Conservation Assessment of the Kit Fox in Southeast Oregon

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Disclaimer

This Conservation Assessment was prepared to compile the published and unpublished information on the kit fox (Vulpes macrotis). If you have information that will assist in conserving this species or questions concerning this Conservation Assessment, please contact the interagency Conservation Planning Coordinator for Region 6 Forest Service, BLM OR/WA in Portland, Oregon, via the Interagency Special Status and Sensitive Species Program website at **http://www.fs.fed.us/r6/sfpnw/issssp/contactus/**

Executive Summary

Species: Kit fox (*Vulpes macrotis*)

Management Status: The kit fox is a BLM Sensitive Species. The kit fox has no other special federal status at the species level, but the San Joaquin kit fox (*V. m. mutica*) whose range is entirely within California is listed as Endangered under the Endangered Species Act. The kit fox is listed as a State Threatened species in Oregon.

Range: The geographic range of the kit fox stretches across most of the desert regions in the western United States and Mexico, including the Sonoran, Chihuahua, Mohave, and Painted Deserts, across most of the Great Basin, and the San Joaquin Valley of California. In Oregon, the species is confined to the southeast portion of the state.

Habitat: Kit foxes are most closely associated with sclerophyllous shrublands and shrub-grass habitats in desert and semiarid climates. In the Great Basin, kit foxes use habitat types dominated by creosote bush (*Larrea tridentata*), shadescale (*Atriplex confertifolia*), greasewood (*Sarcobatus vermiculatus*), and pickleweed (*Allenrolfea ocddenta*), as well as grassland plant communities and stabilized dunes. Den sites, typically underground, are a crucial element of kit fox habitats.

Threats: The most serious threats to the Oregon kit fox population are habitat loss due to altered wildfire regimes and declining habitat suitability associated with non-native grass invasions, processes that are likely to be exacerbated by climate change forecasted for the region. Energy development and mining are predicted to increase within the geographic range of the kit fox in Oregon and have the potential to impact the species, but much of the known range is protected as wilderness study area under BLM resource management plans.

Conservation Opportunities: Between 1994 and 2012 there had been only a single sighting of a kit fox in Oregon and the species has received little attention by conservationists. A recent camera survey by the Oregon Wildlife Institute and the Oregon Department of Fish and Wildlife demonstrated that the kit fox continues to occupy its known geographic range in the state, with 9 of the 10 detections occurring on BLM-administered lands and one detection on a tract administered by the Oregon Division of State Lands (DSL). There remain many information gaps about kit fox distribution, abundance, and habitat use in Oregon. Addressing these gaps with research and monitoring efforts would permit more informed decisions about balancing kit fox conservation with other on-going land uses and predicted future developments.

Contents

Introduction

Goal

The purpose of the Interagency Special Status/Sensitive Species Program (ISSSSP), which funded this conservation assessment, is to conserve species and the ecosystems on which they depend until their special status is no longer warranted (ISSSSP 2014). The kit fox (*Vulpes macrotis*) appears on the current (2015) BLM list of Sensitive Species, as well as the previous 2008 and 2011 lists. This assessment has been prepared with the intent of synthesizing scientific knowledge about the status of the kit fox, it's biology and ecology, threats to its persistence in Oregon, and approaches to kit fox conservation in the state. The overarching goal of the assessment is to address information needs of the ISSSSP, federal and state land managers working in the Northern Basin and Range ecoregion, and other wildlife conservation programs concerned with securing a future for the kit fox in Oregon.

Scope

This conservation assessment examines the ecology, limiting factors, and management of the kit fox with the intent of improving the understanding of the species' status in Oregon. The paucity of empirical information for the kit fox in Oregon necessitated that the assessment be largely founded on literature from outside the state, although the synthesis of background material is focused on the Oregon population of the kit fox. This assessment is based on peer-reviewed research and non-refereed agency publications, interviews with state and federal wildlife biologists, and utilized spatially-explicit datasets that were the basis for the maps included in this document. In a few cases, I cited information despite being unable to find the original source. I only used indirect sources when I believed the information was particularly important for the assessment and after I made substantial effort, but failed to find the original document. When using such information I have provided literature citations for both the primary document and secondary source where it appeared.

Management Status of the Kit Fox

The kit fox has no special federal status at the species level under the Endangered Species Act, but a subspecies, the San Joaquin kit fox (*Vulpes macrotis mutica*), was one of the earliest species to be listed as federally endangered under the Endangered Species Preservation Act of 1966 (80 Stat. 926; 16 USC 668aa(c)) and a recovery plan for the subspecies was published in 1983 (USFWS 1983). A petition to delist the San Joaquin kit fox as federally endangered was filed in 1992, arguing that the kit fox was actually a subspecies of the widespread swift fox. Based on genetic studies, the USFWS determined that the San Joaquin population was sufficiently distinct to warrant listing as endangered regardless of its subspecies status (USFWS 1992).

In Oregon, the kit fox is a Bureau of Land Management (BLM) sensitive species (BLM 2011).

The kit fox is listed as a state threatened species in Oregon (ODFW 2014). The listing occurred under an administrative rule that preceded the Oregon Endangered Species Act of 1987. Consequently, there have been no survival guidelines or management/recovery plans prepared for the kit fox, conservation actions required by Oregon administrative rules for species listed after 1993. (pers. comm., Martin Nugent, ODFW). It is however unlawful for anyone to 'take' a kit fox anywhere in the state.

NatureServe has assigned the kit fox a global rank of '*G4*', which is interpreted as "apparently secure" when considering the entire geographic range of the species. However the kit fox is assigned a state rank of '*S1*' in Oregon, a designation that identifies the kit fox as "critically imperiled" in the state.

Natural History of the Kit Fox

Taxonomy & Systematics

Merriam (1888) was the first to distinguish the kit fox from the previously described swift fox (*Vulpes velox*; *in* Audubon and Bachman 1851) and by 1902 Merriam had described two more subspecies of kit fox. As more fox specimens were collected during biological surveys in the far west, no less than seven other naturalists had proposed nine different taxonomic revisions to the swift-kit fox species complex by 1938 (Table 1., Dragoo and Wayne 2003).

It is clear that the Rocky Mountains present a major barrier to the movement of small foxes. This physical separation and geographic patterns of morphological differences among specimens led to a general recognition that the Rocky Mountains caused a divergence between major taxa within the swift-kit fox complex, with swift fox taxa assigned to the east and the kit fox to the west of this demarcation (Mercure et al. 1993). However, there is an area of contact in New Mexico and northern Texas where swift and kit foxes hybridize (Rohwer and Kilgore 1973). Hall (1981) decided that the gene flow occurring among populations in the contact area precluded recognition of *V. macrotis* as a distinct species and instead identified it as one of 10 subtaxa in *V. velox*.

In a morphometric analysis of 844 specimens collected across the geographic ranges of swift and kit foxes, Dragoo et al. (1990) found a gradient of differentiation where sub-taxa in closest proximity to the area of contact between swift and kit foxes were very similar and morphological characteristics gradually diverged with increasing distance from the contact area. Based on these results, Dragoo et al. (1990) agreed with Hall (1981) in questioning the validity of the kit fox as a distinct species and they proposed the recognition of *V.*

velox and two sibling subspecies, *V. v. velox* and *V. v. macrotis*.

Mercure et al. (1993) examined mitochondrial DNA differentiation among a large number of samples across the geographic ranges of swift and kit foxes. These authors found two distinct groupings of swift-kit fox genotypes separated by the Rocky Mountains, as well as evidence for gene flow between these groups in the contact area previously identified by Rohwer and Kilgore (1973), among others. Mercure et al. (1993) concluded that the divergence they found between the genotypes on either side of the Rocky Mountains warranted recognition of both the swift and kit fox as valid species, although they acknowledge the soundness of contrary opinions and discussed the challenges posed by swift-kit fox systematics to the fundamental definition of a species.

Mercure et al. (1993) also identified 7 different clades within *V. macrotis* whose genetic clustering could be accounted for by the limited dispersal capabilities of kit foxes and topographic barriers which restricted gene flow among populations. Nevertheless, these authors found that only the San Joaquin kit fox was geographically isolated and showed sufficient genetic differentiation to be classified as a subspecies.

The 2014 Revised Checklist of North American Mammals (Bradley et al. 2014) and the U.S. Fish and Wildlife Service recognize the swift fox as a separate monotypic species, and two subspecies of the kit fox: *V. m. mutica* occurring in the San Joaquin Valley of California and *V. m. macrotis* throughout the remainder of the recognized range of the species, which includes Oregon.

San Joaquin kit fox (*Vulpes macrotis mutica*)

Description

The kit fox is the smallest canid occurring in Oregon (Verts and Carraway 1998). Sexual dimorphism is not pronounced, but males are heavier than females on average. Egoscue (1962) reported that males ranged between 3.75-5.51 lbs. (1.7-2.5 kg, *n* = 10) and females ranged between 3.53-4.63 lbs. (1.6-2.1 kg, *n* = 6) for kit foxes in Utah. Zoellick and Smith (1992) reported that average weights were 4.01 lbs. (1.82 kg, n = 4) for males and 3.68 lbs. (1.67 kg, n = 4) for females. The species is slender in appearance, has the largest ears relative to body size of any canid in North America, and has a long tail that is approximately 40% of total length (McGrew 1979). Color of the pelage varies geographically. Verts and Carraway (1998) describe kit foxes from Oregon as having a dorsal pelage of "grizzled brownish-gray medially blending to grizzled gray then to light buff laterally and finally to white on chest and venter". Ears are tan or gray on the back and the pinnae have a thick border of white hairs along the inner margin. The tail has a prominent black tip.

Range, Distribution, and Abundance

Geographic Range

The geographic range of the kit fox stretches across most of the desert regions in the western United States and Mexico, including the Sonoran, Chihuahua, Mohave, and Painted Deserts, across most of the Great Basin, and the San Joaquin Valley of California (Fig. 1, McGrew 1979).

Kit foxes are believed to have arrived near the southern boundary of their geographic range in Mexico during the middle Holocene (8,000 to 4,500 years before present) when mesic grasslands were at their greatest extent in the region (Maldonado et al. 1997). Climate change since that time has led to an overall expansion of xeric conditions across the southern Chihuahuan Desert causing kit fox populations to become isolated in high-elevation prairies (Maldonado et al. 1997).

A map of known kit fox locations in Idaho indicates that the species is distributed as far north as the Salmon River, although most sightings are concentrated in the southwest corner of the state (ICDC 2005).

Radio-collared kit fox vixen.
Malheur County, Oregon.

Distribution in Oregon

Bailey (1936) stated that the distribution of the kit fox was generally confined to the Owyhee Valley and perhaps the smaller valleys of Malheur County, Oregon which extend into Nevada based on a few specimens known to him. There were only a small number of additional specimens and sightings reported later in the twentieth century. The northernmost of these was the discovery of 12 kit fox skulls in a cave occupied by a bobcat located approximately 12 miles (19 km) north of Burns Junction, Oregon (Benedict and Forbes 1979). Three different surveys in southeastern Oregon conducted by DeStefano (1990), Keister (1994),and Keister and Immell (1994) yielded kit fox detections in an area bounded by the Steens Mountain to the west, the Sheepshead Mountains to the north, the Owyhee Canyon to the east and the Trout Creek Mountains to the south. These kit fox locality records have been compiled and mapped by the Oregon Biodiversity Information Center (ORBIC,Fig. 2).

Laughlin and Cooper (1973) reported a surprising capture of a kit fox near Klamath Falls, Oregon. This record is approximately 160 miles (257 km) west of the nearest other kit fox observation in Oregon and 165 miles (266 km) from the nearest San Joaquin kit fox record to the south in California.

