parvus	24-Aug-07	-60.087	11.716	39.01506	-114.213

pocket mouse						
Deer Mouse	Peromyscus maniculatus	06-Aug-07	-59.981	25.851	38.91668	-114.147
Pinon mouse	Peromyscus truei	14-Aug-07	-59.353	14.04	39.00751	-114.208
Pinon mouse	Peromyscus truei	04-Aug-09	-59.24	13.45	38.9147	-114.153
Pinon mouse	Peromyscus truei	08-Aug-08	-58.2485	10.31813	39.01672	-114.213
Least chipmunk	Tamias minimus	07-Aug-08	-58.14869	17.10909	39.05505	-114.312
Pinon mouse	Peromyscus truei	28-Jul-09	-58.11	12.36	39.01482	-114.216
Uinta chipmunk	Tamias umbrinus	14-Aug-07	-57.967	7.061	39.00667	-114.211
Canyon mouse	Peromyscus crinitus	07-Aug-09	-57.87	15.08	38.91889	-114.152
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-57.67	12.63	39.05673	-114.306
Pinon mouse	Peromyscus truei	13-Aug-07	-57.635	13.441	38.90838	-114.156
Pinon mouse	Peromyscus truei	08-Aug-08	-57.29103	12.43848	39.01609	-114.214
Deer Mouse	Peromyscus maniculatus	31-Jul-09	-57	14.11	39.05352	-114.318
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-56.97973	17.26813	39.05266	-114.311
Pinon mouse	Peromyscus truei	03-Aug-07	-56.809	14.269	39.00542	-114.208
Montane vole	Microtus montanus	03-Aug-07	-56.704	20.091	39.04882	-114.32
Deer Mouse	Peromyscus maniculatus	02-Aug-07	-55.996	16.771	39.05273	-114.318
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-55.77	13.11	39.05042	-114.321
Deer Mouse	Peromyscus maniculatus	06-Aug-09	-55.57	14.37	38.91246	-114.154
Pinon mouse	Peromyscus truei	04-Aug-09	-55.38	13.07	38.91514	-114.155
Pinon mouse	Peromyscus truei	14-Aug-09	-55.33	13.71	38.9095	-114.172

Least chipmunk	Tamias minimus	28-Jul-09	-54.39	21.8	39.0573	-114.305
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-54.22	8.24	39.05256	-114.311
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-53.95	12.53	38.91242	-114.17
Pinon mouse	Peromyscus truei	05-Aug-09	-52.56	12.56	38.91504	-114.154
Deer Mouse	Peromyscus maniculatus	07-Aug-09	-52.38	10.27	39.05637	-114.312
Pinon mouse	Peromyscus truei	13-Aug-09	-52.36	13.35	38.91749	-114.149
Western Harvest mouse	Reithrodontomys megalotis	27-Jul-07	-52.074	16.023	38.91383	-114.151
Western Harvest mouse	Reithrodontomys megalotis	14-Aug-07	-51.814	15.239	39.01437	-114.216
Deer Mouse	Peromyscus maniculatus	07-Aug-09	-51.23	8.03	39.05352	-114.311
Cliff chipmunk	Tamias dorsalis	02-Aug-07	-50.861	18.839	39.00773	-114.211
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-50.47	17.66	39.05165	-114.317
Pinon mouse	Peromyscus truei	24-Jul-07	-50.43667	20.4845	38.91909	-114.152
Pinon mouse	Peromyscus truei	07-Aug-09	-49.82	15.64	38.90831	-114.173
Pinon mouse	Peromyscus truei	27-Jul-07	-48.721	12.491	38.91508	-114.154
Western Harvest mouse	Reithrodontomys megalotis	31-Jul-08	-47.37188		38.98792	-114.234
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-45.58	12.71	39.0533	-114.311
Western Harvest mouse	Reithrodontomys megalotis	30-Jul-08	-44.89517	15.21885	39.05794	-114.305
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-42.48	13.81	39.05681	-114.312
Pinon mouse	Peromyscus truei	30-Jul-07	-35.986	11.487	39.00542	-114.208

Pinon mouse	Peromyscus truei	29-Jul-09	-34.97	16.29	39.01516	-114.215
Western Harvest mouse	Reithrodontomys megalotis	20-Aug-07	-20.357	10.225	38.91278	-114.153
Pinon mouse	Peromyscus truei	09-Aug-07	-20.318	8.196	38.91821	-114.15

Appendix 5. Stable isotope values (δD and δ18O) for small mammal body water samples in the South Snake Range. Analysis of δ^{18}O and δD were completed simulataneously using a Los Gatos Research Liquid Water Isotope Analyzer (LWIA-24d), with a precision of 0.2‰ and 0.6‰ respectively. Batch sample set-up used the procedure outlined in Nelson (2000) and Nelson and Dettman (2001). Memory correction was addressed by rejecting the first four injections of each sample. The remaining four injections of each isotope run were drift corrected (procedure used in Nelson and Dettman 2001) using in-house standards. The in-house standards (calibrated by VSMOW and SLAP) have isotopic values within the range of our data, thus reducing the influence of memory. The final isotopic composition of a sample was determined by taking the average of the drift corrected injections (Williams 2013). To build internal consistency and ensure direct comparability between instruments, samples were run in batches with calibrated lab standards. Data and equipment were checked for precision by running duplicates of samples and standards and normalized against standards for accuracy using linear regression.

Small mammals were anesthetized using isoflurane inhalant, restrained by the nape of the neck, thumb pressure applied to the external jugular vein caudal to the mandible, and the upper eyelid elevated. A micro-hematocrit capillary tube was inserted into the medial canthus of the eye at a 30° - 45° angle. The tube was rotated into the retro-orbital sinus and blood collected by capillary action into the tube. When the blood has been collected, jugular pressure was released, and pressure applied to the orbital region with gauze until clotting was achieved, and a small amount of antibiotic ophthalmic ointment (bacitracin-neomycin-polymixin) applied to the corner of the eye (Timm 1979, Suckow et al. 2001). Approximately 0.1 mL of blood was collected. Capillary tubes were sealed with critoseal in the field and flame sealed in the laboratory. Water from blood samples was extracted cryogenically prior to isotopic analysis (Ehleringer et al. 2000). Blood water is generally considered representative of body water in small mammals, and hereafter we refer to blood and body water as equivalents (Longinelli 1984).

CommonName	ScientificName	TrapDate	dD_blood	d18O_blood	Latitude	Longitude
Great Basin pocket mouse	Perognathus parvus	30-Jul-08	-80.6	-3.34	39.01948	-114.125
Great Basin pocket mouse	Perognathus parvus	31-Jul-08	-78.77	-1.74	39.01793	-114.125
Deer Mouse	Peromyscus maniculatus	30-Jul-07	-77.35	-2.81	39.01377	-114.217
Deer Mouse	Peromyscus maniculatus	14-Aug-09	-71.83	-2.84	39.01025	-114.212
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-71.1	-1.63	39.01641	-114.128

Western Harvest mouse	Reithrodontomys megalotis	16-Aug-07	-71.1	-1.59	39.00994	-114.212
Western Harvest mouse	Reithrodontomys megalotis	01-Aug-07	-68.4	-1.75	39.00984	-114.208
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-67.69	-4.47	39.05524	-114.306
Great Basin pocket mouse	Perognathus parvus	08-Aug-07	-65.8	-1.56	39.04878	-114.32
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-65.3	0.22	39.01752	-114.126
Chisel toothed kangaroo rat	Dipodomys microps	31-Jul-08	-64.97	-0.85	39.01914	-114.125
Cliff chipmunk	Tamias dorsalis	13-Aug-08	-64.8	-5.19	38.91749	-114.149
Great Basin pocket mouse	Perognathus parvus	10-Jul-08	-64.7	-1.58	39.01617	-114.125
Deer Mouse	Peromyscus maniculatus	14-Sep-07	-64.65	-2.81	38.91192	-114.154
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-64.47	-2.7	39.05319	-114.311
Deer Mouse	Peromyscus maniculatus	23-Jul-07	-63.9	-0.2	39.05452	-114.306
Western Harvest mouse	Reithrodontomys megalotis	31-Jul-09	-63.42	-3.99	39.00977	-114.208
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-63.41	-2.02	39.0509	-114.316
Montane vole	Microtus montanus	15-Aug-07	-63	-2.55	39.00996	-114.208

Deer Mouse	Peromyscus maniculatus	30-Jul-08	-62.51	-2.42	39.05418	-114.311
Deer Mouse	Peromyscus maniculatus	12-Aug-09	-62.51	-1.34	39.0097	-114.211
Western Harvest mouse	Reithrodontomys megalotis	23-Jul-08	-61.9	-3.09	39.01495	-114.235
Great Basin pocket mouse	Perognathus parvus	10-Aug-08	-61.53	-1.21	39.01985	-114.127
Great Basin pocket mouse	Perognathus parvus	24-Aug-07	-61.5	-2.39	39.01506	-114.213
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-61.46	-2.49	39.04963	-114.321
Uinta chipmunk	Tamias umbrinus	26-Jul-07	-61.4	-3.72	39.05075	-114.316
Cliff chipmunk	Tamias dorsalis	15-Sep-07	-61.4	-1.82	38.91235	-114.152
Western Harvest mouse	Reithrodontomys megalotis	16-Aug-07	-61.2	-2.74	39.01015	-114.208
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-61.14	-3.9	39.05501	-114.306
Great Basin pocket mouse	Perognathus parvus	10-Aug-08	-60.78	-1.52	39.01908	-114.127
Pinon mouse	Peromyscus truei	05-Sep-07	-60.7	-3.86	38.91697	-114.148
Deer Mouse	Peromyscus maniculatus	03-Aug-07	-60.49	-3.16	39.05078	-114.321
Least chipmunk	Tamias minimus	31-Jul-07	-60.39	-2.56	39.05372	-114.311
Deer Mouse	Peromyscus maniculatus	01-Aug-08	-60.39	-2.49	38.98968	-114.241

Great Basin pocket mouse	Perognathus parvus	27-Aug-07	-59.94	-1.86	39.01625	-114.209
Uinta chipmunk	Tamias umbrinus	27-Jul-07	-59.8	-2.57	39.05075	-114.316
Deer Mouse	Peromyscus maniculatus	25-Jul-08	-59.67	-4.45	39.01457	-114.236
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-59.5	-2.05	39.01011	-114.212
Deer Mouse	Peromyscus maniculatus	14-Aug-08	-59.1	-3.62	39.00968	-114.208
Western Harvest mouse	Reithrodontomys megalotis	30-Jul-07	-59	-4	39.01031	-114.212
Montane vole	Microtus montanus	25-Sep-07	-58.5	-4.63	39.05258	-114.301
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-57.9	-2.74	38.91242	-114.17
Western Harvest mouse	Reithrodontomys megalotis	15-Sep-07	-57.4	-1.7	38.91684	-114.147
Great Basin pocket mouse	Perognathus parvus	30-Jun-09	-57.27	-2.41	38.97359	-114.174
Chisel toothed kangaroo rat	Dipodomys microps	30-Jul-08	-56.9	-1.41	39.01966	-114.126
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-56.71	-2.3	39.04963	-114.321
Western Harvest mouse	Reithrodontomys megalotis	14-Aug-07	-56.7	-1.77	39.01044	-114.212
Deer Mouse	Peromyscus maniculatus	17-Aug-07	-56.6	-2.01	39.00871	-114.208
Western	Reithrodontomys	14-Aug-	-56.2	-2.9	39.01044	-114.212

Harvest mouse	megalotis	08				
Great Basin pocket mouse	Perognathus parvus	29-Jul-08	-56.16	-2.17	39.01924	-114.127
Deer Mouse	Peromyscus maniculatus	18-Aug-09	-56.11	-2.97	38.91363	-114.178
Least chipmunk	Tamias minimus	09-Aug-07	-55.7	-2.39	39.05056	-114.316
Deer Mouse	Peromyscus maniculatus	20-Aug-09	-55.58	-3.52	38.9131	-114.178
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-55.52	-1.92	39.01366	-114.217
Deer Mouse	Peromyscus maniculatus	06-Aug-07	-55.2	-1.67	38.91656	-114.147
Deer Mouse	Peromyscus maniculatus	25-Sep-07	-54.8	-3.58	39.05313	-114.302
Western Harvest mouse	Reithrodontomys megalotis	20-Aug-07	-54.8	-1.08	38.91278	-114.153
Great Basin pocket mouse	Perognathus parvus	07-Aug-08	-54.6	-2.47	39.01672	-114.213
Uinta chipmunk	Tamias umbrinus	27-Jul-07	-54.49	-2.66	39.0549	-114.306
Deer Mouse	Peromyscus maniculatus	14-Aug-07	-54.37	-2.19	39.01382	-114.208
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-54.36	-0.78	39.05278	-114.311
Pinon mouse	Peromyscus truei	13-Aug-07	-54.17	-1.7	39.00609	-114.211
Western Harvest mouse	Reithrodontomys megalotis	05-Sep-07	-54.1	-0.24	38.91268	-114.153

