

SPECIES REPORT
Sierra Nevada Red Fox (*Vulpes vulpes necator*)

U.S. FISH AND WILDLIFE SERVICE
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INTRODUCTION

We, the US Fish and Wildlife Service, intend this report to summarize the best available scientific and commercial information available on the Sierra Nevada red fox (SNRF, *Vulpes vulpes necator*). We will use this information as a basis for actions relevant to the Endangered Species Act of 1973, as amended (“Act”, 16 U.S.C. 1531 *et seq.*). Prior to each such action, we will revise the report as necessary to reflect new information that may have become available.

Citations in this report incorporate use of the term “*Id.*”, which is short for “*Idem.*” (meaning “the same”) and indicates that the information provided is supported by the same material as in the previous citation. If the information source is the same, but the page number is different, then the “*Id.*” citation may indicate the new page. For instance: “*Id.* at 540.”

On April 27, 2011, we received a petition from the Center for Biological Diversity (CBD) to list the SNRF as an endangered or threatened species under the Act. We published a 90-day finding in the Federal Register (FR) on January 3, 2012 (77 FR 45), in which we determined that the petition had presented substantial information to indicate that listing may be warranted. As required by the Act, we then undertook a status review of the SNRF, and have incorporated our findings into this report.

ACRONYMS AND SUBSTITUTIONS USED

°C	degrees Celsius
°F	degrees Fahrenheit
ac	acres
Act	The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 <i>et seq.</i>)
CBD	Center for Biological Diversity
CCR	California Code of Regulations
CDFG	California Department of Fish and Game (now CDFW)
CDFW	California Department of Fish and Wildlife (formerly CDFG)
CESA	California Endangered Species Act
EFF	Elokomin fluke fever
<i>et al.</i>	“and others”
ft	feet
FR	Federal Register
GHG	greenhouse gas
ha	hectares
kg	kilograms
km	kilometers
km ²	square kilometers
lb	pounds
m	meters
mi	miles
mi ²	square miles
mm	millimeters

montane fox	any of three mountain dwelling subspecies of red fox: the SNRF, the Cascade red fox (<i>V. v. cascadenis</i>), or the Rocky Mountain red fox (<i>V. v. macroura</i>)
OAR	Oregon Administrative Rules
ODFW	Oregon Department of Fish and Wildlife
ORV	Off road vehicle
OSV	Over-snow vehicle (snow machine)
p.	page
pp.	pages
SNFPA	Sierra Nevada Forest Plan Amendment
SNRF	Sierra Nevada red fox (<i>Vulpes vulpes necator</i>)
SPD	Salmon poisoning disease
U.S.	United States
U.S.C.	United States Code (Codebook of Federal laws)
we	The United States Fish and Wildlife Service

SPECIES AND SUBSPECIES DESCRIPTION

Red foxes (*Vulpes vulpes*) are small, slender, doglike carnivores (3.5 to 7 kilograms (kg), 8 to 15 pounds (lb)), with elongated snouts, pointed ears, and large bushy tails (Aubry 1997, p. 55; Perrine 2005, p. 1; Perrine *et al.* 2010, p. 5). Diagnostic features, by which red foxes can be distinguished from other small canines, include black markings on the backs of their ears, black shins, and white tips on their tails (Statham *et al.* 2012, p. 123). The fur of most red foxes is primarily yellowish to reddish brown (Perrine *et al.* 2010, p. 5). This is the “red” color phase. At least two additional color phases exist: the “cross” phase and the “black” phase (Aubry 1997, p. 55; Perrine *et al.* 2010, p. 5). The cross phase is primarily grayish-brown, with darker lines along the back and shoulders, crossing behind the neck. The black phase (also called the silver phase) is primarily black, with occasional silver guard hairs. Coat color is genetically determined, but all three color phases may occur in the same litter (Aubry 1983, p. 107; Perrine *et al.* 2010, p. 5). Cross and black phases are generally rare, but tend to be more common in cold mountainous areas (Aubry 1997, p. 55; Perrine *et al.* 2010, p. 5).

SNRF average about 4.2 kg (9.3 lb) for males and 3.3 kg (7.3 lb) for females, as compared to the general North American average of about 5 kg (11 lb) for males and 4.3 kg (9.5 lb) for females (Perrine *et al.* 2010, p. 5). This runs contrary to Bergmann’s Rule, a generalization that homeothermic (warm-blooded) animals in colder regions tend to be larger than closely related animals from warmer climates, in order to more easily conserve heat (Ashton *et al.* 2000, pp. 390, 407). The SNRF’s smaller size may be due to reduced abundance of prey at higher elevations (Perrine *et al.* 2010, p. 5).

The SNRF and two other montane subspecies (see **Taxonomic History and Relationship to Other Fox Subspecies**, below) are characterized by specialized adaptations to cold areas (Sacks *et al.* 2010, p. 1524). Such adaptations include a particularly thick and deep winter coat (Grinnell *et al.* 1937, p. 377), and small toe pads (4 millimeters (mm) (0.2 inches (in)) across or less) that are completely covered in winter by dense fur to facilitate movement over snow

(Grinnell *et al.* 1937, pp. 378, 393; Sacks 2014a, p. 30). The SNRF's smaller size may also facilitate movement over snow by lowering weight supported per square centimeter of footpad (Quinn and Sacks 2014, p. 17).

TAXONOMY AND GENETICS

Taxonomic History and Relationship to Other Fox Subspecies

The SNRF was first identified (as a full species, *Vulpes necator*) in 1900 by Clinton Merriam, who recognized a total of ten North American red fox species, and two subspecies (Merriam 1900, pp. 662, 664). In 1936, all North American red fox species and subspecies were redesignated as subspecies of *Vulpes fulva* (Bailey 1936, pp. 272, 317). The SNRF thus became the subspecies *Vulpes fulva necator*. In his Ph.D. thesis, Charles Churcher (1957, p. 200) redesignated all North American red foxes as subspecies of *Vulpes vulpes*, due to the lack of any clear demarcation between *Vulpes vulpes* foxes in Siberia and *Vulpes fulva* foxes in Alaska. The SNRF thus became *Vulpes vulpes necator*. Churcher (1957, p. 202) also eliminated three of the twelve previously recognized North American subspecies: *Vulpes fulva bangsi*, *V. f. deletrix*, and *V. f. kenaiensis*. Churcher (1957, pp. 193, 195, 202) questioned the distinction of the SNRF from the Cascade red fox (*V. v. cascadiensis*), but concluded he lacked sufficient samples to make a determination. Much of this work, including redesignation of *V. fulva* to *V. vulpes*, was published two years later in the *Journal of Mammalogy*, but the article did not mention elimination of the three North American subspecies (Churcher 1959, p. 519).

Aubry (1997, p. 55) considered the SNRF to be one of nine subspecies of red fox in North America, based on the 12 forms identified by Merriam (1900, pp. 662, 664) minus the three eliminated by Churcher (1957, p. 202). However, Hall (1981, p. 938) continued to recognize *Vulpes vulpes kenaiensis*, leaving the SNRF as 1 of 10 North American subspecies. A recent conservation assessment of the SNRF, conducted for the U.S. Forest Service, adopted Hall's position (Perrine *et al.* 2010, p. 5). The Integrated Taxonomic Information System (ITIS), a database of taxonomic information maintained by a partnership of U.S. Federal agencies continues to recognize all three of the forms purportedly eliminated by Churcher (ITIS 2014, p. 1), thus making the SNRF one of 12 North American subspecies. A 1996 summary of red fox taxonomy by the American Society of Mammalogists also recognizes the three subspecies purportedly eliminated by Churcher (Lariviere and Pasitschniak-Arts 1996, pp. 1, 2). Finally, none of these various counts of North American subspecies reflects the 2010 designation of the Sacramento Valley red fox (*Vulpes vulpes patwin*) (Sacks *et al.* 2010, pp. 1523, 1535). The SNRF can thus reasonably be considered one of 10, 11, or 13 North American subspecies of *Vulpes vulpes*, depending on sources referenced.

The SNRF is one of three closely related and morphologically similar western montane subspecies (Aubry 1983, p. 1; Aubry 1997, p. 55; Perrine *et al.* 2010, p. 5). The other two are the Rocky Mountain red fox (*Vulpes vulpes macroura*) and the Cascade red fox (*Vulpes vulpes cascadiensis*) (Statham *et al.* 2012, p. 122). The Rocky Mountain red fox occurs in the Rockies and other mountainous areas of Idaho, Montana, Wyoming, Utah, Colorado, New Mexico, Nevada, and Eastern Oregon; while the Cascade red fox occurs in the Washington Cascades north of the Columbia River (Sacks *et al.* 2010, pp. 1528, 1536). The range of the Cascade red

fox was previously thought to also include the Oregon Cascades, but recent genetic comparisons have shown red foxes of the Oregon Cascades to be SNRF (Sacks *et al.* 2010, p. 1536) (see Current Distribution, below).

