RARE HERPETOFAUNA & SMALL-MAMMAL SPECIES OF KAIBAB NATIONAL FOREST, NORTHERN ARIZONA: FINAL REPORT

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Prepared for Kaibab National Forest
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PROJECT OVERVIEW

The Kaibab National Forest is comprised of the Tusayan Ranger District on the Kaibab Plateau and north of the Williams Ranger District and south of Grand Canyon National Park; and the North Kaibab Ranger District north of Grand Canyon National Park and south of Utah. The Grand Canyon and Colorado River serves as a formidable spatial barrier between the North Kaibab and the Tusayan and Williams Ranger Districts, limiting dispersal and movement for some species.

Although geographically separated by private and tribal lands, the three districts of the Kaibab National Forest share similar high elevation vegetation communities, comprised primarily of coniferous woodlands, forests and meadows, but also including grasslands and sagebrush, pinyon-juniper forests, ponderosa pine forests, and spruce-fir forests. Vastly different geology and soils (limestone dominated on the north vs. volcanic dominated on the south) also play a significant role in shaping these vegetation types. The Kaibab National Forest has diverse wildlife habitats; from riparian areas in canyon bottoms, to canyons, prairies, plateaus and mountain peaks. This diverse landscape and is host to a number of invertebrate and vertebrate taxa, some of which are rare and/or found nowhere else in the world (i.e., endemic). Little is known about many of these species as exhaustive surveys or monitoring which allows for statistical inference are rarely implemented or completed.

This project was initiated to assist the Kaibab National Forest with the revision of its Land and Resource Management Plan. The main objective of this project was to increase the Forest's existing knowledge base for rare and narrow endemics, and to make that information readily available in a user friendly format. This handbook will be a resource for project specialists, and when used in conjunction with the Forest Plan, should help mitigate any potentially negative impacts that may arise from ground disturbing activities. This will help maintain long term species viability. This information is complementary to information which has been separately compiled in similar format for rare/narrow endemic invertebrates and plants.

We compiled information on vertebrate species known or suspected to occur within the Kaibab National Forest boundaries. Our documentation included a variety of relevant search terms, world-wide web search engines, and online databases and catalogues, as well as published and unpublished written communications with species experts. Online databases included Web of Knowledge, ProQuest Biological Sciences and Google Scholar to identify relevant refereed journal articles; WorldCat for texts; TreeSearch for government documents; NatureServe, International Union for Conservation of Nature (IUCN)Red List of Threatened Species and the Arizona Game and Fish Department's Natural Heritage Program for species information; Pro Quest Dissertations and Theses for theses and dissertations; and VertNet and HerpNet for compilations of museum vouchers. Landscape-level occurrence/estimation range maps were obtained from NatureServe, when available. Regional (i.e., statewide in Arizona) and local (i.e., Kaibab Forest-specific) occurrence/estimation range maps were developed based on locality descriptions in historical records of museum vouchers compiled by HerpNet, VertNet, and Hoffmeister (1987) Mammals of Arizona, as well as graduate research projects, ongoing research at the

Arizona Game and Fish Department Natural Heritage Program, and field notes of professional and citizen scientists. Specific details of sources used to develop occurrence/estimation range maps are footnoted on the maps themselves.

The aforementioned data sources were used to develop a management reference guide specifically for the Kaibab National Forest that includes descriptions of distributions, ecology, life history, threats and management recommendations for five vertebrate "forest planning" species as identified by the Forest Service. The taxa described here include two snake (Squamata: Viperidae and Colubridae) and three rodent (Rodentia: Geomyidae, Heteromyiade and Sciuridae) species; specifically, the Arizona Black Rattlesnake (*Crotalus cerberus*), the Utah Mountain Kingsnake *(Lampropeltis pyromelana infralabialis*), the Northern Pocket Gopher (*Thomomys talpoides kaibabensis*), the Chisel-toothed Kangaroo Rat (*Dipodomys microps*) and the Least Chipmunk (*Eutamias minimus*). Guidance on Forest Service management actions is conveniently provided in a table for each species.

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ARIZONA BLACK RATTLESNAKE (SQUAMATA) OF KAIBAB NATIONAL FOREST

All snakes in the *Crotalus* genus - rattlesnakes - are generally stout-bodied pit-vipers with keeled scales and tail scales modified to form a rattle (*Crotalus* means “rattle”). Rattlesnakes are endemic to and distributed throughout North and South America, from southern Canada to Argentina. Twenty-nine rattlesnake species are currently recognized, and Arizona is host to 13 species in a variety of habitats ranging from desertscrub and semi-grassland to woodland and conifer forest. Rattlesnakes are important predators of a variety of food items, including frogs, toads, lizards, small mammals and birds, and are also prey species for kingsnakes, milksnakes and raptors. Like all viper species, rattlesnakes are venomous and immobilize or kill their prey before consuming it. Because of the use of their venom for defense combined with the high toxicity of their venom, which acts as a neurotoxin or hemotoxin, rattlesnake bites can cause severe tissue damage, necrosis, respiratory failure and/or death in large mammals. Handling or harassing these snakes is often the cause of envenomation; however, ignorance of rattlesnake behavior and fear has spawned eradication programs and willful killing. Conversely, rattlesnakes, and especially rare rattlesnakes, are highly sought after by collectors as pets.

One species of rattlesnake, the Arizona Black Rattlesnake (*Crotalus cerberus*), is almost exclusively endemic to Arizona, with outlying populations found in southwestern New Mexico. Its range roughly follows the Mogollon Rim, extending from mountains in central Mojave County to the White Mountains and to isolated mountains in the south towards the Sky Islands. Since it shares its range with several other rattlesnake species, it is identifiable from most other species found within their range by the distinctive dark coloration and the number and type of scales on the head: *C. cerberus* has three or more and usually four internasal scales and two or three loreal scales per side. This rattlesnake also has the ability for rapid coloration change, which in combination with caring for offspring postnatally, is another way of quickly identifying this species in the field.

Arizona Black Rattlesnake
Viperidae: *Crotalus cerberus* Coues 1875

Fig. 1: Arizona Black Rattlesnake, *Crotalus cerberus*, showing characteristic nearly black body coloration with thin, light-colored crossbars on the dorsal surface. Credit: Photograph courtesy of Jeff Servoss.

Taxonomy

Craniata
Reptilia
Squamata
Viperidae
Crotalus cerberus Coues 1875

The Arizona Black Rattlesnake (*Crotalus cerberus*) is visually unique and striking in its dark, almost black body coloration and thin, light-colored crossbars on its dorsal surface (Fig. 1). It is identifiable from most other rattlesnake species found within its range by the distinctive dark coloration and the number and type of scales on the head. Additional

distinguishing features are the species' ability to change colors rapidly and postnatal care of offspring. Because rattlesnakes in general are highly venomous and potentially dangerous if not given their distance, fear and ignorance has spawned eradication programs and willful killing, especially in areas of human/snake overlap. Conversely, the combination of the striking and beautiful black coloration of this viperid snake, with the willingness to breed in captivity, make it highly sought after by collectors for the pet trade, posing an additional threat.

Description (Coues 1875)

Neonate/Juvenile: Crotalus cerberus neonates are live-birthed, typically between 8.5-10.7 inches (21.5-27.1 cm) in length (Nowak and Amarello, in prep). Juvenile males are typically larger than females, ranging from 13.5-22 inches (34.4-55.7 cm) in snout-to-vent length (SVL), with 18.3 inches (46.4 cm) SVL average. Juvenile females range from 13.4-19.1 inches (34.0-48.4 cm) SVL, with 15.7 inches (39.9 cm) SVL average (Nowak and Amarello, in prep). At birth, neonates are light gray in color with reddish to dark brown dorsal and lateral blotches (Fig. 2), and as they age through juvenile to adulthood, their background coloration darkens and anterior and posterior borders of the mid-dorsal blotches lighten to white to orange.

Fig. 2: Neonate Arizona Black Rattlesnake, *Crotalus cerberus*, showing characteristic light gray background coloration with reddish to dark brown dorsal and lateral blotches. Credit: Photograph courtesy of Tom Brennan.

***Adults*:** *Crotalus cerberus* is a medium-sized, stout-bodied rattlesnake with a slender neck, wide triangular head and keeled dorsal scales. Adult snakes typically range between 20-38 inches (50.9-96.1 cm) SVL and 40 (1000 cm) SVL maximum length (Nowak and Amarello, in prep). Adult females are on average smaller than males, and range from 20-30.1 inches (50.9-76.4 cm) SVL, with 24.2 inches (61.5 cm) SVL average (Nowak and Amarello, in prep). Adult males range from 23.1-37.8 inches (58.7-96.1 cm) SVL, and average 32.2 inches (79.2 cm) SVL (Nowak and Amarello, in prep). In Arizona, Coconino County snakes are generally slightly smaller than snakes from further south in state (e.g., Pima County; Nowak and Amarello, in prep).

Adult *C. cerberus* are typically dark colored – dark brown, dark gray to nearly solid black – with black blotches on their dorsal surface (Fig. 1), but coloration can vary strongly among and within populations, and within individuals. Blotches can be difficult to discern against the dark backgrounds, but light scales on anterior and posterior borders of the blotches appear as thin bands ranging from white to yellow to orange. Interestingly, adults can rapidly (i.e., less than one hour) lighten to a neonate-like coloration of a gray background with reddish or dark gray blotches. This physiological color change can occur naturally in free-range individuals, when individuals are captured or confined, when mortally injured, after feeding, and at night (Nowak and Amarello, in prep.). Although the stimulus and mechanism for this response is not clear and warrants further research, several researches suggest it occurs in response to diel patterns (i.e., 24-hour cycles of daylight followed by night; Lowe *et al.* 1986; Meachum 1999), which may enhance or diminish cryptic camouflage.

Crotalus cerberus usually have three or more and usually four internasal scales and two or three loreals per side (Fig. 3), and 21-29 dorsal scale rows at mid-body (Campbell and Lamar 2004). The number of ventral and subcaudal scales varies by gender, with males having 161-180 ventral scales and 20-26 subcaudal scales, and females having 164-184 ventral scales and 16-24 subcaudal scales (Campbell and Lamar 2004). Cloacal scutes (i.e., anal plate) and subcaudals are usually single (i.e., not divided; Campbell and Lamar 2004).

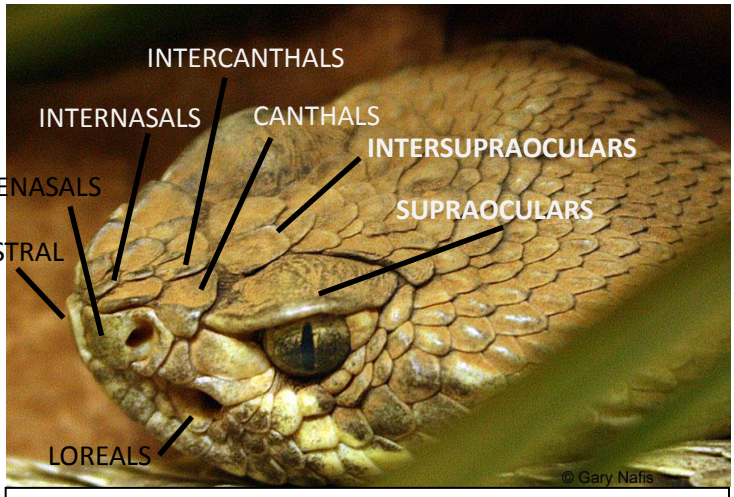

Fig. 3: Nomenclature of snake head scales. In this example, the species is the Mojave Rattlesnake (*C. scutulatus*). *Crotalus cerberus* differs from *C. scutulatus* in having 3-4 internasal scales and 2-3 loreals per side. Credit: Photo courtesy of Gary Nafis.

Similar Taxa

Crotalus cerberus share portions or all of its range with four rattlesnake species: Western Diamond-backed (*C. atrox*), Mohave (*C. scutulatus*), Black-tailed (*C. molossus*) and Prairie (*C. viridis*) rattlesnake, all of which may be found in select areas of the Kaibab

National Forest. In addition, the northwestern-most boundary of its range is in close proximity to the Western Rattlesnake (*C. oreganus*), and neonate *C. cerberus* closely resemble juvenile *C. oreganus* and *C. viridis* in both color and pattern. Only *C. viridis* is likely to be encountered in all three of the Kaibab National Forest's ranger districts; however, *C. atrox* and *C. scutulatus* may be encountered in the southwestern-most regions of the Williams Ranger District, *C. molossus* in the North Kaibab and Williams Ranger Districts, and both *C. oreganus* and the Speckled Rattlesnake (*C. mitchelli*) in the North Kaibab Ranger District. *Crotalus cerberus* is likely to be encountered only in the Williams Ranger District, but can be distinguished from most of these species by their dark background coloration, by the tail coloration and by the presence of three or more internasals contacting the rostral scale. *Crotalus atrox* and *C. scutulatus* have lighter background coloration, distinctive black and white banding on the tail (coon tails), and three or fewer internasals contacting the rostral. *Crotalus molossus* is distinguished from *C. cerberus* by its lighter background coloration and distinctive black tail. *Crotalus cerberus* can usually be distinguished from *C. viridis* and *C. oreganus* after two years of age by their dark background coloration. *Crotalus viridis* also has four more internasals contacting the rostral.

Range

***Regional*:** *Crotalus cerberus* is almost exclusively endemic to Arizona, with contiguous populations found in southwestern New Mexico. This species occurs at elevations ranging from 2953-9843 feet (900-3000 m). Its range roughly follows the Mogollon Rim, extending from mountains in central Mojave County, to the southern portion of Coconino County south of the San Francisco Peaks, to the White Mountains in Apache County and south to the spatially isolated mountain ranges in Cochise, Graham, Pima and Pinal counties (Fig. 4). Populations exhibit a patchy distribution in isolated canyons and mountain ranges; the patchiness of their distribution is likely associated concomitantly with favorable habitat and suitable hibernacula.

Known Localities: Specimens of *Crotalus cerberus* have been vouchered from throughout Arizona, including the Hualapai Mountains, Squaw Peak, Peach Springs and 10 miles of Hackberry in **Mojave County.** In **Coconino County**, from Walnut Canyon, Medicine Valley (San Francisco Mountains), possibly Mount Elden, Oak Creek Canyon and west through the southern half of the Williams Ranger District. In **Yavapai County**, from Sedona, Prescott, edges of Chino Valley, the Bradshaw, Santa Maria and Weaver mountains, Skull Valley, Hillside, Bagdad, Wickenburg, Antelope Creek Canyon, Black Hills, Rimrock and Camp Verde. From the Mogollon Rim, in or near Payson, Pine, Heber, Young, Vernon, Pinetop-Lakeside, Pinedale, Chevelon Creek, East Verde River headwaters, and "in the vicinity of Sand Spring Wash" north of Gisela.

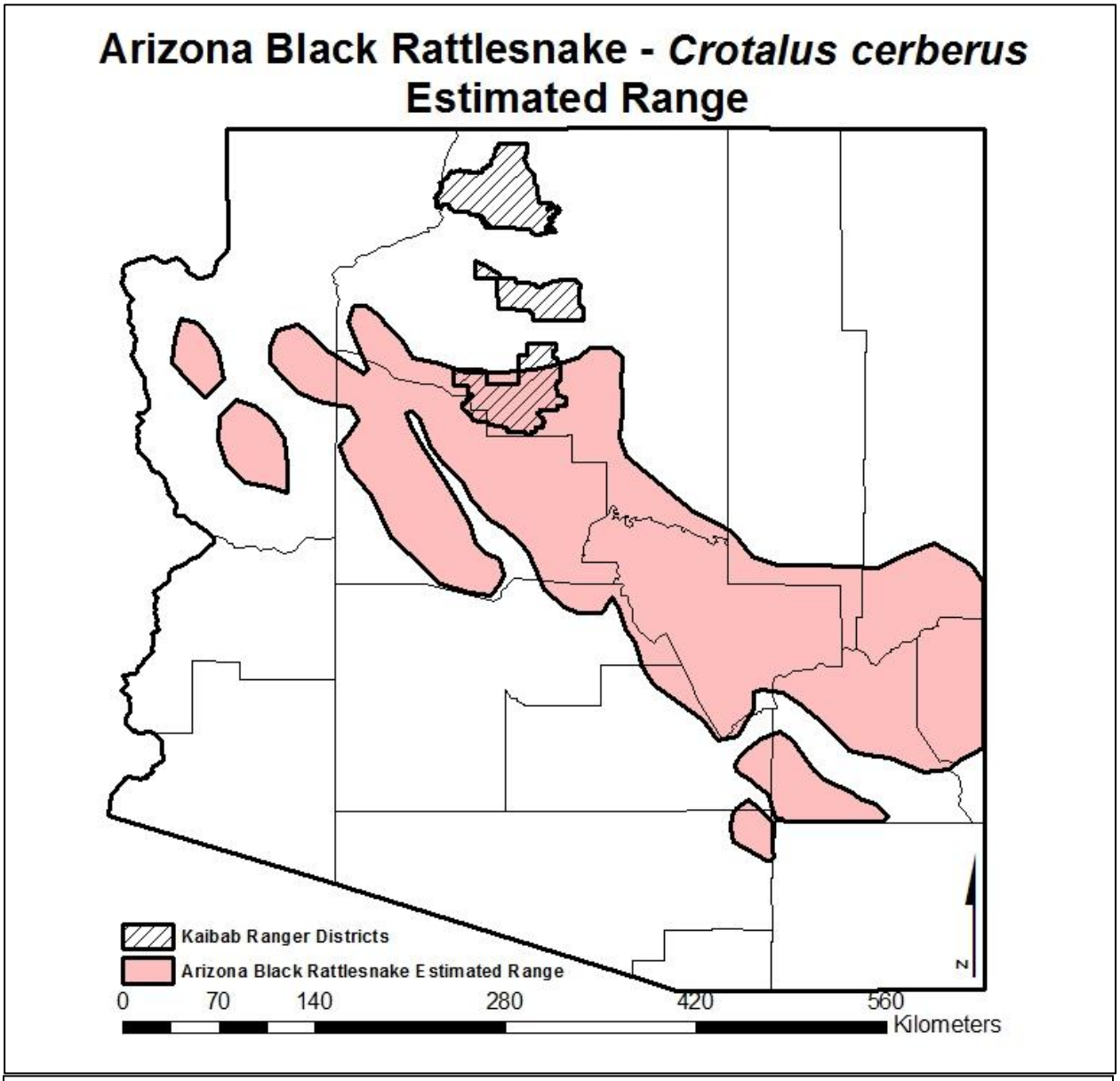

Fig. 4: Regional map of Arizona Black Rattlesnake, *Crotalus cerberus*, occurrence in Arizona. Species localities generated based on Museum of Northern Arizona (MNA) vouchered specimens, field notes of occurrences compiled by AGFD HDMS data (HDMS 2012), research conducted by Erika Nowak (USGS/NAU), Carol Chambers (NAU), Tzeidle Wasserman (NAU; 2014, pers. comm), Justin Schofer (NAU; Schofer 2007) and field notes recorded by Tony Hauserman (Hauserman 2008).

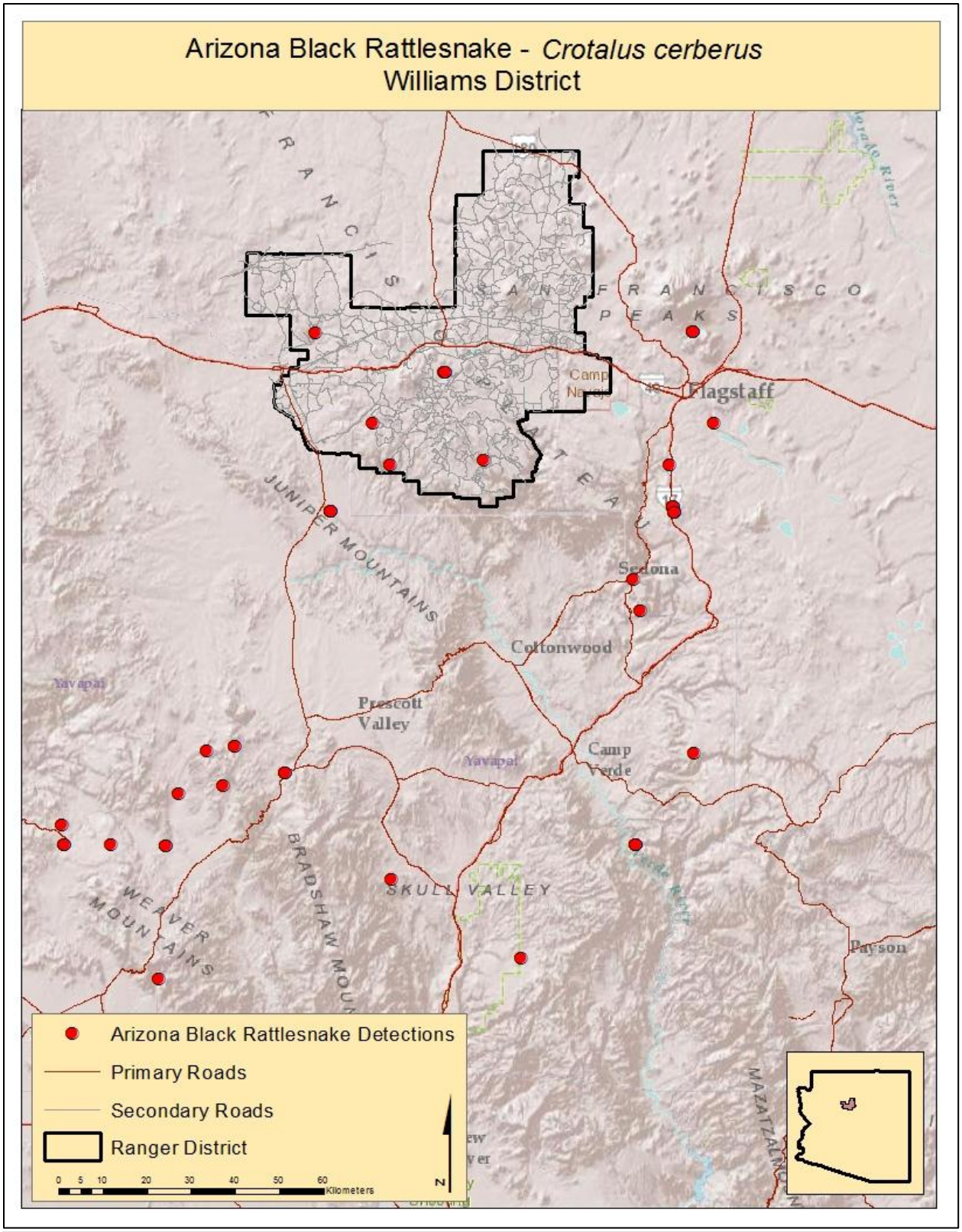

Fig. 5: Map of Arizona Black Rattlesnake, *Crotalus cerberus*, occurrence in the Williams District of Kaibab National Forest. Species localities generated based on MNA vouchered specimens, field notes of occurrences compiled by AGFD HDMS data, USGS and NAU research programs.