The ORBIC database contains one other kit fox record later than the 1994 Keister and Immell survey. This was a sighting of a kit fox crossing a road in December 2006 near Whitehorse Ranch in Harney County (ORBIC 2014).

Milburn and Hiller (2013) conducted a camera survey for kit foxes during July and August 2012 in the same area studied by DeStefano (1990) and Keister and Immell (1994), which resulted in confirmed kit fox detections at one of the camera stations. This was only the second detection of a kit fox in Oregon since 1994. To more fully understand the current population distribution, the Oregon Wildlife Institute (OWI) and ODFW conducted a camera survey for the species from June 2012 to April 2014. Infrared motion-sensing cameras were rotated among 174 different stations in Malheur, Harney, and Lake Counties in Oregon. Many of the camera stations were far outside the core range of the kit fox as identified by the surveys during the 1990s. The survey resulted in kit fox detections at 10 stations, all within the previous known range for the species in Oregon (Fig. 3).

Nine out of ten of the camera stations where kit foxes were detected are located in the High Lava Plains and Dissected High Lava Plateau ecoregions which encompass extensive areas in Malheur and Harney Counties. The High Lava Plains are characterized by gently rolling topography with scattered volcanic buttes; potential natural vegetation is primarily sagebrush steppe and big sagebrush-bunchgrass steppe (Bryce and Woods 2000). The Dissected High Lava Plateau contains alluvial fans, rolling hills, and steep canyons; potential natural vegetation is largely sagebrush steppe with occasional patches of woodlands on gravelly uplands (Bryce and Woods 2000). One camera station where a kit fox was detected is located in the Salt Desert Shrub Valleys ecoregion, a landscape dominated by ephemeral lake basins, playas, and dunes; potential natural vegetation is dominated by alkaline-tolerant shrub communities (Bryce and Woods 2000). It should be noted that kit foxes could be present, but not detected in other habitat types within the 2012-2014 camera survey area.

Population Trends

Kit fox population trends vary across the geographic range of the species. Populations are apparently stable in Arizona (AZGFD 2009) and New Mexico (NMDGF 2013), but the total population in Colorado is probably <100 individuals (Fitzgerald 1996). This already small population is apparently in steep decline (Beck 1999, Beck 2000). In Mexico, kit foxes are reported to be in decline primarily because of the conversion of native grasslands into agricultural fields (Maldonado et al. 1997).

The total population of the San Joaquin kit fox in California was reported to have declined from 8,000-12,000 prior to 1930 to approximately 7,000 in 1975 (Cypher et al. 2000). Since its listing, the spatial distribution of the San Joaquin kit fox has become increasingly fragmented and there is evidence that the subspecies is extirpated from local areas within its historic range (USFWS 2010).

In western Utah, there is evidence that the increasing coyote (*Canis latrans*) population is causing kit foxes to be excluded from their preferred habitats and has caused very high rates of mortality for dispersing foxes, thereby fragmenting the population and increasing the risk of local extirpations. (Kozlowski et al. 2008). Degradation of native plant communities may also be contributing to population declines in Utah (Arjo et al. 2007). Trapping records from Utah show a decrease in the annual harvest of kit foxes from >600 individuals in 1983 to <100 individuals in 1993 (Thacker et al. 1995, *in* Dobkin and Sauder 2004), although declining harvests may be affected by factors other than declining abundance.

My literature review found no information on population status or trends from the northern portion of the kit fox geographic range (i.e., Idaho, Nevada, and Oregon). However, the 2012-2014 kit fox survey by OWI and ODFW indicates kit foxes are still present across much of its geographic range in Oregon as described by Bailey (1936).

Kit fox detected at a camera station in Malheur County, Oregon.

Biology & Ecology

Feeding Habits and Diet

Kit foxes are almost wholly carnivorous and are nocturnal, solitary hunters. McGrew (1979) characterizes their diet as primarily composed of the most abundant rodent or lagomorph occurring in the vicinity of the den. Egoscue (1962) identified black-tailed jackrabbits (*Lepus californicus*) as the most common prey species taken by kit foxes (94% of total prey biomass) with cottontail rabbits (*Sylvilagus* spp.), kangaroo rats (*Dipodomys* spp.), other rodents and birds taken in lesser amounts. Kangaroo rats and jackrabbits are also prominent in the diet of the San Joaquin kit fox in California (Koopman et al. 2001). Prairie dogs (*Cynomys* spp.) are an important prey item of kit foxes where their distributions overlap in Colorado (Eussen 1999, cited in Meany et al. (2006) and Mexico (List and Macdonald 2003).

Although the diet of kit foxes may vary according to the composition of the regional small mammal community, kit foxes do not necessarily respond to a short-term scarcity of their preferred prey by seeking more available foods, even when the shortage may be causing a decline in kit fox abundance and lower reproductive success (Egoscue 1975, White et al. 1996). However, diets may eventually change over long periods. Arjo et al. (2007) found that the primary prey of kit foxes shifted from leporids to nocturnal rodents and kangaroo rats at a site in Utah over a 30-year period, probably because of a regional decrease in jackrabbit populations and increasing competition from coyotes.

Arthropods, especially grasshoppers (Acrididae) and crickets (Gryllidae), are frequently eaten by kit foxes but rarely represent a significant portion of the total prey biomass in their diet (Clark et al. 2005). An exception might be juvenile foxes that are not yet competent hunters and find arthropods to be easier prey (Clark et al. 2005).

Tissue samples collected from San Joaquin kit foxes and subjected to stable isotope analysis revealed that foxes living near urban areas have a diet composed of significant amounts of beef and poultry with $\delta^{13}C/\delta^{15}N$ ratios similar to meat products packaged for human consumption, strongly indicating that kit foxes are exploiting anthropogenic food sources (Newsome et al. 2010)

The diet of kit foxes in Oregon is unknown, but DeStefano (1990) conducted a limited (1174 trap nights) small mammal trapping study and spotlight/road survey to characterize the potential prey of kit foxes in his Oregon study area. The most frequently captured small mammals were the Great Basin pocket mouse (*Perognathus parvus*, 107 captures), Ord's kangaroo rat (*Dipodomys ordii*, 46 captures), and deer mouse (*Peromyscus maniculatus*, 42 captures). Jackrabbits were observed at a rate of 103.3 jackrabbits per 100 miles (161 km) during the spotlight/road survey (DeStefano 1990).

Den Use

Den sites are an essential feature in the life history of the kit fox. Underground dens are used as refugia from predators, to avoid extreme temperatures, and to rear their pups. Kit foxes rarely venture outside their den during daytime. Kit fox home ranges invariably contain multiple dens, around which kit foxes will shift their daily and seasonal patterns of activity (Egoscue 1962). In California, San Joaquin kit foxes were found to use an average of 11.8 different dens (range 1-16 dens) during the year (Koopman et al. 1998). Kit foxes may use a particular den or subset of dens much more frequently than other den sites within their home range and may continue using a preferred site even when it is altered by disturbance (Egoscue 1962, Golightly 1981). Dens are shared by members within a social group (Koopman et al. 2000, Ralls et al. 2001), and occasionally by foxes having no close kinship (Ralls et al. 2001).

Reproduction and Rearing

Kit foxes are generally believed to be monogamous and form pair-bonds lasting as long as both the male and female survive (Egoscue 1962, Ralls et al. 2007). Female yearlings (age = 1 year) are capable of reproduction although they have a markedly lower rate of success than older adults (Cypher et al. 2000).

Male kit foxes join females at a natal den beginning in fall and mating typically follows 1 to 2 months afterward (McGrew 1979), although breeding activities occur later at the northeastern margin of the geographic range (Fitzgerald 1996). Most litters are whelped during January in California (Ralls et al. 2001) and March in Utah (Egoscue 1962). Kit fox pairs produce a single litter per year, typically ranging between 3 to 5 young (McGrew 1979, Cypher et al. 2000). Females leave the natal den infrequently while nursing young and the adult male delivers food to his mate and their pups during this period (Egoscue 1956). Pups emerge from the natal den at 4-5 weeks after birth and have been observed hunting with their parents at 3-4 months of age (McGrew 1979; Fitzgerald 1996). Most pups disperse from their parent's territory before breeding activity commences again in the fall (Egoscue 1962). However, offspring will occasionally remain near parents for an extended period (White and Ralls 1993, Ralls et al. 2001).

Dispersal

Kit foxes exhibit wide variation in rates of philopatry and dispersal. Of 209 juvenile San Joaquin kit foxes monitored during a 15-year period, 32.5% dispersed from their natal home range with males exhibiting a greater tendency to disperse and females a greater tendency toward philopatry (Cypher et al. 2000). However none of the 36 pups in Utah marked in the study by Egoscue (1962) remained in their natal home range. Philopatric offspring rarely resided with their parents. Instead, parents typically shifted their activities away from the portion of the home range occupied by the offspring (Koopman et al. 2000).

Juvenile dispersal peaks during July in California (Koopman et al. 2000) and late summer in Utah (Egoscue 1962). Mean age of dispersal among San Joaquin kit foxes is 8 months (range 4-32 months; Koopman et al. 2000)

Dispersal is a hazardous period for kit foxes. Koopman et al. (2000) found that 65% of dispersing San Joaquin kit foxes died within 10 days after leaving their natal home range, while in Utah, none of the 6 juvenile foxes followed by Kozlowski et al. (2008) survived longer than 6 months.

Demography

Population Density

Estimates of kit fox population density vary greatly among different studies and across different geographic regions. At the southern portion of the geographic range, density estimates range from 0.12/mi^2 to 0.31/mi^2 (0.32/km^2 to 0.8/km^2) in Mexico (List and Macdonald 2006), and 0.31 /mi^2 to 0.97/mi^2 (0.38/km^2 to 2.5/km^2) in Arizona (Zoellick and Smith 1992). Egoscue (1975) estimated that density ranged from 0.18/mi^2 to 0.40/mi^2 (0.47/km^2 to 1.04/km^2) in a Utah study area. In a 15-year study of the San Joaquin kit fox at a 83.4-mi^2 (216-km^2) study area in California, density estimates ranged from 0.65/mi^2 to 0.8/mi^2 (1.68/km^2 to 0.21/km^2, Cypher et al. 2000).

Studies across the geographic range of the kit fox indicate that food availability is the primary factor regulating population density (Egoscue 1962, White et al. 1996, Cypher and Scrivner 1992, Cypher and Spencer 1998).

There has been no formal analysis of kit fox density in Oregon. However, DeStefano's (1990) survey results and the anecdotal information that was available led him to conclude that the Oregon population was probably much more sparse than in California, Utah, or more central portions of the geographic range where kit fox densities had been previously estimated.

Keister and Immell (1994) made an effort to estimate kit fox abundance in southeastern

Oregon based on limited home range data and a comparison of sighting frequencies between kit foxes and coyotes (with known density) These investigators reported density to be between 0.02/mi^2 and 0.10/mi^2 (0.5/km^2 to 0.26/km^2) although added a disclaimer that their approach "produced rough estimates at best" (Keister and Immell 1994). Other researchers have questioned the validity of this estimate (Verts and Carraway 1998).

Recruitment

At the Dugway Proving Ground, Utah, the reproductive rate (number of pups per female per year) ranged from 1.0 to 4.2 (mean = 2.08, n = 13 years) for 78 female foxes (Table 2, Arjo et al. 2007).

A 15-year study of San Joaquin kit foxes in California determined the mean litter size to be 3.8 (88 adult females, 1980-1995) and the rate of reproduction success (i.e., ≥1 pup from a litter observed during April-May) was 61.1 ±0.1% (n = 126) for adult females and 18.2 ±0.1% (n = 22) for yearling (age = 1 year) females (Cypher et al. 2000).