The three montane subspecies, including the SNRF, are descendants of “Nearctic” foxes that first colonized North America from Asia by crossing the Bering Land Bridge prior to the Illinoian glaciation, around 200,000 years ago or earlier (Aubry *et al.* 2009, pp. 2679–2682; Perrine *et al.* 2010, p. 5; Sacks 2014a, pp. 9–13). When the subsequent and most recent glacial period (the Wisconsinan) began about 100,000 years ago, those foxes established refugia in the area that would become the continental United States, while a group of “Holarctic” red foxes conducted a second migration across the land bridge from Asia and established themselves in Alaska and Canada. As average temperatures warmed and the Wisconsinan glaciers retreated about 10,000 years ago, western populations of the Nearctic foxes retreated to cold, snowy habitats in the western mountains of the continental United States (Perrine *et al.* 2007, p. 1089).

Genetics

Genetic data, as used here, typically involves comparing the sequences of DNA bases (adenine, cytosine, guanine, and thymine) on one strand of a given stretch of DNA for several individuals. Information from recent genetic comparisons has been used to distinguish SNRF from Cascade red foxes, thereby redefining the ranges of both (Sacks *et al.* 2010, p. 1536). Genetic distinctions have also been shown between the three types of red foxes currently living in California: SNRF, Sacramento Valley red foxes, and descendants of nonnative foxes imported for fur farms (Sacks *et al.* 2010, pp. 1524, 1527–1529). Genetic comparisons have demonstrated that SNRF from the vicinity of Sonora Pass, in California, are descendants of the original SNRF population in that area (Statham *et al.* 2012, p. 129). SNRF from the Lassen and Sonora Pass sighting areas are also genetically distinguishable from each other, and from other subspecies (Statham *et al.* 2012, pp. 129–130). Finally, genetic data also indicate that SNRF near Lassen Peak (i.e., the Lassen sighting area) comprise a small population that passed through a bottleneck (declined significantly in size) relatively recently (Sacks *et al.* 2010, pp. 1523, 1536). We discuss these genetic findings in more detail below.

A comparison of DNA from cellular organelles called mitochondria (mtDNA) obtained from numerous historical samples (bone or skin snips from museum specimens) has shown that red foxes in the Oregon Cascades (previously considered Cascade red foxes, see Historical Range, below) are much more closely related to SNRF than they are to the Cascade red foxes in the Washington Cascades (Sacks *et al.* 2010, pp. 1525, 1530 table 2, 1536). The study’s authors therefore concluded (*Id.* at 1536) that the red foxes of the Oregon Cascades are SNRF rather than Cascade foxes, and that SNRF and Cascade foxes are separated by the Columbia River, which provides a long-term barrier to interbreeding.

SNRF in California are genetically distinguishable from lowland California red fox populations using mtDNA comparisons (Perrine *et al.* 2007, pp. 1089–1090; Sacks *et al.* 2010, pp. 1527–1528; Statham *et al.* 2012, pp. 126–128). One such lowland population, the Sacramento Valley red fox, although related to SNRF from the southern Cascades, is sufficiently distinct as to constitute a separate subspecies: *Vulpes vulpes patwin* (Sacks *et al.* 2010, pp. 1523, 1533–1535).

SNRF and Sacramento Valley red foxes are also separated from each other by about 65 km (40 mi) of mid-elevation terrain from which red foxes appear to be absent (Sacks *et al.* 2010, p. 1535). Researchers found other lowland California red foxes living in the San Joaquin Valley, the San Francisco Bay area, and southern California, to be descended from a mix of subspecies from several areas, including eastern North America, Alaska, and western Canada and Holarctic subspecies, and thus to be nonnative in California (Perrine *et al.* 2007, p. 1090; Sacks *et al.* 2010, pp. 1527, 1533).

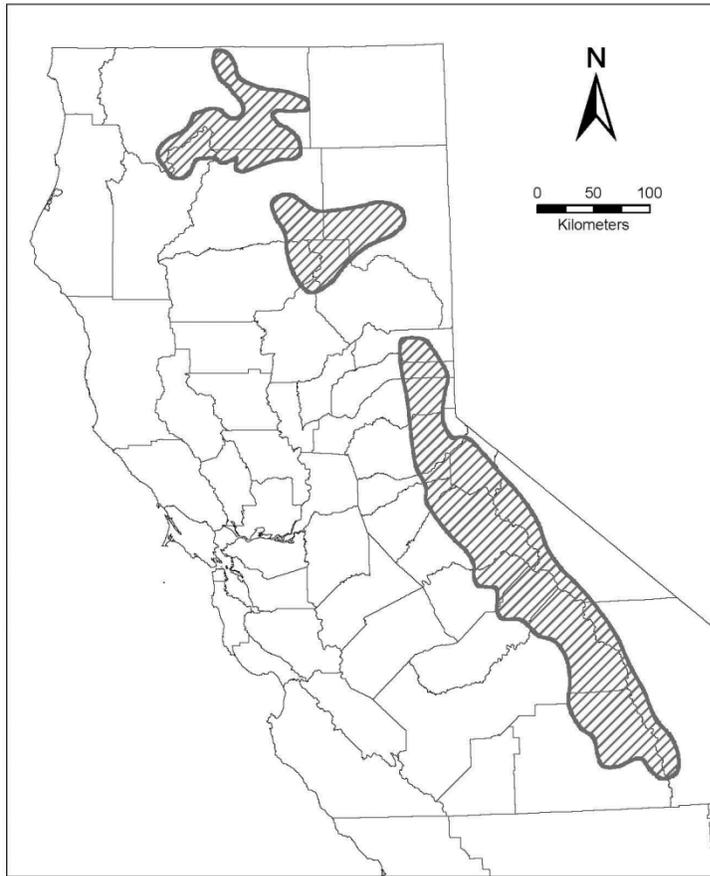
Analyses using both mtDNA and microsatellites indicate that red foxes currently living near Sonora Pass, California, are descendants of the SNRF population that was historically resident in the area (Statham *et al.* 2012, pp. 126–129). Additional weak support for this conclusion was provided by the sighting of several cross phase foxes at the Sonora Pass Siting Area, but not at the Lassen sighting area (Statham *et al.* 2012, p. 130). Historically, cross and black phase foxes were much more common in the Sonora Pass area (*Id.*).

RANGE AND DISTRIBUTION

Historical Range

Grinnell *et al.* (1937, pp. 381–382) defined the range of the SNRF in California as three separate areas: (1) the area of Mt. Shasta, primarily in the Cascades but extending slightly into the Trinity Mountains; (2) in the California Cascades around Lassen Peak; and (3) along the upper elevations of the Sierra Nevada Mountain Range from Tulare to Sierra Counties (see Map 1).

Map 1: SNRF Historical Range in California



(From Perrine *et al.* 2010, p. 4; based on Grinnell *et al.* 1937, p. 382.)

The eastern extent of the SNRF’s range is somewhat unclear. A range map provided by Grinnell *et al.* (1937, p. 382) indicates that the range comes close to Nevada around Lake Tahoe, but remains wholly within California, implying the SNRF was considered a California endemic. This implication may simply result from Grinnell *et al.’s* (1937, pp. 381–382) intent to focus exclusively on California, as indicated by the title of the work: “Fur-Bearing Mammals of California.” Grinnell *et al.* (1937, p. 381) also describe the SNRF range as its “distribution area in California.” In contrast, Perrine *et al.* (2010, pp. 3–4) described the SNRF’s historical range as including “the mountains of western Nevada,” although the map provided was essentially the same as Grinnell *et al.’s* (1937, p. 382), and did not indicate any occupied areas in Nevada. The inclusion of western Nevada appears to have been based on a range map of North American red fox subspecies by Hall (1981), which drew the SNRF’s range to include most of the southern half of Nevada as well as the California’s Central Valley and northwestern mountains (Coastal and Klamath Ranges). Subsequent genetic studies have distinguished SNRF from red foxes in California’s Central Valley and the Great Basin area of Nevada (Sacks *et al.* 2010, p. 1533; Sacks *et al.* 2010b, p. 1090; Sacks *et al.* 2015, pp. 7, 16). No other sources have included the northwestern mountains of California in the SNRF’s historical range, and we are not aware of red-fox sightings in those areas within the last 50 years, but there were numerous nonnative red-fox fur farms throughout that area from the 1920s through the 1940s (Lewis *et al.* 1995, p. 30).

Accordingly we consider the SNRF historical range in California to be as mapped by Grinnell *et al.* (1937, p. 382) and Perrine *et al.* (2010, p. 4) (shown above).