Kaibab National Forest – North Kaibab Ranger District: The actual distribution of *Crotalus cerberus* within the North Kaibab Ranger District is not known as no occurrences have been documented. Although the habitat in the mountainous and riverine habitats of the North Kaibab District appears to be suitable, it has not been collected from these locales. It is likely that the Colorado River imposes an insurmountable barrier to northward dispersal.

Kaibab National Forest – Tusayan Ranger ***District:*** The actual distribution of *Crotalus cerberus* within the Tusayan Ranger District is not known as no occurrences have been documented. It has not been collected from these locales, and habitat in the District may not be suitable, it may be displaced by very similar species (i.e., C. viridis), or other unidentified factors may be limiting the species' distribution north of the Williams Ranger District.

Kaibab National Forest – Williams Ranger District: *Crotalus cerberus* has been collected throughout the southern portion of the Williams Ranger District, on the San Francisco Peaks approximately 20 km from the District's eastern boundary, and approximately 15 km southwest of the District's southwestern-most boundary (Fig. 5). The rocky and riverine habitat along the Mogollon Rim margin and within the District is considered suitable.

Habitat Requirements

Arizona Black Rattlesnake are usually found in mesic habitats but also dry rocky slopes and rock slides in a wide variety of biotic communities, from desertscrub to coniferous forests. Biotic communities include higher altitudinal Arizona Upland Desertscrub, Interior Chaparral, Great Basin Conifer Woodland, Madrean Evergreen Woodland and Petran Mountain Conifer Forest plant communities (Brennan and Holycross 2008). At lower elevations between 900-1230 meters below the Mogollon Rim, *C. cerberus* are often associated with riparian habitats (streams and rivers and associated washes and canyons), near springs, wet meadows, and natural and anthropogenic lentic (i.e., pond and lake) habitats (Nowak and Amarello, in prep). Volcanic rock outcrops and talus slopes appear to provide hibernacula at higher elevations between 2130-3000 meters, as *C. cerberus* appears to be strongly associated with these areas. At both low and high elevational sites, *C. cerberus* has also been strongly associated with downed woody debris, and it may be that this association is more important than tree species associations (Schofer 2007; van Riper 2012).

Ecology and Life History

Crotalus cerberus appears to be chiefly diurnal predators, especially at higher elevations, but at lower elevations have been observed nocturnally crossing roads. *C. cerberus* appears to prefer fully-shaded hiding areas, then partially shaded, and areas in full sun the least; this behavior, however, may be elevational dependent. While hunting, *C. cerberus* will often use downed woody debris, such as logs and stumps, for cover or platforms as well as hunt margins of pools of water. As dietary generalists, *C. cerberus* consume lizards, birds and small mammals: documented lizards include spiny lizards (*Sceloporus sp.*), whiptails (*Aspidoscelis sp.*) and tree lizards (*Urosaurus sp.*); birds include nuthatches (*Myiarchus sp.*), flycatchers (*Myiarchus sp.*) and quail (*Callipepla sp.*); and small

mammals include cactus mice (*Peromyscus sp.*), squirrel (*Eutamias sp.* and *Ammospermophilus sp.*), woodrat (*Neotoma sp.*), and prairie dog (*Cyomys sp.;* Nowak and Amarello, in prep). *C. cerberus* are also predated, and are likely taken by raptors such as Common Black Hawk (*Buteogallus anthracinus*), milksnakes and kingsnakes (*Lampropeltis sp.*), and are willfully killed by humans. Although the longevity of *C. cerberus* in the wild is currently unknown and warrants research, a captive specimen lived almost 12.5 years.

Reproductive activity in female *C. cerberus* roughly corresponds temporally with spring peaks in annual male spermatogenic (i.e., sperm-production) cycles, with enlarged follicles and vitellogenesis recorded in females from May through September and male spermatogenesis from June through October. However, the breeding season does not begin until mate guarding and courtship, which typically occurs in mid-July to early September. Although the gestation period is currently unknown, females give birth to live neonates from early August to mid-September. (Nowak 2005; Schofer 2007). Birthing in some females is apparently biennial (Nowak 2009). Litter sizes range from 2-11 offspring, with litters averaging in size from 5.8 to 7.4. Litter sizes in free ranging snakes from central and southern Arizona are generally consistent with litter sizes of captive-breeding snakes, ranging from 2-8, while three litters in northern Arizona were consistently four offspring in each litter. Neonate *C. cerberus* remain with their mothers until their first ecdysis (i.e., shed) at two years. Guarding behavior by female *C. cerberus* of neonates has been observed (Amarello 2012).

Behavior

Crotalus cerberus individually or communally den in hibernacula during cold, winter months, but emerge from dens and become active from April or May to October. In Coconino County, emergence dates ranged from April 20-30 with April 29 the median date; however, a juvenile *C. cerberus* was visible in the opening of a hibernaculum as early as March 19 (and while there was still snow on the ground). Ingress into dens at these sites occurred on October 2; however, actively rattling *C. cerberus* has been observed inside or near the opening of dens as late as November 11.

In Coconino County, home ranges for male *C. cerberus* averaged 27.1 hectares (ha) with a range of 21-91.2 ha. Female *C. cerberus* appear to have much smaller ranges than males, with a Gila County female tracking 2.0 ha when pregnant and 2.63 ha when not pregnant. When compared to home ranges for male *C. cerberus* from Gila County, the females' range is slightly less than ten percent of the males'.

Conservation Status

The IUCN Red List of Threatened Species has not yet assessed *C. cerberus* (IUCN 2013). *Crotalus cerberus* global status and national status is listed as a G5 and N5, respectively (Secure; extensive range, extensive populations or occurrences, and little to no concern of threats or decline). In Arizona, this subspecies is listed as S5 (Secure). It is not currently a federally listed species, nor a state listed species of concern (AGFD 2002). Due to their status, conservation measures to protect *C. cerberus* are currently not practiced.

Threats

Crotalus cerberus have likely been affected by urbanization through habitat destruction and fragmentation. The habitats of these snakes are generally fragmented due to unsuitable landscapes surrounding already inhabited areas and development into Wildland-Urban Interfaces, particularly highly valued riparian areas. In addition, increases in recreational usage of public lands and wilderness area likely increases encounters and the willful killing of these snakes at the human and rattlesnake nexus. They are also collected for the pet trade. Although collection is regulated to some degree (AGFD 2002), meaning that collectors cannot legally capture specimens without a valid Arizona hunting license and that certain federal and state lands (e.g., National Park Service and Arizona State Parks, respectively) are closed to collecting, the level of compliance with collectors obtaining hunting licenses and the number of specimens legally or illegally collected is unknown, as there are currently no reporting requirements. Consequently, there is no way to track legally collected. Collectively, it is not known if these occurrences have posed a major threat to the species.

Mitigation of Management Practices

Populations of *Crotalus cerberus* and its habitat may be affected by Forest Service management practices on the Williams Ranger District; however, more information on this species ecology is needed before deleterious management practices can be effectively mitigated. It is unclear what effect livestock and wildlife grazing have on the species, especially in mesic areas associated with springs, streams and rivers. However, it is important to note that there are no rivers on the Williams Ranger District and streams that do occur are restricted to a total of approximately ¼ mile in length... It is also unknown if this subspecies is sensitive to clearing, thinning or prescribed fire; however, since this species requires downed woody debris and snags for hunting and refugia and likely uses brush piles, it is recommended that riparian areas and rocky areas are not cleared and brush piles, if burned, are burned during winter months when the snakes are likely to be found in hibernacula. It is recommended that brush piles are disassembled and snakes are looked for immediately prior to burning. It is also recommended that any management practices with potential impacts to hibernacula (i.e., dens) are avoided completely.

Restoration/Conservation Opportunities

Restoration and conservation opportunities for Arizona Black Rattlesnake likely will be hindered by scanty information available regarding population dynamics, by the topographic relief and ruggedness of their habitats, and by their secretive habits. The most effective conservation method is to better manage existing habitats by reducing wildlife and livestock impacts in riparian areas, limiting access to species habitats, limiting non-native species introductions, and appropriate prescribed burning management. In practice, effective habitat management will require investment in inventory, research and monitoring information. Monitoring for this taxa should include monitoring of habitat conditions and periodic monitoring of Arizona Black Rattlesnake populations to identify trends leading to precipitous declines in population levels or changes in species (see Information Gaps section for specific monitoring recommendations).**Table 1: Common general and specific Forest Service management practices, potential impacts, and mitigation actions.**

General Activity	Management Action	Impacts	Mitigation Actions
Brush control	Mechanical cutting of juniper with lop and scatter to 18 to 24 inches from the ground	Wood chip cover of springs and streams	Avoid chipping near natural water sources.
Brush control	Mechanical removal of emory oak, manzanita, and other brushy vegetation.	Loss of terrestrial foraging habitats, refugia during daytime	Avoid removal of brush vegetation from *C. cerberus* habitat
Construction	Drainage or stream crossings by trails or roads with insertion of proper culverts to allow for water flow	Erosion, water quality, soil disturbance and/or compaction	Minimize road and trail impacts that may affect *C. cerberus* habitat and activity.
Construction	Road construction	Soil compaction, dust, noise	Schedule road construction work to minimize *C. cerberus* population and habitat impacts, including potential dispersal; specifically, avoid dens completely and construction-associated disturbances from mid-April to mid-October.
Forest management	Prescribed burning	Increased soil temperature during fire, loss of terrestrial foraging habitats and refugia, heavy equipment impacts	Avoid burning *C. cerberus* habitat or conduct prescribed fires in winter to minimize seasonal impacts on wildlife and habitats.
Forest management	Timber harvest using thinning in Ponderosa Pine	Increased soil temperature during fire, loss of terrestrial foraging habitats and refugia, heavy equipment impacts	Avoid concentrating slash in burn piles, conduct prescribed fires in winter to minimize seasonal impacts on *C. cerberus* and habitats.
Forest management	Underburning using prescribed fire in Ponderosa Pine	Increased soil temperature during fire, loss of terrestrial foraging habitats and refugia, heavy equipment impacts	Avoid burning *C. cerberus* habitat or conduct prescribed fires in winter to minimize seasonal impacts on *L. p. infralabialis* and habitats.

General Activity	Management Action	Impacts	Mitigation Actions
Livestock management	Fencing to exclude or concentrate livestock or wildlife	Fencing may exclude wildlife or concentrate livestock or wildlife into sensitive areas, such as springs and stream-riparian zones	Assess and manage fencing to minimize grazing impacts on *C. cerberus* habitats, particularly springs and streams.
Livestock management	Livestock grazing management	Erosion, dust, vegetation removal, increased soil and surface water temperatures, water quality degradation	Use exclosure fencing to keep livestock away from stream margins and aquatic habitats.
Pest control	Non-native invasive plant species treatment (either mechanically or via herbicide)	Reduction or elimination of vegetation may increase erosion and dust, and/or decrease prey species.	Ensure herbicides are safely stored and handled, tested to prevent unanticipated impacts on *C. cerberus,* and apply appropriately and minimally (avoiding non-target flora) to *C. cerberus* habitats using integrated pest management plans (USFWS 2010)
Pest control	Release of non-native species	Predation, competition, disease transmission to native taxa	Control non-native fauna as feasible, using integrated pest control (USFWS 2010) and long-term planning.
Water resources management	Electroshocking fish as a monitoring activity	Electrical impacts on larger aquatic organisms, such as large aquatic invertebrates (e.g., hellgrammites) and fish. No effect on *C. cerberus.*	Not applicable to *C. cerberus.*
Water resources management	Spring or stream capture and diversion	Reduction or elimination of surface flows	Ensure wildlife water supplies and habitat are not reduced.
Water supplies management	Spring and stream monitoring	Flow and water quality may dwindle or disappear without regular monitoring	Regularly monitor springs and streams, and more frequently during drought, to ensure flowing waters are available and of high quality.

Information Gaps

Very little is known about this species in its northern habitat and its distribution in the Williams Ranger District, so inferences are drawn from what is documented about *C. cerberus* from lower elevational or latitudinal habitats, which may or may not be relevant. The Colorado River likely imposes an impenetrable barrier preventing the occurrence of the *C. cerberus* in the North Kaibab Ranger District, and several factors, including poor habitat, very limited water resources and competition with similar species may limit the occurrence in the Tusayan Ranger District. How *C. cerberus* distributions are affected by nonhuman predators and parasites, changing climates and changing biotas in response to climate change, as well as the natural history and interspecific relationships of *Crotalus* species are poorly understood. In addition, studies on *C. cerberus* population demographics, habitat and life history, as well as a full taxonomic review to determine the phylogeography of this species, are needed. However, as evidenced by the number and emphasis of publications relating to snakes in general, studies of rattlesnake behavior and ecology have markedly increased in recent years, a trend that appears in large part due to changing social attitudes about snakes (Beaman & Hayes 2008). This encouraging development may well facilitate support for both monitoring programs as well as partnerships of the Forest Service with academic research facilities to conduct monitoring, demography, ecology and behavior.

Monitoring for snakes is especially difficult as terrestrial snakes are either not that common or not that easily seen, as they are generally secretive, highly mobile and do not exhibit territoriality or site fidelity unless associated with hibernacula. When planning projects, the best way to monitor for snakes is to target areas where they are known to occur (such as hibernacula, talus slopes, woody debris or riparian areas) at times when they are active seasonally (e.g., mid- to late-April to mid- to late-October) and diurnally (e.g., dawn to mid-morning and early evening to dusk). In summary, short of conducting some type of survey, there is now way to determine if snakes are present or absent, and it is important to bear in mind that that non-detection of snakes does not indicate absence.

References Cited

Amarello, M. 2012. Social Snakes? Non-random association patterns detected in a population of Arizona black rattlesnakes (*Crotalus cerberus*). Master's thesis, Arizona State University, U.S.A.

Arizona Game and Fish Department (AGFD). 2002. *Lampropeltis pyromelana infralabialis.* Unpublished abstract compiled and edited by the Heritage Data Management System, Arizona Game and Fish Department, Phoenix, AZ. 4 pp.

Beaman K.R., and W. K. Haye. 2008. Rattlesnakes: Research trends and annotated checklist. In: Hayes et al. (eds.), The biology of rattlesnakes. Loma Linda University Press, pp. 5-16.

Brennan, T. C. 2009. Arizona Black Rattlesnake, Crotalus cerberus. Available http://www.reptilesofaz.org/Snakes-Subpages/h-c-cerberus.html. (Accessed: May 14, 2013).

Brennan, T. C., and A. T. Holycross. 2009. *A Field Guide to Amphibians and Reptiles in Arizona.* Arizona Game and Fish Department, Phoenix, AZ, 150 pp.

Campbell, J.A., and W. W. Lamar. 2004. *Crotalus oreganus* Holbrook, 1840. Pp. 564–570 in The venomous reptiles of the western hemisphere, Volume II. Cornell University Press, U.S.A.

Coues E. 1875. Synopsis of the reptiles and batrachians of Arizona; with critical and field notes, and an extensive synonymy. Report upon Geographical and Geological Explorations and Surveys West of the One Hundredth Meridian. Volume V. Zoology: Reports upon the Zoological Collections Obtained from Portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during the Years 1871, 1872, 1873, and 1874: 585-633 + 10 lithographic plates (3 are chromolithographs).

Crother B. I. 2000. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. Herpetological Circular, No. 29: 1-82.

Crother B. I., J Boundy, J. A. Campbell, K. de Quieroz, D. Frost, D. M. Green, R. Highton, et al. 2003. Scientific and standard English names of amphibians and reptiles of North America north of Mexico: Update. Herpetological Review, vol. 34, no. 3. 196-203.

Hauserman, T. 2008. Rattlesnake relocation field notes, 2003-2008. Unpublished field notebook.

HDMS. 2013. Heritage Data Management System (HDMS) Species Locations. Arizona Game and Fish Department, U.S.A

IUCN. 2013. The IUCN Red List of Threatened Species. Available http://www.iucnredlist.org/search. (Accessed: May 14, 2013).

Lowe, C. H., C. R. Schwalbe, and T. B. Johnson. 1986. The Venomous Reptiles of Arizona. Arizona Game and Fish Department, U.S.A.

Meachum, C. 1999. A brief history of the Arizona Black Rattlesnake. Cold Blooded News 26 (3):1–9.

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: May 14, 2013).

Nowak, E. M. 1998. Effects and effectiveness of rattlesnake relocation at Montezuma Castle National Monument. M.S. Thesis, Northern Arizona University, U.S.A

Nowak, E. M. 2005. Ecology of the Arizona Black Rattlesnake (*Crotalus* [*viridis*] *cerberus*) at Tonto National Monument, Arizona. Unpublished final report to Desert Southwest Cooperative Ecosystem Studies Unit. US Geological Survey, Southwest Biological Science Center, Colorado Plateau Research Station, U.S.A**.**

Nowak, E. M. 2009. Ecology and management of venomous reptilian predators. Ph.D. Dissertation, Northern Arizona University, U.S.A.

Schofer, J. X. 2007. Movements, thermal biology, habitat use, and natural history of *Crotalus cerberus* in Northern Arizona. Master's thesis, Northern Arizona University, U.S.A.

Stebbins, R. C. 2003. *A Field Guide to Western Reptiles and Amphibians*. Third Edition. Houghton Mifflin Company, Boston, MA, 560 pp.

USFWS. 2010. Integrated Pest Management. United States Fish & Wildlife Service (USFWS) Integrated Pest Management Policy 569 FW 1.

van Riper, C., III. J. R. Hatten, J. T. Giermakowski, D. Mattson, J. A. Holmes, M. J. Johnson, E. M. Nowak, K. Ironside, M. Peters, P. Heinrich, and C. R. Schwalbe. 2012. Forecasting climate impacts on wildlife of the arid Southwest at regional and local scales using downscaled climate models. Administrative final report to NCCWSC. U.S. Geological Survey, Southwest Biological Science Center, U.S.A.

UTAH MOUNTAIN KINGSNAKE (SQUAMATA) OF KAIBAB NATIONAL FOREST

All snakes in the *Lampropeltis* genus - kingsnakes and milksnakes - are medium-sized constrictors with smooth scales and a shiny gloss to the scales (*Lampropeltis* means "shiny skin"). Kingsnakes are distributed from Canada to northern South America. In Arizona, kingsnakes are found in a variety of habitats ranging from desert scrub and grassland to woodlands and coniferous forests. Kingsnakes are important predators of a variety of food items, including frogs, toads, lizards, rodents, bird eggs and hatchling and fledgling birds, and some species eat other snakes, including rattlesnakes. Generally considered mild-mannered, some kingsnake species can be excitable when encountered or handled and may rattle their tails, hiss and/or strike.

The *Lampropeltis* genus contains approximately a dozen species, with three species of the *Lampropeltis* genus found in northern Arizona: the common kingsnake (*Lampropeltis getula*), the Sonoran mountain kingsnake (*L. pyromelana*), and the milksnake (*L. triangulum*). Three subspecies of the Sonoran mountain kingsnake are found in Arizona: the Utah mountain kingsnake (*L. p. infralabialis*) in the northern part of the state, the Arizona mountain kingsnake (*L. p. pyromelana*), and the Huachuca mountain kingsnake (*L. p. woodini*) of the Huachuca Mountains of southern Arizona and New Mexico.

Several snake species display the characteristic, black, white and red tri-coloration of the Sonoran mountain kingsnake species, including the venomous Sonoran coralsnake (*Micruroides euryxanthus*), Sonoran shovel-nosed snake (*Chionactus palarostris*), western shovel-nosed snake (*Chionactus occipitalis*), variable sandsnake (*Chilomeniscus stramineus*), groundsnake (*Sonora semiannulata*), thornscrub hook-nosed snake (Gyal*opion quadrangulare*), long-nosed snake (*Rhinocheilus lecontei*), and milksnake. Of these snakes, all except the groundsnake, long-nosed snake and milksnake are distributed in the central to southern portion of Arizona and do not occur in Coconino or Mojave counties.

In identifying *Lampropeltis pyromelana infralabialis* and other cryptically-colored snake species found within their range, the most easily discernible feature is the color of the snout: Sonoran mountain kingsnake subspecies have a white snout while groundsnakes have a red snout and milksnakes a black snout. While the tricolored morph of the long-nosed snake's snout is also white, the black saddles on the back are ringed by a thin white line and the banding pattern is often speckled. Both the Arizona Mountain kingsnake and Huachuca mountain kingsnake have 10 lower labial (infralabial) scales while the Utah mountain kingsnake has nine.

Utah Mountain Kingsnake
Colubridae: *Lampropeltis pyromelana infralabialis* Tanner 1953

Fig. 1: Utah Mountain Kingsnake, *Lampropeltis pyromelana infralabialis,* showing tricolored banding pattern, white snout, and black mask. Credit: Photograph courtesy of Tom Brennan.

Taxonomy

Craniata
- Reptilia
  - Squamata
    - Colubridae
      - *Lampropeltis pyromelana infralabialis* Tanner 1953

The beautiful tricolor markings of this colubrid snake make it highly sought after by collectors for the pet trade. Due to their coloration, they are often mistakenly identified as the highly venomous coralsnakes and killed. That they are mountain dwellers, living in rocky areas and canyon lands with dense clumps of vegetation, rocks and logs, concomitant with their reclusive behavior, has likely enabled their persistence.

Description (Tanner 1953)

Neonate/Juvenile: Utah Mountain Kingsnake, *Lampropeltis pyromelana infralabialis,* hatchlings are typically between 8-11 inches (20-28 cm) in length (AGFD 2002). Their banded phases and stripes generally occur with the offspring from same clutches.

***Adults*:** Adult *L. p. infralabialis* have smooth scales and are typically between 18-45 inches (46-114 cm) in length (AGFD 2002). These tri-colored snakes have black (B), orange or red (R), and white (W) or yellow arranged in bands (rings) across their body with R inserted between BWB codons, resulting in a BWRWBRBWRWBR pattern (Fig. 1). The amount of red found in the bands is variable, and can completely split the black bands, form a wedge on each side, or form a wide band with narrow black border (Stebbins 2003). Black bands often narrow or disappear on the sides. Their white-yellow bands are encompassed by black bands, resulting in their orange-red bands never coming in contact with the white-yellow bands. They usually have 42-57 white-yellow bands on the body and 9-10 on their tail (AGFD 2002). The pattern on dorsal scales is imperfectly carried onto the ventral scales, with more than half of their white-yellow bands extending unbroken across the belly (Stebbins 1996). A distinguishing characteristic from other cryptically colored snakes, including the Coralsnake and Milksnake, is the head pattern: the first white-yellow band encompasses the rear of the head and is separated from the white snout by a black mask. Their identifying scalation is: 21-23 dorsal, 213-230 ventral, 59-79 subcaudal, 7-8 supralabial, 9 infralabial and the analplate is single (Koenig 2002).

Similar Taxa

Three snake species superficially resemble *L. p. infralabialis*, but are generally not found in the same range. The California Mountain Kingsnake is distinguished by the solid black or black with red markings on the snout, and the black bands on the sides of the body do not usually narrow approaching the ventral scales (Stebbins 2003). The Milk Snake has a black snout and fewer than 200 ventral scales in areas of overlap with *L. pyromelana* species (Stebbins 2003). The Coralsnake has a black snout and broad red bands bordered with white or yellow (Stebbins 2003).