Deer Mouse	Peromyscus maniculatus	03-Jul-07	-53.9	-2.29	39.05416	-114.312
Deer Mouse	Peromyscus maniculatus	02-Aug-07	-53.8	-3.01	39.04878	-114.32
Western Harvest mouse	Reithrodontomys megalotis	05-Sep-07	-53.8	-2.98	38.91684	-114.147
Deer Mouse	Peromyscus maniculatus	13-Aug-07	-53.31	-2.51	39.01063	-114.212
Deer Mouse	Peromyscus maniculatus	23-Aug-07	-53.2	-1.82	39.00989	-114.211
Western Harvest mouse	Reithrodontomys megalotis	14-Aug-07	-52.97	-2.83	39.00992	-114.208
Deer Mouse	Peromyscus maniculatus	06-Aug-07	-52.9	-2.14	38.91668	-114.147
Western Harvest mouse	Reithrodontomys megalotis	10-Jul-08	-52.9	-1.63	38.98569	-114.242
Western Harvest mouse	Reithrodontomys megalotis	05-Sep-07	-52.7	-0.51	38.91253	-114.154
Western Harvest mouse	Reithrodontomys megalotis	17-Sep-07	-52.66	-1.08	38.91928	-114.142
Deer Mouse	Peromyscus maniculatus	08-Aug-08	-52.6	-2.84	39.04982	-114.321
Deer Mouse	Peromyscus maniculatus	12-Aug-08	-52.46	-2.67	39.01383	-114.217
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-52.39	-0.99	39.0512	-114.317
Great Basin pocket mouse	Perognathus parvus	08-Aug-08	-52.28	-2.38	39.05657	-114.312

Deer Mouse	Peromyscus maniculatus	07-Aug-09	-52.27	0.01	38.91371	-114.151
Montane vole	Microtus montanus	04-Aug-09	-52.21	-2.38	39.05595	-114.306
Western Harvest mouse	Reithrodontomys megalotis	09-Jul-08	-52.1	1.56	38.98564	-114.242
Deer Mouse	Peromyscus maniculatus	03-Aug-07	-51.8	-4.02	39.05824	-114.305
Great Basin pocket mouse	Perognathus parvus	24-Aug-07	-51.8	-1.19	39.01525	-114.21
Deer Mouse	Peromyscus maniculatus	01-Aug-07	-51.79	-1.18	39.01097	-114.208
Deer Mouse	Peromyscus maniculatus	02-Aug-07	-51.69	-0.99	39.05273	-114.318
Deer Mouse	Peromyscus maniculatus	26-Jul-07	-51.3	0.35	39.05695	-114.313
Western Harvest mouse	Reithrodontomys megalotis	25-Jul-08	-51.13	-2.66	39.01821	-114.229
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-50.95	-3.16	38.91249	-114.17
Deer Mouse	Peromyscus maniculatus	13-Aug-08	-50.87	-4.16	39.01038	-114.212
Long-tailed vole	Microtus longicaudus	31-Jul-09	-50.56	-4.89	39.04889	-114.32
Deer Mouse	Peromyscus maniculatus	23-Jul-07	-50.55	-0.89	39.05278	-114.311
Deer Mouse	Peromyscus maniculatus	26-Jul-07	-50.4	-2.64	38.91362	-114.151

Cliff chipmunk	Tamias dorsalis	25-Jul-07	-49.99	-1.23	38.91159	-114.17
Western Harvest mouse	Reithrodontomys megalotis	22-Aug-07	-49.86	-2.44	39.01015	-114.208
Deer Mouse	Peromyscus maniculatus	24-Jul-07	-49.8	0.28	39.05464	-114.319
Deer Mouse	Peromyscus maniculatus	01-Aug-07	-49.7	0.14	39.05078	-114.321
Western Harvest mouse	Reithrodontomys megalotis	02-Aug-07	-49.62	-3.37	39.01044	-114.212
Western Harvest mouse	Reithrodontomys megalotis	27-Aug-07	-49.6	-1.33	39.00992	-114.21
Montane vole	Microtus montanus	04-Aug-09	-49.5	-2.33	39.05608	-114.306
Deer Mouse	Peromyscus maniculatus	25-Jul-07	-49.49	-0.27	39.05649	-114.306
Western Harvest mouse	Reithrodontomys megalotis	02-Aug-07	-49.33	-2.8	39.01031	-114.212
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-49.12	-2.99	39.05253	-114.311
Deer Mouse	Peromyscus maniculatus	13-Aug-09	-49.12	-0.24	38.91384	-114.183
Deer Mouse	Peromyscus maniculatus	07-Aug-07	-49.1	-0.04	39.05069	-114.316
Great Basin pocket mouse	Perognathus parvus	17-Aug-07	-48.5	-0.21	38.91115	-114.154
Deer Mouse	Peromyscus maniculatus	11-Jul-08	-48.38	1.54	38.98508	-114.243
Cliff chipmunk	Tamias dorsalis	07-Aug-07	-48.3	-2.83	38.90839	-114.173

Great Basin pocket mouse	Perognathus parvus	31-Jul-08	-48.25	-1	39.01966	-114.126
Deer Mouse	Peromyscus maniculatus	29-Jun-09	-48.16	-2.91	38.93169	-114.254
Deer Mouse	Peromyscus maniculatus	06-Aug-07	-48.02	-1.69	38.91246	-114.154
Deer Mouse	Peromyscus maniculatus	23-Jul-07	-48	2.11	39.05673	-114.306
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-47.8	2.38	39.01799	-114.126
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-47.64	-0.16	39.05501	-114.306
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-47.53	-1.02	39.05256	-114.311
Western Harvest mouse	Reithrodontomys megalotis	24-Jul-07	-47.42	-1.45	38.91383	-114.151
Deer Mouse	Peromyscus maniculatus	31-Jul-08	-47.33	-0.74	38.98956	-114.243
Pinon mouse	Peromyscus truei	30-Jul-08	-47.08	-0.02	38.91234	-114.17
Deer Mouse	Peromyscus maniculatus	04-Aug-09	-47.06	-1.92	38.91242	-114.17
Western Harvest mouse	Reithrodontomys megalotis	13-Aug-09	-46.99	1.97	39.00981	-114.208
Deer Mouse	Peromyscus maniculatus	09-Aug-07	-46.8	-1.46	38.91173	-114.17
Deer Mouse	Peromyscus maniculatus	17-Aug-09	-46.59	-1.72	38.91363	-114.178

Deer Mouse	Peromyscus maniculatus	28-Jul-09	-46.45	-1.44	39.00911	-114.208
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-46.45	-0.09	39.05075	-114.316
Deer Mouse	Peromyscus maniculatus	16-Aug-07	-46.4	-1.04	38.91196	-114.169
Great Basin pocket mouse	Perognathus parvus	14-Aug-09	-46.35	0.87	38.91159	-114.17
Western Harvest mouse	Reithrodontomys megalotis	14-Sep-07	-46.3	-0.44	38.91659	-114.148
Cliff chipmunk	Tamias dorsalis	26-Jul-07	-46.19	-1.23	38.90895	-114.172
Western Harvest mouse	Reithrodontomys megalotis	15-Aug-08	-46.16	-0.77	39.0139	-114.217
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-46.09	-2.25	39.0545	-114.306
Pinon mouse	Peromyscus truei	13-Jun-07	-46.09	-0.21	39.01707	-114.22
Deer Mouse	Peromyscus maniculatus	06-Aug-09	-46	-0.96	38.91242	-114.17
Great Basin pocket mouse	Perognathus parvus	15-Aug-07	-45.9	-1.04	39.01562	-114.215
Uinta chipmunk	Tamias umbrinus	26-Jul-07	-45.58	-0.8	39.05251	-114.322
Deer Mouse	Peromyscus maniculatus	05-Aug-09	-45.56	-1.84	38.91241	-114.155
Western Harvest mouse	Reithrodontomys megalotis	14-Aug-07	-45.5	1.31	38.91223	-114.17
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-45.29	0.86	39.0545	-114.312
Least chipmunk	Tamias minimus	07-Aug-	-45.2	-0.19	39.05505	-114.312

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Great Basin pocket mouse	Perognathus parvus	10-Aug-08	-45.1	-1.54	39.01687	-114.128
Deer Mouse	Peromyscus maniculatus	15-Aug-07	-45.1	-0.56	39.01063	-114.212
Deer Mouse	Peromyscus maniculatus	20-Aug-09	-44.66	1.21	38.91587	-114.177
Great Basin pocket mouse	Perognathus parvus	04-Aug-09	-44.61	3.73	39.05809	-114.305
Great Basin pocket mouse	Perognathus parvus	20-Aug-09	-44.58	-0.71	38.91589	-114.184
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-44.58	2.5	39.05566	-114.312
Deer Mouse	Peromyscus maniculatus	08-Aug-08	-44.34	-1.53	39.05628	-114.306
Deer Mouse	Peromyscus maniculatus	24-Jul-07	-44.3	0.84	39.05467	-114.312
Western Harvest mouse	Reithrodontomys megalotis	06-Aug-07	-43.92	-1.7	38.91203	-114.17
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-43.5	4.82	39.01617	-114.128
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-43.47	-1.34	39.05266	-114.311
Deer Mouse	Peromyscus maniculatus	25-Sep-07	-43.46	-1.66	39.05316	-114.304
Cliff chipmunk	Tamias dorsalis	06-Aug-07	-43.4	-1.76	38.91001	-114.171

Deer Mouse	Peromyscus maniculatus	26-Jul-07	-43.4	-1.74	38.90984	-114.155
Deer Mouse	Peromyscus maniculatus	15-Aug-07	-42.88	-1.61	38.90831	-114.173
Long-tailed vole	Microtus longicaudus	29-Jul-09	-42.85	-3.53	39.04883	-114.32
Deer Mouse	Peromyscus maniculatus	07-Aug-07	-42.54	-1.76	38.91264	-114.155
Deer Mouse	Peromyscus maniculatus	04-Jul-07	-42.44	-2.13	39.05325	-114.311
Great Basin pocket mouse	Perognathus parvus	30-Jun-09	-42.4	-0.77	38.97402	-114.177
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-42.23	-2.31	39.04882	-114.32
Western Harvest mouse	Reithrodontomys megalotis	13-Aug-09	-42.03	-0.55	39.00983	-114.211
Deer Mouse	Peromyscus maniculatus	09-Jul-08	-41.98	-1.16	38.98539	-114.242
Deer Mouse	Peromyscus maniculatus	30-Jul-07	-41.98	-0.34	39.05446	-114.306
Deer Mouse	Peromyscus maniculatus	07-Aug-09	-41.97	2.27	38.91374	-114.151
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-41.9	-0.39	39.05289	-114.322
Chisel toothed kangaroo rat	Dipodomys microps	29-Jul-08	-41.9	3.74	39.01961	-114.127
Deer Mouse	Peromyscus maniculatus	31-Jul-07	-41.86	-0.11	39.05758	-114.305

Deer Mouse	Peromyscus maniculatus	11-Aug-09	-41.4	1.41	38.90984	-114.155
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-41.38	0.48	39.05075	-114.316
Pinon mouse	Peromyscus truei	04-Aug-09	-41.09	-0.88	38.9147	-114.153
Deer Mouse	Peromyscus maniculatus	03-Jul-07	-40.7	2.79	39.05023	-114.322
Deer Mouse	Peromyscus maniculatus	09-Aug-07	-40.65	-1.06	39.05056	-114.316
Pinon mouse	Peromyscus truei	04-Aug-09	-40.42	-0.6	38.91514	-114.155
Deer Mouse	Peromyscus maniculatus	08-Aug-08	-40.3	-1.17	39.01626	-114.214
Great Basin pocket mouse	Perognathus parvus	14-Aug-07	-40.04	-0.59	39.01415	-114.217
Great Basin pocket mouse	Perognathus parvus	15-Aug-08	-40.01	-1.32	39.01061	-114.212
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-39.91	-0.59	39.05407	-114.319
Western Harvest mouse	Reithrodontomys megalotis	29-Jul-08	-39.44	-1.47	38.98975	-114.24
Deer Mouse	Peromyscus maniculatus	09-Aug-07	-38.7	-1.16	38.91159	-114.17
Western Harvest mouse	Reithrodontomys megalotis	22-Aug-07	-38.7	-0.74	39.01437	-114.216
Deer Mouse	Peromyscus maniculatus	14-Aug-09	-38.6	0.58	38.91371	-114.151