Rates of reproduction are reported to be strongly affected by prey availability (Egoscue 1975, White and Ralls 1993, Warrick et al. 1999, Cypher et al. 2000).

Rates of immigration and emigration are particularly difficult to estimate and were not reported among any of the kit fox studies I reviewed. However adult dispersal appears to be uncommon. Cypher et al. (2000) did observe a small number of kit fox immigration and emigration events over their 15-year study and their observations led them to conclude the rates of immigration and emigration were probably equal.

Survivorship and Mortality

In a 15-year study of 341 radio-collared adult San Joaquin kit foxes at the Naval Petroleum Reserves, California, annual survival rates ranged from 0.20 to 0.81 (mean survival, all years = 0.44 ± 0.05) and did not differ significantly between males and females (Cypher et al. 2000). The same study followed 184 radio-collared juvenile kit foxes and reported survival rates ranging from <0.01 to 0.31 (mean survival, all years = 0.14 ± 0.03) and did not differ significantly between males and females (Cypher et al. 2000). Of the 237 adult and juvenile foxes with a known cause of death, 199 (83%) were killed by predators, 31 (13%) were killed by vehicles, and the remainder died from disease, drowning, illegal shooting, or burial while in a den (Cypher et al. 2000). Other studies in California reported similar adult annual survival rates: 0.60 on the Carrizo Plain (Ralls and White 1995), and 0.53 at Camp Roberts (Standley et al. 1992). A higher survival rate (0.84) was observed at Lokern, California, possibly because of habitat heterogeneity and greater prey abundance (Nelson et al. 2007).

A study at the US Army Dugway Proving Ground in Utah monitored 28 radio-collared kit foxes from December 1998 to August 2001 and found that only 10 foxes were known to have survived to the end of the study; 7 of the mortalities were due to predation, 1 died of disease, and 1 of an unknown cause (Kozlowski et al. 2008).

Sex Ratio

Cypher et al. (2000) reported that San Joaquin kit fox population sex ratios were approximately 1:1 over the course of their 15-year study, but noted a male-bias during 3 years when survival rates of males and females were approximately equal. Egoscue (1962) reported a slight male bias among adults in Utah and a strong skewness toward males among pups (i.e. 23 males, 13 females).

Energetics and Water Economy

Dissipation of metabolic heat is a critical problem for endotherms inhabiting hot climates. The heat load can become especially acute when an animal is performing an energetically demanding activity such as the pursuit of prey. Golightly and Ohmart (1983) describe how kit foxes and a larger desert-dwelling canid, the coyote, have evolved different mechanisms to survive in environments characterized by hot temperatures and limited supplies of drinking water. Coyotes and many other species of desert-adapted wildlife have a lower basal metabolic rate (BMR) than is predicted by allometric equations used to describe the relationship between BMR and body size (White and Seymour 2003), so desert-adapted animals generate less endogenous heat in an effort to avoid hyperthermia. Coyotes also rely on evaporative cooling to minimize the elevation of their body temperature while exposed to high ambient temperatures, although at the cost of water loss (Golightly and Omart 1984). The BMR of the kit fox is higher than is typical for desert mammals and causes a greater metabolic heat load. The body temperature of kit foxes quickly rises to a lethal level when exposed to ambient temperatures >95^{0}F (>35^0 C; Golightly and Ohmart 1983), which are common in environments inhabited by the species. However the smaller body size of the kit fox increases its thermal conductance and allows for dissipation of metabolic heat without the need for evaporative cooling (Golightly and Ohmart 1983). Whereas the coyote can endure daytime temperatures that are lethal for kit foxes, the kit fox avoids exposure to temperature extremes through behavioral adaptations such as seeking refuge in a den and restricting its outside activities to nighttime.

Kit foxes occupy areas that lack sources of free water much of the year and are therefore believed to obtain their total requirement for water from their prey (Morrell 1972). A portion of the total daily water requirement for a mammal can be produced by their metabolic processes. Golightly and Ohmart (1984) reported that kit foxes need at least 175 g of prey to meet their daily need for water, which is a greater amount of food than kit foxes need to meet their energy requirement. Calculations by Golightly and Ohmart (1984) show that 18% of the total daily water requirement of kit foxes is satisfied by water that is a byproduct of metabolic processes while coyotes having a lower BMR can only produce only 10% of their daily water demand. Therefore coyotes must expend a greater amount of effort than kit foxes in seeking sources of drinking water on the landscape or by consuming a greater amount of prey.

Spacing and Daily Activity Patterns

Kit foxes hunt and perform most other activities outside the den as solitary individuals. Nevertheless, there may be substantial overlap of home ranges among foxes within the same social group (White and Ralls 1993, Ralls et al. 2001).

Kit foxes may adapt their spacing pattern to types and availability of prey. In California (Zoellick et al. 1987) and Utah (O'Neal et al. 1987), kit foxes had small, overlapping home ranges where lagomorphs were abundant, whereas foxes in Arizona (Zoellick and Smith 1992) and California (White and Ralls 1993) that fed on rodents and where the prey base was relatively low had large, non-overlapping home ranges.

In Lokern, CA, Nelson et al. (2007) reported the mean home range size for the San Joaquin kit fox to be 2.28 ±0.17 mi^2 (5.91 ±0.44 km^2, n = 32; minimum convex polygon method). At Carrizo Plains, CA home ranges averaged 4.48 ±0.44 mi^2 (11.6 ± 0.9 km^2 , n = 21; minimum convex polygon method; White and Ralls 1993).

In Arizona, mean home range size for females was 4.13 ±0.46 mi^2 (10.7 ±1.2 km^2, n = 3) and for males was 5.48 ±0.18 mi^2 (14.2 ±1.92 km^2, n = 4) based on the minimum convex polygon method (Zoellick and Smith 1992). The home range of mated females lay almost entirely within the home range of their mates (Zoellick and Smith 1992). These authors reported that the larger home range size among foxes they monitored as compared to home ranges in Utah and elsewhere was probably due to the lower abundance of prey in Arizona (Zoellick and Smith 1992). At the southernmost extent of its geographic range, the mean ±SD home range size was 4.25 ±1.78 mi^2 (11.0 ±4.6 km^2, (List and Macdonald 2003).

Movement patterns of kit foxes vary seasonally and by sex. In Arizona, the mean distance traveled each night was 8.9 ±0.17 mi (14.3 ±0.71 km) for males and 7.3 ±0.67 mi (11.8 ±1.08 km) for females (Zoellick et al. 1989). A study by Girard (2001) found that kit foxes in the Mojave Desert travel up to 20 mi (32 km) during their nightly activities and that males traveled further than females in the same season. The greatest difference in activity between males and females was in the spring (mean daily distance, males = 29.7 ±1.7 km^2, n = 9; females = 2.7 ±1.5 km^2, n = 12) when most females are caring for pups in the den and males provide almost all food for the female and juveniles (Girard 2001). The movements of males extend greater distances during the breeding season, thus causing a seasonal expansion of their home range (Zoellick et al. 1989, Zoellick and Smith 1992).

Habitat Use

Range-Wide Habitat Patterns

Kit foxes are most closely associated with sclerophyllous shrublands and shrub-grass habitats in desert and semiarid climates. In the Great Basin, kit foxes use habitat types dominated by creosote bush (*Larrea tridentata*), shadscale (*Atriplex confertifolia*), greasewood (*Sarcobatus vermiculatus*), and pickleweed (*Allenrolfea ocddenta*), as well as grassland plant communities and stabilized dunes (Egoscue 1962, Kozlowski et al. 2008). In Arizona and New Mexico, radio-collared kit foxes were primarily associated with open areas dominated by creosote bush (Zoellick et al. 1989, Rodrick and Mathews 1999).

In California, salt brush (*Atriplex polycarpa*, *A. spinifera*) scrublands, alkali sink scrublands and grasslands dominated by red brome (*Bromus madritensis*) or wild oats (*Avena* spp.) are considered the most suitable habitat types for San Joaquin kit foxes (Cypher et al. 2013).

At the southernmost extent of their range, kit foxes are primarily associated with Chihuahuan Desert grasslands (Maldonado et al. 1997) that were historically dominated by tobosa (*Pleuraphis mutica*), black grama (*Bouteloua eriopoda*), and sacaton (*Sporobolus* spp.; Desmond and Motoya 2006).

Studies across the geographic range of the kit fox have noted their close association with open and sparsely vegetated plant communities (McGrew 1979, Cypher et al. 2013). However landscape-scale investigations have noted more heterogeneous patterns of habitat use. Kozlowski et al. (2008) found that foxes they studied at the Dugway Proving Grounds, Utah used a variety of vegetation structural conditions. These researchers noted that foxes had incorporated both open and densely vegetated habitat types into their home ranges, the former probably because foxes could detect coyotes at a greater distance and thus afforded foxes safety, while the latter habitat types supported greater prey abundance (Kozlowski et al. 2008). Zoellick et al. (1989) noted that foxes in Arizona used relatively open creosote bush flats to den and rest, whereas most nocturnal hunting was in densely vegetated riparian plant communities.

My literature review revealed negligible information about habitat use by kit foxes across the northern portion of their geographic range, except for some anecdotal information from Oregon (see below).

Denning Habitat

Den sites are most often located in semi-open habitat types or where vegetation height is low enough to permit kit foxes to observe predators at a distance (Egoscue 1962, Zoellick et al. 1989, Arjo et al. 2003). However Arjo et al. (2003) noted that natal den sites in their Arizona study were characterized by taller vegetation and greater shrub cover than at non-natal dens, suggesting that foxes may be adopting a seasonal strategy of concealment while rearing pups, but also diminishing their ability to detect predators at long range.

Kit foxes typically select den sites in well-drained sandy or loamy soils on level or gently sloping terrain (Egoscue 1962, Zoellick et al. 1989, Rodrick and Mathews 1999). Nevertheless, Arjo et al. (2003) reported that 41% of the dens studied at the Dugway Proving Grounds, Utah were in rocky substrates and on rugged topography. This is the same area in which Egoscue studied kit foxes in 1962 and reported "foxes almost invariably denned on flat terrain where vegetation was sparse" (p. 496, Egoscue 1962). Arjo et al. (2003) postulated the change in den site selection by foxes at Dugway Proving Grounds may be the result of an expansion of the coyote population or habitat degradation from invasive cheatgrass (*Bromus tectorum*) causing kit foxes to alter their den site selection.

Manmade structures (e.g., culverts, buildings, pipes) are used as den sites, although infrequently (Koopman et al. 1998, Arjo et al. 2003, Kozlowski et al. 2008).

Habitat Use in Oregon

Information about habitat use by kit foxes in Oregon is drawn from three limited investigations conducted in the 1990s (DeStefano 1990, Keister 1994, and Keister and Immell 1994). All three of these studies were conducted in an area of Malheur and Harney Counties bounded by Steens Mountain to the west, Sheepshead Mountains to the north, the Owyhee Canyon to the east and Trout Creek Mountains to the south. The study area was selected by DeStefano because it contained all of the reliable kit fox sightings up to when he began work on his conservation assessment. The topography of the area is generally characterized by rolling hills alternating with broad valleys that are interspersed with steep buttes, dry washes, playas, and dunes (DeStefano 1990). Vegetation in the study area is dominated by monotypic stands of big sage (*Artemesia tridentata*), with rabbitbrush (*Chrysothamnus nauseosus*), shadscale (*Atriplex* spp.), greasewood, and spiny hopsage (*Grayia spinosa*) present to lesser degrees (DeStefano 1990).

Most of the kit fox observations (5 of 7 tracks and direct visual sightings) recorded by DeStefano (1990) were located in patches of low (plant height 12-23 in., 30-58 cm), open shrublands embedded in the taller, more widely distributed big sage plant community. Whether this represents a preference by kit foxes in Oregon for this habitat type or else reflects greater detectability of foxes and their tracks in low, sparsely vegetated areas is unknown, but DeStefano's findings are consistent with other studies across the geographic range of the kit fox.

