

Appendix S1. Supplementary Methods

The historical portion of the Colorado mammal specimen database was constructed mostly from museum specimen records, and includes records for all mammals in the state from all dates and localities. We received these records by contacting museum personnel or through online data repositories (i.e., GBIF [www.gbif.org], Arctos [<https://arctos.database.museum>]). The museums from which we received specimen data included: Academy of Natural Sciences of Philadelphia, American Museum of Natural History, Angelo State Natural History Collection, Brigham Young University Monte L. Bean Life Science Museum, California Academy of Science, Carnegie Museum of Natural History, Cornell University Museum of Vertebrates, Denver Museum of Nature and Science, Eastern New Mexico University Natural History Museum, Field Museum, Florida Museum of Natural History, Illinois Natural History Survey, James R. Slater Museum of Puget Sound University, Los Angeles County Museum of Natural History, Louisiana State University Museum of Natural Science, Museum of Comparative Zoology Harvard University, Michigan State University Museum, Museum of Southwestern Biology University of New Mexico, Museum of Texas Tech University, New Mexico Museum of Natural History and Science, North Carolina State Museum of Natural Sciences, Oklahoma State University Collection of Vertebrates, Oregon State University Department of Fisheries and Wildlife Mammal Collection, Royal Ontario Museum, San Diego Natural History Museum, Santa Barbara Museum of Natural History, State Museum of Pennsylvania, Sternberg Museum of Natural History Fort Hays State University, Texas A&M University Texas Cooperative Wildlife Collection, United States National Museum of Natural History, Universidad Nacional Autonoma de Mexico, University of Alaska Museum of the North, University of Arizona Collection of Mammals, University of California Berkeley Museum of Vertebrate Zoology, University of Colorado Museum of Natural History, University of Georgia Museum of Natural History, University of Kansas Museum of Natural History, University of Michigan Museum of Zoology, University of Minnesota James F. Bell Museum of Natural History, University of Nebraska State Museum, University of Oklahoma Sam Noble Oklahoma Museum of Natural History, University of Washington Burke Museum, University of Wisconsin Zoological Museum, Utah Museum of Natural History, Western New Mexico University Museum, and Yale University Peabody Museum. This work would not have been possible without the countless number of people contributing, preserving, and supporting natural history collections; we thank each and every one past and present.

The sites of contemporary sampling by the authors included 32 sites from 2010-2012 (Figure S1.1: white circles) with the lowest three sites in the northern Front Range transect resampled in 2017; pilot study sampling in the San Juans in 2007 (blue circles); additional sampling in Mesa Verde National Park in 2018 (live trapping and pitfall sites: black stars, pitfall sites: black dots). For a detailed discussion of the mammal sampling design and results, see (McCain *et al.*, 2018). Overall, the authors' sampling effort for this comparative study included ~77,030 trap-nights in the Front Range and ~81,550 trap-nights in the San Juans plus all the visual surveys and other sighted mammals. These contemporary data were augmented with all other specimen data from those mountain regions collected or documented by other researchers in the Colorado mammal database in 2006 or later.