Pinon mouse	Peromyscus truei	08-Aug-08	-38.3	-1.02	39.01672	-114.213
Deer Mouse	Peromyscus maniculatus	02-Aug-07	-37.9	-2.91	39.01345	-114.208
Long-tailed vole	Microtus longicaudus	30-Jul-09	-37.9	-2.7	39.05056	-114.316
Western Harvest mouse	Reithrodontomys megalotis	15-Sep-07	-37.5	0.04	38.9193	-114.141
Great Basin pocket mouse	Perognathus parvus	09-Jul-08	-37.5	5.46	39.01016	-114.212
Pinon mouse	Peromyscus truei	09-Aug-07	-37.4	0.82	38.91108	-114.171
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-37.07	3.92	39.05854	-114.305
Deer Mouse	Peromyscus maniculatus	15-Sep-07	-36.8	-1.13	38.91623	-114.149
Cliff chipmunk	Tamias dorsalis	26-Jul-07	-36.7	2.23	38.91371	-114.151
Pinon mouse	Peromyscus truei	30-Jul-07	-36.63	-1.44	39.00542	-114.208
Cliff chipmunk	Tamias dorsalis	02-Aug-07	-36.62	-1.1	39.01365	-114.208
Canyon mouse	Peromyscus crinitus	04-Aug-09	-36.54	0.56	38.91843	-114.151
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-36.4	2.27	39.0573	-114.305
Deer Mouse	Peromyscus maniculatus	29-Jul-08	-36.36	1.01	38.98813	-114.234
Deer Mouse	Peromyscus maniculatus	15-Aug-07	-36.3	-0.09	38.90855	-114.156
Pinon mouse	Peromyscus truei	08-Aug-	-36.26	-0.23	39.01609	-114.214

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Deer Mouse	Peromyscus maniculatus	17-Aug-09	-36.23	2.12	38.9148	-114.186
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-36.18	-1.4	39.04933	-114.321
Deer Mouse	Peromyscus maniculatus	01-Aug-07	-35.76	-1.37	39.04878	-114.32
Deer Mouse	Peromyscus maniculatus	14-Aug-07	-35.7	-1.69	39.01366	-114.217
Deer Mouse	Peromyscus maniculatus	30-Jul-07	-35.68	1.62	39.05742	-114.305
Pinon mouse	Peromyscus truei	30-Jul-07	-35.5	0.41	39.01636	-114.214
Deer Mouse	Peromyscus maniculatus	02-Aug-07	-35.49	-0.38	39.05175	-114.317
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-35.47	-0.79	39.05094	-114.321
Great Basin pocket mouse	Perognathus parvus	30-Jun-09	-35.19	1.22	38.97424	-114.175
Pinon mouse	Peromyscus truei	14-Aug-07	-34.8	1.58	39.00751	-114.208
Deer Mouse	Peromyscus maniculatus	06-Aug-08	-34.79	2.02	39.05467	-114.312
Deer Mouse	Peromyscus maniculatus	26-Sep-07	-34.58	-2.2	39.05392	-114.302
Least chipmunk	Tamias minimus	05-Aug-08	-34.35	4.82	39.05637	-114.312

Deer Mouse	Peromyscus maniculatus	31-Jul-08	-34.26	1.38	38.98941	-114.243
Western Harvest mouse	Reithrodontomys megalotis	26-Jul-07	-33.95	-0.93	38.91257	-114.155
Western Harvest mouse	Reithrodontomys megalotis	17-Aug-07	-33.8	-0.15	38.91401	-114.152
Deer Mouse	Peromyscus maniculatus	01-Aug-07	-33.79	1.2	39.05223	-114.317
Deer Mouse	Peromyscus maniculatus	08-Aug-07	-33.71	-1.59	38.91249	-114.17
Deer Mouse	Peromyscus maniculatus	03-Aug-07	-33.6	-1.03	39.00877	-114.211
Deer Mouse	Peromyscus maniculatus	30-Jul-07	-33.42	3.99	39.0545	-114.319
Deer Mouse	Peromyscus maniculatus	17-Aug-07	-33.25	0.33	39.01418	-114.217
Pinon mouse	Peromyscus truei	23-Jul-07	-33.21	1.04	38.91743	-114.149
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-33.06	-0.06	39.00936	-114.208
Western Harvest mouse	Reithrodontomys megalotis	09-Jul-09	-32.93	-1.98	39.01015	-114.212
Western Harvest mouse	Reithrodontomys megalotis	11-Aug-08	-32.9	-2.2	39.00925	-114.208
Western Harvest mouse	Reithrodontomys megalotis	09-Jul-09	-32.73	-0.88	39.01001	-114.212
Pinon mouse	Peromyscus truei	31-Jul-07	-32.67	-0.09	39.00542	-114.208
Least chipmunk	Tamias minimus	01-Aug-07	-32.25	2.4	39.0545	-114.319
Pinon mouse	Peromyscus truei	17-Aug-	-32.22	2.04	38.91713	-114.177

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sagebrush vole	Lemmiscus curtatus	30-Jul-09	-32.21	2.14	39.05446	-114.306
Deer Mouse	Peromyscus maniculatus	07-Aug-08	-31.88	2.2	39.05253	-114.311
Least chipmunk	Tamias minimus	07-Aug-08	-31.81	2.73	39.05253	-114.311
Deer Mouse	Peromyscus maniculatus	19-Aug-09	-31.8	-0.31	38.91443	-114.186
Pinon mouse	Peromyscus truei	28-Jul-09	-31.74	0.21	39.0086	-114.208
Deer Mouse	Peromyscus maniculatus	05-Aug-08	-31.5	6.13	39.05673	-114.306
Deer Mouse	Peromyscus maniculatus	12-Aug-09	-31.49	2.43	39.00887	-114.211
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-31.46	0.49	39.05001	-114.321
Cliff chipmunk	Tamias dorsalis	20-Aug-07	-31.2	2.1	38.91047	-114.154
Canyon mouse	Peromyscus crinitus	07-Aug-09	-30.85	1.41	38.91889	-114.152
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-30.83	-1.38	39.05412	-114.306
Deer Mouse	Peromyscus maniculatus	15-Aug-08	-30.6	1.76	39.01672	-114.213
Great Basin pocket mouse	Perognathus parvus	20-Aug-09	-30.6	9.65	38.9171	-114.187
Deer Mouse	Peromyscus maniculatus	23-Jul-07	-30.56	4.08	39.05873	-114.305

Pinon mouse	Peromyscus truei	23-Jul-07	-30.17	3.01	38.91496	-114.155
Deer Mouse	Peromyscus maniculatus	24-Aug-07	-30.17	3.01	39.0092	-114.212
Pinon mouse	Peromyscus truei	13-Aug-07	-30.1	1.38	39.00751	-114.208
Pinon mouse	Peromyscus truei	24-Jul-07	-30.03	1.04	38.91457	-114.153
Deer Mouse	Peromyscus maniculatus	09-Jul-09	-29.79	1.07	39.01608	-114.223
Pinon mouse	Peromyscus truei	25-Jul-07	-29.77	1.1	38.90831	-114.173
Uinta chipmunk	Tamias umbrinus	26-Jul-07	-29.61	3.03	39.05291	-114.318
Great Basin pocket mouse	Perognathus parvus	09-Jul-09	-29.34	0.5	39.00946	-114.212
Canyon mouse	Peromyscus crinitus	12-Aug-08	-29.29	-0.4	38.91863	-114.151
Western Harvest mouse	Reithrodontomys megalotis	09-Jul-09	-29.16	1.55	39.00974	-114.212
sagebrush vole	Lemmiscus curtatus	30-Jul-09	-29.1	3.65	39.05582	-114.312
Pinon mouse	Peromyscus truei	13-Aug-07	-29.09	1.88	39.00627	-114.211
Deer Mouse	Peromyscus maniculatus	13-Aug-09	-28.84	1.72	38.91126	-114.17
Deer Mouse	Peromyscus maniculatus	25-Jul-07	-28.54	2.22	39.05155	-114.322
Western Harvest mouse	Reithrodontomys megalotis	20-Aug-07	-28.3	0.35	38.91183	-114.17
Western Harvest mouse	Reithrodontomys megalotis	31-Jul-08	-28.2	0.23	38.98765	-114.235

Deer Mouse	Peromyscus maniculatus	07-Aug-08	-28.15	1.56	39.05155	-114.322
Deer Mouse	Peromyscus maniculatus	13-Aug-09	-28	2.97	38.91147	-114.17
Deer Mouse	Peromyscus maniculatus	30-Jul-08	-27.88	0.3	39.05204	-114.317
Deer Mouse	Peromyscus maniculatus	01-Aug-07	-27.85	2	39.04948	-114.321
Pinon mouse	Peromyscus truei	05-Aug-09	-27.8	1.97	38.91504	-114.154
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-27.7	1.2	39.05599	-114.312
Western Harvest mouse	Reithrodontomys megalotis	19-Aug-09	-27.46	1.93	38.9148	-114.186
Cliff chipmunk	Tamias dorsalis	30-Jul-08	-27.42	5.24	38.91529	-114.156
Deer Mouse	Peromyscus maniculatus	27-Jul-07	-27.01	0.74	39.05389	-114.319
Pinon mouse	Peromyscus truei	07-Aug-07	-26.46	0.25	38.91457	-114.153
Pinon mouse	Peromyscus truei	25-Jul-07	-26.36	0.52	38.91826	-114.15
Least chipmunk	Tamias minimus	31-Jul-07	-26.14	4.61	39.05291	-114.318
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-26.03	0.65	39.05303	-114.318
Western Harvest mouse	Reithrodontomys megalotis	11-Aug-09	-25.75	2.38	39.01049	-114.212
Pinon mouse	Peromyscus truei	28-Jul-09	-25.7	0.85	39.01609	-114.214
Least chipmunk	Tamias minimus	09-Aug-07	-25.33	4.26	39.04878	-114.32

Deer Mouse	Peromyscus maniculatus	29-Jul-09	-25.1	1.93	39.05042	-114.321
Pinon mouse	Peromyscus truei	15-Aug-07	-24.6	4.81	38.915	-114.154
Pinon mouse	Peromyscus truei	30-Aug-07	-24.5	0.48	39.01506	-114.213
Pinon mouse	Peromyscus truei	02-Aug-07	-24.29	-0.97	39.01644	-114.213
Deer Mouse	Peromyscus maniculatus	03-Jul-07	-23.76	1.16	39.05274	-114.314
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-23.75	0.43	39.05483	-114.319
Pinon mouse	Peromyscus truei	17-Aug-09	-23.68	2.44	38.91634	-114.187
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-23.6	0.14	39.05464	-114.319
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-23.51	-0.66	39.04948	-114.321
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-23.5	0.16	39.05094	-114.321
Long-tailed vole	Microtus longicaudus	30-Jul-09	-23.4	4.45	39.05428	-114.319
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-22.57	-0.98	39.05042	-114.321
Western Harvest mouse	Reithrodontomys megalotis	07-Aug-08	-22.07	1.18	39.05532	-114.312
Canyon mouse	Peromyscus crinitus	14-Aug-09	-22.03	1.84	38.91889	-114.152

Deer Mouse	Peromyscus maniculatus	29-Jul-09	-21.97	2.52	39.05352	-114.311
Cliff chipmunk	Tamias dorsalis	15-Aug-08	-21.95	3.83	38.90862	-114.173
Western Harvest mouse	Reithrodontomys megalotis	30-Jul-08	-21.9	1.88	38.98765	-114.235
Pinon mouse	Peromyscus truei	27-Aug-07	-21.9	6.45	39.01388	-114.209
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-21.89	1.59	39.05686	-114.305
Pinon mouse	Peromyscus truei	23-Jul-07	-21.7	1.44	38.91858	-114.151
Deer Mouse	Peromyscus maniculatus	28-Jul-09	-21.6	1.52	39.01626	-114.214
Western Harvest mouse	Reithrodontomys megalotis	09-Jul-09	-21.3	0.2	39.01766	-114.229
Pinon mouse	Peromyscus truei	06-Aug-07	-21.3	1.48	38.90961	-114.171
Pinon mouse	Peromyscus truei	28-Jul-09	-20.79	3.93	39.01482	-114.216
Uinta chipmunk	Tamias umbrinus	14-Aug-07	-20.4	5.52	39.00667	-114.211
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-20.39	2.74	39.05532	-114.312
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-20.34	-1.03	39.05175	-114.317
Western Harvest mouse	Reithrodontomys megalotis	28-Jul-09	-20.23	0.41	39.00983	-114.211
Pinon mouse	Peromyscus truei	07-Aug-07	-19.7	3.63	38.91749	-114.149
Canyon mouse	Peromyscus crinitus	04-Aug-09	-19.4	3.77	38.91841	-114.151