Of the 25 kit fox records in the ORBIC database, 8 of the records included brief notes characterizing vegetation in the immediate vicinity of the observation or point of collection. Five of the records described the kit fox location occurring in a salt desert scrub community dominated by shadscale, spiny hopsage, and sagebrush (species unidentified). Two records were in stands of greasewood mixed with rabbitbrush or sagebrush. Two records also noted that the kit fox observation was near stabilized dunes or playa.

Keister and Immell (1994) collected vegetation data along road transects from which they were able to calculate descriptive statistics about plant communities and vegetation structure, thus expanding upon DeStefano's general habitat characterization of the study area. However the study by Keister and Immell (1994) did not further improve upon the knowledge of kit fox-habitat relationships in Oregon.

Community Ecology

Competition & Predation

Multiple studies have demonstrated that coyotes are a significant source of kit fox mortalities through interspecific killing (Cypher and Spencer 1998, Cypher et al. 2000, Arjo et al. 2007, Kozlowski et al. 2008). Coyotes do not often consume kit foxes they kill, so it may be a case of interference competition by coyotes toward kit foxes rather than strictly a predator-prey relationship (Nelson et al. 2007). The two species have overlapping food preferences which results in the potential for coyotes to limit the ability of kit foxes to meet their metabolic demands for survival and reproduction. However, resource partitioning generally permits kit fox populations to successfully coexist in the same environments. There is evidence that kit foxes alter their activity patterns and move to areas where prey are less abundant to avoid contact with coyotes (Nelson et al. 2007, Kozlowski et al. 2008) and kit foxes may also shift the types of prey selected when coyotes limit the availability of preferred species (Arjo et al. 2007).

Red foxes (*V. vulpes*) use dens when rearing pups and have a high dietary overlap with kit foxes which indicates the potential for resource competition (Clark et al. 2005). In California, movement patterns of San Joaquin kit foxes suggested avoidance behavior when near red foxes. However, red fox abundance and distribution may be suppressed by interactions with coyotes to the benefit of kit foxes where all three species co-occur (Clark et al. 2005).

Other predators of kit foxes include bobcats (*Lynx rufus,* Benedict and Forbes 1979), badgers (*Taxidea taxus*, Standley et al. 1992), and raptors.

Coyote detected at one of the camera stations in Malheur County, Oregon.

Diseases and Parasites

Parasites and diseases usually do not seem to play a significant role in limiting kit fox populations (Cypher et al. 2003) although individual foxes are host to fleas, lice, helminths, protozoa, and a variety of other parasites (Egoscue 1956, McGrew 1979). In the southwest and in Utah, the most common flea found on kit foxes is *Pulex irritans* (Egoscue 1962, Turlowski 1974, Harrison et al. 2003). Heavy flea infestations have been reported to be the primary cause of den abandonment (Egoscue 1962). Harrison et al. (2003) noted that all species of fleas found on kit foxes in New Mexico are capable of carrying plague and urged precaution to trappers and biologists handling wild foxes, although 11 San Joaquin kit foxes tested for plague in a region where the disease is widely distributed tested negative for antibodies against *Yersinia pestis* (McCue and O'Farrell 1988).

In a serological survey for diseases of the San Joaquin kit fox (n = 85, 1981-1982; n = 29, 1984), the most frequently found antibodies against pathogens were: canine parvovirus, canine hepatitis virus, and canine distemper virus; none of the foxes displayed clinical symptoms of these or other diseases to which they had an antibody response (McCue and O'Farrell 1988).

Other investigations in have discovered rabid kit foxes (Standley et al. 1992) and this disease probably contributed to a kit fox population decline in California (White et al. 2000).

Conservation

Threat Assessment for Kit Fox Populations in Oregon

Habitat Loss & Degradation

Habitat loss, fragmentation, and diminishing habitat suitability are reportedly among the most serious threats to kit fox populations across the geographic range of the species. The loss or alteration of habitat can lead to declines in prey abundance, decreased availability of den sites, and affect the interspecific relationships of kit foxes with other wildlife species.

Urban Development

Urbanization is one of the principle causes for the loss of kit fox habitat in Colorado and California, whereas in Oregon, the geographic range of the kit fox is confined to the most unpopulated region of the state. The Northern Basin and Range in Oregon is dominated by publically owned lands (i.e., BLM, Oregon Department of State Lands) and scattered, large, private ranches. The area has a human population density of 1/8.29 mi^2 (1/21.5 km^2) and contains only one incorporated city (i.e., Jordan Valley, 2010 population = 181) within 50 miles of a known kit fox location (unpublished GIS analysis conducted by OWI). The threat of habitat loss due to urban development in southeast Oregon is negligible in the foreseeable future.

Energy Development & Mining

Oilfield developments in California may be posing both direct risks to San Joaquin kit foxes through human disturbance at these sites and indirect risks primarily due to habitat degradation (USFWS 2010). Solar facilities as large as 13 mi^2 (33.7 km^2) are planned or under construction in California representing additional habitat losses and are potential movement barriers (USFWS 2010). The cumulative effects of these industrial developments combined with habitat loss caused by agriculture and urbanization represent the most serious threat to the persistence of San Joaquin kit fox populations (USFWS 2010).

Most of the known geographic range of the kit fox in Oregon overlaps possible and potentially leasable oil, gas, and geothermal resources (BLM Vale District 2002, BLM Andrew/Steens ROD/RMP 2005). There is no existing infrastructure for extracting oil or gas within the range of the Oregon population of the kit fox and little exploration has occurred to date. The situation could change in the future when higher gas and oil prices trigger greater interest in exploring the petroleum resources of southeastern Oregon.

There is a plan by an energy company to mine and process uranium at a 450 ac (182 ha) site in the BLM Vale District near the Nevada border, although the plan is "on hold" until issues involving sage-grouse (*Centrocercus urophasianus*) protection are resolved (BLM Energy Report 2013).

The BLM issued a finding of No Significant Impact in 2013 that will allow exploration of geothermal resources on the BLM Burns and Vale Districts (BLM Sage-grouse RMP/EIS 2013). An area of high geothermal resource potential has been mapped on the BLM Vale District that is approximately bounded by Coyote Lake to the north, Highway 95 to the east, and the Trout Creek Mountains to the south and west (Map MIN-2, BLM Vale District 2002). This area includes the south-central portion of the known range of the kit fox in Oregon (Fig. 4). At present there are no geothermal facilities near the known range of the kit fox (BLM Energy Report 2013), but exploration for commercial geothermal development is expected to intensify in the region during the next 10-15 years. However, a portion of the mapped geothermal potential resource is unlikely to be developed in the foreseeable future because it lies within BLM wildness study areas (Fig. 4).

There is also increasing interest in developing wind energy facilities in eastern Oregon. The BLM has granted rights to conduct tests and potentially develop a 13,903 ac facility at Red Mountain and other projects have been proposed at sites within the known range of the kit fox (BLM Energy Report 2013).

There currently are diatomaceous earth mining operations in the BLM Burns and Vale Districts and a greater interest in mining this and other locatable minerals (e.g., perlite, sunstone, bentonite) is forecast in the future (BLM Draft RMP/EIS 2013).

Nine of the 10 stations where kit foxes have been detected during the 2012-2014 camera survey are on BLM-administered lands. The greatest risks posed by energy development and mining activities are the increased human presence on remote lands occupied by kit foxes, potential loss of den sites, and habitat degradation. However, all but two of these stations are in designated BLM wilderness study areas which will limit the disturbance permitted around crucial resource sites, such as kit fox dens (pers. comm. Matt Obradovich, BLM Burns District).

Grazing

Livestock grazing has been one of the most widespread land uses across the arid regions occupied by the kit fox. Livestock can significantly alter the composition and structure of shrubsteppe vegetation and uncontrolled grazing during the early twentieth century contributed to the degradation of rangelands in the Northern Basin and Range ecoregion of Oregon (ODFW 2006). However, the impact of grazing on kit foxes is complex and not well understood.

Kit foxes are most vulnerable to coyotes in tall vegetation and Laughrin (1970 cited in USFWS 2010) suggested that overgrazing on annual grasslands in California probably improved habitat suitability for the San Joaquin kit fox by decreasing plant heights.

Diamond et al. (2009) demonstrated that targeted cattle grazing can remove up to 90% of cheatgrass biomass, resulting in a decreased potential for catastrophic wildfire and presumably, greater habitat security for kit foxes. However, grazing also has the potential to promote the spread of cheatgrass when the abundance of native bunchgrasses is reduced and cattle cause excessive disturbance to biological soil crusts (Reisner et al. 2013).

Grazing can affect the availability of the kit fox's prey base by changing the composition and structure of vegetation. Kangroo rats, an important prey item for kit foxes across their range, prefer open areas with sparse ground cover, possibly because such conditions favor their saltatory locomotion (Goldingay et al. 1997). Based on their research review, Germano et al. (2011) stated that kangaroo rats generally respond positively to grazing. However, interspersed patches of denser vegetation may offer greater food abundance for kangaroo rats (Williams 1985 cited in USFWS 2010), so the effects of grazing on kangaroo rat abundance are likely to be mixed and dependent on site-specific conditions (USFWS 2010).

The known range of the kit fox in Oregon is encompassed by three BLM grazing allotments on the Andrews Resource Area of the Burns District (i.e., Alvord, Tule Springs, and Pueblo Lone Mountain) and five allotments on the Jordan Resource Area of the Vale District (i.e., Saddle Butte, Sheepheads, Coyote Lake, Crooked Creek, Bowden Hills, Barren Valley, 15-Mile Community, and Whitehorse Butte). Livestock grazing on these allotments is mostly confined to winter months because of the marginal capability of the land to grow forage in drier seasons. Livestock grazing may not be permitted at all on BLM allotments during some years when there was only marginal vegetation growth during the previous season (pers. comm. Matt Obradovich, BLM Burns District). The most recent assessments of the BLM grazing allotments indicate that they are in satisfactory condition and are static at that level or are demonstrating an improving trend (BLM Andrews/Steens RMP/EIS 2005, BLM Southeastern Oregon RMP/EIS 2001).

There are three wild horse Herd Management Areas (HMAs) on the BLM Burns and Vale Districts that overlap the area of kit fox detections. The Appropriate Management Level (AML) for these three HMAs is between 459 and 892 horses (pers. comm. Matt Obradovich, BLM Burns District). The herds of wild horses and burros pose a potentially serious threat to the ecological health of rangelands because of their capacity to reduce forage availability for native herbivores, alter the vegetation structure and wildlife habitats, and spread noxious weeds (BLM HMA Environmental Assessment 2011). BLM manages the potential threat posed by wild horses and burros through a robust monitoring program and removing horses and burros when population management levels are exceeded.

The entire known geographic range of the kit fox in Oregon is encompassed by Low Density or Core Area habitats for the greater sage-grouse (BLM Sage-grouse RMP/EIS 2013), whose federal listing status as Candidate species for listing as Threatened or Endangered has greatly elevated attention being given to the conservation of shrubsteppe habitats in Oregon. It seems likely that livestock and wild horse grazing on public lands will be managed even more closely in the future so as to protect the sage-grouse and may have indirect, but beneficial effects for the kit fox.

In other regions, stock tanks and other water supplies for livestock are suspected of permitting coyote and red fox populations to persist on desert landscapes that they would otherwise be unable to occupy, thereby affecting spatial distribution and habitat use of kit foxes (Arjo et al. 2007, USFWS 2010). It is unknown whether artificial water supplies are facilitating a range expansion of coyotes in Oregon.