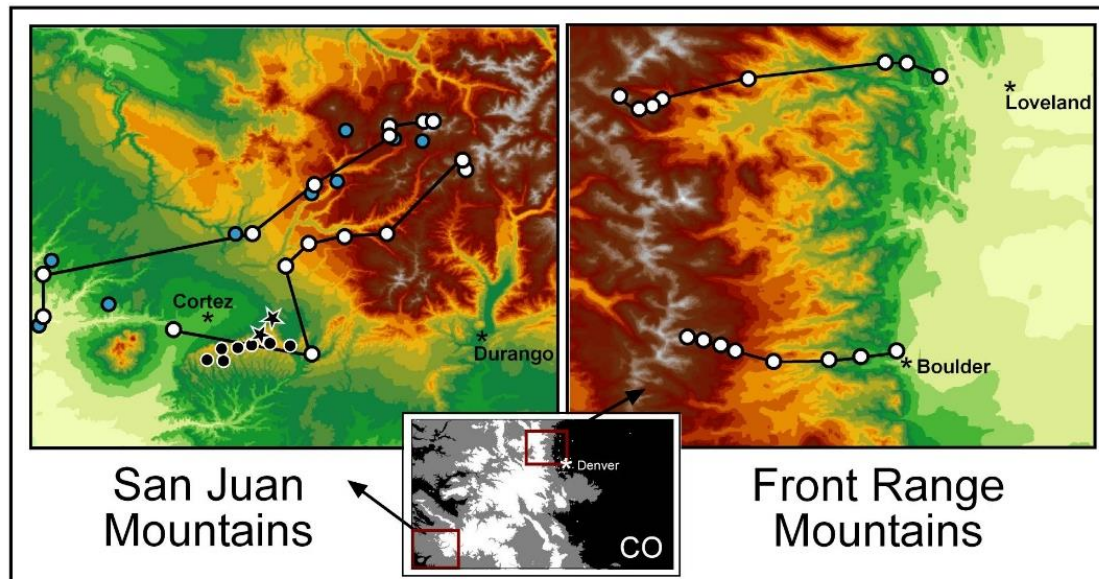


Figure S1.1. The contemporary mammal survey sites in the Colorado Rocky Mountains. The four elevational transects sampled in 2010-2012 in the northeast (Front Range Mountains) and two in the southwest (San Juan Mountains) are shown in white circles connected with black lines. The lower three in the northern Front Range transect were resampled in 2017. The nine sites sampled in the San Juans in 2007 are shown in blue circles, and the sites sampled in Mesa Verde National Park are shown in stars (all survey methods) and black dots (pitfalls & visual surveys).

The Bayesian models: **TIM ADDING** refer to Figure S1.2

We included a second set of Bayesian models for the larger small mammal species (e.g., tree squirrels, marmots). These species historically were live trapped, but also hunted with rifles for collection. Contemporarily, they are still caught in live traps but usually just immature individuals and are now more likely just to be sighted in visual surveys. Thus, these species have a lower sampling effort and their sampling may be less associated with the complete sampling effort of other small mammals, particularly contemporarily. Thus, we used the specimen-localities for just the larger species sampling effort over each gradient per time period to reassess just the larger species Bayesian range limits. The range limits were slightly larger than using the complete sampling effort (Appendix S2). For example, for the four species used in the analyses the differences between the all Bayesian sampling models and the large Bayesian sampling models was on average only 32 m per species. Some of these enlarged ranges appeared implausible given our knowledge of the species on each mountain, and since they are based on few samples, are less well-supported. Thus, we used the all sampling effort Bayesian models for the range shift analyses in the text, but the potential range extensions are shown in Figure 2 as dashed lines.