Pinon mouse	Peromyscus truei	13-Aug-07	-19.2	6.05	38.90838	-114.156
Deer Mouse	Peromyscus maniculatus	24-Jul-07	-18.7	5.03	39.05174	-114.322
Western Harvest mouse	Reithrodontomys megalotis	28-Jul-09	-18.47	3.06	39.01038	-114.212
Canyon mouse	Peromyscus crinitus	18-Aug-09	-18.18	1.71	38.91702	-114.184
Deer Mouse	Peromyscus maniculatus	30-Jul-07	-17.9	2.38	39.05352	-114.318
Deer Mouse	Peromyscus maniculatus	17-Aug-07	-17.9	2.62	38.9152	-114.151
Deer Mouse	Peromyscus maniculatus	29-Jul-09	-17.22	0.86	39.05567	-114.306
Deer Mouse	Peromyscus maniculatus	25-Jul-07	-16.82	4.15	39.05214	-114.322
Pinon mouse	Peromyscus truei	17-Aug-09	-16.72	1.45	38.91587	-114.177
Cliff chipmunk	Tamias dorsalis	02-Aug-07	-16.3	2.24	39.00773	-114.211
Western Harvest mouse	Reithrodontomys megalotis	12-Aug-08	-16.1	3.77	39.01386	-114.217
Pinon mouse	Peromyscus truei	23-Aug-07	-15.94	3.5	39.01544	-114.208
Deer Mouse	Peromyscus maniculatus	12-Aug-09	-15.8	4.8	38.91443	-114.186
Canyon mouse	Peromyscus crinitus	17-Aug-09	-15.55	2.12	38.91759	-114.187
Desert woodrat	Neotoma lepida	08-Aug-07	-15.4	6.52	38.91841	-114.151

Pinon mouse	Peromyscus truei	13-Aug-07	-14.5	7.04	38.90884	-114.172
Canyon mouse	Peromyscus crinitus	14-Aug-09	-14.1	4.89	38.91863	-114.151
Deer Mouse	Peromyscus maniculatus	21-Aug-09	-13.9	3.43	38.91634	-114.187
Pinon mouse	Peromyscus truei	23-Aug-07	-13.64	3.68	39.0147	-114.213
Pinon mouse	Peromyscus truei	29-Jul-09	-13.04	2.7	39.01516	-114.215
Western Harvest mouse	Reithrodontomys megalotis	30-Jul-09	-12.98	2.71	39.00949	-114.208
Deer Mouse	Peromyscus maniculatus	17-Aug-09	-12.9	1.34	38.9133	-114.188
Pinon mouse	Peromyscus truei	23-Aug-07	-12.03	2.88	39.01568	-114.209
Deer Mouse	Peromyscus maniculatus	23-Jul-07	-11.88	5.03	39.05291	-114.318
Pinon mouse	Peromyscus truei	09-Aug-07	-11.8	5.07	38.91821	-114.15
Deer Mouse	Peromyscus maniculatus	17-Aug-09	-11.7	-1.15	38.91181	-114.19
Pinon mouse	Peromyscus truei	23-Aug-07	-11.3	7.57	39.01538	-114.21
Pinon mouse	Peromyscus truei	13-Aug-09	-11.09	3.81	38.91749	-114.149
Pinon mouse	Peromyscus truei	17-Aug-09	-10.76	3.07	38.91446	-114.177
Desert woodrat	Neotoma lepida	20-Aug-09	-9.98	5.05	38.91702	-114.184
Pinon mouse	Peromyscus truei	23-Aug-	-9.8	4.43	39.01527	-114.212

		07				
Cliff chipmunk	Tamias dorsalis	13-Aug-09	-9	7.59	38.915	-114.154
Western Harvest mouse	Reithrodontomys megalotis	12-Aug-09	-7.44	6.64	39.01437	-114.216
Western Harvest mouse	Reithrodontomys megalotis	28-Jul-09	-6.26	0.55	39.0096	-114.208
Deer Mouse	Peromyscus maniculatus	23-Jul-07	-6.03	8.74	39.05289	-114.322
Pinon mouse	Peromyscus truei	19-Aug-09	-1.13	4.19	38.91132	-114.19
Deer Mouse	Peromyscus maniculatus	14-Aug-09	-0.87	3.4	38.91376	-114.187
Desert woodrat	Neotoma lepida	14-Aug-09	3.83	11.14	38.91242	-114.17
Pinon mouse	Peromyscus truei	12-Aug-09	4.18	7.76	38.90862	-114.173
Pinon mouse	Peromyscus truei	14-Aug-09	6.02	8.03	38.90839	-114.173
Pinon mouse	Peromyscus truei	14-Aug-09	8.73	8.2	39.01574	-114.214

Appendix 6. Stable isotope values (δ13C and δ15N) for plant samples in the South Snake Range. Plant samples were collected in Great Basin National Park in August 2007 - 2009. Samples were oven dried at 50°C, ground in a Wiley Mill, and analyzed for stable carbon and nitrogen isotope ratios. Isotopes were analyzed with Brigham Young University's Elemental Analyzer (EA) interfaced to a Delta V Advantage Isotope Ratio Mass Spectrometer (IRMS). Isotope results are presented relative to international standards in conventional delta (δ) notation as per mil (‰): $\delta_{sample} = R_{sample}\text{-}R_{standard}/R_{standard}$ X 1000, where R is the ratio of the heavy isotope to the light isotope. Data are reported relative to Vienna Peedee belemnite marine limestone (VPDB) and were normalized against standards for accuracy using linear regression and checked for precision against duplicate samples. Concentration data was unavailable as the instrument was not calibrated for quantitative analysis. When duplicate samples were analyzed, the mean value was reported. Mean reproducibility for duplicate samples was 0.31‰ ± 0.29 (n=51) for δ^{13}C and 0.69‰ ± 0.61 (n=53) for δ^{15}N. Analytical precision was 0.04‰, determined by measurement of internal standards over several years.

common name	Species	Date	δ^{15}N	δ^{13}C	Latitude	Longitude
white fir	Abies concolor	9/12/2007	0.75	-29.36	39.04885	-114.32
white fir	Abies concolor	9/12/2007	1.13	-30.75	39.05274	-114.311
white fir	Abies concolor	9/12/2007	-1.31	-28.50	39.05415	-114.306
white fir	Abies concolor	9/12/2007	-0.51	-27.39		
monkshood	Aconitum columbianum	8/18/2009	0.67	-28.99		
common yarrow	Achillea millefolium		11.42	-27.45		
common yarrow	Achillea millefolium	8/20/2008	-2.16	-27.32		
common yarrow	Achillea millefolium	8/19/2009	21.29	-27.46		
crested wheatgrass	Agropyron cristatum	8/8/2008	-1.68	-24.51		
crested wheatgrass	Agropyron cristatum	9/12/2007	-1.40	-26.69		
crested wheatgrass	Agropyron cristatum	8/9/2008	-1.08	-24.08		
crested wheatgrass	Agropyron cristatum	8/6/2009	-0.03	-26.63		
bentgrass	Agrostis sp.	8/13/2008	-1.57	-30.24		
Creeping bentgrass	Agrostis stolonifera	8/17/2009	0.99	-24.35		
Saskatoon serviceberry	Amelanchier alnifolia	9/12/2007	0.16		39.01387	-114.217
Indianhemp	Apocynum cannabinum	8/7/2009	7.84	-27.31		
dogbane	Apocynum sp.	9/12/2007	-0.84	-29.16	39.0099	-114.208
rockcress	Arabis sp.	8/8/2008	0.69	-27.22		
white sagebrush	Artemisia ludoviciana	9/12/2007	0.24	-26.32	39.01366	-114.217
big sagebrush	Artemisia tridentata	9/12/2007	0.68	-27.76	38.91125	-114.17
big sagebrush	Artemisia tridentata	9/5/2007	-0.25		38.91382	-114.151
big sagebrush	Artemisia tridentata	9/5/2007	-0.13	-27.41	38.91683	-114.147
big sagebrush	Artemisia tridentata	9/12/2007	2.96		39.00999	-114.208
big sagebrush	Artemisia tridentata	9/4/2007	2.16	-26.16	39.01021	-114.212

big sagebrush	Artemisia tridentata	9/12/2007	1.27	-26.47	39.0133	-114.208
big sagebrush	Artemisia tridentata	9/12/2007	0.04	-26.53	39.05002	-114.321
big sagebrush	Artemisia tridentata	9/12/2007	-1.97	-24.67	39.0535	-114.311
big sagebrush	Artemisia tridentata	9/12/2007	0.92		39.0537	-114.319
big sagebrush	Artemisia tridentata	9/12/2007	-1.18		39.05502	-114.306
big sagebrush	Artemisia tridentata	7/31/2008	-1.31	-25.09		
big sagebrush	Artemisia tridentata	7/31/2008	-1.13	-26.03		
big sagebrush	Artemisia tridentata	7/31/2008	-0.07	-24.98		
big sagebrush	Artemisia tridentata	8/7/2009	0.17	-28.23		
big sagebrush	Artemisia tridentata	7/31/2008	0.38	-26.47		
big sagebrush	Artemisia tridentata	9/12/2007	1.27	-26.50		
big sagebrush	Artemisia tridentata	8/20/2008	1.34	-29.01		
big sagebrush	Artemisia tridentata	8/9/2008	1.82	-24.98		
big sagebrush	Artemisia tridentata	9/12/2007	2.03			
big sagebrush	Artemisia tridentata	8/9/2008	2.06	-23.96		
big sagebrush	Artemisia tridentata	8/18/2009	2.13	-25.05		
big sagebrush	Artemisia tridentata	8/18/2009	2.73	-27.40		
big sagebrush	Artemisia tridentata	9/12/2007	2.83	-25.98		
big sagebrush	Artemisia tridentata	8/7/2008	2.89	-25.25		
big sagebrush	Artemisia tridentata	8/6/2009	3.58	-23.90		
big sagebrush	Artemisia tridentata	8/6/2009	4.60	-25.68		
big sagebrush	Artemisia tridentata	8/19/2009	5.51	-24.30		
big sagebrush	Artemisia tridentata	8/9/2008	7.38	-23.41		
big sagebrush	Artemisia tridentata	8/19/2009	11.78	-27.32		
big sagebrush	Artemisia tridentata	8/9/2009	14.00	-24.85		
Eaton's aster	Symphyotrichium eatonii	8/19/2009	-0.03	-28.88		
milkvetch	Astragalus sp.	8/20/2008	-1.91	-27.19		
shadscale saltbush	Atriplex confertifolia	8/9/2008	1.88	-14.57		
shadscale saltbush	Atriplex confertifolia	8/9/2008	7.06	-15.21		
shadscale saltbush	Atriplex confertifolia	8/8/2008	7.59	-12.16		
water birch	Betula occidentalis	9/5/2007	1.89	-29.53	38.91661	-114.147
water birch	Betula occidentalis	8/18/2009	1.48	-29.46		
cheatgrass	Bromus tectorum	9/12/2007	-5.59	-29.38	38.90961	-114.171
cheatgrass	Bromus tectorum	9/12/2007	1.75	-26.73	39.00886	-114.208
cheatgrass	Bromus tectorum	8/7/2009	-0.99	-25.69		
cheatgrass	Bromus tectorum	8/9/2008	17.95	-26.31		
sedge	Carex sp.	8/19/2009	-0.35	-24.72		
sedge	Carex sp.	8/13/2008	1.99	-26.49		
curl-leaf mountain mahogany	Cercocarpus ledifolius	9/12/2007	-2.63	-26.02	39.05223	-114.317