Water tanks may allow coyotes to encroach upon the most arid habitats used by kit foxes.

Invasive Weeds & Juniper Encroachment

Non-native plant invasions and noxious weeds are among the most serious management issues on shrubsteppe and grassland habitats of the Great Basin and in California. The conversion of native shrub communities to extensive stands of non-native, annual grasslands is reported to be the primary threat to kit fox populations on the Dugway Proving Ground, Utah (Arjo et al. 2007). In California, invasive, non-native plants have altered vegetation structure in kit fox habitats and may be affecting prey availability and the ability of kit foxes to compete with coyotes (USFWS 2010).

In Oregon, invasive plant species and altered wildfire regimes are the two most significant factors contributing to the loss and degradation of sagebrush habitat in the Northern Basin and Range ecoregion (ODFW 2006). It is estimated that the total distribution of noxious weeds is currently expanding at a rate of 12% annually on BLM-administered lands (BLM 2010). The most serious problem is a complex of annual grasses composed of medusahead (*Taeniatherum caput-medusae*), cheatgrass, and North Africa grass (*Ventenata dubia*) which is estimated to occur on 1,000,000 acres of BLM-administered lands in eastern Oregon and which have a very high potential for expanding their populations (BLM Draft RMP/EIS 2013). Monotypic stands of non-native crested wheatgrass (*Agropyron cristatum*) are also widespread in the Northern Basin and Range, a legacy of plantings started during the 1960s to increase livestock forage and restore severely degraded rangelands. Crested wheatgrass continues to be used in some rangeland restoration projects because it is less expensive, more available, and establishes with greater success than native bunchgrasses (Davis et al. 2013).

Non-native plant invasions pose three types of threats to kit foxes in Oregon. The first is the potential to alter the composition of small mammal communities and reduce prey availability for kit foxes. Small mammal diversity is lower in monotypic grasslands than in shrublands (Nelson et al. 2007) and the abundance of kangaroo rats declines when their open habitats are invaded by non-native annual grasses (Arjo et al. 2007). Secondly, non-natal denning habitat is characterized by sparse, short vegetation which allows kit foxes to detect predators at a distance. Tall stands of non-native grass can interfere with the ability of kit foxes to detect and avoid predators (Warrick and Cypher 1998, Nelson et al. 2007). Finally, invasions of non-native, annual grasses can significantly alter the wildfire regime in shrubsteppe plant communities and have contributed to a number of very large fires in the Northern Basin and Range ecoregion (BLM Draft Sage-grouse RMP/EIS 2013). Non-native, invasive grasses become quickly established in burned areas and perpetuate the altered disturbance regime (See *Wildfire* section below for further details).

The distribution of western juniper (*Juniperus occidentalis var. occidentalis*) in Oregon has expanded more than 400% between 1936 and 1988 (Gedney et al. 1999). There is presently more than 2.6 million ha (6.4 million ac) of juniper woodland in Oregon, causing significant fragmentation of sagebrush plant communities (Rowland et al. 2008). The reasons for the expansion are complex: past overgrazing, fire suppression, wetter than average conditions during the late-nineteenth and early-twentieth centuries, and increases in atmospheric CO_2 are reported to be contributing factors (Rowland et al. 2008). Juniper can dominate the sites it invades and exclude shrubs and other understory vegetation, thus representing a threat to kit fox habitats.

Wildfire

A history of fire suppression and invasions of non-native, annual grasses have altered the fire regime in southeast Oregon resulting in larger fires and more frequent fire return intervals (BLM Draft Sage-grouse RMP/EIS 2013). Based on a GIS analysis of BLM fire history data, OWI found that approximately 3700 mi^2 (9583 km^2; 16%) of the Northern Basin and Range ecoregion in Oregon has burned since 2000. The recovery of shrubsteppe plant communities can take long as 100 years on some sites after wildfire (Cooper et al. 2007). However it remains doubtful that recovery can be achieved once cheatgrass has become established without a substantial restoration effort that can interrupt the cycle of wildfire followed by further cheatgass expansion.

Wildfire regimes have been altered across the entire shrubsteppe ecosystem of eastern and central Oregon, but the largest fires during the last 10 years have occurred in southeast Oregon (BLM Draft Sage-grouse RMP/EIS 2013). The Long Draw Fire of 2012 burned more than 550,000 acres in the BLM Burns and Vale Districts, the largest fire in Oregon for more than 100 years (BLM 2013). These large fires have occurred in close proximity to known kit fox sites (Fig. 5) and possibly represent the most significant factor limiting the distribution and suitability of their habitats.

The Long Draw Fire burned more than 550,000 acres in Malheur County, Oregon. Photo taken two years after the fire.

Predator Control and Furbearer Trapping

Measures to control wildlife damage by coyotes, red foxes, badgers, and other mammals have unintentionally resulted in kit fox mortalities. Non-selective application of poisons such as Compound 1080 (sodium fluoroacetate) resulted in widespread mortalities of non-target animals in the past, including kit foxes (Egoscue 1962, McGrew 1977). The use of Compound 1080 is now restricted to protection collars worn by livestock which deliver the poison only when a predator bites the neck of the prey animal, thereby improving selectivity of method. The M-44 device was developed as another approach to deliver poison with greater species selectivity. The M-44 delivers a dose of sodium cyanide when a predator pulls on a baited ejector placed in the ground. There is still the potential for the M-44 to kill non-target animals attracted by the bait to the device. The risk is reduced by restricting the use of the M-44 to state and federal wildlife damage control personnel or licensed private contractors trained in placing the device so as to maximize its selectivity.

Wildlife damage control on the BLM Burns and Vale Districts is administered by the USDA Animal and Plant Health Inspection Service (APHIS) Wildlife Services (WS) program under a memorandum of agreement between the agencies. WS activities on the BLM districts are coordinated through annual work plans which describe the methods by which the WS will conduct interventions in areas where livestock predation is foreseen (Planned Control Areas) as well as in areas where problems are emerging (Non-Planned Control Areas). WS work plans identify specific measures to avoid harming kit foxes while conducting operations within their geographic range, including adjusting pan-tensioning devices on leg-hold traps to minimize the chance of a kit fox triggering the trap and not using M-44 devices within the range of the kit fox (APHIS WS 2012). Coyote control by the WS within the range of the kit fox is primarily conducted by aerial shooting (pers. comm. Scott Torland, ODFW).

The species of primary economic interest to furbearer trappers in southeastern Oregon is the bobcat because of high pelt prices (Hiller 2011). Bobcats typically occur at very low densities in the arid habitats of kit foxes and trappers will generally focus their effort in areas where there is a greater likelihood of success. Furthermore, there is no legal market for kit fox pelts and trappers will try to avoid incidental captures of non-target species in an effort to leave their traps operational until encountered by a bobcat. Therefore, licensed furbearer trappers are unlikely to pose a significant threat to kit foxes.

Recreational Hunting

Coyotes are classified as a "predatory animal" and an "unprotected mammal" in Oregon and can be legally harvested year-round. Statistics compiled by the ODFW furbearer program indicate that Malheur and Harney Counties have the highest levels of coyote harvest in the state, with 835 and 486 coyotes taken respectively during 2010-2011 (Hiller 2011). These statistics do not include coyotes that were taken during WS predator control programs or for other wildlife damage purposes.

There is widespread interest in shooting coyotes as a recreational sport. Coyote shooting competitions have been held near Burns (Bend Bulletin, 01/14/2015) and in Harney County (Oregon Hunters Association 2013). Unlike WS predator control agents, recreational hunters probably are unaware of the range of the kit fox, its status as a threatened species in Oregon, nor have training in distinguishing juvenile coyotes from kit foxes. Coyote pups can appear very similar to kit foxes (Clark 2010), so indiscriminate shooting of canids by hunters may pose a moderate threat to kit foxes. However, recreational coyote hunting may reduce the level of competition by coyotes on kit foxes. At present, there is insufficient information to assess the risk or benefits posed to kit foxes

Interspecific Competition

Coyotes are the primary competitor of kit foxes and are one of the most significant causes of kit fox mortality across the range of the species. No recent estimates of coyote population status or trends for southeast Oregon were found during this review. Hiller (2011) included information that showed harvest levels of coyotes were higher in southeast Oregon than any other region of the state, but the harvest level may simply reflect a greater effort to shoot and trap coyotes in that region. Detections of coyotes during the 2012-2014 camera survey indicate the species is relatively common within the known range of the kit fox (Fig. 6). Most of the known kit fox range in Oregon is open to winter grazing and water tanks are widely dispersed throughout the area. Coyotes are known to use livestock water supplies in other regions of the kit fox range, whether coyotes are exploiting this manmade resource in Oregon is unknown.

Coyotes undoubtedly occur across the geographic range of the kit fox in Oregon, but the level of competition or mortality risk to foxes is unknown. Red foxes are an important competitor of kit foxes where both species co-occur on agricultural lands. Keister and Immell (1994) noted that red fox populations were expanding at that time near Ontario, Vale, and Baker, Oregon with occasional sightings in Harney Valley. The present status of the red fox in southeast Oregon is unknown, but the species is not well adapted to the very arid habitats of the kit fox in Oregon and red foxes were not detected at any of the 2012-2014 camera stations.

Recovery efforts for the gray wolf (*Canis lupus*) should allow for the species to expand its range across much of Oregon during the next two or three decades. Whether the gray wolf can persist in the arid regions of southeast Oregon largely depends upon future prey availability (i.e., mule deer in eastern Oregon) and human tolerance for its presence (ODFW Wolf Plan 2010). The presence of the wolf is expected to alter existing interspecific relationships among carnivores and species such as the red or kit fox might benefit as coyotes emigrate or engage in avoidance behaviors (ODFW Wolf Plan 2010).

The complexity of interspecific relations among the kit fox and other carnivores makes it difficult to assess the potential threat of coyotes or other competitors in Oregon. There is no research from the northern geographic range of the kit fox and inferences based on information from California or Utah populations would be untenable.

Roads and Off-Road Vehicles

Traffic-related deaths have been noted as a minor source of kit fox mortality on rural landscapes (Egoscue 1962, Cypher et al. 2000, Koopman et al. 2000, Arjo et al. 2007, Cypher et al. 2009) and may significantly limit kit fox populations in urban areas (Bjurlin et al. 2005). The threat is greatest on high-speed, arterial roads even when kit foxes cross local roads at a proportionally higher frequency (Bjurlin et al. 2005).

Although the known geographic range of the kit fox in Oregon is traversed by hundreds of miles of roads, most are unimproved with long segments containing natural impediments to driving at high speed (e.g., rocky surfaces, washboard surfaces). These backroads are used primarily by ranchers, BLM personnel, and hunters during the day. State Highway 78, U.S. Highway 95, and some segments of Whitehorse Ranch Road, do support greater volumes of high-speed traffic and are the roads probably posing the greatest risk of traffic-related mortality to kit foxes in Oregon. Keister and Immell (1994) reported that three kit foxes were known to have been killed on Highway 95 during the two years immediately previous to their study. A kit fox killed on Highway 78 was discovered in January 2015 (pers. comm., Phillip Milburn, ODFW). However, the degree of risk posed by vehicles cannot be known given the lack of data to support an analysis.

The extensive network of unimproved roads also expands public access to remote

BLM-administered lands and may increase the threat to kit foxes from indiscriminate shooting by predator hunters. Morrell (1972) stated that illegal shooting may have been the greatest threat to the population of San Joaquin kit foxes he monitored.

Habitats occupied by kit foxes may be impacted by off-highway vehicles (OHV) because of their potential to disturb soils and vegetation, destroy burrows of kit fox prey species, and cause direct damage to kit fox dens. OHVs also expand public access to remote lands, thereby increasing the risk that human presence will interrupt kit fox activities, as well as making kit foxes more vulnerable to illegal shooting (Jensen 1972, *in* McGrew 1977). Rodrick and Mathew (1999) identified off-road traffic as the most serious threat to the population of kit foxes they studied in New Mexico.