It remains possible that the SNRFs historical range may extend slightly into Nevada in places where the eastern Sierra Nevada mountains extend past the California border. The Center for Biological Diversity ((CBD) 2011, pp. 8–9) considered the range to extend slightly into Nevada near Lake Tahoe, and redrew the Grinnell *et al.* map (1937, p. 382) accordingly. However, CBD did not specify the information on which they based their revision. That information may be a report of a cross-phase red fox collected in 1934 near Marlette Lake, Nevada (Statham *et al.* 2012, p. 130), which is about 1.6 km (1 mi) east of Lake Tahoe and 8.5 km (5.3 mi) east of the California border, in Washoe County, Nevada at an elevation of 2,389 m (7,838 ft). We consider it likely that this cross-phase fox was an SNRF, based on the high elevation, and on the proximity of the sighting to the SNRF range mapped by Grinnell *et al.* (1937, p. 382). The historical range thus likely extends at least 10 km (6.2 mi) into Nevada in that area.

As with the question of the eastern extent of the SNRF's range into Nevada, it is likely that Grinnell *et al.* (1937, pp. 381–382) did not consider whether the range of the SNRF might extend north into Oregon. The northernmost portion of the SNRF's range as mapped by Grinnell *et al.* (1937, p. 382) stops just short of the Oregon border in Siskiyou County, California. Grinnell *et al.* (1937, p. 381) mention that prior to their work, all montane red foxes from the Yosemite region of California northward into Oregon and Washington were considered Cascade red foxes. Joseph Grinnell conducted an independent analysis and “found no basis in the material for recognizing more than one form of red fox within California” (Grinnell *et al.* 1937, p. 381). The map provided by Grinnell *et al.* (1937, p. 382) reflects this by indicating that the SNRF's range extends to the Oregon border. There is no indication, however, that Grinnell applied additional analysis to montane foxes in Oregon to determine whether they too might be SNRF. Grinnell *et al.* (1937, pp. 380–381) merely noted that the type locality for the Cascade red fox is near Mount Adams, Washington, and that the Cascades fox “may be, and indeed likely is, a perfectly good race.”

Accordingly, when Sacks *et al.* (2010, p. 1536) revised the northern extent of the SNRF's historical range to include the Oregon Cascades (see Genetics, above), they were essentially completing Grinnell *et al.*'s (1937) work. The historical range is now considered to include the Oregon Cascades, north to the Columbia River, wherever those mountains exceed 1,200 m (3,937 ft) in California (Perrine *et al.* 2010, p. 8) and 1,219 m (4,000 ft) in Oregon (Aubry *et al.* 2015, p. 1).

Current Distribution

We consider SNRF “sightings” to be those records with reliable or independently verified information (such as photographs or genetically tested sample material) showing the location of an SNRF at some point in time. We have characterized the locations of recent sightings (since 2000) into seven loosely clustered “sighting areas”, two of which are in California, and five of which are in Oregon (see Table 1 and Map 2). We are currently aware of two sightings that have occurred outside of these areas. One was in Round Valley, California, about 113 km (70 mi) southeast of the Sonora Pass sighting area, but within the historical range of the species (CDFW

2015, p. 3). This consisted of a picture taken from a CDFW helicopter (*Id.*). The other was a “road-killed pup” found in June of 2014 near Silver Lake, Oregon, about 80 km (50 mi) west of the Crater Lake sighting area (Doerr 2015, p. 14).

Although numerous sightings may possibly result from a few individuals, we consider sighting areas with numerous sightings more likely to indicate the presence of resident populations in which SNRF establish territories and spend the majority of their time. These areas include Sonora Pass, Lassen, Crater Lake, Willamette Pass, Mt. Washington, and Mt. Hood (see USFWS 2015, p. 2 for Willamette Pass and Mt Washington). Studies conducted at the Lassen and Sonora Pass sighting areas provide population size estimates and evidence of multiple resident SNRF, thereby demonstrating that these sites support resident populations (Sacks *et al.* 2010, p. 1532 (referring to Lassen as the “modern Southern Cascades population); Quinn and Sacks 2014, p. 2). The Dutchman Flat sighting area, with only a few sightings, may indicate either resident

Map 2: SNRF Sighting Areas



Table 1: SNRF Sighting Areas

Location	State	County	Primary Land Owners	Number of Sightings ¹	Number of Individuals Distinguished	Estimated Population Size
Sonora Pass	CA	Tuolumne Mono Alpine	Toiyabe NF Stanislaus NF Yosemite NP	Hundreds ²	8 ³	29 adults (14 breeding, 15 nonbreeding) ⁴
Lassen	CA	Lassen Plumas Tehama	Lassen NF Lassen NP	Hundreds ⁵	23 ⁶	42 adults (21 breeding, 21 nonbreeding) ⁷
Crater Lake	OR	Klamath, Douglas	Crater Lake NP, Rogue River - Siskiyou NF Fremont-Winema NF	36 ⁸	4	Unk
Willamette Pass	OR	Lane	Willamette NF	5 ⁹	2	Unk
Dutchman Flat	OR	Deschutes	Deschutes NF	16 ¹⁰	1	Unk
Mt Washington	OR	Linn, Jefferson, Deschutes	Willamette, Deschutes NFs	58 ¹¹	3 ¹²	Unk
Mt Hood	OR	Clackamas, Hood River	Mt Hood NF	15 ¹³	3	Unk

populations or areas through which dispersing SNRF occasionally pass. At least one sighting in each area is based on the location of sample material confirmed by genetic testing to be from an SNRF.

¹ Photo, or genetic analysis of hair or scat sample. Note: all locations include genetic confirmation of at least one sample as SNRF

² Sacks *et al.* 2015, p. 3.

³ *Id.*. Two nonnatives and 11 hybrids also detected.

⁴ 14 breeding adults (estimated range 10 to 20) (Sacks *et al.* 2015, pp. 3, 14). 15 nonbreeding adults (estimated range of 0 to 30, based on rough estimates of ratios of nonbreeders to breeders in other red fox subspecies) (Sacks 2015, p. 1; Sacks *et al.* 2015, p. 14).

⁵ Sightings included scat samples, camera trap sightings, and telemetry fixes, winter 1998 through winter 2003 (Perrine *et al.* 2005, pp. 39, 91, 123).

⁶ Collected 1951–2008 (Rickman 2014, p. 2; Sacks *et al.* 2010, pp. 1525, 1529)

⁷ 21 breeding adults, with 95 percent confidence interval of 13 to 34 (Sacks *et al.* 2010, pp. 1532, 1536–1537). 21 nonbreeding adults (estimated range of 0 to 42, based on rough estimates of ratios of nonbreeders to breeders in other red fox subspecies) (Sacks 2015, p. 3).

⁸ Sacks 2014, p. 2, Mohren 2014, p. 2

⁹ Sacks 2014, p. 2; Doerr 2015, p. 2

¹⁰ Ferland 2014, p. 2

¹¹ Mohren 2014, p. 2; Sacks 2014, p. 2; Doerr 2015, pp. 1, 5, 8–11

¹² USDA 2015, p. 2

¹³ Sacks 2014, pp. 4–5; Akins and Sacks 2015, p. 1

Almost all sighting areas are entirely on Federal land, within either National Parks (Yosemite, Lassen Volcanic, and Crater Lake National Parks) or National Forests (Stanislaus, Lassen, and Humboldt-Toiyabe National Forests in California; Umpqua, Willamette, Deschutes, and Mt. Hood National Forests in Oregon). There are also some small private inholdings in the Lassen sighting area at which some SNRF have been sighted (CDFW 2015, p. 2). All sighting areas are in the Cascade Mountains, with the exception of the Sonora Pass sighting area, which is in the Sierra Nevada Mountains. The two California sighting areas were known in the 1930s to be occupied by SNRF (Grinnell *et al.* 1937, pp. 381–382) and in 1993 and 2010 were found to still be occupied (Perrine 2005, pp. 4, 167–168; Statham *et al.* 2012, p. 123). The five Oregon sighting areas were first identified in 2012 and 2013, after publication of our 90-day finding on a petition to list the SNRF as an endangered or threatened species (77 FR 45). Accordingly, we did not mention the Oregon sighting areas in that 90-day finding.

We delineated the seven SNRF sighting areas based on results of various carnivore and fox surveys conducted from 1996 through 2014 (Perrine 2005; Mohren 2014; Sacks 2014; Ferland 2014; Akins 2014, entire; Doerr 2015, entire) across large portions of the historical range of the subspecies. From 1996 to 2002, carnivore surveys using track plates and baited camera stations were conducted across most of the SNRF's California range, both by National Forest biologists (Perrine *et al.* 2010, pp. 8, 11), and by members of the USDA's Pacific Southwest Research Station (Zielinski *et al.* 2005, entire). The survey conducted by Zielinski *et al.* (2005, p. 1394) did not detect SNRF anywhere in the California historical range, despite overlapping the Lassen sighting area. However, none of their survey plots in that area happened to fall within the grid cells where Perrine (2005, p. 87) detected SNRF somewhat later. Similar surveys were conducted in Oregon in 2013 and 2014 (Mohren *in litt.* 2014, p. 1) resulting in the five Oregon sighting areas now known. The National Park Service also conducted similar surveys in Kings Canyon, Sequoia, and Yosemite National Parks (Perrine *et al.* 2010, pp. 8–9). Several anecdotal sightings have been reported across the California range in the 1980s and 1990s, but without independent confirmation from photographic or genetic data, such sightings are considered unreliable (Perrine *et al.* 2010, pp. 9, 13, McKelvey *et al.* 2008, entire).