Three subspecies of the Sonoran mountain kingsnake are found in Arizona (Fig. 2): *L. p. infralabialis* in the northwestern portion of the state, north of the Colorado River, is distinguishable by nine lower labial scales (infralabials). The Arizona Mountain Kingsnake (*L. p. pyromelana*) is found south of the Colorado River throughout the central and southern portion of the state, and is distinguishable by 10 infralabials. The Huachuca Mountain Kingsnake (*L. p. woodini*) is confined to the Huachuca Mountains of southern Arizona and New Mexico, and is also distinguishable by 10 infralabials.

Range

***Regional*:** *Lampropeltis pyromelana infralabialis* are endemic to the American Southwest north of the Colorado River. They occur from the extreme northwestern corner of Arizona on the Arizona Strip, including the Virgin Mountains, Mohave County (AGFD 2002), through western and central Utah northward to the Great Salt Lake, and spottily in eastern Nevada, where they are confined to Water and Sawmill canyons in the Egan Range of White Pine County, Nevada, and Washington County, Utah (AGFD 2002). Small populations occur at elevations ranging from 3000-9000 feet (305-914 m).

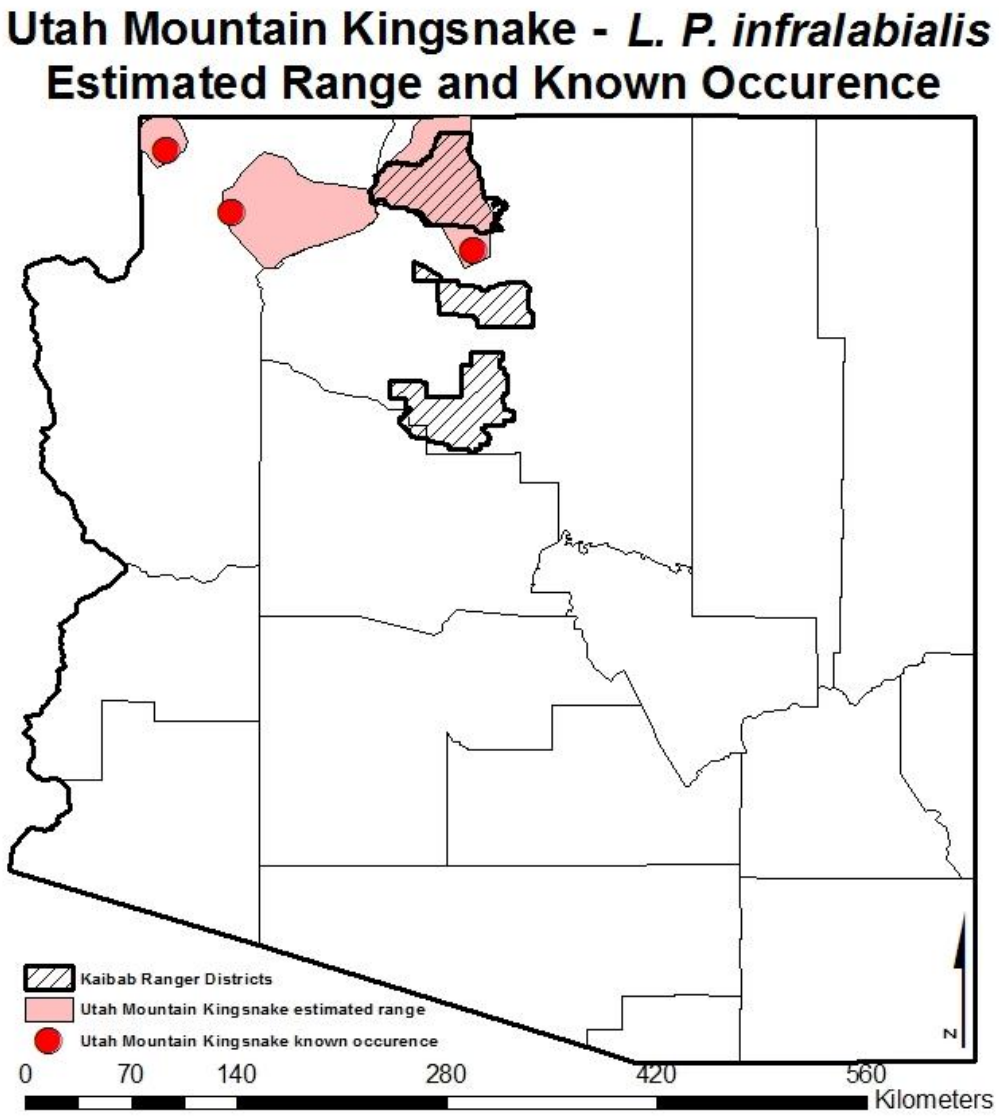

Fig. 2: Regional map of Utah Mountain Kingsnake, *Lampropeltis pyromelana infralabialis*, occurrence in Arizona. . Map generated based on map by Brennan & Holycross (2009) and point locations described in HerpNet (2013).

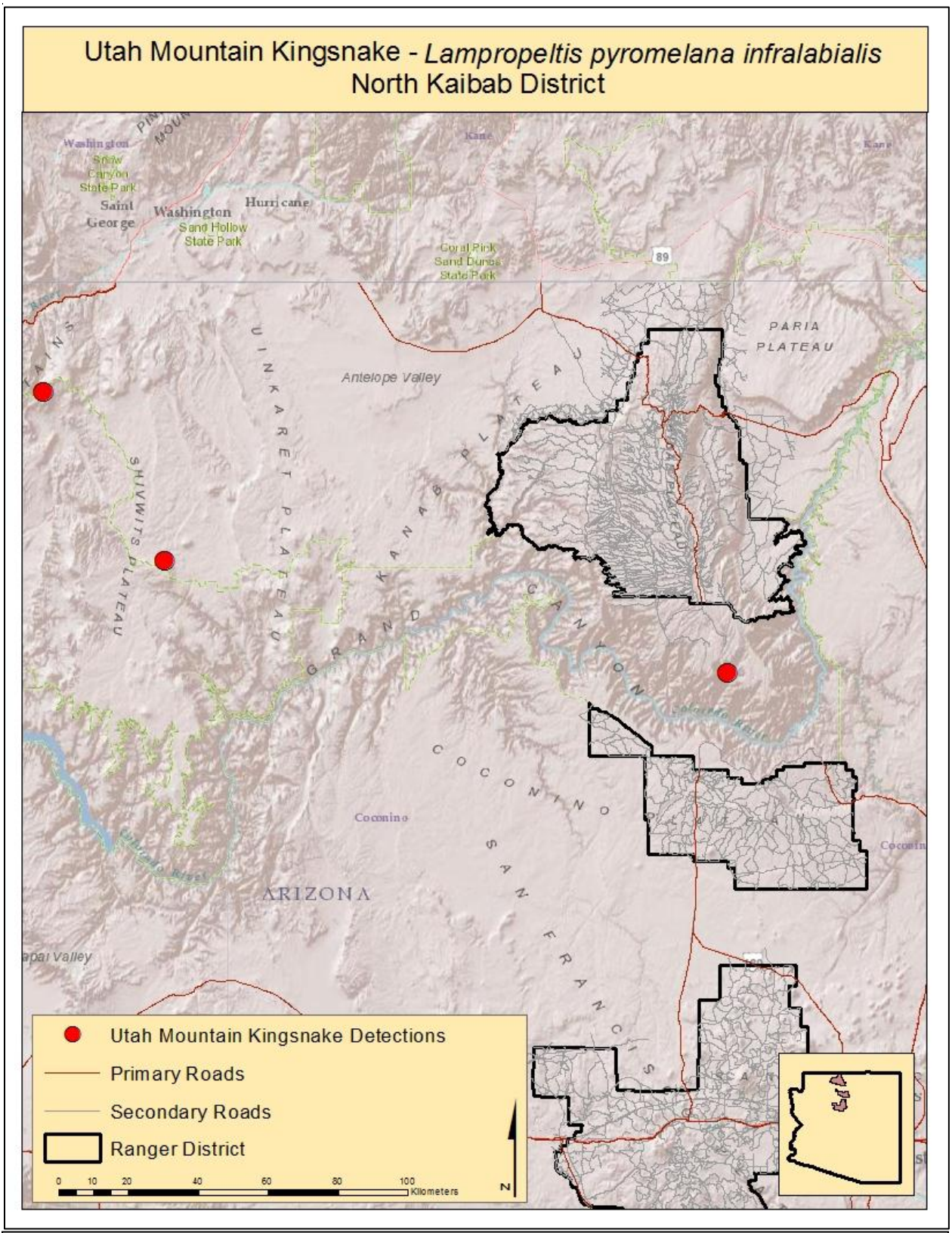

Fig. 3: Map of Utah Mountain Kingsnake, *Lampropeltis pyromelana infralabialis*, occurrence in the Williams District of Kaibab National Forest. Point locations described in HerpNet (2013).

Known Localities: Most collected specimens of *L. p. infralabialis* have occurred in Utah. In Arizona**,** 7-8 specimens have been collected: one specimen in the University of New Mexico (UNM) collection was collected in 1871 but has no further locality information (HerpNet 2013); five specimens were collected from or near Bright Angel Point, North Rim of the Grand Canyon (Tanner 1953); and Koenig (2004) documents the capture of two specimens in Mohave County, with one specimen captured in 1992 on Black Rock Mountain and a second specimen captured in 2001 on Poverty Mountain. A second specimen in the UNM collection collected near Prescott in Yavapai County (HerpNet 2013) and a specimen collected 15 miles south of Williams in the Williams Ranger District of the Kaibab National Forest (HerpNet 2013), are now thought to represent a similar subspecies, the Arizona mountain kingsnake (*L. p. pyromelana)*.

Kaibab National Forest – North Kaibab Ranger District: *Lampropeltis pyromelana infralabialis* is thought to reside primarily north of the Colorado River but it has never been documented within the boundaries of the North Kaibab Ranger District. Although the habitat in the mountainous and riverine areas of the North Kaibab District appears to be suitable, it has not been collected from these locales but has been collected immediately south of the District. Further, *L. p. infralabialis* has yet to be detected in Grand Canyon National Park.

Kaibab National Forest – Tusayan Ranger District: *Lampropeltis pyromelana infralabialis* has not been collected south of the Colorado River and is not known to occur on the Tusayan Ranger District. Although suitable habitat may occur in the District , it has not been collected from these locales. It is likely that the Colorado River poses a barrier to its southward migration.

Kaibab National Forest – Williams Ranger District: *Lampropeltis pyromelana infralabialis* has not been collected south of the Colorado River and is not known to occur on the Williams Ranger District Although the rocky and riverine habitat along the Mogollon Rim margin appears to be suitable, it has not been collected from additional locales. It is likely that the Colorado River poses a barrier to its southward migration.

Habitat Requirements

Lampropeltis pyromelana infralabialis are found primarily in mountainous terrain from chaparral and pinyon-juniper woodlands to ponderosa pine-Douglas fir woodlands; specifically, in Interior Chaparral, Great Basin Conifer Woodland, Madrean Evergreen Woodland and Petran Mountain Conifer Forest plant communities. The dominant vegetation of a specimens found in Mohave County was characterized by ponderosa pine, New Mexico locust and sagebrush (Breck Bartholomew, pers. comm.; cited in Koenig 2002) and by pinyon-juniper (Koenig 2004). Although snakes are often located on heavily wooded, rocky slopes or in steep canyon bottoms with rocky areas with abundant litter, dense vegetation, or rotting logs that are near springs or streams, both specimens found in Mojave County were in rocky areas with extensive south-facing rock slides and no streams or permanent water in the area (Koenig 2004). In transition zones, they are also found in open rolling hills and grasslands (Brennan 2008).

Ecology and Life History

As a chiefly diurnal predator, *L. pyromelana* ssp. are primarily encountered foraging during cooler parts of the day, in early to midmorning after sunup and or evening just prior to sunset. It is probably nocturnal in warm weather, as it is occasionally encountered foraging on warm, moist nights (Holycross & Brennan 2009). *Lampropeltis pyromelana infralabialis*, are secretive and try to remain hidden while foraging. *L. pyromelana* ssp. are primarily ground-dwellers, but also adept climbers and have been found in trees, on high boulders, and high on cliff faces (Koenig 2004). They prey on lizards, rodents, nestling birds, occasionally bats (Holycross & Brennan 2009; Greene 1997), and possibly snakes. They are powerful constrictors and kill their prey by suffocation, and like milksnakes, are immune to rattlesnake venom.

Behavior

Lampropeltis pyromelana infralabialis prefer cool temperatures that range from 18-22°C and are believed to spend the majority of their time underground. They are usually secretive, sheltering in rock piles and preferring to be hidden by undergrowth when aboveground and foraging, and even while basking will remain well hidden. They are also semi-arboreal (plan their foraging and escape behavior (Greene 1997). They hibernate during the winter and mate in early-spring (mid-March) through early summer (early July). They are oviparous and lay 6-12 eggs per clutch, with an incubation period between 65-85 days. Little is known about their breeding behavior other than what has been observed in captivity.

When threatened, *L. p. infralabialis* use several bluff postures as defense. They will vibrate their tail, mimicking a rattlesnake, and strike. They will sometimes roll into a ball, protecting their head in the center and evert (i.e., turn outward) the lining of the cloaca, which discharges feces and pungent, foul-smelling musk. When handled, these snakes will writhe, bite and exude musk.

Conservation Status

The IUCN Red List of Threatened Species lists *Lampropeltis pyromelana* as LC (Least Concern but has not yet assessed the *L. p. infralabialis* subspecies (IUCN 2013). *Lampropeltis pyromelana infralabialis* global status and national status is listed as a T3 and N3, respectively (vulnerable; restricted range and very few populations or occurrences); in Arizona, this subspecies is listed as S1 (**Critically Imperiled**—At very high risk of extirpation; NatureServe 2013). This subspecies is of concern in Arizona due its naturally extremely restricted range in canyon areas, very few populations or occurrences and severe threats. It is not currently a federally listed species, nor a state listed species of concern (AGFD 2002). Due to their status, conservation measures to protect *L. p. infralabialis* are currently not being practiced.

Threats

Lampropeltis pyromelana infralabialis have likely been affected by urbanization through habitat destruction and fragmentation. The habitats of these snakes are generally fragmented due to unsuitable landscapes surrounding already inhabited areas. They are also collected for the pet trade. Although collection is regulated (AGFD 2002), meaning that

collectors cannot capture specimens without a valid hunting license and that certain federal and state lands (e.g., National Park Service and Arizona State Parks, respectively) are closed to collecting, the level of compliance with collectors obtaining hunting licenses and the number of specimens legally or illegally collected is unknown. For the most part though, these occurrences are not considered to have posed a major threat to the species and many localized populations of Utah mountain kingsnake reside in protected areas in the United States, but not in Mexico.

Mitigation of Management Practices

Populations of *L. p. infralabialis* and its habitat may be affected by Forest Service management practices on the Williams Ranger District; however, more information on this species ecology is needed before deleterious management practices can be effectively mitigated. It is unclear what effect livestock and wildlife grazing have on the species. It is also unknown it this subspecies is sensitive to clearing, thinning or prescribed fire; however, since this species requires dense cover for refugia and likely uses brush piles, it is advisable that riparian areas and rocky areas are not cleared and brush piles, if burned, are burned during winter months when the snakes are likely to be found in hibernacula. It is advisable that brush piles are disassembled and snakes are looked for immediately prior to burning.

Restoration/Conservation Opportunities

Restoration and conservation opportunities for *L. p. infralabialis* likely will be hindered by scanty information available regarding population dynamic, by the topographic relief and ruggedness of their habitats, and by their secretive habits. The most effective conservation method is to better manage existing habitats by reducing wildlife and livestock impacts in riparian areas, limiting access to species habitats, limiting non-native species introductions, and appropriate prescribed burning management. In practice, effective habitat management will require investment in inventory, research and monitoring information. Monitoring for this taxon should include monitoring of habitat conditions and periodic monitoring of *L. p. infralabialis* populations to identify trends leading to precipitous declines in population levels or changes in species (see Information Gaps section for specific monitoring recommendations).

Table 1: Common general and specific Forest Service management practices, potential impacts, and mitigation actions.

General Activity	Management Action	Impacts	Mitigation Actions
Brush control	Mechanical cutting of juniper with lop and scatter to 18 to 24 inches from the ground	Wood chip cover of springs and streams	Avoid chipping near natural water sources; monitor.
Brush control	Mechanical removal of emory oak, manzanita, and other brushy vegetation.	Loss of terrestrial foraging habitats, refugia during daytime	Avoid removal of brush vegetation from *L. p. infralabialis* habitat

General Activity	Management Action	Impacts	Mitigation Actions
Construction	Drainage or stream crossings by trails or roads with insertion of proper culverts to allow for water flow	Erosion, water quality, soil disturbance and/or compaction	Minimize road and trail impacts that may affect *L. p. infralabialis* habitat and activity.
Construction	Road construction	Soil compaction, dust, noise	Schedule road construction work to minimize *L. p. infralabialis* population and habitat impacts, including potential dispersal.
Forest management	Prescribed burning	Increased soil temperature during fire, loss of terrestrial foraging habitats and refugia, heavy equipment impacts	Avoid burning *L. p. infralabialis* habitat or conduct prescribed fires in winter to minimize seasonal impacts on wildlife and habitats.
Forest management	Timber harvest using thinning in Ponderosa Pine	Increased soil temperature during fire, loss of terrestrial foraging habitats and refugia, heavy equipment impacts	Avoid concentrating slash in burn piles, conduct prescribed fires in winter to minimize seasonal impacts on *L. p. infralabialis* and habitats.
Forest management	Underburning using prescribed fire in Ponderosa Pine	Increased soil temperature during fire, loss of terrestrial foraging habitats and refugia, heavy equipment impacts	Avoid burning *L. p. infralabialis* habitat or conduct prescribed fires in winter to minimize seasonal impacts on *L. p. infralabialis* and habitats.
Livestock management	Fencing to exclude or concentrate livestock or wildlife	Fencing may exclude wildlife or concentrate livestock or wildlife into sensitive areas, such as springs and stream-riparian zones	Assess and manage fencing to minimize grazing impacts on kingsnake habitats, particularly springs and streams.
Livestock management	Livestock grazing management	Erosion, dust, vegetation removal, increased soil and surface water temperatures, water quality degradation	Use exclosure fencing to keep livestock away from stream margins and aquatic habitats.

General Activity	Management Action	Impacts	Mitigation Actions
Pest control	Non-native invasive plant species treatment (either mechanically or via herbicide)	Reduction or elimination of vegetation may increase erosion, dust	Ensure herbicides are safely stored and handled, tested to prevent unanticipated impacts on *L. p. infralabialis,* and apply appropriately and minimally (avoiding non-target flora) to *L. p. infralabialis* habitats using integrated pest management plans (USFWS 2010).
Pest control	Release of non-native invertebrates (e.g., crayfish) and vertebrates (e.g., bullfrogs, tiger salamanders, fish, cats)	Predation, competition, disease transmission to native taxa	Control non-native fauna as feasible, using integrated pest control (USFWS 2010) and long-term planning.
Water resources management	Spring or stream capture and diversion	Reduction or elimination of surface flows	Ensure wildlife water supplies and habitat are not reduced.
Water supplies management	Spring and stream monitoring	Flow and water quality may dwindle or disappear without regular monitoring	Regularly monitor springs and streams, and more frequently during drought, to ensure flowing waters are available and of high quality.

Information Gaps

Very little is known about this subspecies, so inferences are drawn from what is documented about the species *Lampropeltis pyromelana.* How tricolored *Lampropeltis* species (both kingsnakes and milksnakes) distributions are affected by changing climates and changing biotas in response to climate change, as well as the natural history and interspecific relationships of tricolored *Lampropeltis* species are poorly understood (Greene 1997). In addition, studies on *L. p. infralabialis* distribution, population demographics, habitat and life history, as well as a full taxonomic review to determine the validity of this species, are needed (AGFD 2002).

Monitoring for snakes is especially difficult as terrestrial snakes are either not that common or not that easily seen, as they are generally secretive, highly mobile and do not exhibit territoriality or site fidelity unless associated with hibernacula. When planning projects, the best way to monitor for snakes is to target areas where they are known to occur (such as hibernacula, talus slopes, woody debris or riparian areas) at times when they are active seasonally (e.g., mid- to late-April to mid- to late-October) and diurnally (e.g., dawn to mid-morning and early evening to dusk). In

summary, short of conducting some type of survey, there is now way to determine if snakes are present or absent, and it is important to bear in mind that that non-detection of snakes does not indicate absence.

References Cited

Arizona Game and Fish Department. 2002. *Lampropeltis pyromelana infralabialis.* Unpublished abstract compiled and edited by the Heritage Data Management System, Arizona Game and Fish Department, Phoenix, AZ. 4 pp.

Brennan, T. C. 2009. Sonoran Mountain Kingsnake, Lampropeltis pyromelana. *http://www.reptilesofaz.org/Snakes-Subpages/h-l-pyromelana.html.*

Brennan, T. C., and A. T. Holycross. 2009. *A Field Guide to Amphibians and Reptiles in Arizona.* Arizona Game and Fish Department, Phoenix, AZ, 150 pp.

Koenig, H. F. 2004. The Utah mountain kingsnake (*Lampropeltis pyromelana infralabialis*) in Arizona (Tanner, 1953). Sonoran Herpetologist 17(3): 29-30.

Koenig, H. F. *2002. Lampropeltis pyromelana infralabialis*. www.kingsnake.com/king/pyromelana/infralabialis.html.

Greene, H. W. 1997. Snakes: the evolution of mystery in nature. University of California Press, Berkeley and Los Angeles, CA, 697 pp.

HDMS. 2013. Heritage Data Management System (HDMS) Species Locations. Arizona Game and Fish Department, U.S.A

IUCN. 2013. The IUCN Red List of Threatened Species. Available http://www.iucnredlist.org/details/63831/0. (Accessed: May 14, 2013).

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: May 14, 2013).

Stebbins, R. C. 2003. *A Field Guide to Western Reptiles and Amphibians*. Third Edition. Houghton Mifflin Company, Boston, MA, 560 pp.

Tanner, W. W. 1953. A Study of Taxonomy and Phylogeny of *Lampropeltis pyromelana* Cope. The Great Basin Naturalist 13, (1-2): 47-66.

Tanner, W. W. 1983. *Lampropeltis pyromelana*. *Catalogue of American Amphibians and Reptiles* 342: 1-2.

USFWS. 2010. Integrated Pest Management. United States Fish & Wildlife Service (USFWS) Integrated Pest Management Policy 569 FW 1.

KAIBAB NORTHERN POCKET GOPHER (RODENTIA) OF KAIBAB NATIONAL FOREST

Northern Pocket Gophers are a widely distributed, small, fossorial (burrowing) rodent species in North America, and get their name from the fur-lined cheek pouches, or pockets, that are used to carry food. Unlike the cheek pockets of sciurids (squirrels), their pockets open on the outside of the cheek and must be everted to empty and clean.