Public OHV use is restricted to designated roads across most of the known range of the kit fox in Oregon under the transportation management plans by the BLM Burns and Vale Districts or because of their status as wilderness study areas (BLM Andrews/Steens RMP/EIS 2005, BLM Southeastern Oregon RMP/EIS 2001). The BLM has dedicated several large areas for recreational OHV use in eastern Oregon, but none are in the known geographic range of the kit fox in Oregon. OHV use is predicted to expand as improved technology permits vehicles to travel greater distances and vehicle costs decrease (BLM Draft Sage-Grouse RMP/EIS 2013).

Climate Change

Recently there has been intense interest in the potential effects of climate change on vegetation patterns and disturbance dynamics in the Pacific Northwest. Climate change studies for the Northern Basin and Range and Columbia Plateau physiographic provinces are unanimous in forecasting increasing average annual temperatures, with most models predicting the greatest temperature rise during summer months (OCCRI 2010, Rogers et al. 2011, Michalak et al. 2014, Mote et al. 2014, Creutzburg et al. 2015).

There is less concurrence among the modeling studies regarding predicted changes in precipitation patterns across the Northern Basin and Range and Columbia Plateau. However most studies forecast even less summer rainfall in this already arid region (Michalak et al. 2014, Mote et al. 2014) or more precipitation occurring in winter (OCCRI 2010, Rogers et al. 2011, Cruetzburg 2015), thereby making the difference between the winter/wet season and summer/dry season more pronounced than in the existing climatic regime.

Atmospheric CO^2 levels are projected to continue rising in the foreseeable future (IPCC 2007) which may increase the efficiency by which some plants can utilize soil moisture, thereby promoting the expansion of their populations or allowing them to persist under increasing drought stress (Morgan et al. 2004).

The modeling studies vary in their predictions for the response of plant communities to climate change. However, several studies have forecasted an expansion of woodland and forest vegetation into areas currently dominated by shrub steppe habitat types as a consequence of warmer temperatures and greater precipitation in winter (Rogers et al. 2011, Michalak et al. 2014, Creutzburg et al. 2015). Modeling studies also indicate that more productive, moist shrub steppe vegetation types will increase while dry shrub steppe types will contract (Michalak et al. 2014, Creutzburg et al. 2015).

Research by Chambers et al. (2007), Bradley (2009), and Creutzburg et al. (2015) indicates that climate change is likely to exacerbate invasions of exotic grasses across shrub steppe plant communities, which may promote more severe wildfire regimes in southeast Oregon in the future (Creutzburg et al. 2014, Creutzburg et al. 2015).

To examine the relationship between existing climate patterns and kit fox distribution in Oregon, I mapped known fox locations detected during the 2012-2014 kit fox camera survey and by DeStefano (1990) with an overlay of the Köppen-Geiger climate classification (Kottek et al. 2006). The resulting map indicates that all of the kit fox observations occur in the dry steppe class (Köppen-Geiger class *BSk*, Fig. 7), the most arid region in Oregon. Some climate change projections indicate that dry steppe and salt desert habitat types will transition into more mesic type plant communities toward the end of the twenty-first century (Creutzburg et al. 2014, Creutzburg et al. 2015).

The consequences of climate change for the kit fox in southeastern Oregon cannot be predicted with certainty given the lack of information about the ecology of the kit fox in the state and the range of alternative futures that are predicted by different climate-vegetation modeling studies. Nevertheless, most of the research to-date forecasts significant increase in wildland fire and degradation of shrub steppe plant communities driven by exotic grass invasions and encroachment by juniper woodlands in the Northern Basin and Range ecoregion. These present potentially serious threats to the quality and amount of habitat for kit foxes in Oregon and may alter food availability and the kit fox's relationships with its competitors.

Approaches to Kit Fox Conservation

Existing Management and Conservation Efforts

In 1983, the BLM, USFWS, Oregon Wildlife Commission, and Game Division of Oregon State Police signed a memorandum of understanding (MOU) titled, *Concerning Management of Kit Fox (Vulpes macrotis) and Habitats Thereof in Southeastern Oregon* and a *Kit Fox Habitat Management Plan* (MOU 1983). The MOU and management plan delineated a mapped management area, characterized potential threats to the kit fox on the BLM Vale District, and described a plan that was principally designed to minimize incidental kit fox mortality from furbearer trapping, predator control efforts, as well as an effort to decrease the coyote population in the area. The current BLM resource management plan for the Vale District refers to the kit fox management plan (p. 88, BLM SEO RMP 2001) and recent WS work plans (e.g., APHIS WS 2012) generally follow the management prescriptions described in the 1983 kit fox MOU. The kit fox is a BLM sensitive species which also affords the species elevated consideration when the BLM is preparing environmental assessments.

The 2006 Oregon Conservation Strategy created a network of Conservation Opportunity Areas (COAs), stating that, "focusing investments on priority landscapes can increase likelihood of long-term success over larger areas, improve funding efficiency and promoting cooperative efforts across ownership boundaries" (p. 21, ODFW 2006). COAs have a strong influence on where state and non-profit grant programs distribute conservation grants. None of the mapped COAs overlap the core geographic range of the kit fox, thereby creating a disadvantage toward proponents of habitat restoration or management projects that could benefit the kit fox.

The background review conducted for this conservation assessment did not discover any past or ongoing effort dedicated to the conservation of the kit fox or its habitats by the state or private, non-profit organizations, other than the support by ODFW for the 2012-2014 camera survey and the kit fox resource selection study recently begun by Dr. Tim Hiller.

Kit Fox on State Lands

Because the listing of the kit fox as state threatened preceded the Oregon Endangered Species Act Amendment of 1995, there was no state conservation assessment or survival guidelines prepared for the kit fox. As a consequence, there has been no analysis of the potential contributions that the Oregon Division of State Lands (DSL) can make toward kit fox conservation. DSL administers one large tract in Malheur County on which a kit fox was detected during our 2012-2014 camera survey, as well as several smaller parcels on which kit foxes may potentially occur.

Research and Monitoring

The research review conducted for this conservation assessment revealed very little information about the kit fox from the northern portions of the species' geographic range (i.e., Nevada, Idaho, and Oregon). Consequently, it was necessary to draw upon kit fox research from other regions and from a different subspecies (V. *m. mutica*) than occurs in Oregon. The degree to which these studies accurately represent the natural history of Oregon kit foxes is uncertain.

The sagebrush steppe region is being impacted by altered wildfire regimes, noxious weed invasions, and climate change. There is a crucial need to better understand how the kit fox and other wildlife of the Oregon desert are likely to respond to these major environmental stressors so wildlife agencies and land managers can develop strategies to conserve threatened species and their habitats. Furthermore, there is likely to be greater interest in energy projects and mining in the Northern Basin and Range ecoregion that will prompt environmental impact assessments by the BLM. Given the paucity of information about kit fox distribution and habitat use in Oregon, there is limited capability to analyze the impacts of projects on kit fox populations and their habitats.

Kit fox den discovered in 2015 as the result of monitoring performed by ODFW.

The following is a list of research and monitoring priorities based on factors that are potentially limiting the kit fox population in Oregon that were identified during the above threat assessment:

Geographic Range & Distribution

The distribution of the kit fox in Oregon has been described from less than 50 known locations of the species in the state. Understanding the types of environmental stressors and human land uses affecting the kit fox depends on reliable knowledge about where the species occurs.

Resource Selection

There is significant variation in physiography, vegetation patterns, and small mammal communities across the Great Basin that affect the availability of resources on which kit foxes depend. Almost everything that is known about the prey of the kit fox, its species-habitat relationships, and den site selection is drawn from research conducted in the central and southern portions of the geographic range. The abundance and survival of kit foxes are especially sensitive to the availability of food, which is probably threatened by the cycle of cheatgrass invasion followed by wildfire on the shrub steppe. Research that can elucidate resource selection by the population of kit foxes inhabiting Oregon is needed to fully understand the effects of altered disturbance regimes and human land use on the species.

Dr. Tim Hiller (Mississippi State University) and ODFW implemented a study of resource selection by kit foxes in Oregon during 2014 to address some of these information gaps. This study is ongoing as of June 2015.

Monitoring Land Uses

OHVs have been implicated in disturbing the activity of kit foxes in other states and have the potential to damage den sites. OHV may also increase the risk of illegal shooting of kit foxes by improving access to remote areas.

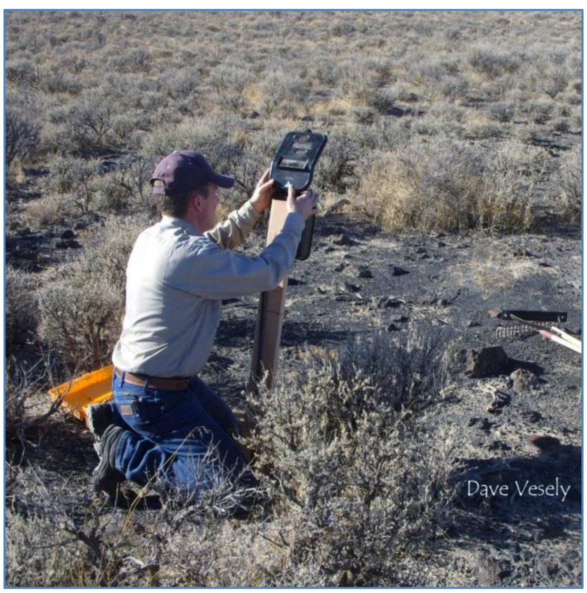
OHV use is expected to increase in southeastern Oregon (BLM Draft Sagegrouse RMP/EIS 2013). Although BLM Burns and Vale District transportation plans generally restrict OHV to designated roads across most of the known range of the kit fox, the extent and remoteness of this area make it challenging to assess the degree of compliance by the public to BLM regulations.

One approach to assess the threat to kit foxes by OHV use is to study patterns of vehicle traffic traveling in the core range of the kit fox by trail camera surveillance or satellite imagery. Cameras could be used to monitor vehicular traffic through kit fox areas and analyze seasonal patterns of access, frequency of access after dark, and number of OHV vehicles transported on road vehicles into kit fox areas. High-resolution satellite imagery may be used to detect off-road OHV trails and large areas of disturbed soils. Such types of data could be used as the basis for a preliminary analysis of public access in the vicinity of kit fox occupied habitats and may be useful for designing interventions to minimize the risk of human disturbance to kit foxes.

Grazing by livestock and wild horses can have beneficial or detrimental effects on kit fox habitats depending on its extent and intensity. Although habitat conditions for prong-horn, elk, sage-grouse, and other wildlife are regularly assessed in BLM allotments, no similar evaluations are conducted for kit fox habitat, at least in part because of an inadequate understanding about what constitute suitable kit fox habitat in Oregon. This again calls to the need for greater research on habitat use by kit foxes in the northern portion of their geographic range.

Furbearer Trapping & Recreational Coyote Hunting

Licensed furbearer trapping probably does not currently pose a significant threat to kit foxes because the distribution of targeted furbearers (i.e., bobcats) seems to have minimal overlap with kit foxes. Nevertheless, the potential risk could be further minimized if information about the threatened status of the kit fox and its geographic range is made available to trappers on websites or as brochures. In addition, information on how to avoid incidental capture of kit foxes could be developed and distributed to increase public awareness. I recommend similar information be disseminated at BLM district offices in eastern Oregon to inform coyote hunters about the presence of the kit fox on lands where they may be hunting.



ODFW staff contributed much of the effort needed for the 2012-2014 kit fox camera survey.