National Park Service biologists, using a motion sensitive camera, have recently recorded the presence of an adult red fox, presumably an SNRF, in the extreme northern portion of Yosemite National Park (Kolipinski 2015, pp. 1–2). We consider that individual likely to be part of the Sonora Pass population based on location, elevation, and the presence of contiguous subalpine habitat preferred by SNRF extending from the Sonora Pass area south into Yosemite National Park where the new fox was sighted (Quinn and Sacks 2014, p. 2).

ECOLOGY

Habitat

SNRF use multiple habitat types in the alpine and subalpine zones (near and above treeline) (CDFG 1987, p. 3). In addition to meadows and rocky areas (USDA 2009, p. 506), SNRF use high elevation conifer habitat of various types (Perrine 2005, pp. 63–64). Nearest the treeline in the Lassen sighting area, where habitat use has been best documented, SNRF frequent subalpine conifer habitat dominated by whitebark pine (*Pinus albicaulus*) and mountain hemlock (*Tsuga*

mertensiana) (Perrine 2005, pp. 6, 63–64; CDFW undated, p. 3; Verner and Purcell undated, p. 3). Such conifer habitat has been described as typically “open” (Verner and Purcell undated, p. 1), and “patchy” (Lowden 2015, p. 1). We lack similarly specific habitat descriptions for Oregon. The CDFW has also documented SNRF year-round in the Caribou Wilderness area of the Lassen National Forest, which is at somewhat lower elevation than that documented by Perrine (2005, pp. 63–64).

Perrine’s 2005 study (*Id.*) found that SNRF in the Lassen area descend (particularly during winter) into high elevation conifer areas below the subalpine zone. In the Lassen sighting area, this habitat consists primarily of red fir (*Abies magnifica*), white fir (*Abies concolor*), and lodgepole pine (*Pinus contorta*) (Perrine 2005, pp. 63–64; CDFW undated, p. 3; Barrett 1988, p. 3). SNRF were also found to be loosely associated with montane chaparral communities, dominated by ceanothus and manzanita (*Arctostaphylos*) species, and bitter cherry (*Prunus emarginata*) (Perrine 2005, p. 75; CDFW undated, p. 4).

In winter, radio-collared SNRF from the Lassen sighting area moved to somewhat lower locations, averaging elevations that were 479 m (1,572 ft) lower than in summer, and reaching as low as 1,410 m (4,626 ft) (Perrine 2005, pp. 2, 162). Possible reasons for this elevational migration include lessened snow depths at lower elevations (Perrine 2005, pp. 80, 81), unsuccessful dispersal movements by non-breeding individuals (Statham *et al.* 2012, p. 130), and lack of suitable prey at high elevations in the Lassen area (see **Feeding**, below). Similar elevational migrations were not seen at the Sonora Pass sighting area (Statham *et al.* 2012, p. 130), but Grinnell *et al.* (1937, p. 388) noted such migrations in historical populations of the Mt. Whitney region (southern Sierra Nevada Mountains). The extent to which SNRF in Oregon may descend in elevation during winter months is unknown, but Cascades foxes (*Vulpes cascadenensis*) living in the Washington Cascades Mountains are not known to do so (Aubry 1983, p. 134). However, an SNRF was identified on April 4, 2014, in the Mt. Washington sighting area at an elevation of 1,265 m (4,150 ft) (Doerr 2015, pp. 3–5, 13–14 (line 7)), and a fox scat genetically identified as SNRF was collected at 1,463 m (4,800 ft) at the Mt. Hood sighting area on May 12, 2013 (Akins 2014, p. 2).

While on these lower winter ranges, SNRF at the Lassen sighting area showed a preference for what Perrine (2005, pp. 67, 74, 90) referred to as “mature closed canopy conifer forests”¹⁴, despite the rarity of this forest structural category (less than 7 percent) in the area studied (*Id.* at 67). As Perrine (*Id.* at 74) indicated: “On average, a 1 percent increase in the extent of mature closed-canopy forest caused a 3.5 percent increase in the odds of detecting red fox.” Perrine (*Id.* at 90) defined this category as having higher than 40 percent canopy closure, and tree trunks of larger than 60 cm (23.6 in) diameter at breast height (dbh). Note that this forest category does not use tree-size or canopy-closure standards established by the California Wildlife Habitat Relationships (CWHR) information system established by CDFW (Mayer and Loudenslayer 1988, p. 16). The extent to which mature closed canopy conifer forest may coincide with “late successional” or “old growth” forests is unclear. Old growth Douglas fir (*Pseudotsuga*

¹⁴ Note that “mature closed-canopy forest” is abbreviated in Perrine 2005, pp. 67, 68, and 77 as “56MD”, but the description of this abbreviation given on p. 90 is “mature open-canopy forest”. Since the definition on p. 90 includes “>40% canopy closure”, we consider the term “open-canopy” in that description to be an error.

menziesii) in the Pacific Northwest has been characterized as including large numbers of trunks of greater than 100 cm (39.4 in) dbh (Strittholt *et al.* 2006, p. 364), while old growth in Sierra Nevada ecosystems has been characterized according to structural complexity rather than dbh or canopy specifications (Erman *et al.* 1997, p. 96).

SNRF's preference for mature closed canopy forests in the Lassen sighting area may result from one or more factors, including: (1) lessened snow depth and consequent ease of travel; (2) availability of sheltered day-rest areas formed by downed woody debris or low-hanging conifer boughs; or (3) increased access in day-rest areas to prey living below the snow (Benson *et al.* 2005, p. 128; Perrine 2005, pp. 78, 80–81; Perrine 2010, pp. 19, 29). Having traveled to lower elevations for any of the reasons discussed above, SNRF may also make greater use of closed canopy forests at those elevations because that habitat provides greater visual cover, and presents greater obstacles to any coyotes that might chase them (Benson *et al.* 2005, p. 128; Perrine *et al.* 2010, p. 29). Benson *et al.* (2005, p. 128) found that two female SNRF in the Lassen sighting area traveled greater distances in forests and lesser distances in the open than was expected based on availability of the habitats. They defined forested habitat as having greater than 40 percent canopy closure from trees (*Id.* at 127). Anything with less canopy closure was considered “open” or “shrub” habitat (*Id.*). They also found that the SNRF typically altered their direction of travel to proceed inside forest edges, rather than continuing their line across open habitat (*Id.* at 128). They noted that forested areas likely provide better opportunities than other habitats for both hiding and escaping from coyotes (*Id.*).

Feeding

Like other red foxes in North America, SNRF appear to be opportunistic predators and foragers, with a diet primarily composed of small rodents, but also including deer carrion (*Odocoileus hemionus*) (particularly in winter and spring), and manzanita berries (*Arctostaphylos nevadensis*) (particularly in fall) (Perrine *et al.* 2010, pp. 24, 30, 32–33). SNRF are most active at dusk and at night (Perrine 2005, p. 114) when many rodents are most active. High elevation lagomorphs, such as snowshoe hare (*Lepus americanus*) and pika (*Ochotona princeps*), were not an important food source in the Lassen area, possibly due to scarcity in the region (Perrine 2005, pp. 29–30). This may help explain the winter descent of Lassen-area SNRF to somewhat lower elevations, as discussed under **Habitat**, above. Cascade foxes (which are montane-dwelling like SNRF) are not known to descend during the winter, and subsist primarily on snowshoe hare during that time (Aubry 1983, p. 109). SNRF at the Sonora Pass sighting area also are not known to descend in winter, and snowshoe hare and white tailed jackrabbit (*Lepus townsendii*) are likely to constitute an important food source (Rich 2014, p. 1).