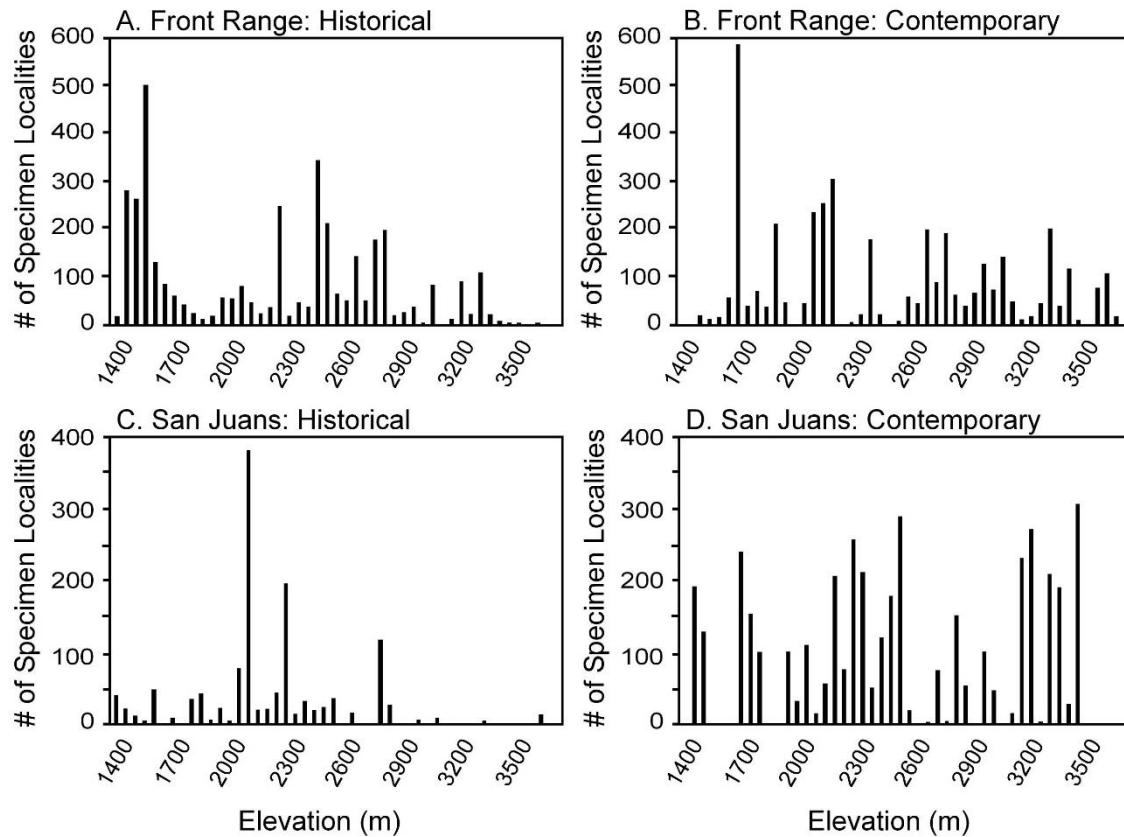


Figure S1.2. The historical and contemporary distribution of mammal specimen-localities along the Front Range (A, B) and San Juan (C, D) elevational gradients. These sums were used in the Bayesian undersampling models and give a minimum indication of the sampling effort on both mountains. This underestimates the sampling effort, since trap-nights per band were not recorded, thus unpreserved captures, specimens on non-target species, and efforts with few or no captures or specimens are not included.

For testing the phylogenetic signal in the lower and upper range shifts, we used the mammal supertree (Bininda-Emonds et al., 2007) pruned to the taxa included in each mountain dataset. Phylogenetic signal was calculated with *phylosignal* (Keck et al., 2016) in R (Team, 2019) using all five significance tests (*Cmean*, *I*, *K*, *K.star*, and *Lambda*). Table S1.1 includes all of the *phylosignal* test values and significances; all of which are non-significant.

Table S1.1. Statistics from phylogenetic signal tests in the upper and lower range shifts ($p = p$ -value).

Range Limit	<i>Cmean</i>	<i>p</i>	<i>I</i>	<i>p</i>	<i>K</i>	<i>p</i>	<i>K.star</i>	<i>p</i>	<i>Lambda</i>	<i>p</i>
FR Lower	0.119	0.073	0.047	0.085	0.279	0.113	0.289	0.147	0.242	0.203
FR Upper	-0.135	0.754	-0.062	0.571	0.178	0.534	0.185	0.534	<0.001	1.000
SJ Lower	-0.107	0.685	-0.087	0.705	0.120	0.936	0.139	0.950	<0.001	1.000
SJ Upper	-0.046	0.416	-0.036	0.368	0.224	0.383	0.229	0.478	<0.001	1.000

Supplementary Methods Literature Cited

- Keck F, Rimet F, Bouchez A, Franc A (2016) phylosignal: an R package to measure, test, and explore the phylogenetic signal. *Ecology and Evolution*, **6**, 2774-2780.
- Mccain CM, King SRB, Szewczyk T, Beck J (2018) Small mammal species richness is directly linked to regional productivity, but decoupled from food resources, abundance, or habitat complexity. *Journal of Biogeography*, **45**, 2533–2545.
- Team RDC (2019) R: A language and environment for statistical computing. pp Page, Vienna, Austria, R Foundation for Statistical Computing.