Conclusion

The 2012-2014 camera survey conducted by OWI and ODFW conclusively demonstrated that the kit fox is still present in southeastern Oregon. The camera survey did not result in a substantial expansion of the known geographic range of the kit fox in Oregon, but there certainly remains the possibility that the species is more widespread than the infrequent, scattered sightings indicate. The camera survey did result in the discovery of a kit fox on a tract of land administered by Oregon DSL, as well as on BLM lands.

Habitat loss resulting from agriculture and urbanization has been identified as the most serious threat to kit fox populations in other states, but is unlikely to present a significant risk to the species in Oregon in the foreseeable future. Energy development and mining have had minimal impact on kit fox habitats in Oregon to date, but these industries are expected to take greater interest in the Northern Basin and Range in the near future. Presumably, NEPA (National Environmental Policy Act) procedures that the BLM are required to follow will prompt impact assessments of proposed developments and protect the kit fox where developments can be expected to harm their populations.

Several studies have highlighted the sensitivity of kit fox populations to prey availability, which could be affected by the conversion of shrub-dominated plant communities to non-native, annual grasslands, and the subsequent alteration of the wildfire regime. Climate change is expected to have significant effects on shrub steppe plant communities of the Northern Basin and Range. Available evidence suggests that these interrelated factors: non-native plant invasions, altered wildfire regimes, and climate change represent the most serious threat to the future of the kit fox in Oregon.

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Tim Hiller, PhD, past coordinator of the ODFW furbearer program (now at Mississippi State University) and Philip Milburn, ODFW Ontario District Biologist, were instrumental in expanding the kit fox camera survey far beyond the number of stations that were originally planned for this effort. Tim and Philip have applied for and received additional funding from ODFW to conduct a study of resource selection by kit foxes in southeast Oregon, which undoubtedly will address some of the information gaps about the kit fox population of southeastern Oregon.

More thanks are due to Lindsey Wise of the Oregon Biodiversity Information Center who assisted with preparation of the map used in Fig. 2.

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Oregon Wildlife Institute

The Oregon Wildlife Institute was founded in 2007 with a mission of conserving and enhancing wildlife resources through research, education, and conservation planning. Our emphasis is on making science, management, and education matter.

Figures

Figure 1. Geographic range of the kit fox. Data source: Patterson, B. D., G. Ceballos, W. Sechrest, M. F. Tognelli, T. Brooks, L. Luna, P. Ortega, I. Salazar, and B. E. Young. 2007. Digital Distribution Maps of the Mammals of the Western Hemisphere, version 3.0. NatureServe, Arlington, Virginia, USA.

Figure 2. Known locations of the kit fox prior to 2012. The spatial precision of the locality data has been generalized to the scale of a 36-mi^2 township to protect sensitive kit fox sites. Data courtesy of Oregon Biodiversity Information Center.

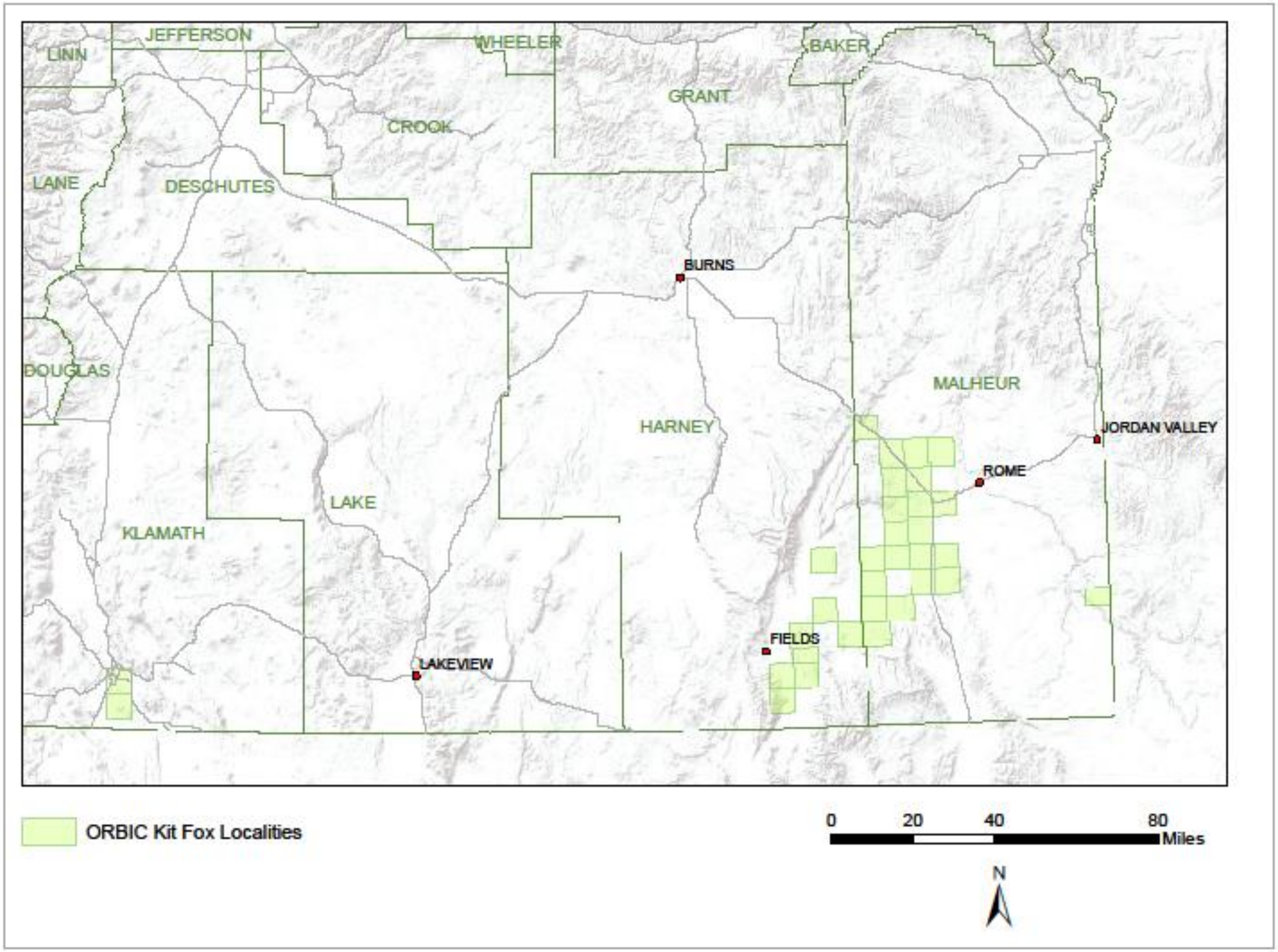

Figure 3. 2012-2014 kit fox camera stations, DeStefano (1990) kit fox detections, and Level III Ecoregions of southeastern Oregon. Ecoregion data source: Oregon Geospatial Enterprise Office.

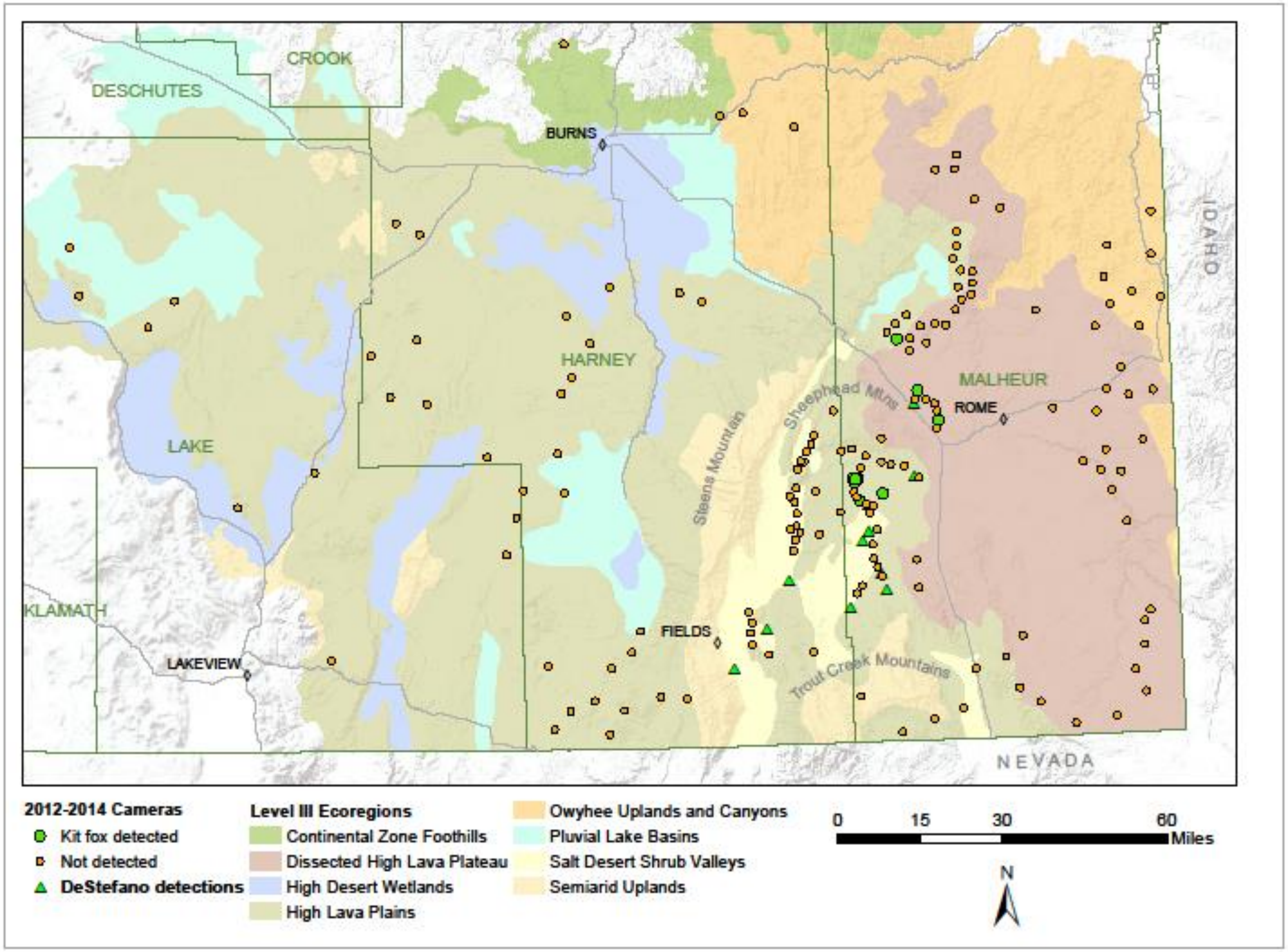

Figure 4. BLM mineral lease stipulations, geothermal resource area, and wilderness study area boundaries in the vicinity of the known range of the kit fox in Oregon. Mineral stipulation descriptions: *Withdrawn*-unavailable of leasable minerals, *Open*-available for leasable minerals with standard stipulations, *OpenNSO*-leasable minerals available, but no surface occupancy, *OpenCSU*-leasable minerals available with special stipulations. Geothermal resource potential area was drawn after Map Min-2 in BLM Vale District (2002).