Pocket gophers are adept at digging, with enlarged, large-clawed front paws. Both the eyes and ears are small, the snout and around the ears and eyes are whiskered, the fur is pliable and the tail is sparsely haired, all attributes for a fossorial life style.

Unlike moles, pocket gophers are not insectivorous or vermivorous (worm-eating), but are entirely herbivorous, consuming roots, bulbs, leaves and stems of plants. Pocket gophers do not need a source of open water, obtaining sufficient moisture from their food. Since pocket gophers excavate extensive burrow systems and cache seeds and plant material in underground chambers, they are ecologically important as both ecosystem engineers and prey species. Multiple studies have documented that their fossorial activities influence soil structure, microtopography, habitat heterogeneity, plant species diversity and abundance, and primary productivity. In addition, they are important prey species for a number of vertebrates, including snakes, owls and raptors, and mustelids, canids and felids.

In northern Arizona, several morphologically very similar species of northern pocket gopher overlap in select parts of their ranges on the Kaibab Plateau. The two species in areas of near contact are distinguishable based on a variety of morphological and cellular-level attributes. In addition, two subspecies of northern pocket gopher of small body and cranial size occur in northern Arizona; however, their ranges are not known to overlap. In general, very little is known about this species; what is known is based on preserved specimens and closely-related Utah subspecies studied by Anderson (1978).

Kaibab Northern Pocket Gopher
Geomyidae: *Thomomys talpoides kaibabensis* Goldman 1939

Fig. 1: Northern Pocket Gopher, *Thomomys talpoides*, uncharacteristically above ground, showing brown-colored pelt, thick body, strongly clawed forefeet, and small ears with prominent black patch around and behind each ear. Credit: Photograph courtesy of Fred Bentler of www.bentler.us.

Taxonomy

Chordata
- Mammalia
  - Rodentia
    - Geomyidae
      - *Thomomys talpoides kaibabensis* Goldman 1939

The Kaibab Northern Pocket Gopher, *Thomomys talpoides kaibabensis,* is one of several subspecies of *T. talpoides* of small body and cranial size that occur in northern Arizona, and is morphologically very similar to and overlaps in select parts of its range on the Kaibab Plateau with *T. bottae*. Size differences between *T. talpoides* and *T. bottae* are indistinguishable; however, the two species in areas of near contact are distinguishable based on coat markings and coloration, skull morphology, dentition and number of chromosomes.

Description (Hoffmeister 1986)

Neonate/Juvenile: Newborn offspring develop pelage at nine days, with erect pinnae and active movement of the young occurring at 16 days, eye and ear opening occurring at 26 days, and molt to adult pelage occurring at approximately 90 days (Anderson 1978; cited by Hoffmeister 1986).

***Adult*:** In Arizona, adult *T. t. kaibabensis* are a small-sized subspecies compared to *T. t. fossor* and to most other *Thomomys* species. General characteristics of pocket gophers include thick bodies, strongly clawed forefeet, externally opening cheek pouches that are large and fur-lined, short , sparsely furred tails, small ears, long, heavy incisors, ever-growing cheek teeth, and an absence of postorbital processes on frontals (Fig. 1). Coat color is geographically variable. *T. t. kaibabensis* is distinguishable from other *Thomomys* species and subspecies by chestnut coloring on the top of the head and a prominent black patch around and behind each ear. Other prominent distinguishing features are not superficially evident but are notable in skull morphology, dentition and karyotype, specifically: the sphenoidal fissure is never large and is closed or slit-like; anterior prism of lower premolars is not rounded but appears broken away on the lingual side; the baculum is usually more than 20 mm long in adults; the incisive or palatine foramina is anterior to a plane through the anterior border of the infraorbital canal; and diploid number of chromosomes is likely 48 but is less than 70. The only apparent sexual dimorphism in *Thomomys* species is that males are significantly larger than females in all measurement aspects.

Similar Species

Two subspecies of Northern Pocket Gopher, *T. t. fossor* and *T. t. parowanensis*, are found are near the northern Arizona range of *T. t. kaibabensis*. *T. t. fossor* is found in the Chuska Mountains, Apache County, Arizona, and is larger both externally and cranially than *T. t. kaibabensis* (Hoffmeister 1986).. *T. t. parowanensis* is found in the Beaver Mountains, southern Utah, and is smaller than *T. t. kaibabensis* (Hoffmeister 1986). Subspecies of Botta's Pocket gopher, *T. bottae,* are found throughout Arizona, and the two species cannot be distinguished by features of size, but rather *T. bottae* has less prominent black features around the ears, the top of the head is less conspicuously chestnut-colored, sphenoidal features are smaller, roundish anterior prism of the lingual-side premolars, shorter baculu (<20 mm), plane of the infraorbital canal passes through the incisive foramina, and 70 or more diploid chromosomes (Hoffmeister 1986). The only potential locality overlap between the two species is the western edge of Grand Canyon National Park at Muav Saddle and Swamp Lake (Hoffmeister 1986).

Range

***Regional*:** The range of *T. talpoides* subspecies is restricted to the western United States and southwestern Canada, with northern Arizona and northern to central New Mexico the southwestern limit of the species range (Fig. 2; Patterson *et al*. 2003). In Arizona, two subspecies of *T. talpoides* are found (Fig. 3): *T. t. fossor* is found in the Chuska Mountains, Apache County, and *T. t. kaibabensis* is found exclusively on the Kaibab Plateau, Coconino County (Hoffmeister 1986).

Known Localities:

Hoffmeister (1986) reports *T. t. kaibabensis* from Arizona: Jacob Lake; VT Park; Greenland Spring; De Motte Park; Bright Angel Spring; Fawn Spring; Kanbownits Spring; Tipover Spring; Robbers Roost Spring; Road W-3 near Grand Canyon National Park entrance; Thompson Canyon, 0.5 mi north of Bright Angel RS; 5 mi. north, 1 mi. east of Bright Angel RS; The Basin; E-2 and W-2 of Fuller Canyon (N Rim); Wahalla Plateau, Greenland Lake (N Rim); Swamp Lake; Marble Flats (N Rim); Bright Angel Point; Snowshoe Cabin.

Kaibab National Forest – North Kaibab Ranger District: The range of *T. t. kaibabensis* on the North Kaibab District is indicated in Fig. 4, and appears to show that only a small amount of potential habitat exists on the District, and is restricted to a north-south transect of the center of the District with detections fanning southward outside of the southern border of the District towards the Colorado River boundary. This distribution reflects sampling efforts associated with proximity to Forest Service roads, and likely does not represent the true distribution of the subspecies in the region. Since this subspecies is expected to occur in high elevation meadows throughout the District, the distribution of this species may reflect a lack sampling effort or may reflect habitat that is disturbed and therefore unsuitable. Barring unsuitable habitat, populations are likely to be detected throughout the District and on adjacent North Kaibab District lands.

Kaibab National Forest – Tusayan Ranger District: The actual distribution of *T. t. kaibabensis* within the Tusayan District is not known as no occurrences have been documented; however, it is not known if sampling for this species has occurred in this district. Since appropriate habitat for this subspecies is expected to occur in the District, the rarity of this species may reflect a lack sampling effort or may reflect habitat that is disturbed and/or unsuitable. Conversely, the absence of this subspecies in the Tusayan Ranger District may reflect an insurmountable barrier to dispersal, for example, the Colorado River.

Kaibab National Forest – Williams Ranger District: The actual distribution of *T. t. kaibabensis* within the Williams Ranger District is not known as no occurrences have been documented; however, it is not known if sampling for this species has occurred in this district. Since appropriate high meadow habitat for this subspecies occurs in the District, such as Sitgreave Mountain, Bill Williams Mountain or Kendrick Peak, the rarity of this species may reflect a lack sampling effort or may reflect habitat that is disturbed and/or unsuitable. Conversely, the absence of this subspecies in the Williams Ranger District may reflect an insurmountable barrier to dispersal, for example, the Colorado River.

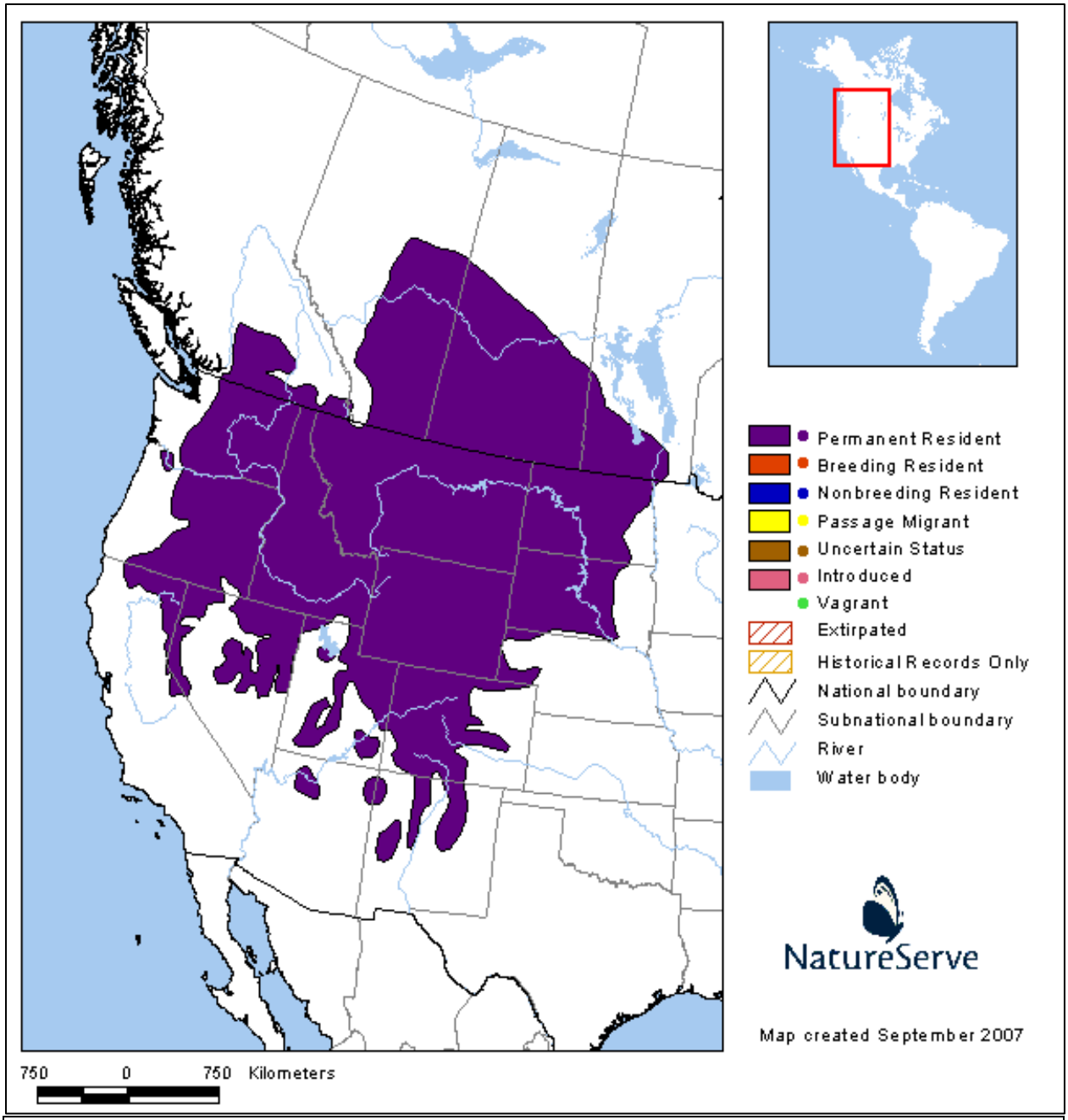

Fig. 2: Landscape map of Northern Pocket Gopher, *Thomomys talpoides*, distribution in western North America (Patterson *et al.* 2003). Data provided by NatureServe in collaboration with Bruce Patterson, Wes Sechrest, Marcelo Tognelli, Gerardo Ceballos, The Nature Conservancy-Migratory Bird Program, Conservation International-CABS, World Wildlife Fund-US, and Environment Canada-WILDSPACE.

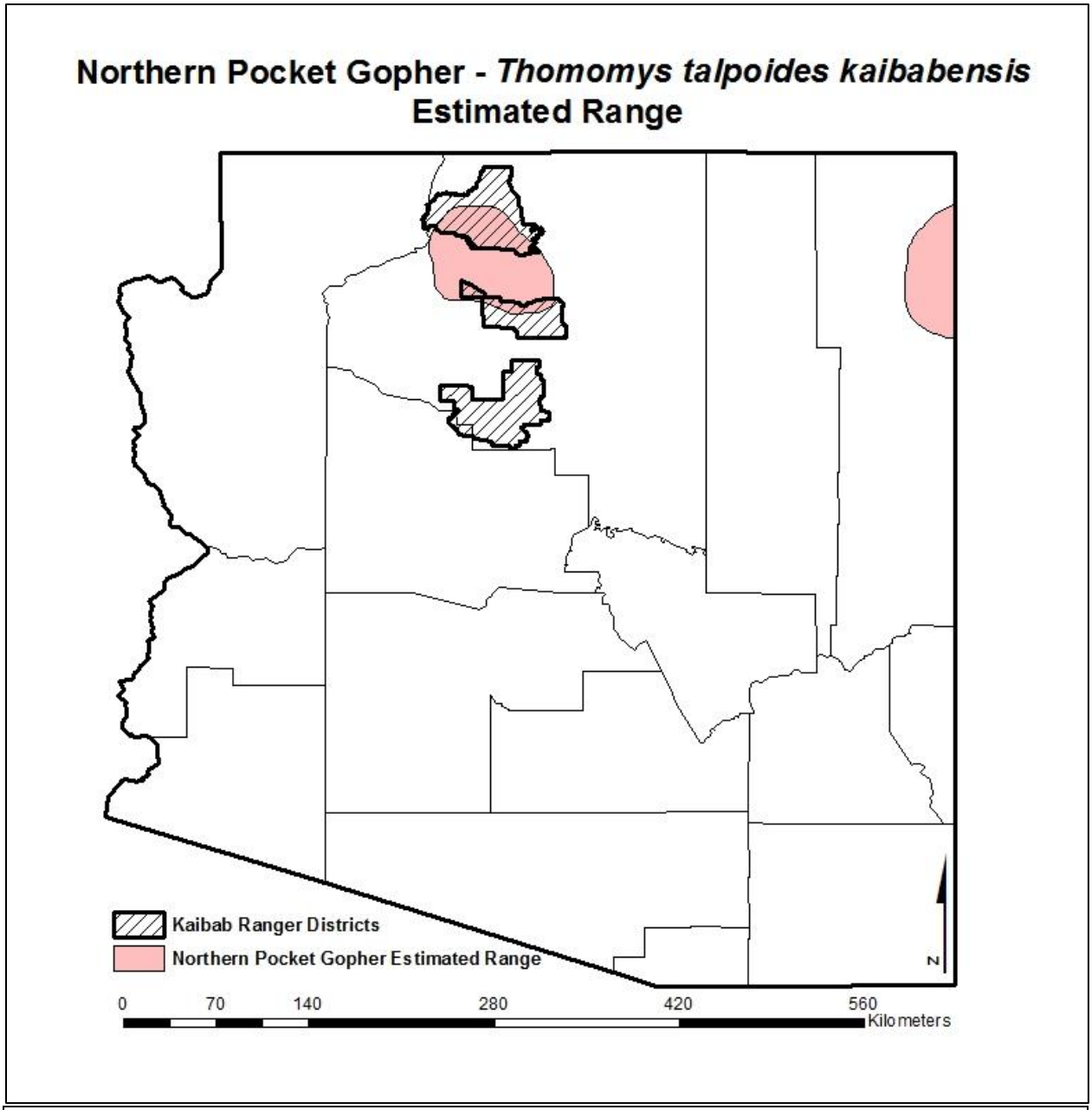

Fig. 3: Map of Northern Pocket Gopher, *Thomomys talpoides kaibabensis*, distribution in Arizona, showing estimated range in the Tusayan and North Kaibab districts of Kaibab National Forest. Estimated range in Arizona in based on known occurrences documented in museum vouchers from Hoffmeister (1987).

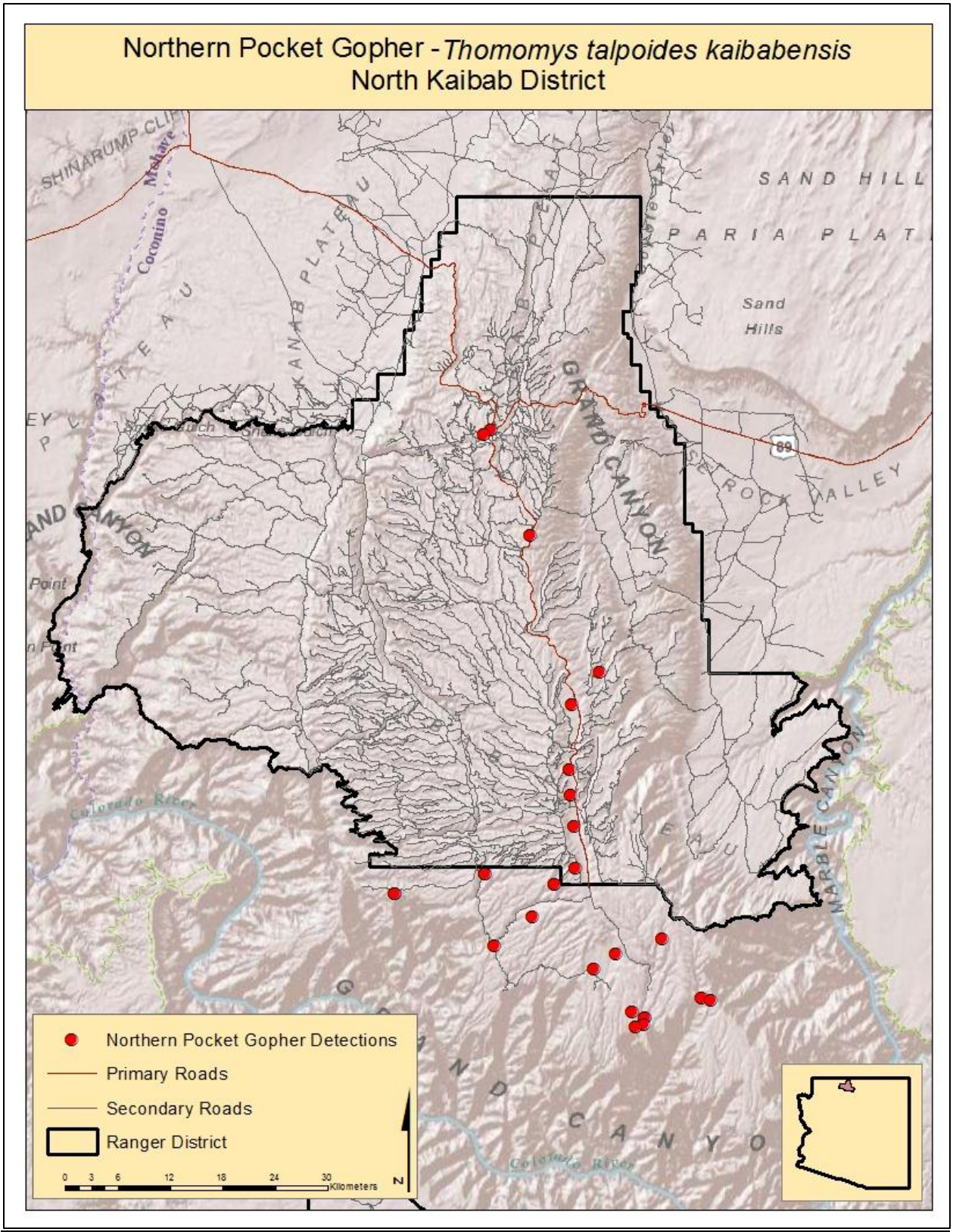

Fig. 4: Map of Northern Pocket Gopher, *Thomomys talpoides kaibabensis*, occurrence in and near the North Kaibab District of Kaibab National Forest based on Hoffmeister (1987).

Habitat Requirements

Northern pocket gophers are fossorial (i.e., living in the soil), and appear to reside exclusively in high mountain meadows surrounded by Ponderosa pine or spruce-fir forests. In Arizona, Northern Pocket Gophers appear to reach the limits of their southwestern range in high mountain meadows of the Kaibab Plateau and in the Chuska (including Tunitcha and Lukachukai) mountains, as they have not been found in high mountain meadows of the San Francisco Peaks or White and Graham mountains (Hoffmeister 1986). All specimens collected were found between 7,700 and 9000 ft (2347- 2743 m). Most known localities in the Kaibab are meadows associated with springs.

Ecology and Life History

Pocket gophers are ecologically important as prey species and as ecosystem engineers, as their fossorial activities influence soil structure, microtopography, habitat heterogeneity, plant species diversity and abundance, and primary productivity (NatureServe 2013). In northern Arizona meadows, both roots and above-ground parts of grasses, forbs and shrubs are likely consumed (Hoffmeister 1986). Collected food materials are often stored in underground chambers or under snow (NatureServe 2013).

Females are typically monoestrous, with mating occurring from March to mid-June (NatureServe 2013). Parturition in Utah species begins in early May to late June and extends for four to six weeks to early June or through July, respectively, depending on locality (Anderson 1978; cited by Hoffmeister 1986). The gestation period is typically 18-20 days (Anderson 1978; NatureServe 2013). Litter sizes range from 4-7 offspring, with young born in leaf or grass-lined nest in a natal chamber that is part of the underground tunnel system (NatureServe 2013). Newborns, like other rodent species, are born with eyes closed and hairless, but develop pelage at nine days. The young move actively and pinnae become erect at 16 days (Hoffmeister 1986). Dispersal of young from natal burrow occurs at approximately two months of age (NatureServe 2013), with molt to adult pelage at approximately three months of age (Hoffmeister 1986).

Adult phenology is circadian with activity peaks at dawn and dusk, and peak burrowing activity occurring when soils are loose during the fall and spring (NatureServe 2013). Although active year-round with no evidence of hibernation, they may be periodically inactive in winter and midsummer (NatureServe 2013).

Behavior

Thomomys talpoides behavior has not been documented in the field, primarily because the animals are solitary, spending most of their time within their tunnels, and when they make a rare appear above ground they seldom venture more than a meter from the burrow entrance. They are thought to be primarily solitary In a laboratory setting adult animals are generally intolerant of each other, and will spar (rear up on hind legs and make jabs or thrusts with their forelimbs) or squabble (lunging and biting at each other) upon encountering the other until one backs down or retreats.

Conservation Status

The IUCN Red List of Threatened Species lists *T. talpoides* as LC (Least Concern; IUCN 2013). NatureServe (2013) lists *T. talpoides* global status as G5 (Secure) with a national status of N5 (Secure). Because *T. t. kaibabensis* is not listed as a subspecies, there is no rounded global status listed. *Thomomys talpoides* is listed as S4 (Apparently Secure) in Arizona and S3S4 (Vulnerable-Apparently Secure) in the Navajo Nation (NatureServe 2013). The numeric range rank used by the Navajo Nation indicates uncertainty about the status of the species or status of the associated ecosystem.