Appendix S2. The dataset of small mammal species tested for elevational range changes in the Front Range and San Juan Mountains of Colorado. USA. The taxonomic order, family of rodents, and species name are list for each mountain range. The probability of detection is how likely a single individual of a species is to be detected based on contemporary mark and recapture statistics. Telev. Rng = the location of the species on the mountain: montane, low elevation, or cosmopolitan (across most elevations). Max. Lat. Is the highest latitude in the geographic range of the species in North America. Rng Edge = the location of the study area in relationship to the species geographic edge, if it is not on an edge in the cardinal directions then it is the middle. The empirical number of specimens, lower elevational limit and upper elevational limit are shown for the historical and contemporary time periods as are the Bayesian 95% lower and upper limits in both time periods. The Bayesian models using all the specimen data include "All" in the header whereas those specifically for larger rodents include "Large" in the header. Finally, the elevation change in the lower, upper, and overall combined limits are shown and the type of shift (upward, downward, none, or local extirpation). All elevational values are in meters.

Taxon	Species	Mountain	Probability Detection	Elev. Rng	Max. Lat.	Rng Edge	Empirical: Historical			Bayesian: All, Hist.		Bayes.: Large, Hist.		Empirical: Contemporary			Bayesian: All, Cont.		Bayes.: Large, Cont.		Lower Change	Upper Change	Overall Change	SHIFT
							Data #	Lower	Upper	Lower	Upper	Lower	Upper	Data #	Lower	Upper	Lower	Upper	Lower	Upper	Change	Change	Change	
Rodentia, Sciuridae	Callospermophilus lateralis	Front Range	0.170	Montane	56.4	East	135	1760	3388	1700	3549			100	1939	3356	1750	3799			50	250	300	UP
Rodentia, Heteromyidae	Dipodomys ordii	Front Range	0.220	Low	--	--	29	1524	1890	1438	2049			0	--	--	--	--			--	--	--	EXTIR.
Rodentia, Sciuridae	Ictidomys tridecemlineatus	Front Range	0.241	Low	54.9	West	48	1492	1876	1438	2199			2	1545	1550	1438	1799			0	-400	-400	DOWN
Rodentia, Sciuridae	Marmota flaviventris	Front Range	0.241	Montane	51.1	East	34	1628	3688	1600	3799	1550	3799	34	1863	3737	1750	3799	1650	3799	150	0	150	UP
Rodentia, Cricetidae	Microtus longicaudus	Front Range	0.184	All	68.1	East	97	1506	3353	1438	3549			66	1704	3607	1438	3799			0	250	250	UP
Rodentia, Cricetidae	Microtus montanus	Front Range	0.122	All	52.9	East	129	1506	3528	1438	3649			62	1513	3725	1438	3799			0	150	150	UP
Rodentia, Cricetidae	Microtus ochrogaster	Front Range	0.228	Low	56.0	West	143	1484	2218	1438	2299			31	1532	2242	1438	2549			0	250	250	UP