yellow rabbitbrush	Chrysothamnus viscidiflorus	8/7/2008	-1.08	-25.34		
yellow rabbitbrush	Chrysothamnus viscidiflorus	8/20/2008	-0.76	-26.62		
yellow rabbitbrush	Chrysothamnus viscidiflorus	7/31/2008	0.11	-23.52		
yellow rabbitbrush	Chrysothamnus viscidiflorus	8/20/2008	0.98	-28.57		
yellow rabbitbrush	Chrysothamnus viscidiflorus	7/31/2008	2.45	-26.85		
western white clematis	Clematis ligusticifolia	8/20/2008	0.03	-28.09		
redosier dogwood	Cornus sericea	9/5/2007	-1.37	-28.95		
redosier dogwood	Cornus sericea	8/7/2009	0.73	-26.99		
springparsley	Cymopterus sp.	9/12/2007	4.60	-29.36		
squirreltail	Elymus elymoides	8/6/2009	-2.48	-16.55		
slender wheatgrass	Elymus trachycaulus	8/19/2009	0.51	-23.35		
jointfir	Ephedra sp.		4.06	-22.69		
Nevada jointfir	Ephedra nevadensis	9/12/2007	0.86	-25.48	39.01438	-114.216
mormon tea	Ephedra viridis	9/12/2007	-2.23	-25.05	38.91	-114.171
mormon tea	Ephedra viridis	9/5/2007	-0.16	-25.07	38.91471	-114.153
mormon tea	Ephedra viridis	8/7/2009	-0.55	-21.58		
mormon tea	Ephedra viridis	8/19/2009	2.75	-25.55		
horsetail	Equisetum sp.	9/12/2007	3.70	-28.08	38.91237	-114.17
horsetail	Equisetum sp.	9/5/2007	0.53	-30.14	38.91663	-114.147
horsetail	Equisetum sp.	7/30/2008	-2.44	-27.06		
horsetail	Equisetum sp.	8/20/2008	3.55	-27.29		
horsetail	Equisetum sp.	9/12/2007	0.62	-28.76	39.00986	-114.208
rubber rabbitbrush	Ericameria nauseosa	8/7/2009	1.38	-28.15		
rubber rabbitbrush	Ericameria nauseosa	8/17/2009	4.90	-25.06		
rubber rabbitbrush	Ericameria nauseosa	8/9/2008	6.51	-22.29		
rubber rabbitbrush	Ericameria nauseosa	8/18/2009	1.79	-23.16		
rubber rabbitbrush	Ericameria nauseosa	9/12/2007	0.04	-30.08	38.91214	-114.17
rubber rabbitbrush	Ericameria nauseosa	9/5/2007	3.63	-27.22	38.91683	-114.147
rubber rabbitbrush	Ericameria nauseosa	9/4/2007	-0.16		39.01062	-114.212
rubber rabbitbrush	Ericameria nauseosa	9/12/2007	-0.17	-25.71	39.05254	-114.318
rubber	Ericameria nauseosa	9/12/2007	0.22	-28.60	39.05448	-114.312

rabbitbrush						
rubber rabbitbrush	Ericameria nauseosa	9/12/2007	0.67	-29.75		
rubber rabbitbrush	Ericameria nauseosa	9/12/2007	2.68	-29.69		
rubber rabbitbrush	Ericameria nauseosa	9/12/2007	-0.93	-25.83	39.05464	-114.306
rubber rabbitbrush	Ericameria nauseosa	9/12/2007	3.88	-25.44	39.05464	-114.306
slender buckwheat	Eriogonum microthecum	10/31/2008	-1.17	-25.72		
slender buckwheat	Eriogonum microthecum	8/18/2009	4.41	-27.94		
redroot buckwheat	Eriogonum racemosum	8/7/2008	0.70	-27.39		
	forb	9/12/2007	1.61	-28.36	39.05428	-114.312
	forb	9/12/2007	1.82	-27.42		
	forb	9/12/2007	0.41	-34.52	39.05054	-114.316
	forb	8/18/2009	4.97	-28.69		
	forb (Asteracea)	8/20/2008	0.56	-27.28		
	forb (Asteracea)	10/31/2008	0.33	-25.44		
	forb (Asteracea)	10/31/2008	-2.15	-24.02		
gilia	Gilia sp.	8/20/2008	2.16	-24.57		
	grass	9/5/2007	-1.29	-26.84	38.91382	-114.151
	grass	9/5/2007	-1.34	-24.72	38.91704	-114.148
	grass	9/4/2007	0.18		39.00956	-114.211
	grass	9/12/2007	0.26		39.00978	-114.208
	grass	9/4/2007	0.08	-27.50	39.01038	-114.212
	grass	9/12/2007	-0.35	-26.00	39.01471	-114.216
	grass	9/12/2007	-2.15		39.01508	-114.215
	grass	9/12/2007	2.59	-26.34	39.05252	-114.311
	grass	9/12/2007	-4.36	-26.70	39.0535	-114.311
	grass	9/12/2007	-0.22	-27.37	39.05626	-114.306
	grass	8/7/2008	-0.91	-25.74		
	grass	9/12/2007	-0.39	-28.22		
	grass	9/12/2007	0.51	-25.56		
	grass	7/31/2008	0.99	-25.14		
	grass	8/20/2008	1.19	-25.77		
	grass		1.21	-25.16		
	grass	7/31/2008	20.03	-26.55		
	grass	8/7/2008	-0.41	-28.01		
	grass	8/13/2008	3.72	-24.86		
	grass	8/18/2009	1.53	-25.25		
curlycup gumweed	Grindelia squarrosa	8/20/2008	0.07	-26.70		

broom snakeweed	Gutierrezia sarothrae	8/17/2009	2.10	-26.49		
broom snakeweed	Gutierrezia sarothrae	8/9/2008	5.48	-22.33		
Achnatherum hymenoides	Indian ricegrass	9/12/2007	-0.84		39.0135	-114.208
Achnatherum hymenoides	Indian ricegrass	7/31/2008	-3.66	-25.37		
Achnatherum hymenoides	Indian ricegrass	8/9/2008	-3.51	-25.22		
Achnatherum hymenoides	Indian ricegrass	7/31/2008	-2.02	-27.85		
Achnatherum hymenoides	Indian ricegrass	7/30/2008	-1.60	-25.42		
Achnatherum hymenoides	Indian ricegrass	8/13/2008	0.04	-23.91		
Achnatherum hymenoides	Indian ricegrass	8/9/2008	2.99	-23.52		
Achnatherum hymenoides	Indian ricegrass	7/31/2008	16.30	-27.47		
Achnatherum hymenoides	Indian ricegrass	8/8/2008	21.09	-27.04		
scarlet gilia	Ipomopsis aggregata	8/18/2009	2.31	-26.19		
rush	Juncus sp.	9/12/2007	0.69	-28.45	38.91224	-114.17
rush	Juncus sp.	9/13/2007	0.03	-24.48	39.00983	-114.208
rush	Juncus sp.	9/12/2007	0.42		39.00983	-114.208
rush	Juncus sp.	9/12/2007	0.51	-28.19	39.00985	-114.208
rush	Juncus sp.	9/12/2007	0.09		39.00991	-114.208
rush	Juncus sp.	9/4/2007	-0.57	-30.08	39.01044	-114.212
rush	Juncus sp.	9/12/2007	0.59	-28.84	39.01368	-114.217
rush	Juncus sp.	8/13/2008	-0.45	-27.78		
Utah juniper	Juniperus osteosperma	9/12/2007	-0.57	-27.13	38.91106	-114.171
Utah juniper	Juniperus osteosperma	9/12/2007	-1.97	-24.86	38.9109	-114.155
Utah juniper	Juniperus osteosperma	9/5/2007	-0.57	-24.39	38.91457	-114.153
Utah juniper	Juniperus osteosperma	9/4/2007	-0.51	-24.06	39.00876	-114.211
Utah juniper	Juniperus osteosperma	9/12/2007	0.60	-24.11	39.00886	-114.208
Utah juniper	Juniperus osteosperma	9/12/2007	1.33	-23.02	39.01131	-114.208
Utah juniper	Juniperus osteosperma	7/31/2008	-3.23	-25.58		
Utah juniper	Juniperus osteosperma	7/30/2008	-2.04	-22.82		
Utah juniper	Juniperus osteosperma	7/31/2008	-1.51	-24.48		
basin wildrye	Leymus cinereus	8/20/2008	-9.40	-24.74		
basin wildrye	Leymus cinereus	8/18/2009	-0.01	-24.48		
basin wildrye	Leymus cinereus	8/18/2009	0.34	-24.52		
basin wildrye	Leymus cinereus	8/20/2008	1.62	-26.29		
basin wildrye	Leymus cinereus	8/8/2008	1.67	-24.37		
basin wildrye	Leymus cinereus	8/1/2008	1.78	-26.62		

basin wildrye	Leymus cinereus	8/20/2008	2.10	-27.80		
basin wildrye	Leymus cinereus	8/19/2009	3.65	-25.91		
basin wildrye	Leymus cinereus	8/18/2009	4.36	-26.20		
basin wildrye	Leymus cinereus	8/6/2009	4.48	-26.15		
silvery lupine	Lupinus argenteus	9/12/2007	-2.98	-28.04	39.05291	-114.318
silvery lupine	Lupinus argenteus	7/31/2008	-1.82	-28.48		
silvery lupine	Lupinus argenteus		-1.04	-28.24		
silvery lupine	Lupinus argenteus	7/31/2008	-0.74	-24.16		
silvery lupine	Lupinus argenteus	8/7/2008	6.92	-25.74		
creeping barberry	Mahonia repens	9/12/2007	-0.94	-27.56	39.0504	-114.321
watercress	Nasturtium officinale	8/13/2008	2.58	-29.69		
green molly	Bassia americana	8/9/2008	9.21	-23.58		
plains pricklypear	Opuntia polyacantha	9/12/2007	1.64	-12.40	39.01099	-114.208
plains pricklypear	Opuntia polyacantha	8/9/2008	-2.72	-11.88		
beardtounge	Penstemon sp.	8/6/2009	-1.00	-26.82		
beardtounge	Penstemon sp.	8/18/2009	0.71	-26.57		
beardtounge	Penstemon sp.	8/19/2009	10.51	-27.72		
wild crab apple	Peraphyllum ramosissimum	9/12/2007	-1.45	-26.90	39.05115	-114.321
Engelmann spruce	Picea engelmannii	8/7/2008	0.55	-26.54		
limber pine	Pinus flexilis	8/7/2008	2.79	-21.50		
singleleaf pinyon	Pinus monophylla	9/12/2007	-1.39	-26.82	38.91148	-114.17
singleleaf pinyon	Pinus monophylla	9/5/2007	-2.73	-24.20	38.91457	-114.153
singleleaf pinyon	Pinus monophylla	9/5/2007	-0.76	-23.20	38.91698	-114.148
singleleaf pinyon	Pinus monophylla	9/12/2007	0.09	-25.75	39.00886	-114.208
singleleaf pinyon	Pinus monophylla	9/12/2007	0.35	-24.37	39.01063	-114.208
singleleaf pinyon	Pinus monophylla	9/12/2007	0.88	-22.86	39.01484	-114.216
singleleaf pinyon	Pinus monophylla	9/12/2007	0.91	-23.11	39.05138	-114.321
singleleaf pinyon	Pinus monophylla	7/31/2008	-5.14	-25.16		
singleleaf pinyon	Pinus monophylla	8/18/2009	-2.97	-19.86		
singleleaf pinyon	Pinus monophylla	7/31/2008	-2.08	-24.40		
singleleaf pinyon	Pinus monophylla	8/13/2008	-1.22	-24.26		
singleleaf	Pinus monophylla	8/17/2009	-0.13	-20.88		

pinyon						
singleleaf pinyon	Pinus monophylla	9/1/2008	-0.04	-21.70		
singleleaf pinyon	Pinus monophylla	8/6/2008	0.27	-23.75		
singleleaf pinyon	Pinus monophylla	8/8/2008	1.56	-22.35		
singleleaf pinyon	Pinus monophylla	7/31/2008	1.83	-22.51		
singleleaf pinyon	Pinus monophylla	7/31/2008	12.42	-23.77		
singleleaf pinyon	Pinus monophylla	8/7/2009	12.65	-23.79		
bluegrass	Poa sp.	8/18/2009	-1.49	-23.90		
bluegrass	Poa sp.	8/18/2009	4.98	-26.09		
narrowleaf cottonwood	Populus angustifolia	9/12/2007	-0.11	-32.02	38.91235	-114.17
narrowleaf cottonwood	Populus angustifolia	9/12/2007	-2.30	-31.50	38.91265	-114.155
narrowleaf cottonwood	Populus angustifolia	9/5/2007	0.28	-29.32	38.91378	-114.151
narrowleaf cottonwood	Populus angustifolia	9/5/2007	-2.97	-31.53	38.91665	-114.147
narrowleaf cottonwood	Populus angustifolia	8/20/2008	-1.75	-30.64		
narrowleaf cottonwood	Populus angustifolia	8/7/2009	-1.25	-27.19		
narrowleaf cottonwood	Populus angustifolia	8/13/2009	-0.41	-26.04		
quaking aspen	Populus tremuloides	9/12/2007	2.55	-25.82	39.05286	-114.311
quaking aspen	Populus tremuloides	9/12/2007	0.50		39.0543	-114.306
quaking aspen	Populus tremuloides	8/7/2008	-0.77	-31.05		
quaking aspen	Populus tremuloides	9/12/2007	0.84			
quaking aspen	Populus tremuloides	9/12/2007	1.12	-31.31		
quaking aspen	Populus tremuloides	8/1/2008	3.01	-25.98		
western chokecherry	Prunus virginiana	9/12/2007	0.55	-28.25	38.91248	-114.155
western chokecherry	Prunus virginiana	9/12/2007	0.27	-27.69	39.05019	-114.321
western chokecherry	Prunus virginiana	8/8/2008	-1.90	-28.38		
western chokecherry	Prunus virginiana	8/17/2009	1.48	-23.24		
western chokecherry	Prunus virginiana	8/18/2009	1.81	-27.45		
bluebunch wheatgrass	Pseudoroegneria spicata	8/7/2008	-0.97	-26.77		
bluebunch	Pseudoroegneria spicata	7/31/2008	0.51	-24.91		