Threats

Threats to *T. t. kaibabensis* are primarily related to the quality of their habitat and the land use practices therein. Historic range management practiced by ranchers and the Forest Service likely contributed to the loss of habitat of this species. Specifically, fire suppression and agricultural practices that that impact either vegetation or water supplies of high elevation meadows, and maintaining high densities and durations of livestock grazing, combined with the introduction of a nonnative grass species, cheat grass (*Bromus tectorum*) may adversely alter high mountain meadow communities in a manner that increases the frequency and intensity of wildfire. The result is a cascading effect that promotes the growth of cheat grass and the frequency of high-intensity burns. Conversely, long-term invasion of meadowlands by surrounding conifers would be detrimental to the species, so some level of fire is likely necessary to prevent encroachment. In addition, roads, including narrow roads, are a primary deterrent to the dispersal of most small mammals (Oxley et al. 1974). Oxley et al. (1974) note that small mammals rarely cross roads wider than 30 meters, and compaction of dirt roads will impede burrowing activity.

Mitigation of Management Practices

Forest Service management practices may affect *T. t. kaibabensis* and its high mountain meadows habitat on the North Kaibab Ranger District (Table 1), and detailed studies regarding the species demography, spatial use and ecology are necessary before current management practices can be effectively mitigated for the long-term protection for this species. In the absence of further studies, grazing limits should be placed on the species' habitat areas to allow for natural recruitment of meadowland grasses. Grazing limits may include exclosures, shift of use or reductions in livestock density on existing high mountain meadow pastures. Because livestock water sources serve as livestock and wildlife ungulate attractants resulting in loss of vegetation and compaction and degradation of soils, placement of new livestock water sources within this habitat type should be avoided. Because *T. t. kaibabensis* are dependent on healthy meadowland grass and forb communities and are active year-round, such communities should not be prescriptively burned, and if burned, burning should occur in winter months when the species is least active. Pest control using herbicides for non-native invasive plant species, such as cheat grass, should surgically target specific species and ensure that native grasses, forbs and shrubs are not adversely affected.

Restoration/Conservation Opportunities

Thomomys talpoides kaibabensis is one of is one of several highly restricted taxa on the North Kaibab Ranger District, as it appears to be endemic exclusively to the Kaibab Plateau. Restoration and conservation opportunities for this subspecies will be hindered by the lack of biological and ecological information available. For instance, virtually nothing is known about this subspecies, with the sole sources of documentation by Hoffmeister (1986) informative but subspecies accounts by Durrant (1946) uninformative, so the little that we do know about the subspecies is inferred from studies conducted on other subspecies of *T. talpoides.* Invoking the Precautionary Principle (i.e., first, do not harm; and second, do not let the absence of scientific certainty preclude the taking of action), the most effective conservation method is to better manage existing habitats, which should include cheatgrass control measures including herbicidal control, high-rotation, low-duration livestock grazing; and/or exclusion fencing to keep livestock out of known *Thomomys talpoides kaibabensis* population areas; and/or maintaining meadowlands from forest encroachment by prescriptive burning; and or creating dispersal corridors connecting high mountain meadows. In practice, effective habitat management will require investment in inventory, research and monitoring information. Monitoring for this taxon should include monitoring of range conditions in the occupied portion of the Kaibab Plateau and periodic monitoring of *T. t. kaibabensis* populations to identify trends leading to precipitous declines in population levels or changes in species.

Table 1: Common general and specific Forest Service management practices, potential impacts, and mitigation actions.

General Activity	Management Action	Impacts	Mitigation Actions
Brush control	Mechanical cutting of juniper with lop and scatter to 18 to 24 inches from the ground	Wood chip cover of high elevation meadow areas	Avoid chipping near high elevation meadow areas.
Construction	Drainage or stream crossings by trails or roads with insertion of proper culverts to allow for water flow	Erosion, soil disturbance and/or compaction	Minimize road and trail impacts on high elevation meadow areas that may affect *T. t. kaibabensis* habitat and activity.
Forest management	Prescribed burning	Increased temperature during fire, loss of habitat, heavy equipment impacts	Avoid burning or conduct prescribed fires to minimize seasonal impacts on *T. t. kaibabensis* populations.

General Activity	Management Action	Impacts	Mitigation Actions
Forest management	Timber harvest using thinning in Ponderosa Pine	Increased temperature during fire, charcoal and sediment inflow into aquatic habitats; heavy equipment impacts	Not applicable to *T. t. kaibabensis.*
Forest management	Underburning using prescribed fire in Ponderosa Pine	Increased charcoal and sediment inflow into aquatic habitats; heavy equipment impacts	Not applicable to *T. t. kaibabensis.*
Livestock management	Fencing to exclude or concentrate livestock or wildlife	Fencing may exclude wildlife or concentrate livestock or wildlife into sensitive areas	Assess and manage fencing to minimize grazing impacts on *T. t. kaibabensis* habitats, particularly high elevation meadows.
Livestock management	Livestock grazing management	Erosion, dust, vegetation removal, increased soil temperature	Rotate livestock from areas of use frequently or reduce livestock concentrations to ensure maintenance and recruitment of grassy vegetation.
Livestock management	Livestock water sources (stock tanks)	Erosion, dust, vegetation removal, increased soil temperature	Avoid placing new livestock water sources in *T. t. kaibabensis* habitats.
Pest control	Non-native invasive plant species treatment (either mechanically or via herbicide)	Reduction or elimination of vegetation may increase erosion, dust	Ensure herbicides are safely stored and handled, tested to prevent unanticipated impacts on *T. t. kaibabensis,* and apply appropriately and minimally (avoiding non-target flora) to *T. t. kaibabensis* habitats using integrated pest management plans (USFWS 2010).
Pest control	Release of non-native invertebrates and vertebrates (e.g., feral cats)	Predation, competition, disease transmission to native taxa	Control non-native fauna as feasible, using integrated pest control (USFWS 2010) and long-term planning.
Water supplies management	Spring and stream monitoring	Flow and water quality may dwindle or disappear without	Regularly monitor springs and streams, and more frequently during drought, to ensure flowing waters are available and

General Activity	Management Action	Impacts	Mitigation Actions
		regular monitoring	of high quality.

Information Gaps

Management of Kaibab Northern Pocket Gopher populations may be improved through both project level monitoring and, if possible, applied research facilitated through third party entities (e.g., collaborations with educational institutions) as administrative studies.

Project-level Monitoring: Specific questions to be addressed by possible project-level monitoring for effects that could inform future management include:

1) What are *T. t. kaibabensis* population trends within and among years, particularly in relation to fire frequency, cheatgrass encroachment and other anthropogenic impacts, and can population dynamics for this species be modeled?

2) What are vegetation responses to subsequent northern pocket gopher responses in areas where livestock density or impacts have declined?

Applied Research: Applied research implemented as administrative studies through third party entities may answer the following specific questions important for managing *Thomomys* species populations:

1) Since little is known of home ranges or dispersal distances for *Thomomys* species (NatureServe 2013), but is estimated at one kilometer for unsuitable habitat based on observations by Nowak (1999) that *Thomomys* wanders up to 1000 meters in search of better habitat conditions, what are home ranges or dispersal distances of *T. t. kaibabensis*?

2) What are the specific habitat requirements of *T. t. kaibabensis*?

3) What is the spatial use of *T. t. kaibabensis*?

4) What is the demographic distribution of *T. t. kaibabensis*?

5) Are latitudinal and elevational gradients important to *T. t. kaibabensis* presence; i.e., what are limiting factors to the species distribution in lower elevations or southern latitudes?

6) What are the implications of global climate change on *T. t. kaibabensis*?

References Cited

Durrant, S. D. 1946. The Pocket Gophers, Genus Thomomys, of Utah, University of Kansas Museum of Natural History V1 No. 1. University of Kansas, Lawrence, KS, 84. pp.

HDMS. 2013. Heritage Data Management System (HDMS) Species Locations. Arizona Game and Fish Department, U.S.A

Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona Press and Arizona Game and Fish Department, Tucson AZ, 602 pp.

Huntly, N., and R. Inouye. 1988. Pocket gophers in ecosystems: patterns and mechanisms. BioScience 38:786-793.

Ingles, L. G. 1952. The ecology of the mountain pocket gopher, *Thomomys monticola*. Ecology 33:87-95

Ingles, L. G. 1952. The ecology of the mountain pocket gopher, *Thomomys monticola*. Ecology 33:87-95.

MacMahon, J. A. 1999. Northern Pocket Gopher (*Thomomys talpoides*). Pages 474-477 *in* D. E. Wilson and S. Ruff, editors. The Smithsonian book of North American mammals. Smithsonian Institution Press in association with the American Society of Mammalogists, Washington.

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: April 30, 2013).

Nowak, R. M. 1999. Walker's mammals of the world. Sixth edition. Johns Hopkins University Press, Baltimore. Two volumes, 1, 936 pp.

Oxley, D. J., M. B. Fenton and G. R. Carmody. 1974. The effects of roads on populations of small mammals. Journal of Applied Ecology 11: 51-59.

Patterson, B.D., G. Ceballos, W. Sechrest, M.F. Tognelli, T. Brooks, L. Luna, P. Ortega, I. Salazar, and B.E. Young. 2003. Digital Distribution Maps of the Mammals of the Western Hemisphere, version 1.0. NatureServe, Arlington, Virginia, USA.

Thaeler, C. S., Jr. 1985. Chromosomal variation in the THOMOMYS TALPOIDES complex. Acta Zoologica Fennica 170:15-18.

USFWS. 2010. Integrated Pest Management. United States Fish & Wildlife Service (USFWS) Integrated Pest Management Policy 569 FW 1.

Verts, B. J., and L. N. Carraway. 1999. *Thomomys talpoides*. Mammalian Species 618:1-11.

Wilson, D. E., and D. M. Reeder (editors). 2005. Mammal species of the world: a taxonomic and geographic reference. Third edition. The Johns Hopkins University Press, Baltimore. Two volumes. 2,142 pp. Available online at: http://www.bucknell.edu/msw3/.

CHISEL-TOOTHED KANGAROO RAT (RODENTIA) OF KAIBAB NATIONAL FOREST

Kangaroo rats, genus *Dipodomys*, are small-sized desert-dwelling rats that are both excellent burrowers and jumpers (hence the name "kangaroo"). In general, the most readily identifiable characteristic of this clade that distinguishes them from all other rodents is their bipedal jumping or hopping locomotion; however, kangaroo rats use both bipedal and quadrupedal locomotion. Other easily discernible characteristics of the clade include pelt patterning and limb and tail morphology. Less easily identifiable characteristics are found on the skull, including morphology of the teeth and bony structures of the skull.

There are 16 species of *Dipodomys* broadly distributed in desert areas from southwestern Canada to central Mexico, including all of the western and southwestern, and the western Great Plains states of the United States. In general, *Dipodomys* prefer areas with sandy soils, sparse grass and desert shrub vegetation. Arizona is host to five *Dipodomys* species, distributed throughout the state except on the Mogollon Rim. Two of the five species, the Chisel-toothed Kangaroo Rat, *Dipodomys microps,* and the Banner-tailed Kangaroo Rat, *D. spectabilis,* occur in northern Arizona; however, only *D. microps is* distributed in Mohave and Coconino counties potentially within the Kaibab National Forest.

There are 13 subspecies of chisel-toothed kangaroo rats, *Dipodomys microps,* so named for its chisel-shaped lower incisors, which are used to strip the epidermal layer and reach the palatable and water-rich interior of desert shrub leaves. This species is able to subsist on perennial shrubs in the absence of open sources of water, hence it is ideally adapted for survival in desert climates where rainfall is intermittent, infrequent, or absent. Two subspecies of *D. microps* are found in Mohave and Coconino counties and the ranges of these subspecies are not known to overlap, with *D. m. celsus* mostly in northern Mohave County and the northwestern-most corner of Coconino county, *D. m. leucotis* in northern Coconino County.

Chisel-toothed Kangaroo Rat
Heteromyidae: *Dipodomys microps* Goldman 1924

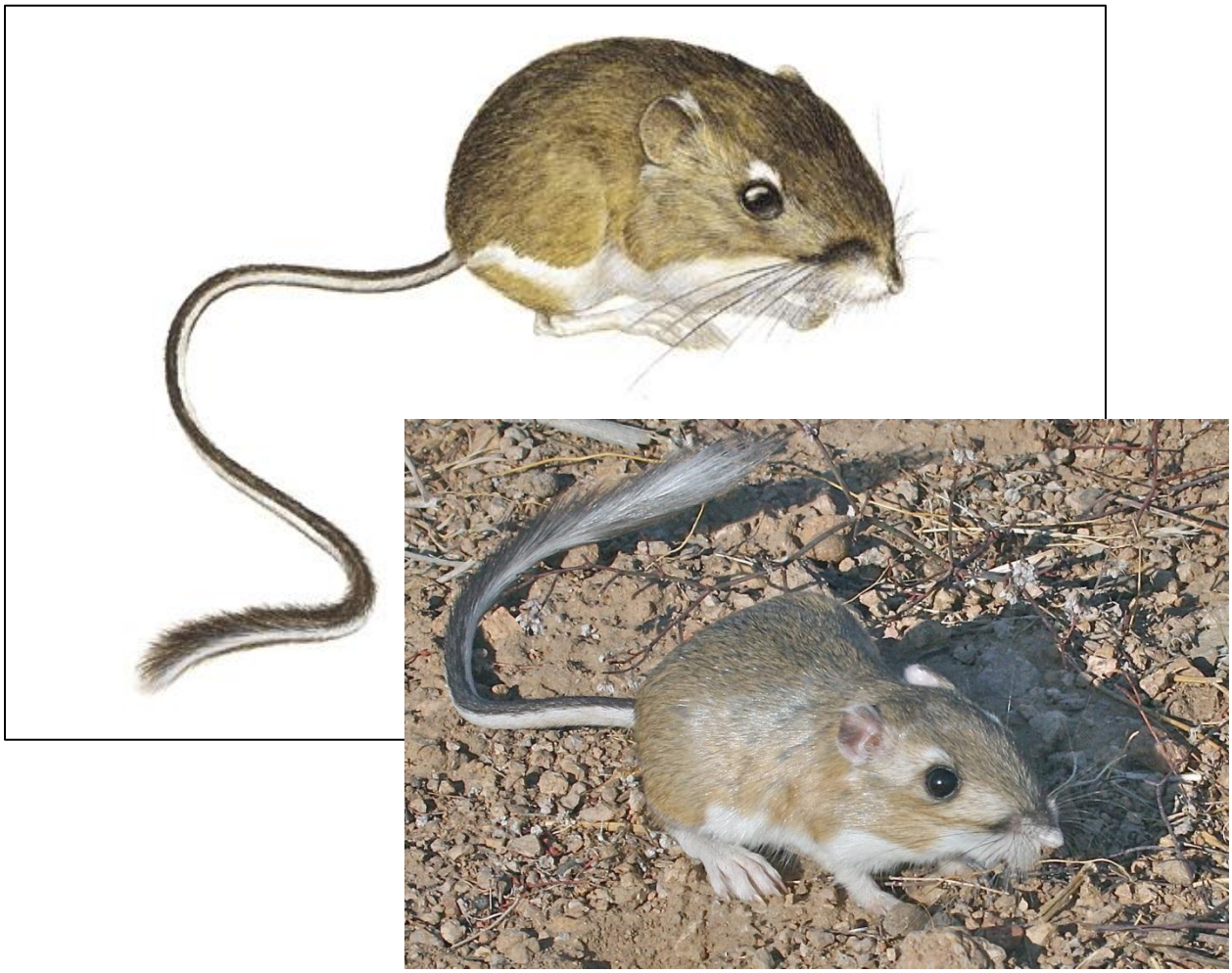

Fig. 1: Chisel-toothed Kangaroo Rat, *Dipodomys microps*, showing tawny-colored pelt, long, tufted tail and long hind feet, relatively short front feet, white stripe on the thigh extending to the base of the tail, lateral white stripes on the tail with a dark stripe above, and white underparts. Credit: Painting by Elizabeth McClelland from Kays and Wilson's *Mammals of North America*, © Princeton University Press (2002); Photograph by A. Ambrose and courtesy of The Mammal Image Library of The American Society of Mammalogists.

Taxonomy

Craniata
- Mammalia
  - Rodentia
    - Heteromyidae
      - *Dipodomys microps* Goldman 1924

The Chisel-toothed Kangaroo Rat, *Dipodomys microps,* is one of two species of kangaroo rat that occur in northern Arizona (Fig.1). The two species are visually very similar but morphologically distinct, based on the number of toes on the hindfoot (4 or 5), the face of lower incisors (rounded or flat) and the length of the hindfoot (Hoffmeister 1986), and the ranges of the two species are not known to overlap. Two subspecies of *D. microps* are found in northwestern Arizona in Mohave and Coconino counties, *D. m. celsus* and *D. m. leucotis*; the two subspecies confusingly share common names, with *D. m. celsus* referred to as Chisel-toothed Kangaroo Rat, and *D. m. leucotis* commonly called Houserock Valley Chisel-toothed Kangaroo Rat, Arizona Chisel-toothed Kangaroo Rat, House Rock Valley Kangaroo Rat and Marble Canyon Kangaroo Rat (AGFD 2001). The ranges of these subspecies are not known to overlap; in areas of near contact, the two subspecies are morphologically distinguishable based on external and cranial measurements, with *D. m. celsus* smaller than *D. m. leucotis*.

Description (Hayssen 1991)

Neonate/Juvenile: Near term fetuses and neonates average 4.0 g each (Hayssen 1991) and like other rodent pups, are born with eyes closed and hairless but quickly develop adult coloration of the pelt. At four weeks of age, pups will average 21 g in weight (Hayssen 1991). Male juveniles do not become sexually reproductive in the season of their birth, however, female juveniles can (NatureServe 2013). Juveniles appear morphologically indistinguishable from adults, but are deemed as adult when the premolar (P4), located behind the one incisor and in front of the three molars (Fig. 2), becomes sufficiently worn to become ovalized in shape (Hoffmeister 1986).

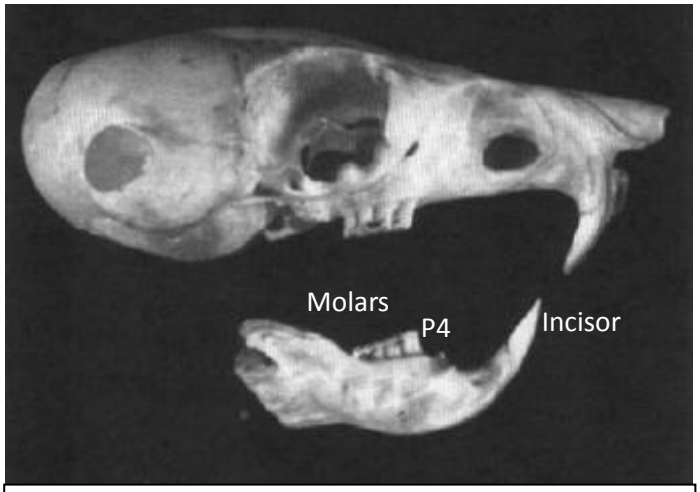

Fig. 2: Lateral view of *Dipodomys microps* skull, showing locations of the incisor, premolar (P4) and molar teeth. Image by F. Belouin from Hayssen (1991) and courtesy of The Mammal Image Library of The American Society of Mammalogists,

***Adult*:** Adult *D. microps* are medium-sized compared to other kangaroo rat species, with a body length (nose to anus) of 4-5 inches (10.2-12.7 cm), tail length of 5.5-7.5 in. (14.0-19.1) and weight of 2.5-3.2 oz. (72-91 g). The two subspecies of *D. microps* found in northern Arizona have grayish-brown coats above, large eyes that are luminous when spotlighted at night; long, tufted tails and long hind feet; relatively short front feet; a white stripe on the thigh extending to the base of the tail; lateral white stripes on the tail with a dark stripe above and usually below; and white underparts. Less easily identifiable characteristics are found on the skull, including chisel-shaped lower incisors, hypsodont molars and greatly enlarged auditory bullae (hollow bony structures that enclose parts of the middle and inner ear, located on the ventral, posterior portion of the skull). *D. microps* is distinguishable from other *Dipodomys* species

based on a combination of morphological features, including the number of toes on the hindfoot (5), the face of lower incisors (flat), the length of the hindfoot (42-45 mm) and the presence, absence or characteristics of the ventral tail stripe (blackish and broad).

Similar Species

Three species of kangaroo rat, Ord's Kangaroo Rat (*D. ordii*), Merriam's Kangaroo Rat (*D. merriami*) and Desert Kangaroo Rat (*D. deserti*), are found throughout the northeastern Arizona range of both subspecies of *D. microps*, and the Banner-tailed Kangaroo Rat (*D. spectabilis*) has been found near *D. m. leucotis* populations on the northeastern corner of Coconino County (Hoffmeister 1986). *D. microps* can be distinguished morphologically from all four cryptic *Dipodomys* species in Arizona based on the cross-section face of the lower incisors, which are rounded and awl-shaped in all other species but flat-fronted and chisel-shaped in *D. microps.* If the lower incisors are not readily apparent, *D. microps* is distinguishable based on a combination of morphological features, including the number of toes on the hindfoot (4 or 5), the face of lower incisors (rounded or flat), the length of the hindfoot (Hoffmeister 1986) and in some cases, the color of cheek pouch fur (Spicer and Johnson 1988). *D. ordii* has a shorter hind foot (36-43 mm), the ventral tail strip is present but not dark and broad (Hoffmeister 1986), and cheek pouches are lined with dusky fur rather than white (Spicer and Johnson 1986). *D. merriami* has fewer toes on the hind foot (4), the length of the hind foot is shorter (< 41 mm), and the ventral tail strip is present but not dark and broad. *D. spectabilis* has fewer toes on the hind foot (4), and the length of the hind foot is longer (> 45 mm). *D. deserti* has fewer toes on the hind foot (4), the length of the hind foot is longer (> 45 mm) and the ventral tail strip is absent or narrow.

Range

***Regional*:** *Dipodomys microps* is endemic to the southwestern United States, with the species primarily distributed throughout most of Nevada with smaller distributions in contiguous states; specifically, southeastern and northwestern California, southeast Oregon, southwest Idaho, northwestern and southwestern Utah, and northwestern Arizona. Its range reflects bordering by the Wasatch Mountains to the east, the Colorado River to the south and the Cascade and Sierra Nevada Mountains to the west. In Idaho, *D. microps* range extends into Raft River Valley, Cassia County, and into the Elmore Desert, Elmore County (Haysen 1991). In California, it has a discontinuous distribution of relict populations in San Bernardino County and an isolated population occurs in Joshua Tree National Monument, Riverside County (Haysen 1991).