Rodentia, Cricetidae	Microtus pennsylvanicus	Front Range	0.189	Low	70.3	West	269	1494	1984	1438	2049			9	1519	1942	1438	2099			0	50	50	NONE
Rodentia, Cricetidae	Myodes gapperi	Front Range	0.210	Montane	62.4	East	102	2515	3353	2350	3549			59	2611	3310	2450	3549			100	0	100	UP
Rodentia, Cricetidae	Neotoma mexicana	Front Range	0.289	Low	41.0	North	125	1489	2537	1438	2649			158	1538	2187	1438	2399			0	-250	-250	DOWN
Rodentia, Sciuridae	Otospermophilus variegatus	Front Range	0.241	Low	41.9	North	41	1517	2134	1438	2299	1438	2299	1	1717	1717	1550	1899	1438	2049	112	-400	-288	DOWN
Rodentia, Heteromyidae	Perognathus fasciatus	Front Range	0.220	Low	--	--	10	1524	1524	1438	1599			0	--	--	--	--			--	--	--	EXTIR.
Rodentia, Heteromyidae	Perognathus flavus	Front Range	0.220	Low	--	--	11	1524	1524	1438	1599			0	--	--	--	--			--	--	--	EXTIR.
Rodentia, Cricetidae	Peromyscus maniculatus	Front Range	0.429	All	65.6	Middle	931	1489	3588	1438	3599			1948	1518	3731	1438	3799			0	200	200	UP
Rodentia, Cricetidae	Peromyscus nastutus	Front Range	0.197	Low	41.2	North	167	1494	2560	1438	2699			81	1660	2155	1438	2399			0	-300	-300	DOWN
Rodentia, Cricetidae	Phenacomys intermedius	Front Range	0.175	Montane	58.7	East	19	2742	3673	2600	3799			37	2700	3700	2450	3799			-150	0	-150	DOWN
Rodentia, Cricetidae	Reithrodontomys megalotis	Front Range	0.234	Low	50.6	Middle	53	1531	2084	1438	2249			169	1682	2239	1438	2399			0	150	150	UP
Rodentia, Sciuridae	Sciurus aberti	Front Range	0.241	Low	41.3	North	38	1641	2638	1550	2699	1450	2749	12	1724	2673	1500	2799	1450	2799	-50	100	50	NONE
Soricidae	Sorex cinereus	Front Range	0.200	All	70.3	East	77	1492	3353	1438	3499			63	2798	3452	2550	3649			1112	150	1262	UP
Soricidae	Sorex hoyi	Front Range	0.112	Montane	67.4	South	22	2638	2936	2550	3049			16	2806	3447	2500	3749			-50	700	650	UP
Soricidae	Sorex monticolus	Front Range	0.112	All	69.4	East	103	1628	3505	1450	3699			95	1726	3493	1438	3799			-12	100	88	UP
Soricidae	Sorex palustris	Front Range	0.200	All	65.1	East	61	1591	3307	1450	3449			3	2786	2859	2550	3049			1100	-400	700	UP
Rodentia, Sciuridae	Tamias minimus	Front Range	0.240	All	66.4	East	302	1796	3600	1750	3749			445	1546	3492	1438	3599			-312	-150	-462	DOWN
Rodentia, Sciuridae	Tamias quadrivittatus	Front Range	0.238	Low	41.0	North	49	1585	2795	1438	2849			60	1721	2659	1500	2799			62	-50	12	NONE
Rodentia, Sciuridae	Tamias umbrinus	Front Range	0.325	Montane	45.4	East	77	2134	3414	1950	3599			59	2343	3385	2250	3599			300	0	300	UP
Rodentia, Sciuridae	Tamiasciurus hudsonicus	Front Range	0.241	All	67.8	East	143	1766	3475	1700	3649	1650	3649	126	1882	3356	1750	3599	1550	3599	50	-50	0	NONE
Rodentia, Dipodidae	Zapus hudsonicus preblei	Front Range	0.293	Low	65.0	South	32	1553	1634	1450	1699			6	1726	2130	1500	2349			50	650	700	UP