Reproduction

Although little direct information exists regarding SNRF reproductive biology, there is no evidence to suggest it is markedly different from lowland dwelling North American red fox subspecies (Aubry 1997, p. 57). Those subspecies are predominately monogamous and mate over several weeks in the late winter and early spring (*Id.*). The gestation period for red fox is 51 to 53 days, with birth occurring from March through May in sheltered dens (Perrine *et al.* 2010, p. 14). SNRF use natural openings in rock piles at the base of cliffs and slopes as denning sites

(Grinnell *et al.* 1937, p. 394). They may possibly also dig earthen dens, similar to Cascade red foxes, though this has not been directly documented in SNRF (Aubry 1997, p. 58; Perrine 2005, p. 153). Grinnell *et al.* (1937, p. 394) report that SNRF litters average six pups with a range of three to nine; however, recent evidence suggests that litter sizes of two to three are more typical, and that reproductive output is generally low in montane foxes (Perrine 2005, pp. 152–153) (see also Small Population Size and Isolation, below). Red fox pups in general are typically weaned by 8 to 10 weeks of age, begin exploring their parents' home range by 12 weeks (June through August), and disperse in the early fall when fully grown (Perrine *et al.* 2010, pp. 14–15).

Demographic Information

Dispersal distances have not been documented for SNRF, but one study found juvenile male red foxes in the American Midwest dispersed 30 km (18.6 mi) on average, while juvenile females dispersed an average of 10 km (6.2 mi) (Statham *et al.* 2012, p. 130). A few young red foxes (5 percent) dispersed over 80 km (50 mi) in their first year (*Id.*).

In the Lassen sighting area, adult SNRF established large summer home ranges averaging 2,564 hectares (ha) (6,336 acres (ac)), with individual home ranges ranging from 262 ha (647 ac) to 6,981 ha (17,250 ac) (Perrine 2005, pp. 2, 159)¹⁵. Winter home ranges were even larger, averaging 3,255 ha (8,042 ac), and ranging from 326 to 6,685 ha (806 to 16,519 ac) (*Id.* at 159). Home ranges at the Sonora Pass sighting area averaged 910 ha (2,249 ac) (Quinn and Sacks 2014, pp. 2, 11)

The average lifespan, age-specific mortality rates, sex ratios, and demographic structure of SNRF populations are not known, and are not easily extrapolated from other red fox subspecies because heavy hunting and trapping pressure on those other subspecies likely skew the results (Perrine *et al.* 2010, p. 18). However, three SNRF identified in the Lassen sighting area lived at least 5.5 years (CDFW 2015, p. 2), and a study conducted at the Sonora Pass sighting area found the average annual adult survival rate to be 82 percent, which is relatively high for red foxes (Quinn and Sacks 2014, pp. 10, 14–15, 24).

SIGHTING AREA STATUS AND TRENDS

General

Based on interviews with trappers, Grinnell *et al.* (1937, p. 396) described SNRF population numbers as “relatively small, even in the most favorable territory,” and reported that SNRF likely occurred at densities of 1 per 2.6 square km (1 per square mi). Perrine *et al.* (2010, p. 9) concluded from this that SNRF likely occur at low population densities even within areas of high relative abundance. Although it is relatively easy to document the presence of SNRF at a given location and date using camera traps (Perrine 2005, p. 71), they are very difficult to capture live using boxtraps (Perrine 2005, p. 135). Boxtraps are designed to avoid injury, but require the

¹⁵ Perrine (2005, p. 137) also indicates an average summer home-range size of 2,323 ha (5,740 ac), but this figure is obtained by averaging mean home range size for each fox across all seasons studied, without weighting according to the number of seasons for which data was collected on each fox (ranging from 2 to 5).

SNRF to enter an enclosed space to obtain a bait, which SNRF are rarely willing to do (Perrine 2005, p. 135; Sacks 2014a, pp. 54–60). Consequently, researchers have been unable to estimate SNRF population sizes using mark-recapture techniques, which are the simplest and most common methods. Additionally, the known SNRF sighting areas other than Lassen have been identified relatively recently, leaving little time for the accumulation of data regarding status and trends.

As indicated by sighting and trapping data obtained by the California Department of Fish and Wildlife (CDFW; formerly California Department of Fish and Game, CDFG) (Schempf and White 1977, p. 44), SNRF numbers in California fell considerably in the mid-1900s as compared to trapping data reported by Grinnell *et al.* (1937, p. 389). As discussed below under “Hunting and Trapping,” the average annual harvest of SNRF pelts in California declined from the 1920s (21 pelts per year) to the 1940s and 50s (6.75 pelts per year) (Grinnell *et al.* 1937, p. 389; Perrine 2005, p. 154). Sightings became rare after the 1940s (about twice per year in the 1950s and 1960s) (Schempf and White 1977, p. 44). The reduced harvest and sightings of SNRF in California led to a prohibition on fox trapping throughout the state in 1974, and to listing of the SNRF as a threatened species under the California Endangered Species Act (CESA) in 1980 (Statham *et al.* 2012, p. 123).

Information is not currently available regarding the abundance or trends of SNRF populations in Oregon.

Lassen Sighting Area

The Lassen sighting area includes sightings in the Lassen Volcanic National Park, Lassen National Forest (including the Caribou Wilderness), and some small private inholdings used primarily as timberlands (CDFW 2015, p. 2). A single SNRF was also sighted in 2013 by a camera trap near Humbug Summit, roughly 32 km (20 mi) south of the Lassen sighting area (CDFW 2015, p. 2). No additional sightings in the area were obtained despite use of multiple cameras over several months, so it is likely the single sighting was of a transient individual.

Using microsatellite DNA comparisons, Sacks *et al.* (2010, pp. 1532, 1536–1537) estimated that the effective size of the population at the Lassen sighting area (referred to in the study as the modern Southern Cascades population) is 21 breeding individuals, with a 95 percent confidence interval of 13 to 34 breeding individuals (see also Statham *et al.* 2012, pp. 122, 123). The “effective size” of the population refers to the number of breeding individuals in an “ideal” population (with discreet, non-overlapping generations, equal contribution of all members to the next generation, and free mixing prior to mate choice), that experiences the same amount of genetic drift (random change in gene frequencies) as the actual population (Lande and Barrowclough 1987, pp. 88–89). Actual SNRF populations are likely to be somewhat larger than their effective population sizes because they include non-breeding individuals, including pups, and (possibly) adult offspring remaining on their parents territory to help raise their siblings. Such “helpers” are not uncommon in other red fox subspecies, though clear evidence of them has not been demonstrated in SNRF (Wildlife Online 2015, p. 60; Sacks 2015, p. 1). A high-end estimate of actual population size for the Lassen sighting area might therefore assume two non-breeders for every breeder, resulting in a total population of about 63 individuals (Sacks 2015, p.

1). The addition of non-breeding adults would not change the effective size of the population, however, so the population would remain as subject to inbreeding depression as if the nonbreeders were not present.

Sacks *et al.* (2010, p. 1529) also estimated the effective population size of the population at the Lassen sighting area by comparing mtDNA across both modern individuals and museum samples, resulting in an estimate with a 95 percent confidence interval of 0 to 40 breeding individuals. The authors (*Id.* at 1536–1537) considered the microsatellite-based estimate of 21 to be the most robust, in part because this estimate was obtained solely from modern samples rather than from comparisons with museum specimens whose genetic diversity might possibly be underestimated using the sequencing methods available.

CDFW obtained 187 SNRF samples of scat and hair from the Lassen sighting area between 2007 and 2013, and was able to genetically identify 18 separate individuals from those samples (CDFW 2015, p. 2), thereby supporting the low population estimate of Sacks *et al.* (2010, p. 1532). CDFW was also able to identify the source individuals for over 100 SNRF genetic samples collected in the Caribou Wilderness in 2012 and 2013, and found that no new individuals entered the population in that area during those years (CDFW 2015, p. 3). Successful reproduction in that portion of the sighting area during those years was thus apparently low or nonexistent. However, CDFW cameras did photograph an SNRF near the Caribou Wilderness in 2009 that appeared visibly pregnant (*Id.*).

Perrine's (2005, p. 135) trapping data from 2000 to 2002 also tends to indicate a small population size in the Lassen sighting area. Perrine trapped and radio-collared what he considered to be virtually all the SNRF present in the western portion of Lassen Volcanic National Park (roughly an eighth of the entire Lassen sighting area) (Perrine 2005, p. 135). He considered virtually all SNRF in the area likely to have been trapped based on subsequent camera-trap sightings and on 17 months of box-trapping efforts resulting in recaptures of previously trapped individuals, but no new captures (*Id.*). The total number of individuals trapped and collared was five (*Id.*).

Genetic evidence also indicates the population in the Lassen sighting area markedly decreased in size (experienced a “population bottleneck”) sometime between 1930 and 2000 (Sacks *et al.* 2010, pp. 1523, 1532, 1536). Such a decrease at Lassen would be consistent with the decreased sightings reported by Schempf and White (1977, p. 44) throughout California (discussed above under “General”). The reasons for the decrease remain unclear.

In 2011, and again in 2013, CDFW collected samples near the Caribou Wilderness indicating the presence of a nonnative red fox, most closely related to foxes of mixed fur-farm and Rocky Mountain red fox ancestry from the Rocky Mountain and intermountain (Great Basin) regions (CDFW 2015, p. 3).