Of the two subspecies of *D. microps* found in northern Arizona, the ranges of *D. m. celsus* and *D. m. leucotis* are bounded by the canyons of the Colorado River (Hayssen 1991) and various plateaus. *Dipodomys microps celsus* is mainly distributed in the northwestern-most portion of Arizona, with a small area of distribution in southwestern-most Utah, and a very small distribution in southeastern Nevada (Fig. 4). *Dipodomys microps leucotis* is endemic to Arizona, found only in **House Rock Valley** on the north and west sides of the Colorado River (Fig. 4). *D. m. leucotis* appears to be geographically isolated from all other *D. microps* subspecies by the Colorado River to the east and south, the Paria Plateau to the north, and the Kaibab Plateau to the west of House Rock Valley. The exception to this is a single straggler captured immediately east of Navajo Bridge in 1949 (AGFD). This animal

appears to have crossed the river on Navajo Bridge, which may allow the species to disperse eastward and southward using the manmade structure as an unintended wildlife crossing (Hayssen 1991).

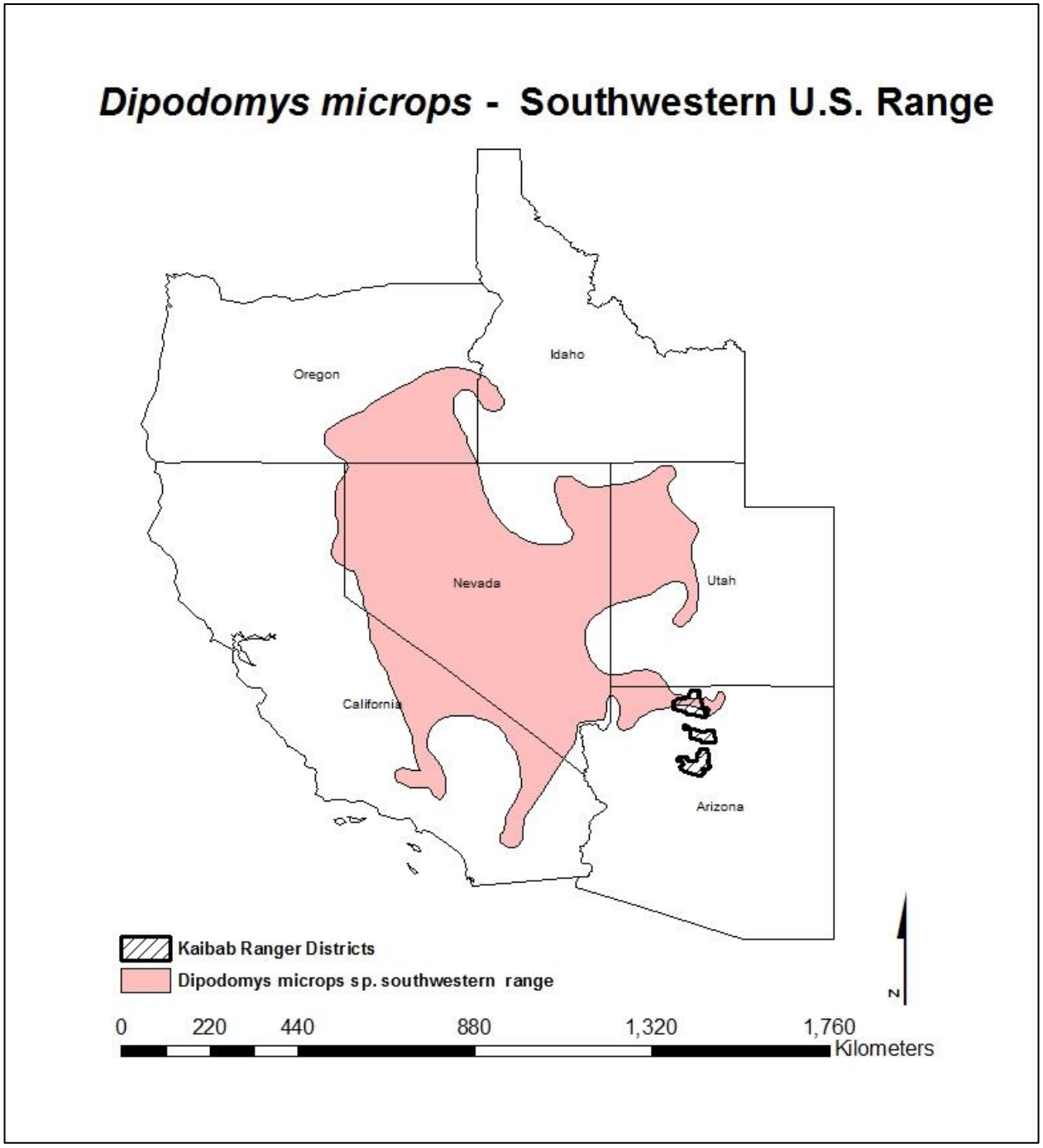

Fig. 3: Regional range map of Chisel-toothed Kangaroo Rat, *Dipodomys microps*, primary distribution in Nevada and contiguous states, showing Kaibab National Forest Ranger Districts. Map generated based on map by K. Zaffiro as modified from Hall, 1981 (Hayssen 1991).

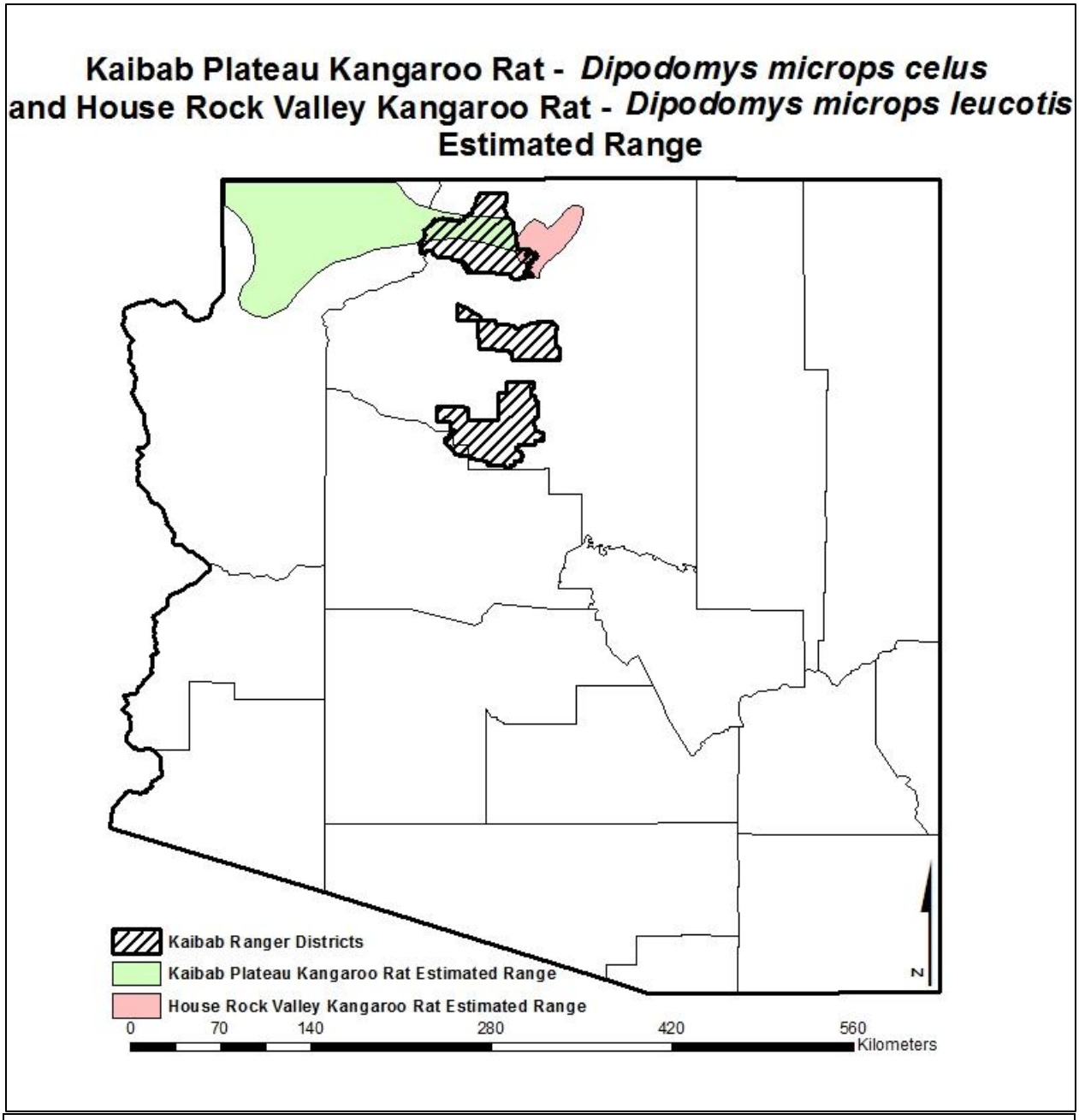

Fig. 4: Map of Chisel-toothed Kangaroo Rat, *Dipodomys microps*, distribution in Arizona, showing estimated range in and near the North Kaibab District of Kaibab National Forest. Map generated based on map by K. Zaffiro as modified from Hall, 1981 (Hayssen 1991) and Hoffmeister (1987).

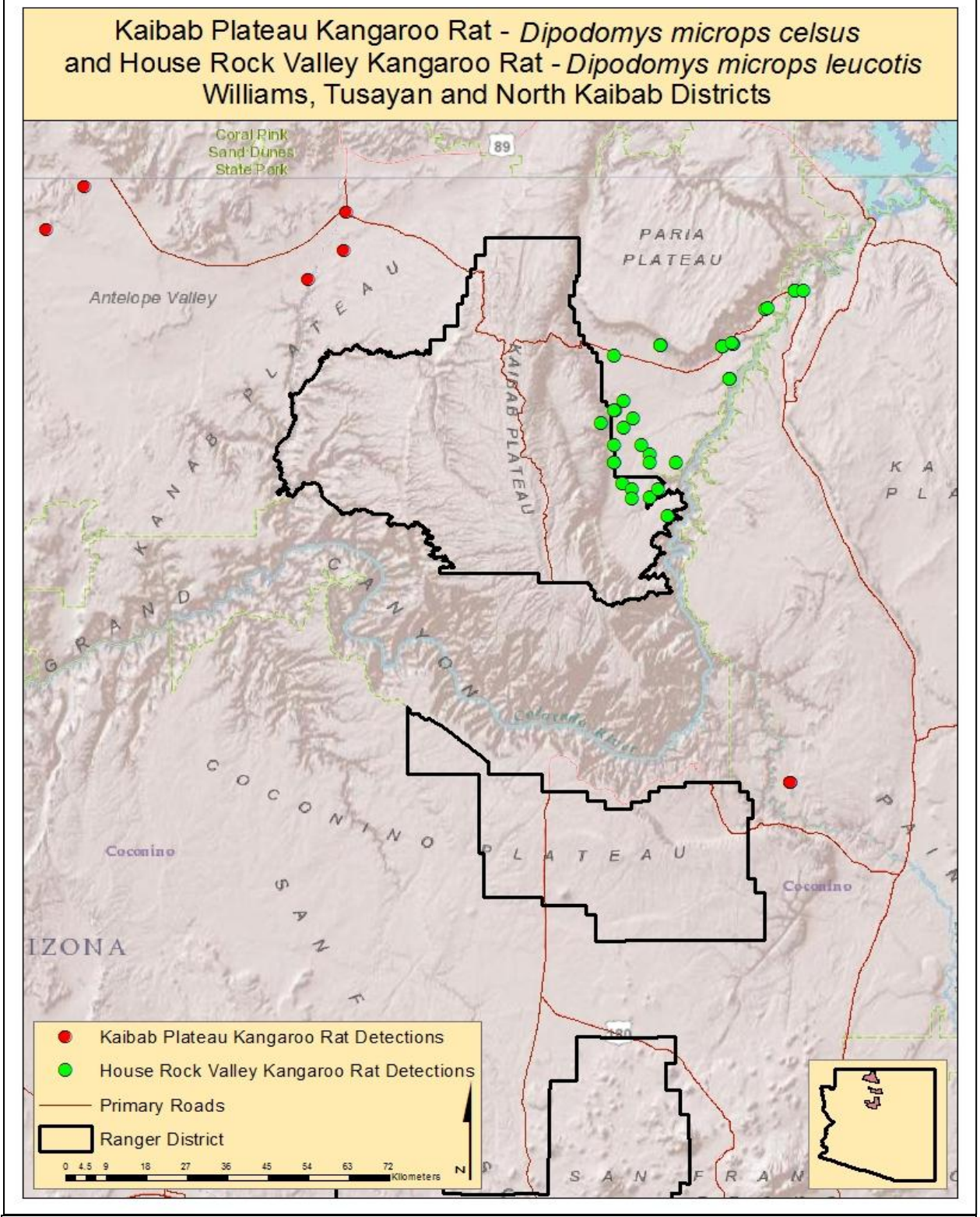

Fig. 5: Map of Chisel-toothed Kangaroo Rat, *Dipodomys microps leucotis and D. m. celsus*, occurrence in and near the North Kaibab District of Kaibab National Forest. Point locations from Hoffmeister (1987) and HDMS (2013).

Known Localities: Hayssen (1991) reports 13 type localities of *D. microps* from within its range (Fig 3). Hoffmeister (1986) reports *D. m. celsus* from Arizona: Mojave Co., 7.75 Mi. south of St. George, Utah; 5.3 Mi. south of Utah line, Main St, road toward Wolf Hole; Wolf Hole, on road to St. George, Utah; 12 Mi. north of Wolf Hole on road to St. George, Utah; 6 Mi. and 10 Mi. north of Wolf Hole; Kanab Wash, southern boundary of Kaibab Indian Reservation; 16.2 Mi. west of junction of Navajo Trail and Colorado City-Tuweep Roads; 7.5 Mi. east of junction of Main St. and Navajo Trail Roads, Hurricane Valley; 3 Mi. west of Lower Pigeon Spring; Coconino Co., Fredonia; 4.5 Mi. south of Fredonia. Hoffmeister (1986) reports *D. m. leucotis* from Arizona: Coconino Co., 6 Mi. west of Lee's Ferry bridge; 6 Mi. west of Colorado River Bridge, House Rock Valley; 1Mi. east of Colorado River bridge; 6 Mi. west of Grand Canyon Bridge, Marble Canyon; 6 Mi. southwest of Navajo Bridge, House Rock Valley; 3 Mi. west, 2 Mi. south of Marble Canyon; 7 Mi. east of Jacob's Pools, House Rock Valley; 6.5 Mi. south, 6 Mi. south of Marble Canyon, House Rock Valley, North Canyon.

Kaibab National Forest – North Kaibab Ranger District: The potential range of *D. m. celsus* in northern Arizona and on the North Kaibab Ranger District is indicated in Fig. 4, and shows that potential habitat exists on the Kanab Plateau on the western area of the District. *D. m. celsus* has not been detected within the District, with detections occurring to the north and west of the District in Antelope Valley (Fig. 5). Since this subspecies is expected to occur in the District, the rarity of this species may reflect a lack sampling effort or may reflect habitat that is disturbed and therefore unsuitable, as *D. microps* subspecies have been shown to be sensitive to perennial shrub loss associated with livestock and agricultural practices (Hoffmeister 1986; O'Farrell 1995). The Kaibab Plateau serves as a barrier to dispersal to the eastern portion of the District; hence, the distance separating this subspecies and the *D. m. leucotis* is approximately 40 miles (Spicer and Johnson 1988).

The range of *D. m. leucotis* on the North Kaibab Ranger District is indicated in Fig. 4, and shows that only a small amount of potential habitat exists on the District, and is restricted to the eastern area of the District bordering or containing portions of House Rock Valley. Within House Rock Valley, the relative abundance of *D. m. leucotis* is low and patchily distributed (Fig. 5), with the subspecies occupying approximately half (73,624 acres) of its potential and former habitat (150,000 acres, AGFD 2001). The rarity of this species appears to be primarily due to intensive past and present livestock and agricultural disturbances. Areas of past or present disturbances where shrubs have been removed or where livestock tends to aggregate, such as around livestock water sources, are devoid of *D. m. leucotis* populations (AGFD 2001).

Kaibab National Forest – Tusayan Ranger District:

Both subspecies of *D. microps* are thought to reside primarily north of the Colorado River, with the Colorado River posing a barrier to its southward and eastward dispersal. The actual distribution within the District is not known as no occurrences have been documented; however, the *D. m. celsus* subspecies has been documented in the Painted Desert approximately 10 km northeast of the Tusayan Ranger District (Fig. 5). Given the species' history of using manmade structures (i.e., roads and bridges) as corridors to overcome historic barriers to dispersal, it should be assumed that suitable habitat of the

Coconino Plateau within the boundaries of the Tusayan Ranger District may eventually, if not already, harbor populations of this species.

Kaibab National Forest – Williams Ranger District:
Both subspecies of *D. microps* are thought to reside primarily north of the Colorado River, with the Colorado River posing a barrier to its southward and eastward dispersal. Although the *D. m. celsus* subspecies has been documented in the near vicinity of the Tusayan Ranger District, it is not known to occur in the Williams Ranger District. Although the shrub-dominated Great Basin desertscrub habitat in portions of the Williams Ranger District appears to be suitable, it has not been collected from additional locales.

Habitat Requirements

Dipodomys microps are found in shrub-dominated Great Basin desertscrub communities at elevations ranging from 3200 to 6500 feet (976-1983 m). This species prefers moderately deep soils containing a rocky or gravelly component; however, *D. m. leucotis* has been captured in areas with shallow, sandy soils (Spicer and Johnson 1988). Habitat with good shrub cover but sparse grasses is essential for this species, as there is an inverse correlation between kangaroo rat density and grass abundance (Hoffmeister 1986), while loss of shrub cover results in displacement by Merriam's kangaroo rat (Hoffmeister 1986).

Dipodomys microps celsus in northern Mohave County are most frequently associated with areas dominated by four-wing saltbush (*Atriplex canescens*) and blackbrush (*Coleogyne ramosissima*), but also associated with desert thorn (*Lycium sp.*), mormon tea (*Ephedra sp*.), snakeweed (*Gutierrezia sarothrae*), narrow-leaved yucca (*Yucca angustissima*) and penstemon (*Penstemon sp.)* (Hoffmeister 1986; AGFD 2001). Saltbush dominated communities typically contain sparse grass associations of blue grama (*Bouteloua gracilis*), indian ricegrass and sand dropseed (*Sporobolus cryptandrus*), as well as rabbitbrush (*Chrysothamnus viscidiflorus*), mormon tea, winterfat (*Krascheninnikovia lanata*) prickly pear (*Opuntia sp.*) and snakeweed (AGFD 2001). Blackbrush dominated communities typically include narrow-leaved yucca, indian ricegrass (*Achnatherum hymenoides*) and ephedra (AGFD 2001).

Dipodomys microps leucotis in House Rock Valley, Coconino County, favor shadscale and saltbush dominated areas, and to a lesser degree blackbrush dominated areas. Shadscale dominated communities usually contain fluff grass (*Erioneuron pulchellum*), galleta (*Hilaria jamesii*), indian ricegrass and prickly pear (AGFD 2001). Also of note is that *D. m. leucotis* were captured in areas with sparse, scattered junipers (*Juniperus sp*.) as well as open sandy areas below the Vermillion Cliffs southwest of the Marble Canyon settlement (Hoffmeister 1986).

Ecology and Life History

Mating in *D. microps* is seasonal, and usually occurs from February to mid-March when females become sexually receptive and somewhat coincides with sperm male production from late autumn (October or November) to late spring (April-June). Females can reproduce at less than one year of age (i.e., in the year of the birth), but males cannot. The median length of the estrous cycle is 12.5 days, with females sexually receptive for one day

of each cycle (Hayssen 1991). Pregnancy in females occurs from April to June. Gestation time, from first copulation to pup birth, is 30-34 days (Hayssen 1991). Litter sizes are 1-3 pups; however, litters of one are uncommon and litters of three are not produced by young-of-the-year (Hayssen 1991). Females usually produce one litter per year, but in years of exceptionally good environmental conditions, can produce more than one. Reproduction in *D. microps* coincides with peaks in water content and new growth in perennial shrubs, such as *Atriplex sp*., and when environmental conditions preclude reproduction in *D. merriami*, which coincides with annual herbs. The life span is typically four to five years.

Behavior

Dipodomys microps are semi-fossorial (burrowing), nocturnal, and active above-ground (terrestrially) year-round. Entrances to kangaroo rat burrows can usually be identified by mounds up to one foot (0.31 m) in height and six feet (1.8 m) in diameter. Kangaroo rats often use runways that radiate outwards up to 120 feet (36.6 m) (Hoffmeister 1986). Terrestrial activity may vary with temperature, but they are most active nocturnally in the first few hours after sunset. Nocturnal terrestrial behaviors include foraging, caching of food items, socializing and sandbathing. Underground, they are active throughout the day and year-round, with activities including resting and copraphagy (eating feces). Sandbathing replaces grooming as an important maintenance behavior, and may function for parasite control or olfactory communication.

Dipodomys microps can use either bipedal or quadrupedal locomotion. Bipedal locomotion is saltatorial (that is, hopping); this form of locomotion increases the average distance covered compared to quadrupedal hops by a factor of 1.4. Saltatorial locomotion is one of several characteristics that can be used to distinguish kangaroo rats from other similarly sized and colored rodents. The mode of saltatorial locomotion can also be used to distinguish *D. microps* in the field from its congeneric *D. merriami*: when humans are encountered, the path that *D. microps* takes from human observers is linear and directly away while the path that *D. merriami* takes is erratic (Hayssen 1991).

Conservation Status

Dipodomys microps celsus has not yet been assessed by the IUCN Red List of Threatened Species (IUCN 2013). However, NatureServe (2013) lists *D. m. celsus* global status as G5T4 with a national status of N4 and rounded global status of T4 (apparently secure; extensive range and many populations or occurrences). In Arizona, however, this species is listed as S2 (Imperiled—at high risk of extinction) and S1 (Critically Imperiled—at very high risk of extinction) in Utah (NatureServe 2013). It is of concern in Arizona due its naturally extremely restricted range in canyon areas, very few populations or occurrences and severe threats. It is not currently a federally listed species, nor a state listed species of concern (AGFD 2002). Due to their status, conservation measures to protect *D. m. celsus* are currently not being practiced.

The IUCN Red List of Threatened Species lists *D. m. leucotis* as VU (Vulnerable; IUCN 2013). *Dipodomys microps leucotis* global status is listed as G5T2Q with a national status of N2 and rounded global status of T2 (imperiled; restricted range and few populations or occurrences); in Arizona, this subspecies is listed as S2 (Imperiled Imperiled—at high risk of extinction) and S1 (Critically Imperiled—at very high risk of extinction) in the Navajo Nation (NatureServe 2013).

Threats

Threats to *Dipodomys microps* are primarily related to the quality of their habitat and the land use practices therein. Historic range management practiced by ranchers and the Forest Service likely contributed to the loss of habitat of this species. Specifically, fire suppression and agricultural practices that removed shrubby vegetation and maintained high densities and durations of livestock grazing, combined with the introduction of a nonnative grass species, cheat grass (*Bromus tectorum*) likely altered the shrub–dominated communities of House Rock Valley and the Kanab Plateau in a manner that increased the frequency and intensity of wildfire. The result is a cascading effect that promotes the growth of cheat grass and the frequency of high-intensity burns. Conversely, long-term invasion of desertscrub habitat by trees, such as junipers, would be detrimental to the species, so some level of fire is likely necessary to prevent encroachment.