Rodentia, Dipodidae	Zapus princeps	Front Range	0.293	Montane	62.3	East	109	2006	3259	1900	3349			89	2402	3140	2250	3299			350	-50	300	UP
Rodentia, Sciuridae	Ammospermophilus leucurus	San Juans	0.241	Low	44.1	East	13	1418	2134	1414	2299			6	1506	1735	1414	1949			0	-350	-350	DOWN
Rodentia, Sciuridae	Callospermophilus lateralis	San Juans	0.170	Montane	56.4	South	33	1981	3109	1650	3399			70	2227	3524	1900	3799			250	400	650	UP
Rodentia, Cricetidae	Microtus longicaudus	San Juans	0.184	Montane	68.1	South	59	2050	2827	1900	3049			17	2079	3411	1900	3599			0	550	550	UP
Rodentia, Cricetidae	Microtus mogollonensis	San Juans	0.220	Low	31.3	North	26	2133	2407	1950	2649			21	1494	2384	1414	2499			-536	-150	-686	DOWN
Rodentia, Cricetidae	Microtus montanus	San Juans	0.122	All	52.9	South	57	1895	3407	1550	3799			81	1812	3519	1600	3749			50	-50	0	NONE
Rodentia, Cricetidae	Myodes gapperi	San Juans	0.210	Montane	62.4	South	10	2827	2840	2600	3049			83	2570	3530	2400	3749			-200	700	500	UP
Rodentia, Cricetidae	Neotoma albigula	San Juans	0.257	Low	39.0	North	17	1483	2085	1414	2249			20	1512	2020	1414	2199			0	-50	-50	NONE
Rodentia, Cricetidae	Neotoma mexicana	San Juans	0.289	Low	41.0	North	46	1610	2285	1450	2449			66	1715	2570	1550	2649			100	200	300	UP
Rodentia, Sciuridae	Otospermophilus variegatus	San Juans	0.241	Low	41.9	North	20	1610	2202	1450	2399	1414	2649	25	1482	2530	1414	2799	1414	2849	-36	400	364	UP
Rodentia, Cricetidae	Peromyscus boylii	San Juans	0.434	Low	46.3	Middle	44	1418	2444	1414	2649			96	1482	2510	1414	2699			0	50	50	NONE
Rodentia, Cricetidae	Peromyscus crinitus	San Juans	0.372	Low	--	--	31	1418	2307	1414	2449			0	--	--	--	--			--	--	--	EXTIR.
Rodentia, Cricetidae	Peromyscus maniculatus	San Juans	0.429	All	65.6	Middle	535	1418	3691	1414	3799			1481	1486	3538	1414	3749			0	-50	-50	NONE
Rodentia, Cricetidae	Peromyscus truei	San Juans	0.428	Low	46.7	Middle	76	1418	2354	1414	2549			394	1481	2513	1414	2699			0	150	150	UP
Rodentia, Cricetidae	Reithrodontomys megalotis	San Juans	0.234	Low	50.6	Middle	30	1610	2597	1414	2799			60	1486	2426	1414	2499			0	-300	-300	DOWN
Soricidae	Sorex monticolus	San Juans	0.112	Montane	69.4	South	21	2115	2827	1800	3099			143	2507	3530	1850	3799			50	700	750	UP
Rodentia, Sciuridae	Tamias minimus	San Juans	0.240	All	66.4	South	130	1981	3407	1700	3649			1057	1503	3559	1414	3749			-286	100	-186	DOWN
Rodentia, Sciuridae	Tamias quadrivittatus	San Juans	0.238	All	41.0	Middle	29	1840	3386	1650	3599			13	2410	2570	2350	2749			700	-850	-150	UP
Rodentia, Sciuridae	Tamias rufus	San Juans	0.231	Low	40.8	South	22	1418	2264	1414	2499			50	1503	2348	1414	2449			0	-50	-50	NONE
Rodentia, Dipodidae	Zapus princeps	San Juans	0.293	Montane	62.3	South	25	2050	3407	1900	3649			30	2079	3433	1900	3599			0	-50	-50	NONE