Sonora Pass Sighting Area

The Sonora Pass sighting area includes several multi-year residents (Quinn and Sacks 2014, p. 2), and so may be considered a population site rather than merely a dispersal area from some

undiscovered population. Researchers (Sacks *et al.* 2015, p. 3) conducting a study in the area from 2011 through 2014 used genetic tests to identify eight SNRF. With the exception of a female killed on U.S. Highway 395, possibly while dispersing, all SNRF sightings were found within an area of 13,000 ha (32,124 ac), extending both north and south from California State Route 108, within 3 km of the Sierra Crest (Quinn and Sacks 2014, p. 10). This study area constituted 20 to 50 percent of the contiguous high quality habitat for SNRF in the region (*Id.* at 14). The additional high quality habitat primarily extends south into the northern portion of Yosemite National Park (*Id.* at 10, 36), and is included in the area we have roughly defined as the Sonora Pass sighting area (see Map 2, above). That area was poorly surveyed because it required overnight backpacks to access (*Id.* at 6). We consider it likely that the data obtained by Quinn and Sacks (2014, entire) is representative of the entire population in the region, because the area studied was of high quality habitat similar to the rest of the high quality habitat in the region (*Id.* at 14), and because the area studied was large enough (*Id.* at 10, 14) to make unlikely the possibility that only unusual SNRF happened to be included.

Two of the eight native SNRF identified in the study area were males and six were females (including one killed on Interstate 395 prior to systematic monitoring) (Sacks *et al.* 2015, pp. 3, 14, 22). Based on the extent of suitable habitat in the Sonora Pass sighting area, and on the number of adult SNRF per hectare in the surveyed portion of the habitat at any given time (usually six adults in 13,000 ha (32,124 ac)), the researchers estimated the total number of adult SNRF in the entire Sonora Pass sighting area to be roughly 14, with a likely range of 10 to 20 (*Id.* at 3, 11, 14). Repeated resampling of individuals over the 3-year study period (2011 through 2014) suggests that most adults with territories overlapping the study area were found (*Id.* at 14). However, the researchers indicated their estimates were “crude,” and that the total number of adults in the population could possibly be as high as 50 due to the presence of nonbreeding helpers at natal den sites (*Id.* at 11, 14).

Low population size estimates were also supported by analyses of genetic diversity, however (Quinn and Sacks 2014, pp. 13–14). For instance, the average heterozygosity (a measure of genetic diversity) in nuclear DNA (from the cell nucleus) for SNRF at the Sonora Pass sighting area (0.44) was lower than at the Lassen sighting area (0.53), suggesting that the population size at the Sonora Pass sighting area may be smaller (*Id.*). Current heterozygosity levels at the Sonora Pass sighting area are also considerably lower than heterozygosity levels present historically (0.64), thus indicating a recent negative trend in population size (*Id.*). Reductions in the diversity of mitochondrial DNA (mtDNA, from cell organelles called mitochondria) since historical times also indicate a recent decline in population numbers (*Id.* at 14).

Sacks *et al.* (2015, pp. 3, 9) found no evidence to indicate that any SNRF successfully produced surviving, non-hybrid, pups during their 3-year study period. Two adult individuals were determined genetically to be the daughters of a known breeding SNRF pair, however (*Id.*).

In 2012, two nonnative adult male red foxes entered the area studied by Sacks *et al.* (2015, pp. 3, 16). The nonnative males paired with SNRF females, producing a total of at least seven hybrid pups in 2013, and ultimately resulting in at least four more in 2014 (*Id.* at 16, 30). Genetic studies indicated this was the first example of interbreeding between natives in the population, and nonnatives, in several decades at least (*Id.* at 9). The nonnative males were not closely

related, but both showed a combination of fur-farm stock and Rocky Mountain red fox ancestry, and likely originated from a population somewhere in the Great Basin of Nevada (*Id.* at 16). They may thus have been related to the nonnative male found at the Lassen sighting area (discussed above). The nearest known such population is 150 km (93 mi) from the Sonora Pass sighting area (*Id.* at 17). A native SNRF male disappeared from the study area shortly after the arrival of the two nonnative males (*Id.* at 3, 16). The missing individual was one of only two adult native SNRF males documented on the study area (*Id.* at 14). The missing individual was also the only SNRF male in the area known to have successfully reproduced (by fathering two sibling females that were adults at the time of the study) (Quinn and Sacks 2014, p. 14). A third nonnative male of unknown origin was also detected at the Sonora Pass sighting area in 2014, but it is not known to have bred (Sacks *et al.* 2015, pp. 16, 22).

Oregon Sighting Areas

Information is not currently available regarding population abundance or trends in any of the Oregon sighting areas. These sighting areas are located in the vicinities of, (from south to north), Crater Lake, Willamette Pass, Dutchman Flat, Mt. Washington, and Mt. Hood.

Three individuals have been genetically identified from the Mt. Hood sighting area (Akins and Sacks 2015, p. 1), and camera traps have produced 10 photographs of foxes in the area (Sacks 2014, p. 2). Two of the genetically tested individuals had mtDNA more typically found in red foxes of fur-farm stock (Sacks 2014, p. 1). This indicates that hybridization with nonnative foxes has occurred in the past, but the extent of that nonnative genetic introgression cannot be determined without using comparisons of microsatellite DNA, which have not yet been conducted (Sacks 2014, p. 1). Such microsatellite comparisons have not been conducted because a database of microsatellite sequences for historical SNRF populations in the Oregon Cascades has not yet been assembled (Sacks 2014, p. 1). For further discussion of hybridization and its potential impacts, see Hybridization With Other Subspecies, below.

In the other four Oregon sighting areas, samples that have been genetically tested have not been sequenced sufficiently to distinguish individuals, so the number of confirmed samples (from one to four) does not indicate a corresponding number of individuals. Similarly, several photographs from baited camera stations exist, but only those from the Willamette Pass sighting area have been successfully used to distinguish SNRF individuals. Two separate individuals (one cross phase and one black phase) have been distinguished at the Willamette Pass sighting area using photographs (Ferland 2014, p. 1).

POTENTIAL STRESSORS ON THE SUBSPECIES

In this section we review and evaluate historical, current, and future stressors potentially affecting SNRF or their habitat. To identify stressors, we reviewed the best available scientific and commercial information presented in this species report. We define a stressor as any human or natural activity/process that is causing or may cause in the future negative effects resulting in impacts or a possible decline of SNRF individuals or populations, or impacts to suitable habitat.

For each stressor, we estimated the scope of potential impacts and evaluated the potential level of impact the stressor may have on SNRF and its habitat in each sighting area. The scope of a stressor refers to the estimated proportion of suitable habitat within each sighting area or the proportion of a SNRF sighting area that can reasonably be expected to be affected by a stressor based on the best available information. The impact of a stressor refers to the estimated risk level or degree of decline that a stressor may cause to one or more of the sighting areas, or by the amount of suitable habitat that may be lost, degraded, or fragmented based on the best available information.

For each stressor, we summarized the best available scientific information relating to its potential direct (e.g., mortality) and indirect (e.g., habitat effects) impacts on SNRF. If significant information gaps exist, resulting in high levels of uncertainty in determining the scope and impact for particular stressors, we used our best professional judgment. We used three impact level classes—low, medium, and high—to represent the likely impact of stressors to the subspecies. We defined the impact level classes as follows:

1. Low-level impact: Stressor is impacting individual SNRF currently or in the future, or stressor is resulting in a minor amount of habitat impacts currently or in the future.
2. Medium-level impact: Stressor is impacting SNRF at the population (or sighting area) level currently or in the future, or stressor is resulting in more serious impacts to SNRF habitat at the population (or sighting area) level (as compared to a low-level impact) currently or in the future.
3. High-level impact: Stressor is significantly impacting SNRF at the subspecies level currently or in the future, or stressor is causing significant impacts to SNRF habitat at the subspecies level currently or in the future.

In evaluating potential stressors, we considered evidence relevant to both current and future impacts. We found that, for all potential stressors, the likelihood and severity of future impacts became too uncertain to address beyond a 50-year timeframe.

For instance, logging and grazing impacts on National Forest lands are largely regulated by the Northwest Forest Plan (NWFP) and the Sierra Nevada Forest Plan Amendment (SNFPA). These governing regulations were first adopted in 1994 and 2001, respectively, but the primary impetus for their adoption was the question of how best to carry out logging, grazing and vegetation management actions in a manner that is sustainable over the long term and that is consistent with applicable laws, including the Multiple Use – Sustained Yield Act of 1960, the Endangered Species Act of 1973 (Act), and the Federal Land Policy and Management Act of 1976 (USDA and USDI 1994, p. 5; USDA 2001, pp. 1–2). As these governing laws have remained in place for 40 to 50 years, and an important management goal under those laws has been “long-term sustainability” (*Id.*), we consider 50 years a reasonable timeframe for considering future impacts.