wheatgrass						
Stansbury cliffrose	Purshia stansburiana	8/7/2009	-1.52	-21.51		
Stansbury cliffrose	Purshia stansburiana	8/6/2009	-1.05	-21.40		
antelope bitterbrush	Purshia tridentata	7/30/2008	1.33	-24.73		
antelope bitterbrush	Purshia tridentata	9/12/2007	-2.58	-27.06	39.05487	-114.312
antelope bitterbrush	Purshia tridentata	9/12/2007	-1.24	-26.72	39.05689	-114.305
buttercup	Ranunculus sp.	9/12/2007	-0.60	-28.96	39.05098	-114.316
skunkbush sumac	Rhus trilobata	9/12/2007	-1.27	-25.40	38.91248	-114.17
skunkbush sumac	Rhus trilobata	9/5/2007	-2.60		38.91371	-114.151
skunkbush sumac	Rhus trilobata	9/5/2007	-2.35	-29.75	38.91665	-114.147
skunkbush sumac	Rhus trilobata	9/5/2007	0.00	-29.68	38.91665	-114.147
skunkbush sumac	Rhus trilobata	9/4/2007	0.44	-27.80	39.01012	-114.212
skunkbush sumac	Rhus trilobata	9/12/2007	-4.31	-27.46		
skunkbush sumac	Rhus trilobata	8/13/2008	-1.83	-25.07		
skunkbush sumac	Rhus trilobata	8/13/2009	-1.53	-22.20		
skunkbush sumac	Rhus trilobata	8/19/2009	0.08	-24.31		
skunkbush sumac	Rhus trilobata	8/20/2008	1.07	-28.73		
currant	Ribes sp.	8/19/2009	-2.30	-28.94		
currant	Ribes sp.	8/6/2009	-1.05	-26.68		
currant	Ribes sp.	8/6/2009	0.69	-24.36		
Wood's rose	Rosa woodsii	9/5/2007	0.01	-29.24	38.91665	-114.147
Wood's rose	Rosa woodsii	9/12/2007	-1.84		39.00991	-114.208
Wood's rose	Rosa woodsii	9/12/2007	0.42	-27.92	39.00994	-114.208
Wood's rose	Rosa woodsii	9/4/2007	-2.84		39.01058	-114.212
Wood's rose	Rosa woodsii	9/12/2007	0.25		39.05571	-114.306
Wood's rose	Rosa woodsii	8/13/2008	-3.07	-24.20		
Wood's rose	Rosa woodsii	8/8/2008	-2.97	-26.01		
Wood's rose	Rosa woodsii	8/13/2008	-1.52	-21.41		
Wood's rose	Rosa woodsii	9/5/2007	-0.76	-28.65		
Wood's rose	Rosa woodsii	8/20/2008	-0.27	-26.44		
Wood's rose	Rosa woodsii	9/12/2007	1.88	-29.96		
Wood's rose	Rosa woodsii	8/1/2008	2.58	-26.50		

Wood's rose	Rosa woodsii	8/19/2009	3.19	-24.59		
dock	Rumex sp.	8/7/2008	0.39	-27.30		
dock	Rumex sp.	8/19/2009	1.33	-24.83		
prickly Russian thistle	Salsola tragus	8/9/2008	4.68	-15.25		
blue elderberry	Sambucus nigra	8/19/2009	5.77	-27.53		
narrowleaf willow	Salix exigua	8/17/2009	-2.14	-26.75		
willow	Salix sp.	9/12/2007	-2.26	-28.24	39.00991	-114.208
willow	Salix sp.	9/4/2007	-0.04		39.01051	-114.212
willow	Salix sp.	9/12/2007	-1.06	-31.34	39.01374	-114.217
willow	Salix sp.	8/13/2008	2.98	-26.72		
willow	Salix sp.	8/6/2009	4.53	-29.18		
willow	Salix sp.	8/8/2008	7.98	-28.44		
greasewood	Sarcobatus vermiculatus	8/9/2008	3.42	-24.60		
greasewood	Sarcobatus vermiculatus	9/12/2007	6.71	-25.93		
greasewood	Sarcobatus vermiculatus	8/9/2008	8.89	-23.59		
	shrub	9/12/2007	0.50	-26.39	39.04892	-114.321
	shrub	9/12/2007	0.16	-29.57	39.05412	-114.306
	shrub	9/12/2007	0.55	-31.14		
goldenrod	Solidago sp.	9/12/2007	-1.62	-24.99	38.91245	-114.155
gooseberryleaf globemallow	Sphaeralcea grossulariifolia	8/6/2009	1.83	-25.80		
dropseed	Sporobolus sp.	8/9/2008	-1.88	-15.03		
dropseed	Sporobolus sp.	8/9/2008	1.85	-15.75		
dropseed	Sporobolus sp.	8/9/2008	5.19	-15.86		
mountain snowberry	Symphoricarpos oreophilus	9/12/2007	0.32	-25.75	39.04879	-114.32
mountain snowberry	Symphoricarpos oreophilus	9/12/2007	2.92	-29.23	39.05252	-114.311
mountain snowberry	Symphoricarpos oreophilus	9/12/2007	-1.09		39.05353	-114.319
mountain snowberry	Symphoricarpos oreophilus	9/12/2007	-0.09	-28.86	39.05423	-114.306
mountain snowberry	Symphoricarpos oreophilus	7/31/2008	1.03	-23.99		
mountain snowberry	Symphoricarpos oreophilus	7/31/2008	1.32	-23.60		
mountain snowberry	Symphoricarpos oreophilus	8/18/2009	1.94	-27.58		
mountain snowberry	Symphoricarpos oreophilus	8/18/2009	3.99	-27.32		
mountain goldenbanner	Thermopsis montana	8/20/2008	-1.31	-29.28		
mountain goldenbanner	Thermopsis montana	8/1/2008	-0.95	-28.14		

mountain goldenbanner	Thermopsis montana	8/18/2009	2.65	-29.47		
moss		8/13/2008	-2.08	-24.32		

Appendix 7. Stable isotope values (δD and δ18O) for evaporation, rain, snow, and stream samples in the South Snake Range. Stream samples were collected directly from Lehman, Snake, and Strawberry creeks (n=163; elevation range = 1627 – 3044m). Precipitation samples representing meteoric waters were collected from four sites (elevation range = 1627 – 3098m). Snow was collected directly from the ground and melted prior to isotope analysis. Rain was collected from building and gutter run-off or in glass jars under mineral oil and screened funnels to minimize debris accumulation and prevent evaporation. Most samples of meteoric waters were from a single precipitation events (n = 165). Other samples were the aggregate of several precipitation events collected over multiple days (n = 29). Precipitations samples were decanted into in amber glass vials with conical lids, sealed with parafilm, and stored in a dark cabinet at room temperature prior to isotopic analysis. Approximately ten liters of water collected from Lehman Creek was used for an evaporative water experiment sensu (Craig et al. 1963). Water was left in two open containers, to evaporate at room temperature (20°C). Samples were collected from the unevaporated water at 0, 10, 16, 19, 23, and 46 days from experiment initiation (n = 22). Relative humidity, the primary control of evaporation rate, was not recorded but likely approximated outdoor conditions during the experiment (range = 7% - 53%, mean 30%; https://www.wunderground.com/history/; accessed 2 March 2018).

Stable isotope results are presented relative to international standards in conventional δ notation as ‰: $\delta_{sample} = R_{sample}\text{-}R_{standard}/R_{standard}$ X 1000, where R is the ratio of the heavy isotope to the light isotope. Data are reported as the ratio of heavy to light isotopes (^{18}O: ^{16}O; ^{2}H: ^{1}H) normalized to the VSMOW/Standard Light Antarctic Precipitation (SLAP) scale (Coplen 1988, Nelson 2000, Nelson and Dettman 2001). $\delta^{18}O_{VSMOW}$ and δD_{VSMOW} are hereafter referred to as δ^{18}O and δD. Stable isotope ratios of water samples (δD, δ^{18}O) were analyzed at Brigham Young University, Department of Geology, Provo, Utah. Samples (n = 188) were initially analyzed with a Finnigan Delta Plus (Bremen, Germany) isotope ratio mass spectrometer interfaced to a Gasbench (Finnigan, Bremen, Germany) with methods similar to Anderson et al. (2006). For this study, the reproducibility of our internal standard was 0.5‰ for δD and 0.2‰ for δ^{18}O.

Analyses of the remaining precipitation and stream samples (n = 141) were completed using a Los Gatos Research Liquid Water Isotope Analyzer (LWIA-24d), which analyzes δ^{18}O and δD simultaneously, with a precision of 0.2‰ and 0.6‰ respectively. Batch sample set-up used the procedure outlined in Nelson (2000) and Nelson and Dettman (2001). Memory correction was addressed by rejecting the first four injections of each sample. The remaining four injections of each isotope run were drift corrected (procedure used in Nelson and Dettman 2001) using in-house standards. The in-house standards (calibrated by VSMOW and SLAP) have isotopic values within the range of our data, thus reducing the influence of memory. The final isotopic composition of a sample was determined by taking the average of the drift corrected injections (Williams 2013). To build internal consistency and ensure direct comparability between instruments, samples were run in batches with calibrated lab standards. Data and equipment were checked for precision by running duplicates of samples and standards and normalized against standards for accuracy using linear regression. Samples that fell off the meteoric waterline suggested large analytical errors and were removed from the dataset prior to statistical analyses (n = 1 for precipitation and n = 4 for stream samples).

Date Collected	sample_type	δ^{18}O	δD	Latitude	Longitude
10-Aug-08	evaporation	-14.38	-109.7		
10-Aug-08	evaporation	-14.26	-110		

20-Aug-08	evaporation	-10.67	-94.8		
20-Aug-08	evaporation	-10.64	-93.9		
20-Aug-08	evaporation	-10.54	-94.4		
20-Aug-08	evaporation	-9.9	-94		
26-Aug-08	evaporation	-4.75	-71.4		
26-Aug-08	evaporation	-4.72	-72.2		
26-Aug-08	evaporation	-4.56	-72.8		
26-Aug-08	evaporation	-4.42	-74		
29-Aug-08	evaporation	-1.75	-60.9		
29-Aug-08	evaporation	-1.44	-61.2		
29-Aug-08	evaporation	-1.31	-59.4		
29-Aug-08	evaporation	-1.01	-59.4		
3-Sep-08	evaporation	3.58	-38.6		
3-Sep-08	evaporation	3.75	-37.7		
3-Sep-08	evaporation	4.14	-36.2		
3-Sep-08	evaporation	4.4	-34.3		
15-Sep-08	evaporation	24.65	45.8		
15-Sep-08	evaporation	24.67	48		
15-Sep-08	evaporation	25.45	49.4		
15-Sep-08	evaporation	29.59	65.4		
20-Jul-09	rain	-7.94	-58.06	39.00477	-114.219270
12-Aug-09	rain	-1.83	-34.2	39.00477	-114.219270
26-Aug-09	rain	-1.79	-28.88	39.00477	-114.219270
28-Jun-09	rain	-10.39	-83.52	39.00477	-114.219270
2-Jul-09	rain	-9.5	-53.03	39.00477	-114.219270
14-Sep-09	rain	-9.16	-68.45	39.00477	-114.219270
7-Jul-09	rain	-2.53	-31.59	39.00477	-114.219270
7-Jul-09	rain	-1.67	-30.85	39.00477	-114.219270
3-Sep-10	rain	-6.08	-55.82	39.00477	-114.219270
7-Jun-10	rain	-14.13	-103.38	39.00477	-114.219270
6-Apr-10	rain	-13.44	-111.8	39.00477	-114.219270
22-Jun-10	rain	-13.09	-98.93	39.00477	-114.219270
11-Oct-10	rain	-10.56	-71.9	39.00477	-114.219270
20-May-10	rain	-9.69	-72.39	39.00477	-114.219270
22-Apr-10	rain	-9.2	-68.71	39.00477	-114.219270
28-Apr-10	rain	-5.68	-30.2	39.00477	-114.219270
2-Aug-10	rain	NA	NA	39.00477	-114.219270
20-Sep-11	rain	-5.13	-40.2	39.00477	-114.219270
20-Jul-11	rain	-10.45	-82.1	39.00477	-114.219270
11-Jun-09	rain	-20.49	-68.8	39.00477	-114.219268
2-May-09	rain	-12.35	-100.09	39.00477	-114.219268
13-Jun-09	rain	-9.34	-69	39.00477	-114.219268
12-Jun-09	rain	-8.71	-69.6	39.00477	-114.219268