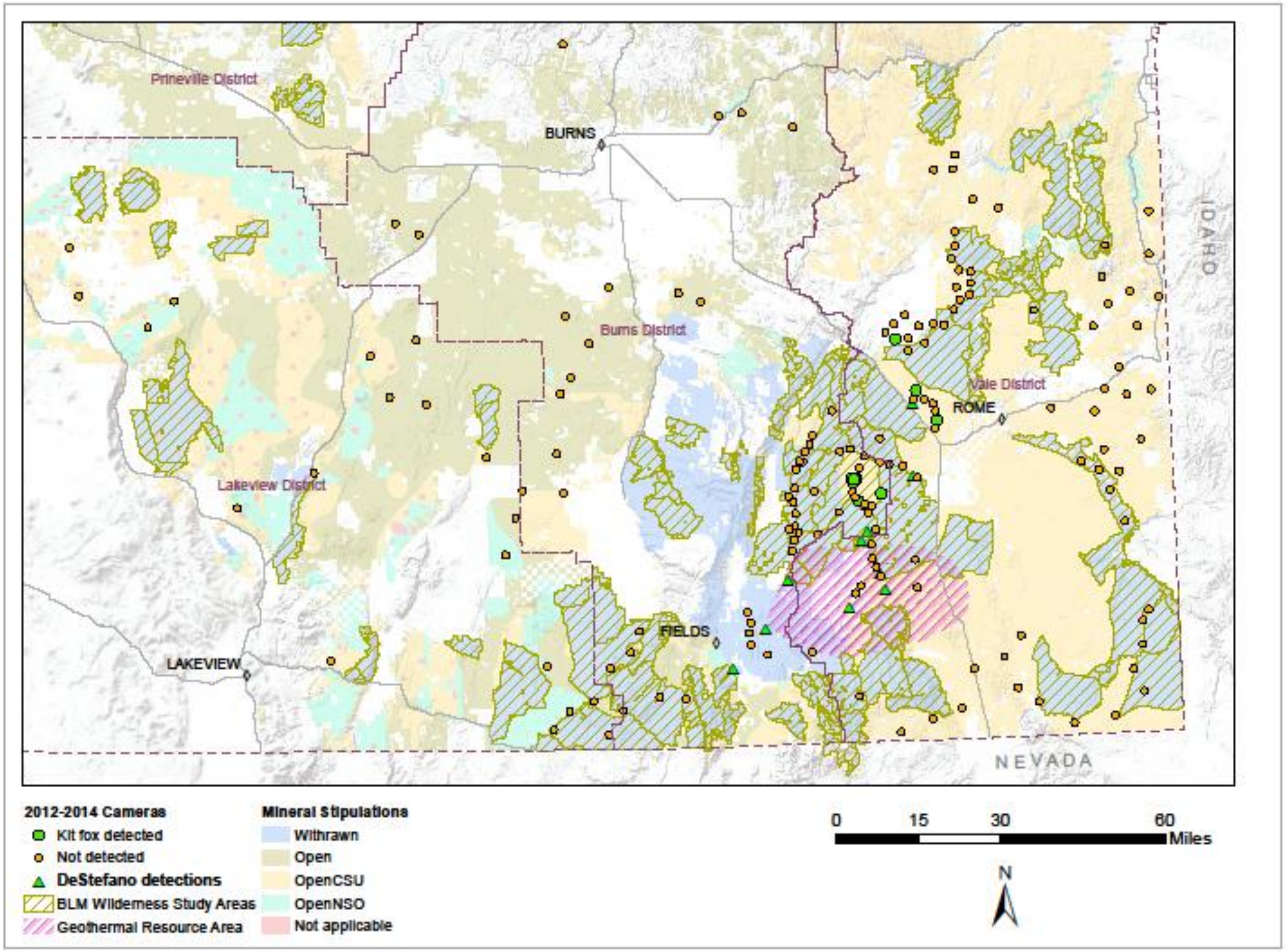

Figure 5. 2012-2014 kit fox camera stations, DeStefano (1990) kit fox detections, and wildfire occurrence since 2000. Data source: BLM Oregon fire history data (GIS database last updated January 30, 2015).

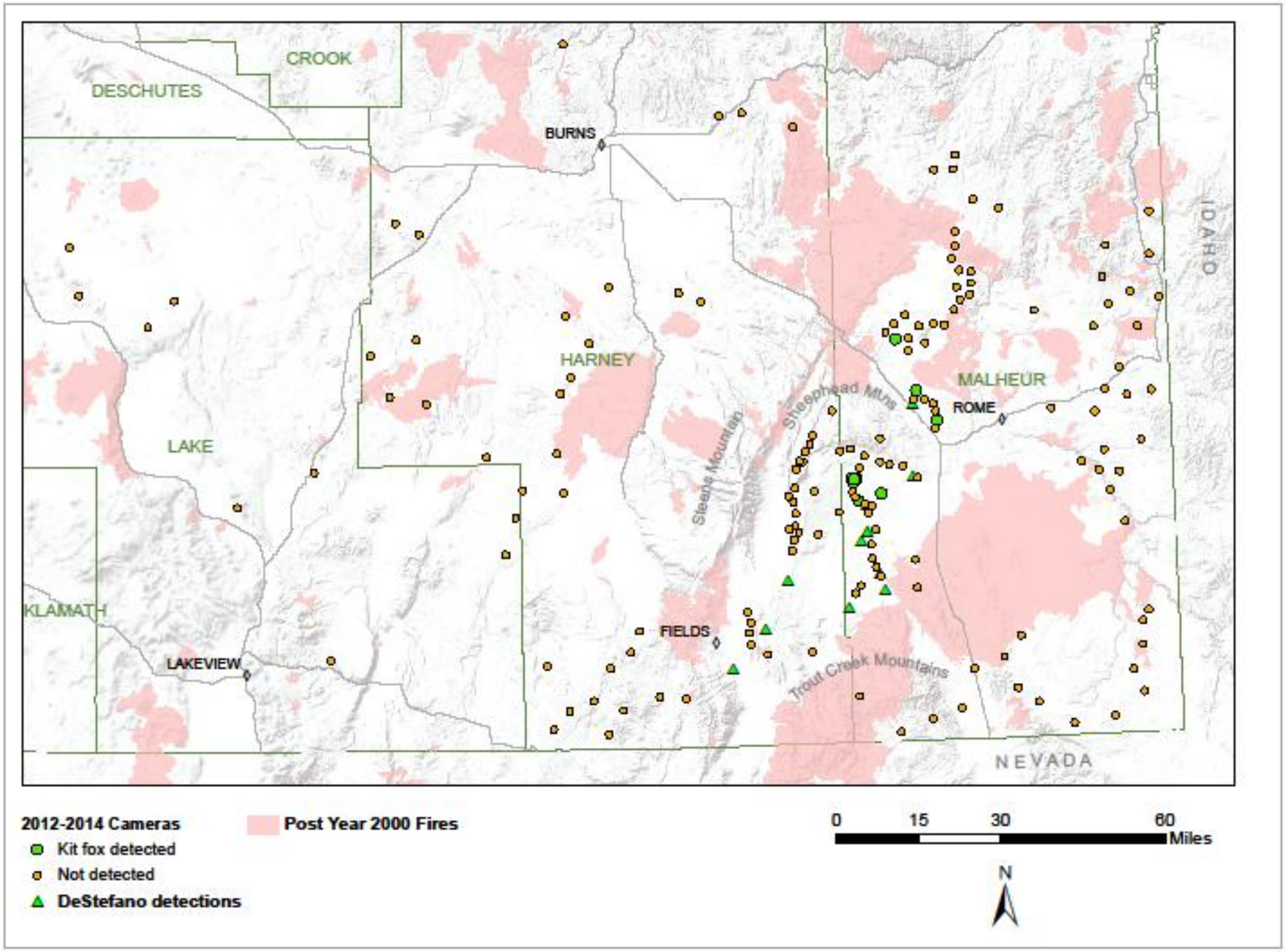

Figure 6. 2012-2014 camera stations with kit fox and coyote presence indicated. Locations of DeStefano (1990) kit fox detections also mapped.

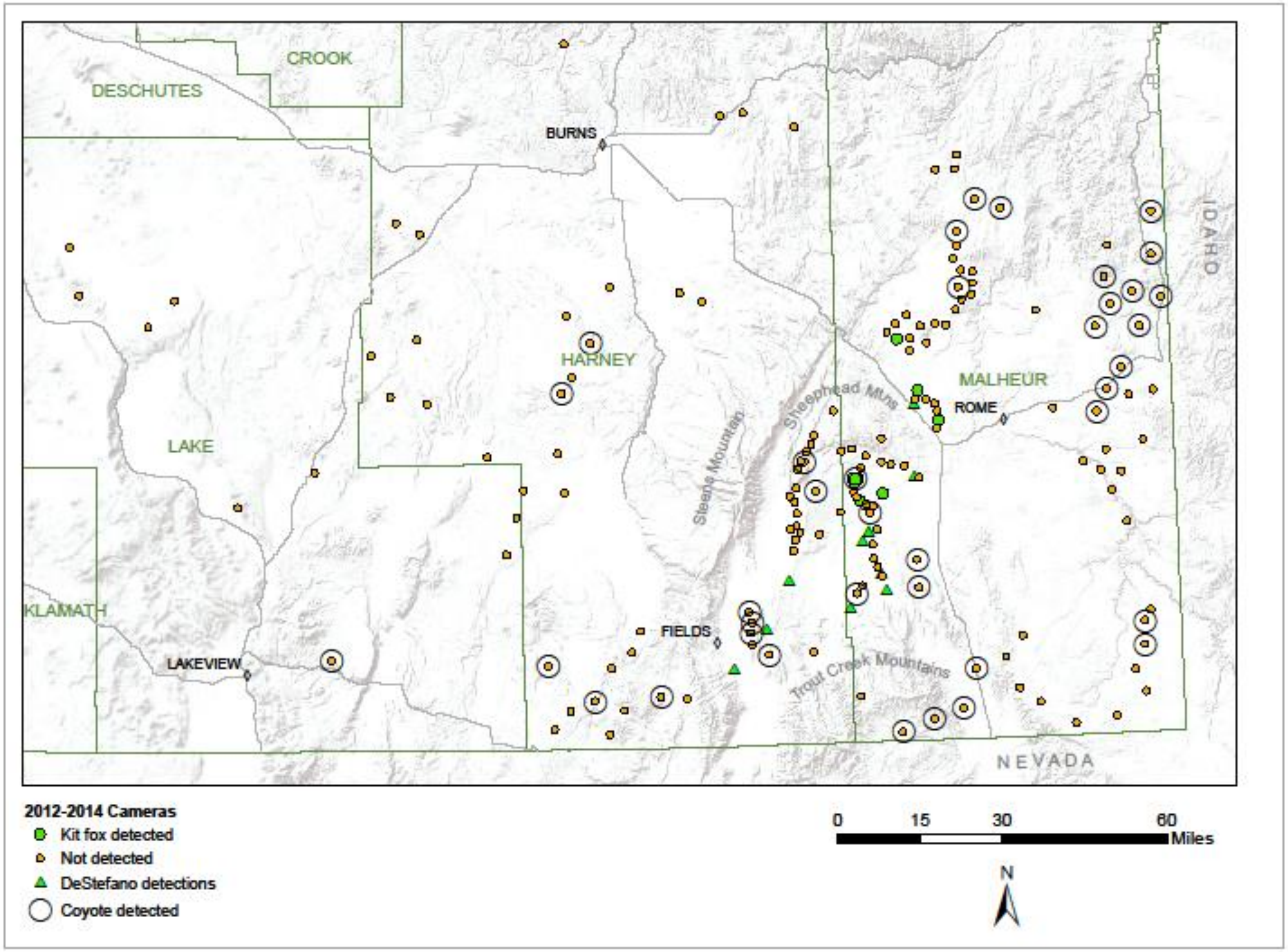

Figure 7. Climatic variation across the region of the 2012-2014 kit fox camera survey. Kit fox detections recorded by DeStefano (1990) are also presented. The climate map is classified according to the Köppen-Geiger classification system (Kottek et al. 2006). Climate data source: State Climate Services for Idaho (1999).