Similarly, laws governing hunting and trapping of red foxes in California and Oregon have remained largely unchanged since 1974 and 1978, respectively (CDFG 1987, p. 4; ODFW 2011, p. 26), so we consider regulatory mechanisms stable enough to support a 50 year timeframe.

In analyzing potential impacts from disease, small isolated populations, hybridization, coyote competition, and vehicles we considered all available information regarding any future changes that could alter the likelihood or extent of impacts. We had no such information extending beyond a 50 year timeframe.

Although information does exist regarding potential impacts from climate change beyond a 50 year timeframe, the projections depend on an increasing number of assumptions, and thus become more uncertain with increasingly large timeframes. We therefore chose a timeframe of 50 years as providing the best balance of scope of impacts considered, versus certainty of those impacts.

Accordingly, all analyses of future impacts are limited to 50 years.

In our 90-day finding on a petition to list the SNRF as endangered or threatened, we indicated we would further consider possible impacts from fire suppression and from “overutilization for commercial, recreational, scientific, or educational purposes,” despite finding that the petition did not present substantial information to indicate listing under the Act may be warranted. We consider the effects of past and present fire suppression policies on wildfire impacts under Wildfire and Fire Suppression, below. The petition’s information regarding overutilization was primarily related to hunting and trapping, which we consider below under Hunting and Trapping. In addition, we note that camera traps have been used throughout the range of the SNRF to ascertain sighting areas, and a study involving camera traps and collection of hair and scats for genetic analysis is currently ongoing at the Sonora Pass sighting area (Quinn and Sacks 2014, entire). We are not aware of evidence suggesting that any of these studies have impacted SNRF in any way.

Logging and Vegetation Management

SNRF use several types of habitat, including forested areas of red fir and subalpine conifer (Perrine 2005, pp. 63, 64, 74, 92). In the Lassen sighting area, they also showed a winter-season only preference for what one researcher characterized as “mature closed-canopy forest” (*Id.* at 74). Logging or vegetation management activities that significantly reduce such habitat from SNRF population centers could thus constitute a stressor to those populations. Logging or vegetation management includes those activities that result in felling of timber, road maintenance, road building, construction of landings, and treatment of activity-generated slash (e.g. broken limbs). Timber felling may result in the partial or complete removal of trees within a designated timber sale unit; this opens up the overstory canopy, reduces potential rest structures used by SNRF, and alters habitat for SNRF prey. Road maintenance, road building, and landing construction may result in the fragmentation of forested stands. Slash that is generated during timber harvest can be treated by a number of mechanical means (e.g. mastication) and can also be machine or hand piled for burning at a later time; these activities may impact prey habitat. Although SNRF are most typically found at higher elevations than commercial logging activities (Perrine *et al.* 2010, p. 29), they can sometimes descend to as low as 4,000 ft, where logging activities are more likely to occur (Perrine *et al.* 2010, p. 8; Sacks 2015, p. 1).

Historical Impacts of Logging and Vegetation Management

The historical extent of commercial logging in high elevation forests of the Sierra Nevada and Cascade Mountains is difficult to estimate, but likely considerable, particularly in California. In the Sierra Nevada Mountains, red fir typically occurs in a belt above a lower elevation zone of mixed conifers that extends down to the foothills (Erman *et al.* 1997, p. 12). The entire assemblage of mixed conifers and red fir has been logged to the point where late successional forests are now found on 13 percent of National Forest lands, as compared with 55 percent in National Parks (in which commercial logging has been prohibited) (Erman *et al.* 1997, p. 99). A 1987 status review by CDFG determined that SNRF habitat was under increasing threat from logging activities (CDFG 1987, p. 1). However, the review also indicated that SNRF near Lassen Volcanic National Park, and Yosemite National Park (which is near the modern Sonora Pass sighting area) were “generally isolated from significant habitat destruction and take” (*Id.*). Because the “habitat destruction” being discussed by the review at that point included logging activities, we consider the review’s earlier discussion of “increasing threat” to refer primarily to habitat impacts from logging within the historical California range, beyond the current sighting areas. Even within such historical range, the review acknowledged a lack of evidence showing direct logging impacts to SNRF, and characterized the “virtual absence” of data as a potential threat in itself (CDFG 1987, p. 1).

The central and southern Cascades of Oregon and Washington contain approximately two thirds of the original old growth conifer forest remaining in either mature or old growth (1.35 million ac (0.55 million ha) out of 3.36 million ac (1.36 million ha)) (Strittholt *et al.* 2006, pp. 367–368). This information does not distinguish higher and lower elevation forests within the region or by state, making it difficult to determine potential historical impacts to SNRF.

Additionally, during the first 15 years of implementation of the Northwest Forest Plan (1994–2008), Moeur *et al.* (2011, pp. i, 15) found a net loss of 1.9 percent of old growth forest from Federal lands. This change was small relative to uncertainties and error rates in the estimates, and was also roughly balanced by recruitment (Moeur *et al.* 2011, p. 31). Recruitment was much more difficult to estimate, however, and most likely occurred through incremental stand growth into the lower end of the size and structural definition of older forests (*Id.*). The biggest change in forest diameter class distributions on Federal lands was an increase in the 25.4 to 50.5 cm (10- to 19.9 in) diameter classes, representing potential recruitment acres into the older forest category (Moeur *et al.* 2011, p. 21). Of the 87,800 ha (217,000 ac) of older forest lost on Federal lands, most of it was due to fire, with approximately 15 percent or less resulting from timber harvest (Moeur *et al.* 2011, pp. 17, 21).

Historical logging has thus reduced, by varying amounts, the amount of high elevation mature closed-canopy conifer forest available to SNRF, which may potentially have impacted historical SNRF winter use of these lower elevational habitats.

Current and Future Impacts of Logging and Vegetation Management

Lassen Sighting Area: In accordance with the conservation purposes of the National Park Service Organic Act (16 U.S.C. 1, *et seq.*), commercial logging is prohibited in Lassen Volcanic National Park, and in all national parks (NPS 2006, sec. 1.4). Lassen Volcanic National Park does remove hazardous accumulations of fuels in accordance with its fire management plan

(NPS 2012, p. 17), and is currently carrying out mechanical thinning on 202 ha (500 ac)) as part of a forest restoration project planned for approximately 600 ha (1,500 ac), with the goal of lowering the risk of stand-replacing fires while maintaining significant old-growth elements and varied stand structure (NPS 2014, p. 2). By maintaining old-growth elements and structure the project minimizes potential impacts to SNRF, such as might otherwise occur through significant changes to canopy closure, prey base, or rest areas.

In addition to establishing best management practices for mechanical treatment and controlled burn projects, the fire management plan also seeks to minimize direct impacts to SNRF by prohibiting such projects in areas occupied by SNRF pups, and by requiring construction of fire lines around known den sites to prevent damage by controlled burns (NPS 2005, p. 96). We therefore consider fire management projects such as this to effectively lower the incidence and extent of large fires while avoiding significant impacts to SNRF.

In Lassen National Forest, as of 2009, approximately 929 ha (2,296 ac) of fuels management projects were taking place, or expected to take place, in areas that overlap to some degree with suitable SNRF lower-elevation winter habitat (USDA 2009, p. 510). As discussed below under EXISTING REGULATORY MECHANISMS, those projects are governed by the Sierra Nevada Forest Plan Amendment (SNFPA), which in most areas requires the retention of tree size and canopy closure characteristics beneficial to SNRF. Also as discussed below, all activities, including fuels management projects, occurring within 8 km (5 mi) of a verified SNRF sighting must be analyzed by forest managers to determine if they have the potential to affect the subspecies (USDA 2004, p. 54).

The most recent Schedule of Proposed Action (SOPA) for the Lassen National Forest (covering projects planned as of December 31, 2014) mentions only one future action potentially involving significant tree removal (USDA 2014a, p. 2). That action involves moving a road away from Scotts John Creek, and reducing fuels in the area through thinning and prescribed fire, at elevations ranging from 1,265 to 2,195 m (4,150 to 7,200 ft) in a location approximately 24 km (15 mi) south of known SNRF sightings. SNFPA restrictions discussed above will apply.

Sonora Pass Sighting Area: We are not aware of commercial logging operations occurring or expected to occur near the Sonora Pass SNRF sightings. Additionally, SNRF from this location are not known to descend to lower elevation forests in winter, as do foxes in the Lassen population (Statham *et al.* 2012, p. 130). This may make them less reliant on mature closed canopy forests than the SNRF at Lassen, and thus less susceptible to overlap with logging (Perrine 2005, pp. 67, 74, 90).