An additional threat to *Dipodomys microps* may be a result of human encroachment and development in their habitat. The AGFD (2001) suggests that free-ranging and/or feral cats may pose a particular predator threat in areas within their habit developed for human habitation, such as the Marble Canyon settlement or near Glen Canyon Recreation Area.

Mitigation of Management Practices

Forest Service management practices may affect *Dipodomys microps* and its habitat on the North Kaibab Ranger District (Table 1), and detailed studies regarding the species demography, spatial use and ecology are necessary before current management practices can be effectively mitigated for the long-term protection for this species. In the absence of further studies, grazing limits should be placed on the species' habitat areas to allow for natural recruitment of saltbush, shadscale and blackbrush vegetation communities (AGFD 2001). Grazing limits may include shift of use or reductions in livestock on existing pastures containing saltbush, shadscale and blackbrush habitat, and placement of new livestock water sources within this habitat type should be avoided (AGFD 2001). Because *Dipodomys microps* are dependent on healthy desertscrub communities and are active year-round, such communities containing saltbush, shadscale and blackbrush habitat should not be prescriptively burned.

Restoration/Conservation Opportunities

Dipodomys microps leucotis is one of several highly restricted taxa on the North Kaibab Ranger District, as it is endemic exclusively to the House Rock Valley. Restoration and conservation opportunities for this subspecies and for *D. m. celsus* likely will be hindered by the lack of biological and ecological information available. For instance, no reproduction studies have been conducted on *D. m. leucotis* (AGFD 2001), so the little that we do know about the subspecies is inferred from studies conducted on other subspecies of *D. microps.* Invoking the Precautionary Principle (i.e., first, do not harm; and second, do not let the absence of scientific certainty preclude the taking of action), the most effective conservation method is to better manage existing habitats, which may necessitate cheatgrass control measures including herbicidal control, high-rotation, low-duration livestock grazing, or exclusion fencing to keep livestock out of known Chisel-toothed Kangaroo Rat population areas. In practice, effective habitat management will require investment in inventory, research and monitoring information. Monitoring for this taxa

should include monitoring of range conditions in the occupied portion of House Rock Valley (AGFD 2001), and periodic monitoring of kangaroo rat populations to identify trends leading to precipitous declines in population levels or changes in species.

Table 1: Common general and specific Forest Service management practices, potential impacts, and mitigation actions.

General Activity	Management Action	Impacts	Mitigation Actions
Brush control	Mechanical cutting of juniper with lop and scatter to 18 to 24 inches from the ground	Wood chip cover of shrub-dominated desertscrub areas	Avoid chipping near shrub-dominated desertscrub areas.
Brush control	Mechanical treatment of chaparral (mastication).	Loss of shrub-dominated desertscrub habitat	Avoid brush removal in shrub-dominated desertscrub areas, as *D. microps* require shrubby vegetation for forage.
Construction	Drainage or stream crossings by trails or roads with insertion of proper culverts to allow for water flow	Erosion, soil disturbance and/or compaction	Minimize road and trail impacts on shrub-dominated desertscrub that may affect *D. microps* habitat and activity.
Construction	Road construction	Soil compaction, dust, noise	Schedule road construction work to minimize *D. microps* population and habitat impacts, including potential dispersal.
Forest management	Prescribed burning	Increased temperature during fire, loss of habitat, heavy equipment impacts	Avoid burning *D. microps* habitat. If burning is necessary, burn during winter months (December and January when D. microps may be less active above-ground.
Forest management	Timber harvest using thinning in Ponderosa Pine	Increased temperature during fire, charcoal and sediment inflow into aquatic habitats; heavy equipment impacts	Not applicable to *D. microps.*

General Activity	Management Action	Impacts	Mitigation Actions
Forest management	Underburning using prescribed fire in Ponderosa Pine	Increased charcoal and sediment inflow into aquatic habitats; heavy equipment impacts	Not applicable to *D. microps.*
Livestock management	Fencing to exclude or concentrate livestock or wildlife	Fencing may exclude wildlife or concentrate livestock or wildlife into sensitive areas	Assess and manage fencing to minimize grazing impacts on *D. microps* habitats.
Livestock management	Livestock grazing management	Erosion, dust, vegetation removal, increased soil temperature	Rotate livestock from areas of use frequently or reduce livestock concentrations to ensure maintenance and recruitment of shrub-dominated desertscrub vegetation.
Livestock management	Livestock water sources (stock tanks)	Erosion, dust, vegetation removal, increased soil temperature	Avoid placing new livestock water sources in *D. microps* habitats.
Pest control	Non-native invasive plant species treatment (either mechanically or via herbicide)	Reduction or elimination of vegetation may increase erosion, dust	Ensure herbicides are safely stored and handled, tested to prevent unanticipated impacts on *D. microps,* and apply appropriately and minimally (avoiding non-target flora) to *D. microps* habitats using integrated pest management plans (USFWS 2010).
Pest control	Release of non-native invertebrates and vertebrates (e.g., feral cats)	Predation, competition, disease transmission to native taxa	Control non-native fauna as feasible, using integrated pest control (USFWS 2010) and long-term planning.

General Activity	Management Action	Impacts	Mitigation Actions
Water resources management	Spring or stream capture and diversion	Reduction or elimination of surface flows	Not applicable to *D. microps.*
Water supplies management	Spring and stream monitoring	Resource conditions may dwindle or disappear without regular monitoring	Not applicable to *D. microps.*

Information Gaps

Management of Kangaroo Rat populations may be improved through both project level monitoring and, if possible, applied research facilitated through third party entities (e.g., collaborations with educational institutions) as administrative studies.

Project-level Monitoring: Specific questions to be addressed by possible project-level monitoring for effects that could inform future management include:

1) What are *D. microps* population trends within and among years, particularly in relation to fire frequency, cheatgrass encroachment and other anthropogenic impacts, and can population dynamics for this species be modeled?

2) What are vegetation responses to subsequent kangaroo rat responses in areas where livestock density or impacts have declined?

Applied Research: Applied research implemented as administrative studies through third party entities may answer the following specific questions important for managing *Thomomys* species populations:

1) What are the specific habitat requirements of *D. microps* subspecies?

2) What is the spatial use of *D. microps* subspecies?

3) What is the demographic distribution of *D. microps* subspecies?

4) What are the implications of global climate change on *D. microps* subspecies?

References Cited

Arizona Game and Fish Department (AGFD). 2001. *Dipodomys microps leucotis.* Unpublished abstract compiled and edited by the Heritage Data Management System, Arizona Game and Fish Department, Phoenix, AZ. 7 pp.

Hayssen V. 1991. Dipodomys microps. American Society of Mammalogists 389: 1-9.

HDMS. 2013. Heritage Data Management System (HDMS) Species Locations. Arizona Game and Fish Department, U.S.A

Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona Press and Arizona Game and Fish Department, Tucson, AZ, 602 pp.

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: May 12, 2013).

O'Farrell, M. J. 1995. Distribution of the Houserock Valley Chisel-toothed Kangaroo Rat (*Dipodomys microps leucotis*) Goldman. pp. 1-22.

O'Farrell, M. J. 1997. Densities and habitat affinities of the chisel-toothed kangaroo rat (*Dipodomys microps leucotis* Goldman). O'Farrell Biological Consulting, Las Vegas. pp. 1-24.

Spicer, R. B., and T. B. Johnson. 1988. Unpublished report: Status of the Houserock Valley Chisel-toothed Kangaroo Rat (*Dipodomys microps leucotis* Goldman). Arizona Game and Fish Department, Phoenix. pp. 1-29.

LEAST CHIPMUNK (RODENTIA) OF KAIBAB NATIONAL FOREST

Chipmunks, genus *Neotamias*, are a widely distributed, small squirrel clade in North America. Formerly, western chipmunks were considered morphologically distinct from the closely related eastern chipmunks, genus *Tamias*, and were placed in a separate genus, *Eutamias* (Hoffmeister, 1986). Hoffmeister (1986) identified five *Eutamias* species, Colorado Chipmunk (*E. quadrivittatus*), Cliff Chipmunk (*E. dorsalis*), Uinta Chipmunk (*E. umbrinus*), Least Chipmunk (*E. minimus*) and Gray-collared Chipmunk (*E. cinereicollis*) in Arizona, with all five species found exclusively in coniferous forest and three species, *E. cinereicollis*, *E. minimus* and *E. umbrinus* restricted to montane coniferous forests. Four of the five species were described as occurring in northern Arizona: *E. minimus, E. umbrinus, E. dorsalis* and *E. quadrivittatus*; however, only *E. minimus, E. umbrinus* and *E. dorsalis* were described as found in areas bounded by the three districts of the Kaibab National Forest. Baker *et al*. (2003) placed all North American chipmunks in the genus *Neotamias* based on molecular phylogenetics (Piaggio and Spicer 2001) and ectoparasite variation (Jameson 1999), rendering Hoffmeister's (1986) nomenclature obsolete. Part of the confusion that currently exists is that various biologists and scientists use the generic names *Eutamias*, *Neotamias* and *Tamias* interchangeably. In this guidebook, we use the *Neotamias* nomenclature.

Least chipmunks, *Neotamias minimus*, are mainly granivorous and seasonally frugivorous, feeding on and caching seeds, fleshy fruits and berries that are collected by climbing or that can be reached from the ground. They are ecologically important in dispersing seeds and are an important prey species for a number of vertebrates, including snakes, raptors, mustelids, canids and felids.

A subspecies of *N. minimus, N. m. consobrinus,* is of particular interest to the Kaibab National Forest because of its extremely restricted range in the Kaibab Plateau north and east of the Colorado River.

Least Chipmunk
Sciuridae: *Neotamias minimus consobrinus* Allen 1890

Fig. 1: Least Chipmunk, *Neotamias minimus*, showing four of five dorsal black or dark brown stripes, three dark brown and two whitish facial stripes, light to dark grayish-brown forehead pelage, mixture of gray and buff shoulder pelage, dark orange side of the body pelage, and bushy tail with reddish on underside. Credit: Photograph courtesy of Nicky Davis.

Taxonomy

Chordata
Mammalia
Rodentia
Sciuridae
Neotamias minimus consobrinus Allen 1890

The Least Chipmunk, *Neotamias minimus consobrinus,* is one of several subspecies of small-bodied, diurnal squirrels that occur in northern and eastern Arizona: *N. m. consobrinus* is found on the Kaibab Plateau, *N. m. chuskaensis* is found in the Chuska Mountains, and *N. m. arizonensis* (ne: *E. m. operarius*; Hoffmeister 1986) is found in the White Mountains (NatureServe 2013; Conley 1970). *Neotamias minimus consobrinus,* occurs sympatrically with another *Neotamias* species, *N. umbrinus*, along the North Rim of

the Grand Canyon; however, the small size of *N. m. consobrinus* makes it morphologically distinct from other *Neotamias* species. A recent phylogenetic analyses of nuclear-encoded reproductive protein genes indicates *N. minimus* is most closely related to the sister taxa, *N. alpinis* (Reid et al. 2012)

Description (Hoffmeister 1986)

Neonate/Juvenile: Newborn *N. minimus*, like other rodent species, are born with eyes closed and hairless. It is not clear from the literature when newborns develop pelage, pinnae become erect, active movement begins, or dispersal of young from natal burrow occurs. Molt to adult pelage occurs in June (Hoffmeister 1986).

***Adult*:** General characteristics of *N. minimus* include small external and cranial features, a delicate skull with relatively broad braincase, five dorsal black or dark brown stripes, three dark brown and two whitish facial stripes, forehead pelage is light to dark grayish brown, shoulder pelage is a mixture of gray and buff, sides of the body pelage are dark orange often washed with gray, and the tail is bushy, slightly shorter than the head and body, and reddish on underside (Hoffmeister 1986), as shown in Fig. 1. Coat color is geographically variable, with pelage noticeably lighter and with considerably more gray than specimens in the north central and northern portion of the subspecies range (i.e., Utah and Idaho; Hoffmeister 1986). Adults molt pelage twice per year, in May and September, and molt their tail only once per year (Hoffmeister, 1986). Adult weight is approximately 70 grams and snout to tail length of 9.1 inches (23 cm; NatureServe 2013). Though *N. minimus* females are usually larger than males in all measurement aspects, there is no apparent sexual dimorphism in *N. m. consobrinus* (Hoffmeister 1986).

Similar Species

Three *Neotamias* species occur sympatrically with *N. minimus*: the Colorado Chipmunk, *N. quadrivittatus*, in the Chuska Mountains; the Uinta Chipmunk, *E. umbrinus*, on the Kaibab Plateau along the North Rim of the Colorado River; and Gray-collared Chipmunk, *E. cinereicollis*, in the White Mountains. *N. quadrivittatus* has a longer cranial breadth (> 0.60 in. (15.3 mm)), has bright orange in the shoulder pelage and has only three dark dorsal stripes. *N. umbrinus* has a longer skull, only three dark dorsal stripes with the lateral two or either absent or missing, and is not as gray as *N. minimus*. *Neotamias cinereicollis* has a wider post-orbital breadth (> 0.43 in. (10.8 mm)) and cranial depth (> 0.54 in. (13.7 mm)), and is grayer on the shoulders and cheeks than *N. minimus.*

Range

***Regional*:** The range of *N. minimus* subspecies is restricted to the western United States and Canada, from central Yukon east to Michigan and western Quebec, and south through the western United States with California's Sierra Nevada, northern Arizona and northern New Mexico the southwestern limit of the species range (Fig. 2; Patterson *et al*. 2003). In Arizona, two subspecies of *N. minimus* are found: *N. m. operarius* is found in the Chuska Mountains, Apache County, White Mountains, Apache and Greenlee counties, and *N. m. consobrinus* is found on the Kaibab Plateau, Coconino County (Hoffmeister 1986).

Neotamias minimus consobrinus occupies a fairly large range in the western United States, with the subspecies range extending north from the Kaibab Plateau and northeastern portion of the state (Fig. 3), through southwestern and central Utah to

northern and northeastern Utah (near Salt Lake City) and into mountainous areas in extreme southeastern Idaho (north of Bear Lake County), east to southwestern (Gunnison County), northwestern (Moffat County) and north-central Colorado (Grand County), into south-central and northwestern Wyoming and east to the Wind River Mountains, and ending in the Beartooth Mountains in southern Montana.

Known Localities:
Hoffmeister (1986) reports *N. m. consobrinus* from the Kaibab Plateau in Arizona, Coconino County: Jacob Lake; VT Park; De Motte Park; Bright Angel Spring; Road W-3 near Grand Canyon National Park entrance; 0.5 Mi. south of the North Rim entrance to Grand Canyon National Park; The Basin; and Basin Spring, 4.5 miles northwest of the North Rim Ranger Station.

Kaibab National Forest – North Kaibab Ranger District: The range of *N. m. consobrinus* on the North Kaibab Ranger District is indicated in Fig. 4, and shows that only a small amount of potential habitat exists on the District, and is restricted to a north-south transect running through the approximate center of the District. Detections continue southward outside of the southern border of the District towards the Colorado River boundary. This distribution mostly reflects convenient sampling efforts associated with proximity to Forest Service roads, and likely does not represent the true distribution of the subspecies in the region. Since this subspecies is expected to occur in high elevation mountains throughout the District, the known distribution of this species may reflect a lack sampling effort or may reflect habitat that is disturbed and therefore unsuitable. Barring unsuitable habitat, populations are likely to be detected throughout the District and on adjacent North Kaibab Ranger District lands.

Kaibab National Forest – Tusayan Ranger District: The actual distribution of *N. m. consobrinus* within the Tusayan Ranger District is not known as no occurrences have been documented. Since appropriate habitat for this subspecies is expected to occur in the District, the rarity of this species may reflect a lack sampling effort or may reflect habitat that is disturbed and/or unsuitable. Conversely, the absence of this subspecies in the Tusayan Ranger District may reflect an insurmountable barrier to dispersal, for example, the Colorado River.

Kaibab National Forest – Williams Ranger District: The actual distribution of *N. m. consobrinus* within the Williams Ranger District is not known as no occurrences have been documented. However, AGFD HDMS data reports two captures of both a male and female *N. minimus* in 2002 in Camp Navajo of the Coconino National Forest at the southeast boundary of the Williams Ranger district. Since appropriate habitat for this subspecies occurs in the District, such as Kendrick Peak, Bill Williams Mountain and Sitgreaves Peak, the rarity of this species may reflect a lack sampling effort or may reflect habitat that is disturbed and/or unsuitable. Conversely, the absence of this subspecies in the Williams Ranger District may reflect an insurmountable barrier to dispersal, for example, the Colorado River.

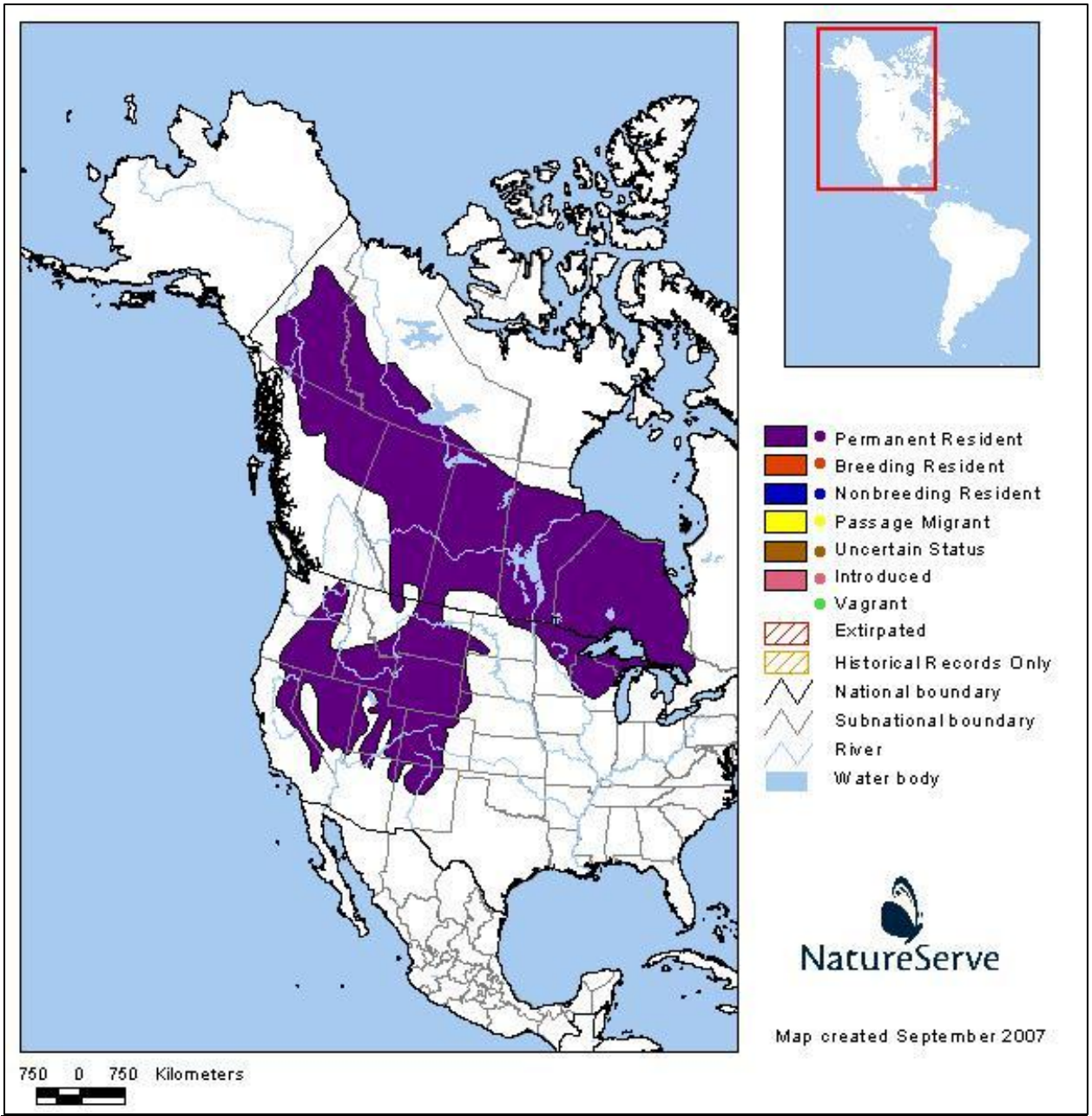

Fig. 2: Landscape map of Least Chipmunk, *Neotamias minimus*, distribution in western North America (Patterson *et al.* 2003). Data provided by NatureServe in collaboration with Bruce Patterson, Wes Sechrest, Marcelo Tognelli, Gerardo Ceballos, The Nature Conservancy-Migratory Bird Program, Conservation International-CABS, World Wildlife Fund-US, and Environment Canada-WILDSPACE.

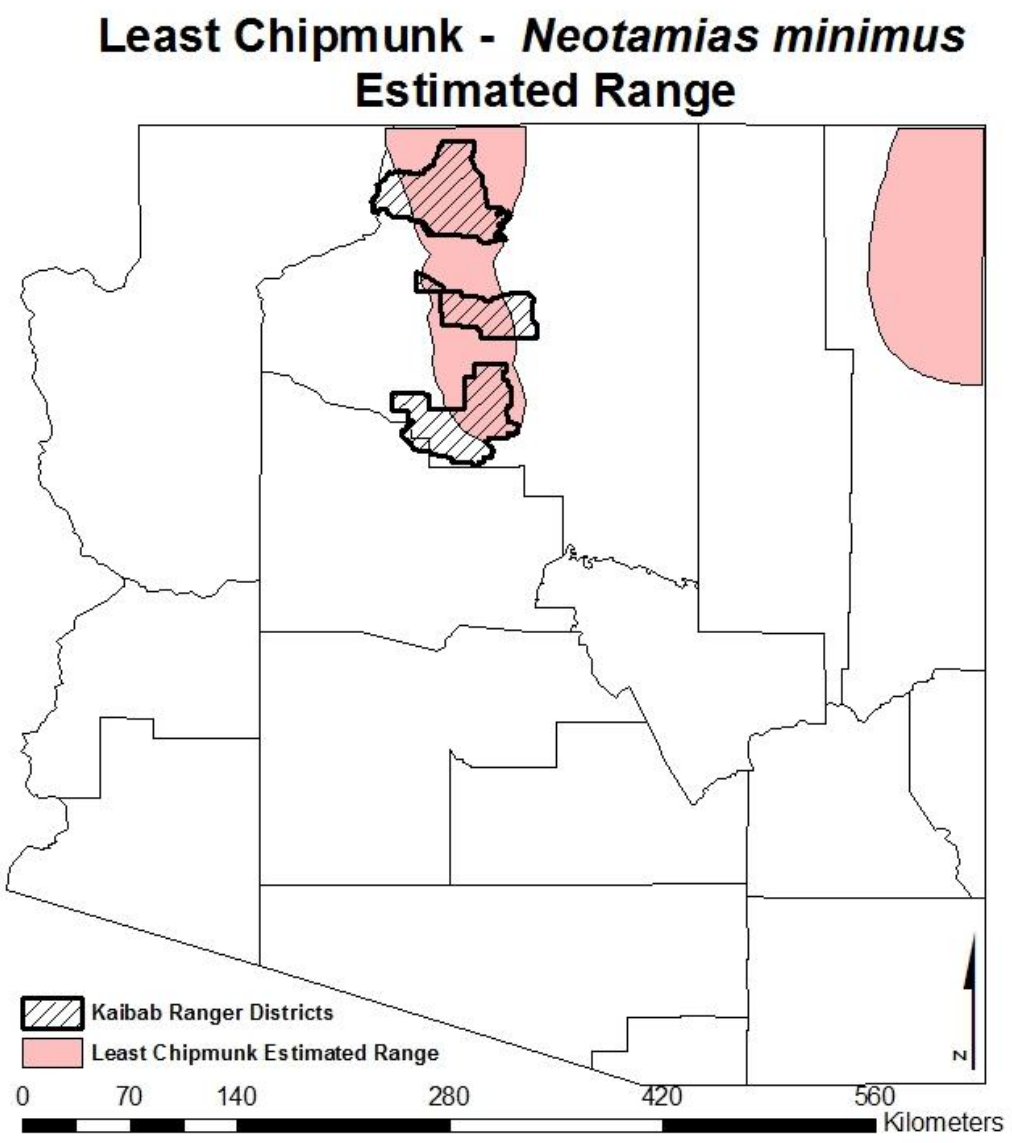

Fig. 3: Range map of Least Chipmunk, *Neotamias minimus consobrinus*, in Arizona, showing potential distribution in and proximal to the North Kaibab District of Kaibab National Forest. Range is extrapolated from NatureServe landscape map boundaries (Patterson *et al.* 2003) and Conley (1970), and HDMS (2013) point data.