18-May-09	rain	-6.3	-46.93	39.00477	-114.219268
25-Apr-09	rain	-11.65	-84.58	39.00477	-114.219268
28-Jun-09	rain	-8.5	-75.43	39.01478	-114.126702
28-Jun-09	rain	-8.05	-75.58	39.01478	-114.126702
20-Jul-09	rain	-7.94	-56.94	39.01478	-114.126702
20-Jul-09	rain	-0.56	-37.08	39.01478	-114.126702
26-Aug-09	rain	0.64	NA	39.01478	-114.126702
20-Oct-09	rain	-13.32	-91.2	39.01478	-114.126702
14-Sep-09	rain	-11.17	-72.94	39.01478	-114.126702
1-Aug-09	rain	-7.09	-73.78	39.01478	-114.126702
7-Jul-09	rain	-1.15	-20.88	39.01478	-114.126702
19-Jul-09	rain	1.09	-32.49	39.01478	-114.126702
10-Dec-10	rain	-22.92	-176.5	39.01478	-114.126702
13-May-10	rain	-17.28	-131.02	39.01478	-114.126702
7-Jun-10	rain	-10.9	-78.99	39.01478	-114.126702
11-Oct-10	rain	-10	-67.6	39.01478	-114.126702
29-Apr-10	rain	-9.04	-60.22	39.01478	-114.126702
20-May-10	rain	-8.88	-70	39.01478	-114.126702
22-Apr-10	rain	-7.59	-56.42	39.01478	-114.126702
28-Apr-10	rain	-6.8	-38.8	39.01478	-114.126702
3-Sep-10	rain	-6.3	-53.78	39.01478	-114.126702
19-Dec-10	rain	-5.37	-65.4	39.01478	-114.126702
20-Jul-11	rain	-6.89	-53.5	39.01478	-114.126702
4-Jun-11	rain	-15.84	-121.9	39.01478	-114.126702
20-Sep-11	rain	-2.77	-30.6	39.01478	-114.126702
25-Apr-09	rain	-16.33	-121.83	39.01478	-114.126700
11-Apr-09	rain	-11.02	-77	39.01478	-114.126700
2-May-09	rain	-10.94	-92.87	39.01478	-114.126700
10-Jun-09	rain	-8.09	-79.1	39.01478	-114.126700
8-Jun-09	rain	-7.97	-71.7	39.01478	-114.126700
13-Jun-09	rain	-7.29	-70.4	39.01478	-114.126700
5-Jun-09	rain	-2.38	-29.43	39.01478	-114.126700
1-Jun-09	rain	1.43	-8.01	39.01478	-114.126700
11-Oct-10	rain	-12.83	-82.4	39.02638	-114.287318
7-Jun-10	rain	-11.97	-85.83	39.02638	-114.287318
6-Sep-10	rain	-9.94	-71.62	39.02638	-114.287318
2-Aug-10	rain	-6.19	-40.6	39.02638	-114.287318
22-Sep-11	rain	-8.31	-57.1	39.02638	-114.287318
8-Jun-11	rain	-15.13	-108.5	39.02638	-114.287318
6-Sep-10	rain	-8.07	-60.85	39.02829	-114.266697
11-Oct-10	rain	-11.56	-76.3	39.02829	-114.266697
2-Aug-10	rain	-6.54	-42.8	39.02829	-114.266697
22-Sep-11	rain	-8.45	-54.6	39.02829	-114.266697

26-Jul-11	rain	-11.82	-90	39.02829	-114.266697
8-Jun-11	rain	-14.9	-111.4	39.02829	-114.266697
	rain	-6.79	-65.54		
22-Sep-07	rain	-15.15	-110.54		
24-Sep-07	rain	-14.3	-102.3		
31-Aug-07	rain	2.84	2.85		
31-Aug-08	rain	-9.63	-63.8		
5-Aug-08	rain	-7.41	-52.5		
5-Aug-08	rain	-7.37	-54.7		
5-Aug-08	rain	-7.37	-52		
7-Aug-08	rain	-6.85	-47.7		
5-Aug-08	rain	-6.02	-45.5		
5-Aug-08	rain	-6.01	-45.6		
5-Aug-08	rain	-5.76	-43.4		
14-Oct-09	rain	-10.08	NA		
9-Nov-08	snow	-16.93	-123.64	39.00477	-114.219270
13-Dec-08	snow	-13.43	-89.95	39.00477	-114.219270
14-Feb-09	snow	NA	-161.6	39.00477	-114.219270
9-Feb-09	snow	-16.2	-117.64	39.00477	-114.219270
27-Jan-09	snow	-21.32	-150.6	39.00477	-114.219270
8-Dec-09	snow	-25.12	-179.55	39.00477	-114.219270
30-Dec-09	snow	-23.53	-176.37	39.00477	-114.219270
28-Dec-09	snow	-18.42	-135.5	39.00477	-114.219270
23-Dec-09	snow	-16.86	-123.77	39.00477	-114.219270
7-Dec-09	snow	-16.77	-111.59	39.00477	-114.219270
7-Dec-09	snow	-16.44	-104.03	39.00477	-114.219270
15-Apr-09	snow	-15.99	-120.95	39.00477	-114.219270
20-Oct-09	snow	-14.21	-97.47	39.00477	-114.219270
30-Sep-09	snow	-12.69	-97.45	39.00477	-114.219270
13-Dec-09	snow	-12.04	-92.45	39.00477	-114.219270
5-Oct-09	snow	-11.5	-75.39	39.00477	-114.219270
5-Oct-09	snow	-11.17	-75.25	39.00477	-114.219270
5-Oct-09	snow	-11.02	-74.81	39.00477	-114.219270
30-Sep-09	snow	-9.11	-71.02	39.00477	-114.219270
24-Nov-10	snow	-19.89	-144.2	39.00477	-114.219270
27-Jan-10	snow	-23.52	-179.72	39.00477	-114.219270
20-Jan-10	snow	-22.46	-169.79	39.00477	-114.219270
26-Jan-10	snow	-19.55	-143.32	39.00477	-114.219270
22-Jan-10	snow	-18.82	-148.29	39.00477	-114.219270
31-Mar-10	snow	-18.13	-135.71	39.00477	-114.219270
22-Feb-10	snow	-17.9	-126.13	39.00477	-114.219270
8-Feb-10	snow	-16.97	-126.78	39.00477	-114.219270
20-Feb-10	snow	-12.94	-96.33	39.00477	-114.219270

19-Feb-10	snow	-12.79	-93.52	39.00477	-114.219270
15-Dec-10	snow	-18.32	-138.9	39.00477	-114.219270
8-Apr-11	snow	-23.51	-175.9	39.00477	-114.219270
7-Jun-11	snow	-13.45	-100.1	39.00477	-114.219270
18-Dec-08	snow	-22.89	-166.43	39.00477	-114.219268
16-Dec-08	snow	-22.14	-158.92	39.00477	-114.219268
28-Dec-08	snow	-19.12	-139.65	39.00477	-114.219268
8-Nov-08	snow	-19	-140.3	39.00477	-114.219268
26-Nov-08	snow	-16.79	-128.94	39.00477	-114.219268
2-Nov-08	snow	-13.05	-89.29	39.00477	-114.219268
2-Nov-08	snow	-9.23	-76.8	39.00477	-114.219268
3-Jan-09	snow	-19.78	-141.71	39.00477	-114.219268
22-Mar-09	snow	-19.3	-142.8	39.00477	-114.219268
22-Mar-09	snow	-17.65	-136	39.00477	-114.219268
4-Apr-09	snow	-16.54	-121.2	39.00477	-114.219268
29-Mar-09	snow	-15.95	-121.67	39.00477	-114.219268
7-Mar-09	snow	-15.32	-106.6	39.00477	-114.219268
4-Apr-09	snow	-15.09	-111.4	39.00477	-114.219268
25-Apr-09	snow	-14.4	-105.1	39.00477	-114.219268
25-Jan-09	snow	-14.11	-100.99	39.00477	-114.219268
11-Apr-09	snow	-13.35	-93.9	39.00477	-114.219268
14-Apr-09	snow	-12.97	-89.38	39.00477	-114.219268
7-Feb-09	snow	-12.19	-81.84	39.00477	-114.219268
3-Apr-09	snow	-11.42	-82.6	39.00477	-114.219268
23-May-10	snow	-14.94	-112.7	39.01728	-114.303384
8-Dec-09	snow	-21.25	-149.06	39.01478	-114.126702
23-Dec-09	snow	-17.79	-129.66	39.01478	-114.126702
30-Sep-09	snow	-14.28	-117.99	39.01478	-114.126702
22-Dec-09	snow	-13.19	-92.52	39.01478	-114.126702
7-Dec-09	snow	-9.29	-67.57	39.01478	-114.126702
7-Dec-09	snow	-9.28	-55.61	39.01478	-114.126702
20-Jan-10	snow	-20.29	-155.34	39.01478	-114.126702
22-Feb-10	snow	-18.16	-132.02	39.01478	-114.126702
31-Mar-10	snow	-16.9	-125.63	39.01478	-114.126702
20-Feb-10	snow	-13.39	-93.78	39.01478	-114.126702
24-Nov-10	snow	-19.41	-134.9	39.01478	-114.126702
15-Dec-10	snow	-18.4	-139.3	39.01478	-114.126702
20-Dec-10	snow	-21.26	-161.7	39.01478	-114.126702
9-Nov-10	snow	-12.48	-92.4	39.01478	-114.126702
8-Apr-11	snow	-22.63	-169.2	39.01478	-114.126702
23-Apr-11	snow	-12.78	-91.1	39.01478	-114.126702
26-Feb-11	snow	-23.14	-171	39.01478	-114.126702
3-Apr-11	snow	-16.2	-124.6	39.01478	-114.126702

31-Jan-11	snow	-20.98	-157.5	39.01478	-114.126702
25-Feb-11	snow	-15.39	-101.5	39.01478	-114.126702
29-Mar-09	snow	-16.21	-123.9	39.01478	-114.126700
22-Mar-09	snow	-14.81	-115.08	39.01478	-114.126700
22-Mar-09	snow	-14.51	-108.6	39.01478	-114.126700
25-Apr-09	snow	-13.28	-95.02	39.01478	-114.126700
7-Mar-09	snow	-10.65	-107.1	39.01478	-114.126700
4-Apr-09	snow	-10.43	-68.2	39.01478	-114.126700
16-Dec-08	snow	-21.65	-151.86	39.01478	-114.126700
18-Dec-08	snow	-19.58	-142.75	39.01478	-114.126700
26-Dec-08	snow	-18.26	-138.76	39.01478	-114.126700
9-Nov-08	snow	-13.03	-98.76	39.01478	-114.126700
9-Nov-08	snow	-12.36	-95.84	39.01478	-114.126700
13-Dec-08	snow	-12.2	-78.75	39.01478	-114.126700
14-Feb-09	snow	-18.4	-129.21	39.01478	-114.126700
9-Feb-09	snow	-17.59	-129.99	39.01478	-114.126700
27-Jan-09	snow	-20.33	-141.91	39.01478	-114.126700
3-Jan-09	snow	-18.7	-145.2	39.01478	-114.126700
7-Feb-09	snow	-11.73	-78.07	39.01478	-114.126700
25-Jan-09	snow	-11.57	-86.43	39.01478	-114.126700
15-Apr-09	snow	-13.8	-107.65	39.02638	-114.287318
26-Jul-11	snow	-12.1	-87.1	39.02638	-114.287318
	snow	-18.06	-142	39.02638	-114.287318
23-May-10	snow	-16.01	-122.42	39.02821	-114.278088
	snow	-17.84	-138.1	39.02829	-114.266697
23-May-10	snow	-15.63	-121.18	39.02863	-114.267019
30-Dec-07	snow	-23.56	-174.1		
13-Oct-09	stream	-16.31	-110.74	38.91248	-114.170029
18-Aug-09	stream	-16.08	-111.66	38.91248	-114.170029
24-Jul-09	stream	-12.83	-110.86	38.91248	-114.170029
31-Aug-10	stream	-15.18	-111.39	38.91248	-114.170029
1-Aug-07	stream	-11.67	-109.88	38.91248	-114.170029
31-Jul-08	stream	-14.73	-114.6	38.91248	-114.170029
31-Jul-08	stream	-14.46	-114.3	38.91248	-114.170029
2-Feb-11	stream	-15.25	-113.8	38.91248	-114.170029
13-May-09	stream	-15.17	-113.4	38.91248	-114.170025
4-Jun-09	stream	-15.13	-112.16	38.91248	-114.170025
14-Nov-08	stream	-15.37	-112.4	38.91248	-114.170025
14-Nov-08	stream	-14.91	-112.3	38.91248	-114.170025
11-Feb-09	stream	NA	-106.2	38.91248	-114.170025
11-Feb-09	stream	NA	-105.8	38.91248	-114.170025
4-Jun-09	stream	-15.31	-112.28	38.91265	-114.154563
13-May-09	stream	-14.94	-112.2	38.91265	-114.154563