Appendix S3. Supplementary Results

The dataset of small mammals used in the elevation shift analyses, and their historical and contemporary range limits both for the empirical data and the Bayesian 95% models are in Appendix S2. Six species in the Front Range Mountains (FR) and 13 species in the San Juan Mountains (SJ) were not sampled sufficiently historically (i.e., fewer than 10 specimens) for robust elevational range comparisons. These are presented here for those who may be interested in specific species (Figure S3.1). Four species were detected historically, albeit rarely, that were undetected contemporarily: *Reithrodontomys montanus* (FR), *Xerospermophilus spilosoma* (both), *Perognathus flavescens* (FR), and *Sorex merriami* (SJ). Four species were caught at lower elevations contemporarily: *Peromyscus boylii* (FR), *Notiosorex crawfordi* (SJ), *Sciurus aberti* (SJ), and *Marmota flaviventris* (SJ). Seven species were caught at higher elevations contemporarily: *Chaetodipus hispidus* (FR), *Sorex merriami* (FR), *Perognathus flavus* (SJ), *Dipodomys ordii* (SJ), *Sorex nanus* (SJ), *Tamiasciurus hudsonicus* (SJ), and *Sorex palustris* (SJ). Lastly, a few species of small mammals that are likely under-sampled contemporarily due to differences in sampling methods (e.g., lack of shooting as a collecting method) and/or their patchy and specialized locations (e.g., particular types of montane streams, rocky outcrops), included *Neotoma cinerea* on both transects, and *Urocitellus elegans* and *Sorex palustris* in the Front Range.

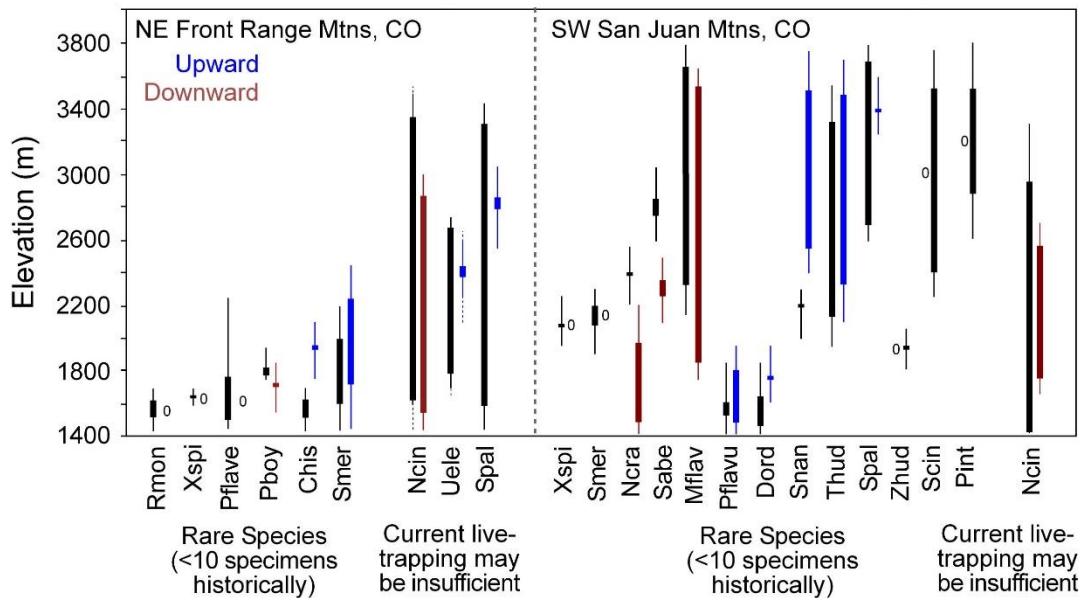


Figure S3.1. Elevational ranges historically and contemporarily for those small mammals that were too rare (<10 specimens historically) to include in the main analyses or potentially too under-sampled contemporarily due to methodological changes.