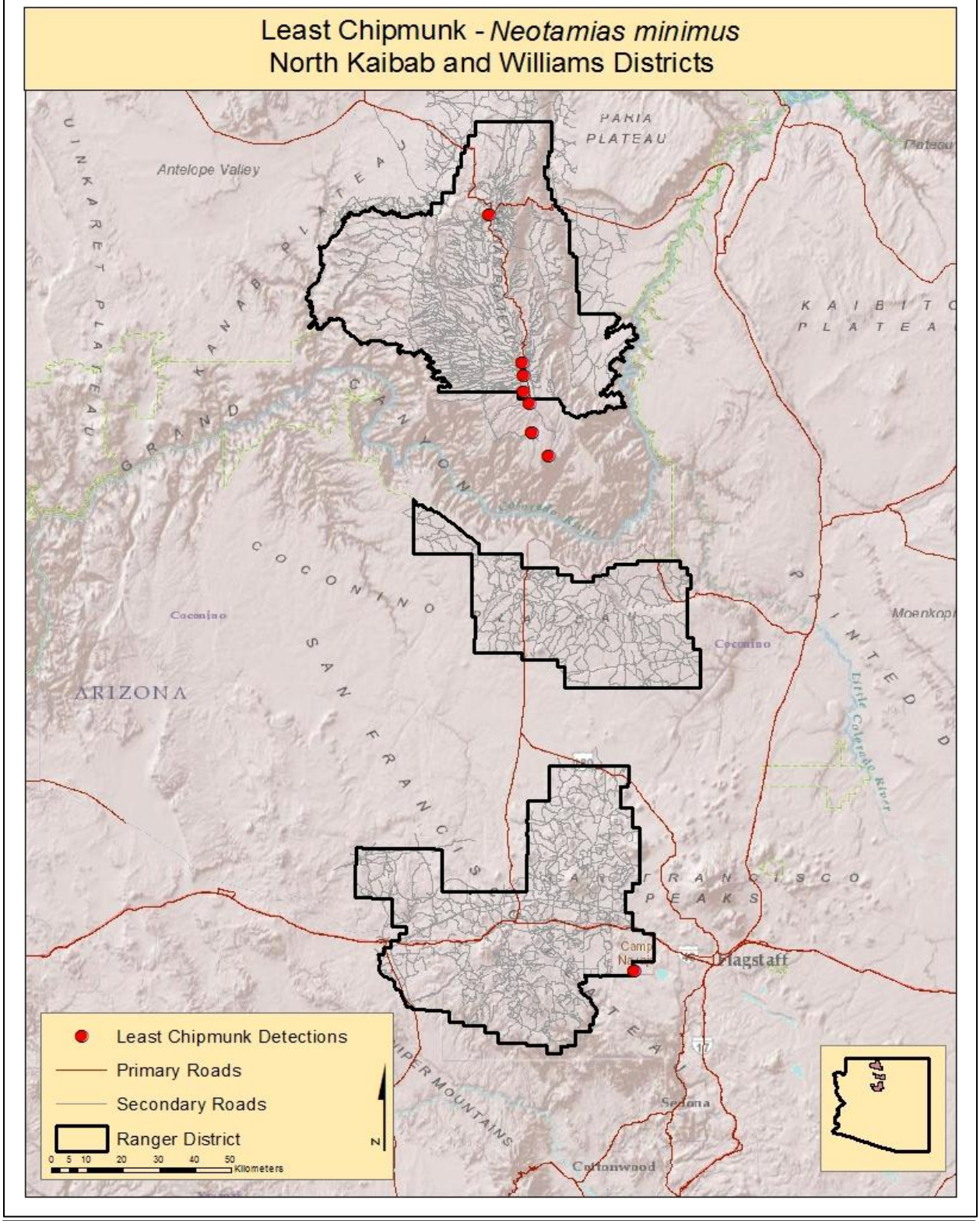

Fig. 4: Range map of Least Chipmunk, *Neotamias minimus consobrinus*, occurrence in and near the North Kaibab District of Kaibab National Forest. Point localities are based on historical detections described in Hoffmeister (1987) and HDMS point data (HDMS 2013).

Habitat Requirements

Neotamias minimus are ground-dwelling and semi-fossorial (burrowing). Although they will use rocky sites, they are the least dependent on rocky sites and on arboreality of other sympatric species, such as *T. quadrivittatus* and *T. umbrinus* (Bergstrom 1986; cited in Bergstrom 1992). Although primarily montane dwelling, Least Chipmunk inhabit a diversity of ecological and environmental regimes ranging from 7,874 to 12,795 feet (2,400- 3,900 m; Sullivan 1985), and McAdoo *et al.* (2006) found them to be the most abundant and widespread diurnal rodent in northeastern Nevada rangeland, inhabiting big sagebrush-dominated moist floodplains and north slopes. Perault et al. (1997) found in areas of sympatric species overlap in the Uinta Mountains, Utah, N. minimus was more common in open areas, such as above treeline, than the conspecific *N. umbrinus*, which was found more commonly in tall, heavily canopied forests, consistent with Bergstrom and Hoffmann (1991) finding of N. minimus exclusively above treeline. Denning (or nesting) behavior varies seasonally, with dens up to one meter below the ground surface in winter, and summer dens typically in above-ground tree cavities, hollow logs or stumps, burrows, under debris and in rock piles (NatureServe 2013).

In Arizona, Hoffmeister (1986) reports that *Neotamias minimus* are found in the northern and eastern portions of the state exclusively in higher mountain spruce-fir forests of the Kaibab Plateau, Chuska Mountains (including Tunitcha and Lukachukai mountains) and White Mountains They have not been found in high mountain forests of the San Francisco Peaks or Graham mountains (Hoffmeister 1986), and the White Mountains were thought to be the limits of their southwestern range (Conley 1970). However, AGFD HDMS data reports two captures of both a male and female *N. minimus* in 2002 in Camp Navajo of the Coconino National Forest. Hoffmeister (1986) notes that they are usually found in rocky areas and open areas within spruce-fir forests. In areas of conspecific range overlap, e.g., *N. umbrinus* on the Kaibab Plateau, *N. minimus* is often found at lower elevations Chappell 1978; Heller 1971) and above treeline (Perault et al. 1997), while *N. umbrinus* partitioned to higher elevational, heavily canopied forests (Perault et al. 1997). Specimens in Arizona have been collected from as high as 11,280 feet (3,438 m; Hoffmeister, 1986).

Ecology and Life History

Neotamias minimus are ecologically important as prey species and minimally as ecosystem engineers, as their burrowing activities may influence soil structure, microtopography, habitat heterogeneity, plant species diversity and abundance, and primary productivity. In all habitat types they are mainly granivorous and seasonally frugivorous, feeding on and caching seeds, fleshy fruits and berries that are collected by climbing or that can be reached from the ground (Hoffmeister 1986). Part of their ecological importance may be in dispersing seeds, and they are an important prey species for a number of vertebrates, including snakes, raptors, mustelids, canids and felids. Average densities range from 5-15 per acre; highly favorable habitats may contain 30 or more per acre. Home range varies from 1-4 acres (NatureServe 2013). Generally small home ranges of 0.2-4.0 hectares and dispersal movement of at least 0.86 km, hence maximum extent of habitat use is up to one km (NatureServe 2013)

Females are typically monoestrous, with reproductive activity corresponding temporally to early spring peaks in annual male spermatogenic cycles (Skryja 1974); consequently, the breeding season begins in early April and extends to mid-May (Skryja

1974), with peak mating occurring in early spring (NatureServe 2013). The gestation period is typically 28-31 days (Skryja 1974; NatureServe 2013), with parturition beginning in early May to mid-June, depending on locality. Litter sizes range from 3-9 (mean of 6) offspring, with only one litter per year unless the first litter fails, in which case a second litter may be produced (Skryja 1974). In Wyoming populations, lactation in females occurred from early May until mid-August, with the seasonal lateness of lactation decreasing with increasing latitude (Skryja 1974). Offspring nurse for up to 49 days (Skryja 1974). Young of year become sexually mature the following spring (Skryja 1974).

Neotamias minimus differs in susceptibility to cuterebrid botfly larvae infestation compared to its sympatric congeners, as less than 1% of T. minimus captured where infested and minimally so (one specimen had only one second-instar larvae), as compared to 60% of sympatric congeners (Bergstrom 1992). These differences in susceptibility may be explained by ecological differences between conspecifics, as *T. minimus* is ecologically distinct in habitat, diet preferences, substrate dependence and degree of arboreality (Bergstrom 1992).

Behavior

Neotamias minimus are territorial, and aggressively defend territories from both intraspecific and interspecific intruders. However, in areas of sympatric overlap with larger, territorially aggressive chipmunks, niche partitioning of sympatric species seems to occur due to the smaller size and ecological distinctiveness of Least Chipmunk diet and habitats (Bergstrom and Hoffmann, 1991). In mesocosm enclosure studies, sexually active males exhibit a hierarchical system with resident males clearly dominant over introduced males, indicated by a pursuit and pseudo-copulatory behavior of the dominant male (Reilly 1972).

Adult phenology is circadian with diurnal activity throughout the day but peaking during sunny, midday hours (NatureServe 2013). They are believed to begin semi-hibernation in late October to early November, and may be active on warm, winter days, but come out of hibernation by February (Pivorun 1976) or mid-March (NatureServe 2013). Pivorun (1975) found that continuous cold temperatures (8-10C) for 101 to 333 (mean of 165) hours of was required before hibernation began, and that *N. minimus* always entered hibernation without an initial test drop stage. Pivorun (1975) observed that *N. minimus* lacks winter fat reserves, so the absence of a test drop stage may be an energetically advantageous compensatory mechanism. Prior to hibernation, *N. minimus* may physiologically or biochemically prepare itself for torpor (Pivorun 1976).

Conservation Status

The IUCN Red List of Threatened Species does not list *N. m. consobrinus* but lists *N. minimus* as LC (Least Concern; IUCN 2013). NatureServe (2013) lists *N. minimus* global status as G5 (Secure), national status of N5 (Secure), Arizona state status as S4 (Apparently Secure) and the Navajo Nation as S3S4 (Vulnerable-Apparently Secure). The numeric range rank used by the Navajo Nation indicates uncertainty about the status of the species or status of the associated ecosystem. The subspecies *N. m. consobrinus* global status is G5TNR (Secure; not yet ranked) and national status is NNR (Not yet ranked), while only Colorado lists the subspecies as S5 (Secure).

Threats

Threats to *N. minimus* are primarily related to the quality of their habitat and the land use practices therein. Historic forest management practiced by Forest Service likely contributed to the loss of habitat of this species. Specifically, fire suppression may adversely alter high mountain forest communities in a manner that increases the frequency and intensity of wildfire. In addition, roads, including narrow roads, are a primary deterrent to the dispersal of most small mammals (Oxley et al. 1974). Oxley et al. (1974) note that small mammals rarely cross roads wider than 30 meters, and compaction of dirt roads will impede burrowing activity.

Mitigation of Management Practices

Forest Service management practices may affect *N. minimus* and its high mountain forest habitat on the North Kaibab Ranger District (Table 1), and detailed studies regarding the species demography, spatial use and ecology are necessary before current management practices can be effectively mitigated for the long-term protection for this species. In the absence of further studies, fire management practices should replicate historic burn cycles. Because *N. minimus* is dependent on high-quality spruce-fir forest habitat, such communities should be thinned and prescriptively burned on a historic burn periodicity. Burning should occur in winter months when the species is hibernating or estivating. Pest control using herbicides for non-native invasive plant species, such as cheat grass, should surgically target specific species and ensure that native grass, forb and shrub species found in spruce-fir forests and their margins are not adversely affected.

Restoration/Conservation Opportunities

Neotamias minimus consobrinus is one of is one of several taxa restricted to the North Kaibab Ranger District by the Colorado River and absence of habitat southward within dispersal distance (i.e., San Francisco Peaks). Restoration and conservation opportunities for this subspecies will be hindered by the lack of biological and ecological information available. For instance, virtually nothing is known about this subspecies, with the sole sources of documentation by Hoffmeister (1986) generally uninformative, so the little that we do know about the subspecies is inferred from studies conducted on other subspecies of *N. minimus.* Invoking the Precautionary Principle (i.e., first, do not harm; and second, do not let the absence of scientific certainty preclude the taking of action), the most effective conservation method is to better manage existing habitats, which may necessitate maintaining high elevational spruce-fir forest communities by preventing catastrophic wildfires, through thinning and prescriptive burning. In practice, effective habitat management will require investment in inventory, research and monitoring information. Monitoring for this taxa should include monitoring of range conditions in the occupied portion of the Kaibab Plateau and periodic monitoring of *N. minimus* populations to identify trends leading to precipitous declines in population levels or changes in species.

Table 1: Common general and specific Forest Service management practices, potential impacts, and mitigation actions.

General Activity	Management Action	Impacts	Mitigation Actions
Brush control	Mechanical cutting of juniper with lop and scatter to 18 to 24 inches from the ground	Wood chip cover of high elevation meadow areas	Not applicable to *N. m. consobrinus*
Brush control	Mechanical removal of emory oak, manzanita, and other brushy vegetation.	Loss of grass-dominated high elevation meadow habitat; soil disturbance and/or compaction	Not applicable to *N. m. consobrinus*
Construction	Drainage or stream crossings by trails or roads with insertion of proper culverts to allow for water flow	Erosion, soil disturbance and/or compaction	Minimize road and trail impacts on high elevation spruce-fir forest areas that may affect *N. m. consobrinus* habitat and activity.
Construction	Road construction	Soil compaction, dust, noise	Schedule road construction work to minimize *N. m. consobrinus* population and habitat impacts, including potential dispersal.
Forest management	Prescribed burning	Increased temperature during fire, loss of habitat, heavy equipment impacts	Avoid burning or conduct prescribed fires to minimize seasonal impacts on *N. m. consobrinus* populations.
Forest management	Timber harvest using thinning in Ponderosa Pine	Increased temperature during fire, charcoal and sediment inflow into aquatic habitats; heavy equipment impacts	Not applicable to *N. m. consobrinus.*
Forest management	Underburning using prescribed fire in Ponderosa Pine	Increased charcoal and sediment inflow into aquatic habitats; heavy equipment impacts	Not applicable to *N. m. consobrinus.*
Livestock management	Fencing to exclude or concentrate livestock or wildlife	Fencing may exclude wildlife or concentrate livestock or wildlife into sensitive areas	Not applicable to *N. m. consobrinus.*

General Activity	Management Action	Impacts	Mitigation Actions
Livestock management	Livestock grazing management	Erosion, dust, vegetation removal, increased soil temperature	Not applicable to *N. m. consobrinus.*
Livestock management	Livestock water sources (stock tanks)	Erosion, dust, vegetation removal, increased soil temperature	Not applicable to *N. m. consobrinus.*
Pest control	Non-native invasive plant species treatment (either mechanically or via herbicide)	Reduction or elimination of vegetation may increase erosion, dust	Ensure herbicides are safely stored and handled, tested to prevent unanticipated impacts on *N. m. consobrinus* and apply appropriately to *N. m. consobrinus* habitats.
Pest control	Release of non-native invertebrates and vertebrates (e.g., feral cats)	Predation, competition, disease transmission to native taxa	Control non-native fauna as feasible, using integrated pest control and long-term planning
Water resources management	Spring or stream capture and diversion	Reduction or elimination of surface flows	Ensure wildlife water supplies and habitat are not reduced.
Water supplies management	Spring and stream monitoring	Flow and water quality may dwindle or disappear without regular monitoring	Regularly monitor springs and streams, and more frequently during drought, to ensure flowing waters are available and of high quality.

Information Gaps

Management of Least Chipmunk populations may be improved through both project level monitoring and, if possible, applied research facilitated through third party entities (e.g., collaborations with educational institutions) as administrative studies.

Project-level Monitoring: Specific questions to be addressed by possible project-level monitoring for effects that could inform future management include:

1) What are *N. m. consobrinus* population trends within and among years, particularly in relation to fire frequency other anthropogenic impacts, and can population dynamics for this species be modeled?

Applied Research: Applied research implemented as administrative studies through third party entities may answer the following specific questions important for managing *Thomomys* species populations:

1) What are home ranges or dispersal distances of *N. m. consobrinus*?

2) What are the specific habitat requirements of *N. m. consobrinus*?

3) What is the spatial use of *N. m. consobrinus*?

4) What is the demographic distribution of *N. m. consobrinus*?

References Cited

Baker, R. J., L. C. Bradley, R. D. Bradley, J. W. Dragoo, M. D. Engstrom, R. S. Hoffman, C. A. Jones, F. Reid, D. W. Rice, and C. Jones. 2003. Revised checklist of North American mammals north of Mexico, 2003. *Museum of Texas Tech University Occasional Papers* 229:1-23.

Bergstrom, B. J. 1986. Ecological and behavioral relationships among three species of chipmunks (Tamias) in the Front Range of Colorado. Ph.D. Dissertation, Univ. Kansas, Lawrence. 111 p.

Bergstrom, B. J. 1992. Parapatry and encounter competition between chipmunk (Tamias) species and the hypothesized role of parasitism. *American Midland Naturalist* 128: 168-179.

Bergstrom, B. J., and R. S. Hoffmann. 1991. Distribution and diagnosis of three species of chipmunks (Tamias) in the Front Range of Colorado. *Southwestern Naturalist* 36:14-28.

Chappell, M. A. and E. M. Dlugosz. 2009. Aerobic capacity and running performance across a 1.6 km altitude difference in two sciurid rodents. *Journal of Experimental Biology* 212: 610-619.

Conley, W. H. 1970. Geographic variation in least chipmunk, Eutamias-minimus, in New Mexico and eastern Arizona. *Journal of Mammalogy* 51: 695-702.

HDMS. 2013. Heritage Data Management System (HDMS) Species Locations. Arizona Game and Fish Department, U.S.A

Hoffmeister, D. F. 1986. *Mammals of Arizona*. University of Arizona Press and Arizona Game and Fish Department, Tucson AZ, 602 pp.

Jameson, E. W., Jr. 1999. Host-ectoparasite relationships among North American chipmunks. *Acta Theriologica* 44:225-231.

McAdoo, J. K., M. R. Barrington, and M. A. Ports. 2006. Habitat affinities of rodents in northeastern Nevada rangeland communities. Western North American Naturalist 66:321-331.

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: April 30, 2013).

Nowak, R. M. 1999. *Walker's mammals of the world. Sixth edition.* Johns Hopkins University Press, Baltimore. Two volumes, 1, 936 pp.

Oxley, D. J., M. B. Fenton and G. R. Carmody. 1974. The effects of roads on populations of small mammals. *Journal of Applied Ecology* 11: 51-59.

Patterson, B. D., G. Ceballos, W. Sechrest, M. F. Tognelli, T. Brooks, L. Luna, P. Ortega, I. Salazar, and B.E. Young. 2003. Digital Distribution Maps of the Mammals of the Western Hemisphere, version 1.0. NatureServe, Arlington, Virginia, USA.

Perault, D. R., P. Wolf, and T. C. Edwards, TC. 1997. Hierarchical analysis of genetic partitioning by Tamias minimus and T. umbrinus. *Journal of Mammalogy* 78: 134-145.

Piaggio, A. J., and G. S. Spicer. 2001. Molecular phylogeny of the chipmunks inferred from mitochondrial cytochrome b and cytochrome oxidase II gene sequences. *Molecular Phylogenetics and Evolution* 20:335-350.

Pivorun, E. B. 1976. Biotelemetry study of thermoregulatory patterns of *Tamias striatus* and *Eutamias minimus* during hibernation. *Biochemistry and Physiology A-Physiology* 53: 265-271.

Reid, N., J. R. Demboski, and J. Sullivan. 2012. Phylogeny estimation of the radiation of western North American chipmunks (Tamias) in the face of introgression using reproductive protein genes. Systematic Biology 61**:** 44-62.

Reilly, R. E. 1972. Pseudo-copulatory behavior in Eutamias minimus in an enclosure. *American Midland Naturalist* 88: 232.

Root, J. J., C. H. Calisher, and B. J. Beaty. 2001. Microhabitat partitioning by two chipmunk species (Tamias) in western Colorado. *Western North American Naturalist* 61: 114-118.

Skryja, D. D. 1974. Reproductive biology of least chipmunk (Eutamias minimus operarius) in southeastern Wyoming. *Journal of Mammalogy* 55: 221-224.

Sullivan, R. M. 1985. Phyletic, biogeographic, and ecologic relationships among montane populations of least chipmunks (Eutamias minimus) in the southwest. *Systematic Zoology* 34: 419-448

USFWS. 2010. Integrated Pest Management. United States Fish & Wildlife Service (USFWS) Integrated Pest Management Policy 569 FW 1.

Willems, N. J. and K. B. Armitage. 1975. Thermoregulation and water requirements in semiarid and montane populations of least chipmunk, *Eutamias minimus*–I. Metabolic-Rate and Body-Temperature. *Comparative Biochemistry and Physiology A-Physiology* 51A: 717-722.

Willems, N. J. and K. B. Armitage. 1975. Thermoregulation and water requirements in semiarid and montane populations of least chipmunk, *Eutamias minimus*–II. Water-balance. *Comparative Biochemistry and Physiology A-Physiology* 52A: 109-120.

Willems, N. J. and K. B. Armitage. 1975. Thermoregulation and water requirements in semiarid and montane populations of least chipmunk, *Eutamias minimus*–III. Acclimatization at High Ambient-Temperature. *Comparative Biochemistry and Physiology A-Physiology* 52A: 121-128.