14-Nov-08	stream	-15.67	-112.7	38.91265	-114.154563
14-Nov-08	stream	-15.18	-112.7	38.91265	-114.154563
11-Feb-09	stream	-15.11	-111.81	38.91265	-114.154563
11-Feb-09	stream	NA	-109.4	38.91265	-114.154563
24-Jul-09	stream	-15.69	-112.19	38.91266	-114.154559
18-Aug-09	stream	-15.49	-74.43	38.91266	-114.154559
13-Oct-09	stream	-15.03	-111.62	38.91266	-114.154559
2-Nov-11	stream	-15.18	-111.8	38.91266	-114.154559
31-Jul-08	stream	-14.52	-114.1	38.91266	-114.154559
31-Jul-08	stream	-14.43	-114.1	38.91266	-114.154559
18-May-11	stream	-15.19	-111.1	38.91266	-114.154559
1-Aug-07	stream	-15.09	-111.46	38.91266	-114.154559
4-Jun-09	stream	-15.37	-112.3	38.91382	-114.151635
13-May-09	stream	-15.32	-112.6	38.91382	-114.151635
14-Nov-08	stream	-15.3	-112.5	38.91382	-114.151635
14-Nov-08	stream	-15.17	-112.5	38.91382	-114.151635
11-Feb-09	stream	-15.32	-112.19	38.91382	-114.151635
11-Feb-09	stream	-15.29	-112.47	38.91382	-114.151635
24-Jul-09	stream	-15.52	-112.11	38.91382	-114.151629
18-Aug-09	stream	-15.19	-112.45	38.91382	-114.151629
13-Oct-09	stream	-15.17	-111.03	38.91382	-114.151629
31-Aug-10	stream	-15.17	-112.13	38.91382	-114.151629
1-Aug-07	stream	-15.72	-111.65	38.91382	-114.151629
31-Jul-08	stream	-14.73	-114.3	38.91382	-114.151629
31-Jul-08	stream	-13.86	-111.2	38.91382	-114.151629
2-Feb-11	stream	-15.16	-111.2	38.91382	-114.151629
24-Jul-09	stream	-15.41	-111.37	38.91646	-114.146980
18-Aug-09	stream	-15.12	-112.07	38.91646	-114.146980
13-Oct-09	stream	-14.87	-110.17	38.91646	-114.146980
11-Jun-10	stream	-14.74	-112.92	38.91646	-114.146980
2-Feb-11	stream	-15.12	-112.8	38.91646	-114.146980
27-May-11	stream	-15.22	-114.3	38.91646	-114.146980
1-Aug-07	stream	-15.54	-111.62	38.91646	-114.146980
31-Jul-08	stream	-13.9	-111.3	38.91646	-114.146980
31-Jul-08	stream	-13.01	-111.7	38.91646	-114.146980
13-May-09	stream	-15.59	-112.4	38.91647	-114.146986
4-Jun-09	stream	-15.25	-112.6	38.91647	-114.146986
14-Nov-08	stream	-15.31	-112.3	38.91647	-114.146986
14-Nov-08	stream	-15.2	-112.3	38.91647	-114.146986
11-Feb-09	stream	-15.18	-112.13	38.91647	-114.146986
11-Feb-09	stream	-15.09	-111.07	38.91647	-114.146986
25-Feb-09	stream	-14.71	-107.7	38.98936	-114.212000
25-Feb-09	stream	-14.71	-107.46	38.98936	-114.212000

	stream	-15.29	-110	39.00983	-114.207800
18-Nov-08	stream	-15.43	-110.5	39.00983	-114.207800
6-Aug-08	stream	-15.02	-109.4	39.00983	-114.207800
6-Aug-08	stream	-14.08	-108.6	39.00983	-114.207800
14-May-09	stream	-15.45	-113.4	39.00983	-114.207800
4-Jun-09	stream	-15.26	-110.5	39.00983	-114.207800
11-Feb-09	stream	-15.04	-109.34	39.00983	-114.207800
11-Feb-09	stream	-14.77	-109.06	39.00983	-114.207800
13-Oct-09	stream	-15.3	-107.43	39.00984	-114.207801
1-Aug-09	stream	-14.93	-108.23	39.00984	-114.207801
27-May-11	stream	-15.49	-115.3	39.00984	-114.207801
3-Feb-11	stream	-14.95	-109.6	39.00984	-114.207801
1-Aug-07	stream	-14.64	-104.88	39.00984	-114.207801
18-Nov-08	stream	-15.32	-109.9	39.00998	-114.208344
18-Nov-08	stream	-15.15	-109.9	39.00998	-114.208344
11-Feb-08	stream	-15.03	-109.66	39.00998	-114.208344
6-Aug-08	stream	-14.85	-109.2	39.00998	-114.208344
6-Aug-08	stream	-14.2	-109.2	39.00998	-114.208344
4-Jun-09	stream	-15.59	-112.1	39.00998	-114.208344
14-May-09	stream	-15.5	-112.9	39.00998	-114.208344
11-Feb-09	stream	-15.15	-110.6	39.00998	-114.208344
18-Aug-09	stream	-15.06	-107.28	39.00998	-114.208338
24-Jul-09	stream	-14.44	-107.97	39.00998	-114.208338
13-Oct-09	stream	-14.37	-107.16	39.00998	-114.208338
24-Jul-09	stream	-14.46	-113.34	39.00998	-114.208338
1-Aug-07	stream	-14.49	-105.19	39.00998	-114.208338
3-Feb-11	stream	-15.08	-110.6	39.00998	-114.208338
18-Nov-08	stream	-15.21	-109.8	39.01062	-114.212135
11-Feb-08	stream	-15.19	-109.14	39.01062	-114.212135
18-Nov-08	stream	-15.14	-110.5	39.01062	-114.212135
14-May-09	stream	-15.66	-113.5	39.01062	-114.212135
4-Jun-09	stream	-15.34	-108.2	39.01062	-114.212135
11-Feb-09	stream	-15.31	-108.28	39.01062	-114.212135
1-Aug-07	stream	-14.4	-105.25	39.01062	-114.212135
6-Aug-08	stream	-14.91	-110	39.01063	-114.212135
6-Aug-08	stream	-14.26	-110	39.01063	-114.212135
18-Aug-09	stream	-15.44	-107.23	39.01063	-114.212135
24-Jul-09	stream	-15.2	-107.69	39.01063	-114.212135
13-Nov-09	stream	-14.94	-107.87	39.01063	-114.212135
31-Aug-10	stream	-14.9	-109.29	39.01063	-114.212135
3-Feb-11	stream	-14.84	-108.9	39.01063	-114.212135
27-May-11	stream	-15.45	-112.9	39.01063	-114.212135
11-Feb-08	stream	-15.33	-109.16	39.01366	-114.217261

11-Feb-08	stream	-15.33	-109.12	39.01366	-114.217261
18-Nov-08	stream	-15.32	-110.3	39.01366	-114.217261
18-Nov-08	stream	-15.2	-110.1	39.01366	-114.217261
7-Aug-08	stream	-13.91	-108.7	39.01366	-114.217261
4-Jun-09	stream	-15.64	-112.5	39.01366	-114.217261
14-May-09	stream	-15.34	-113.5	39.01366	-114.217261
1-Aug-07	stream	-14.68	-104.44	39.01366	-114.217261
24-Jul-09	stream	-15.41	-107.93	39.01367	-114.217258
17-Aug-09	stream	-15.13	-108.41	39.01367	-114.217258
13-Oct-09	stream	-12.53	-108.31	39.01367	-114.217258
27-May-11	stream	-15.7	-115.8	39.01367	-114.217258
14-Nov-08	stream	-15.46	-111.1	39.04879	-114.320443
14-Nov-08	stream	-15.18	-111.4	39.04879	-114.320443
31-Jul-08	stream	-14.58	-112.5	39.04879	-114.320443
31-Jul-08	stream	-14.45	-113	39.04879	-114.320443
26-Feb-09	stream	-15.31	-112.6	39.04879	-114.320443
13-May-09	stream	-15.23	-110.6	39.04879	-114.320443
2-Jun-09	stream	NA	-110.4	39.04879	-114.320443
31-Aug-10	stream	-15.05	-110.25	39.04879	-114.320443
18-May-11	stream	-15.51	-112.7	39.04879	-114.320443
1-Aug-07	stream	-15.38	-111.21	39.04879	-114.320443
18-Aug-09	stream	-15.78	-110.04	39.04879	-114.320440
15-Oct-09	stream	-15.4	-111.72	39.04879	-114.320440
24-Jul-09	stream	-14.41	-111.42	39.04879	-114.320440
24-Jul-09	stream	-15.58	-111.08	39.05066	-114.315909
15-Oct-09	stream	-15.44	-111.25	39.05066	-114.315909
18-Aug-09	stream	-15.19	-111.44	39.05066	-114.315909
22-Mar-10	stream	-14.56	-110.82	39.05066	-114.315909
18-May-11	stream	-15.07	-110.9	39.05066	-114.315909
14-Nov-08	stream	-15.33	-111.1	39.05066	-114.315914
31-Jul-08	stream	-15.27	-112.8	39.05066	-114.315914
14-Nov-08	stream	-15.24	-111.2	39.05066	-114.315914
31-Jul-08	stream	-14.5	-112.4	39.05066	-114.315914
31-Jul-08	stream	-14.18	-111.1	39.05066	-114.315914
31-Jul-08	stream	-14.04	-110.2	39.05066	-114.315914
2-Jun-09	stream	-15.15	-109.39	39.05066	-114.315914
13-May-09	stream	-15.1	-110.3	39.05066	-114.315914
26-Feb-09	stream	-14.98	-111.5	39.05066	-114.315914
1-Aug-07	stream	-15.1	-110.88	39.05066	-114.315914
14-Nov-08	stream	-15.39	-109.35	39.05252	-114.310920
31-Jul-08	stream	-15.36	-112.1	39.05252	-114.310920
14-Nov-08	stream	-15.31	-111.2	39.05252	-114.310920
31-Jul-08	stream	-14.37	-111.9	39.05252	-114.310920

2-Jun-09	stream	-15.38	-109.64	39.05252	-114.310920
26-Feb-09	stream	-15.2	-111.9	39.05252	-114.310920
13-May-09	stream	-15.04	-110.3	39.05252	-114.310920
31-Aug-10	stream	-15.03	-110.26	39.05252	-114.310920
31-Jan-11	stream	-14.84	-109.4	39.05252	-114.310916
18-May-11	stream	-14.93	-111.6	39.05252	-114.310916
1-Aug-07	stream	-15.75	-110.1	39.05252	-114.310916
24-Jul-09	stream	-15.71	-111.71	39.05252	-114.310916
24-Jul-09	stream	-15.28	-110.74	39.05252	-114.310916
15-Oct-09	stream	-15.14	-110.36	39.05252	-114.310916
18-Aug-09	stream	-15.14	-11.89	39.05252	-114.310916
14-Nov-08	stream	-15.21	-110.01	39.05412	-114.305902
14-Nov-08	stream	-15.11	-109.93	39.05412	-114.305902
31-Jul-08	stream	-14.41	-111.8	39.05412	-114.305902
31-Jul-08	stream	-14.12	-111.8	39.05412	-114.305902
26-Feb-09	stream	-15.33	-112.1	39.05412	-114.305902
13-May-09	stream	-15.01	-110.6	39.05412	-114.305902
2-Jun-09	stream	-14.98	-110.45	39.05412	-114.305902
31-Jan-11	stream	-14.66	-109.8	39.05412	-114.305902
1-Aug-07	stream	-15.1	-109.51	39.05412	-114.305902
18-Aug-09	stream	-15.6	-111.9	39.05412	-114.305899
15-Oct-09	stream	-15.56	-110	39.05412	-114.305899
31-Jan-11	stream	-14.62	-108.7		