The Sonora Pass sighting area includes the northern portion of Yosemite National Park. As with Lassen Volcanic National Park (above), commercial logging is prohibited in Yosemite National Park. The Park does remove hazardous accumulations of fuels in accordance with its fire management plan, which specifies restoration target conditions for red fir forest that would emulate structure produced under a natural fire regime (NPS 2009, p. 25). This emphasis on natural forest structure serves to minimize potential impacts to SNRF while lowering the incidence and extent of large fires.

As of 2009, present and reasonably foreseeable fuel treatment projects in the Summit Ranger District of Stanislaus National Forest totaled 6,867 ha (2,779 ac) (USDA 2009, pp. 445–448). All such projects are subject to the SNFPA requirements discussed below under EXISTING REGULATORY MECHANISMS. Planned future actions involving tree removal in the Summit District include a project to remove encroaching conifers from within meadows and aspen stands, and a prescribed burn on 259 ha (640 ac) to reduce extensive fuel build-up and mimic the effects of natural fire regimes (USDA 2014b, pp. 7, 8). We consider these projects likely to benefit SNRF by maintaining naturally occurring fire regimes and meadow habitat used by SNRF.

Fuels management projects are not currently planned within SNRF habitat in the Bridgeport Ranger District of the Humboldt-Toiyabe National Forest (Lowden 2015, p. 1), with the exception of a single fuels reduction project on Swauger Creek, about 10 miles north of Bridgeport, California (USDA 2014c, p. 7). That project, which according to the Schedule of Proposed Actions would help reduce wildfire severity and restore stand health, is currently on hold (*Id.*). If carried out, it will be subject to the SNFPA requirements discussed below under EXISTING REGULATORY MECHANISMS, and thus unlikely to significantly impact SNRF.

Oregon Sighting Areas: As with Lassen Volcanic National Park and Yosemite National Park (above), commercial logging is prohibited in Crater Lake National Park. Crater Lake National Park does remove small diameter (less than 20.3 cm (8 in)) trees as part of their fuels management strategy (NPS 2011, pp. 8–9). When completed in 2015, this activity will result in the removal of small diameter trees on 1,781 to 3,804 ha (4,400 to 9,400 ac) (NPS 2011, p. 10). The annual amount of area treated varies from a low of 53 ha to a high of 1,609 ha (130 to 3,975 ac) (NPS 2011, pp. 11–12). The activities occur in a scattered distribution, span a period of 5 years from 2011 to 2015, and range in size from 2 to 607 ha (5 to 1,500 ac) (NPS 2011, pp. 11–12). The removal of small diameter trees is not expected to result in changes to canopy closure. However, habitat for prey species may be removed, which can alter the distribution and abundance of those species for the short term. Although small diameter tree removal may occur in areas occupied by SNRF, the timing and scale of this activity distributes potential impacts of reduced cover across space and time. However, unlike SNFPA requirements for fuels management actions, the Crater Lake National Park fuels management strategy does not include measures to avoid or mitigate for direct impacts to SNRF, such as noise disturbance or destruction of den sites (*Id.* at 1).

All four remaining Oregon SNRF sighting areas are in national forests subject to vegetation management standards established under the Northwest Forest Plan (NWFP) (USDA 1994, entire). As discussed in EXISTING REGULATORY MECHANISMS, below, the NWFP acts to protect and enhance conditions of late-successional and old-growth forest ecosystems used by species including the northern spotted owl (*Strix occidentalis caurina*). Habitat for the northern spotted owl overlaps lower-elevation portions of SNRF sighting areas in Oregon. The northern spotted owl requires mature forest with at least 60 percent canopy cover for nesting habitat, and at least 40 percent canopy cover for dispersal habitat (77 FR 71876) (although spotted owl stands on the eastern slopes of the Cascades, such as in the Deschutes National Forest, tend to be smaller and to average between 40 and 50 percent canopy cover) (USDA 2015, p. 1). These canopy closure requirements would meet the 40 percent canopy closure preference found by

Perrine (2005, p. 90) for SNRF in the Lassen sighting area. It is not known whether Oregon SNRF have similar preferences. As with the Sonora Pass region discussed above, and unlike the Lassen area, all Oregon sighting areas are likely to support snowshoe hares at high elevations during the winter (Dyck 2014, p. 1; Ferland 2014, p. 1; Willy 2014, p. 1), although they are considered less abundant in the Deschutes National Forest (Dutchman Flat sighting area and part of the Mt. Washington sighting area) (USDA 2015, p. 1). The availability of high-elevation, mid-sized winter prey, may make SNRF in Oregon sighting areas less dependent on deer carrion and other prey in lower elevation closed canopy habitat. This could reduce the need for SNRF to move to lower elevations in the winter and thereby reduce the potential use of mature forests impacted by logging or vegetation management.

To estimate the amount of wilderness, Late Successional Reserves (LSRs), and other old-growth reserves available at each of the four Oregon sighting areas other than Crater Lake National Park, we mapped NWFP land use allocations above 1,219 m (4,000 ft) within a 32 km (20 mi) radius of the center of the Mt. Hood, Mt. Washington, Dutchman Flat, and Willamette Pass sighting areas, and totaled the results. We selected a 32 km (20 mi) radius because radio-collared SNRF in the Lassen region stayed within an area of roughly that size (Perrine 2005, p. 105). Amounts and percentages of reserves available to SNRF were as follows: Mt. Hood – 51,436 ha (127,102 ac) in reserves (73 percent of total area); Mt. Washington – 92,171 ha (227,759 ac) in reserves (65 percent of total area); Dutchman Flat – 85,067 ha (210,204 ac) in reserves (33 percent of total area); Willamette Pass – 126,782 ha (313,286 ac) in reserves (48 percent of total area) (Bridges 2014, p. 6). Accordingly, logging does not appear likely to significantly impact late-successional closed-canopy conifer habitat used by SNRF in Oregon (as indicated by studies carried out at Lassen) (Perrine 2005, pp. 67, 74, 90).

Few timber removal projects are planned or ongoing for the areas surrounding the Oregon sighting areas. Nothing is planned for above 1,219 m (4,000 ft) in the Mt. Hood sighting area (Dyck 2014, p. 1). Two fuel reduction projects and a prescribed burn are planned for the Mt. Washington sighting area, all of which will be carried out in accordance with NWFP requirements (Doerr 2014, p. 1). The Willamette Pass area has no timber activity planned at elevations used by SNRF (Ferland 2014, p. 1). The area around the Dutchman Flat sighting area does include a large number of acres in the “general forest” category, mostly on the east side of the Cascades, between 1,219 and 1,524 m (4,000 and 5,000 ft) in elevation.

Logging and Vegetation Management – Discussion and Summary

Based on the best available information, we find that logging and vegetation management activities are not impacting SNRF, nor are they impacting habitat such that there will be effects to SNRF. Nor are they likely to do so in the future (within 50 years). Therefore, we conclude these activities are not stressors for the purposes of this evaluation.

Wildfire and Fire Suppression

Fire suppression could potentially impact SNRF by changing the habitat to include denser stands of trees and fewer open meadow or shrub areas, thereby potentially affecting the prey base. Fire

suppression might also lead to direct effects on SNRF by allowing greater fuel buildup, thereby producing larger and hotter wildfires.

Perrine *et al.* (2010, p. 29) noted that historical fire suppression activities in the Sierra Nevada mountains had increased forested areas at the expense of more open meadow and riparian areas, but pointed out that this may simply have shifted the prey base somewhat to rodents such as gophers and squirrels (*Thomomys spp.* and *Sciurus spp.*) that are more common in forested areas. As discussed below, small fires can increase growth of young grasses and shrubs, thereby temporarily increasing the prey base (Tesky 1995, p. 7), but we lack information to show that such temporary benefits from small fires occurred regularly enough to affect long-term SNRF population levels. Accordingly, we do not expect fire suppression activities to negatively affect available prey except to the extent that they may allow fuels buildup that increases the risk of stand-replacing fires.

Historical Impacts of Wildfire and Fire Suppression

Historical policies of wildfire suppression in western North America, have led to unnatural fuel accumulations, and an increased risk of uncharacteristically severe wildfires (Miller 2003, p. 379; Truex and Zielinski 2013, p. 85). Wildfires in western states, including California and Oregon, have been more frequent, larger, and more intense in the past 50 years, and particularly in the past 15 years (ISAB 2007, pp. 22–23). These increases are directly correlated with climate change (*Id.*; USDA 2004, p. 6) (see Climate Change, below), and so are likely to continue.

There are no reports of direct mortality to red foxes from fires (Tesky 1995, p. 7). Short-term habitat impacts from smaller fires can actually benefit red foxes by encouraging growth of young grasses and shrubs, leading to increases in small mammal populations preyed on by SNRF (*Id.*). Fruiting shrubs also tend to increase after fire, providing an important supplementary food source (*Id.* at 8; Perrine 2005, p. 191). However, unusually large, hot, or fast moving wildfires could potentially injure SNRF or remove the prey base from an area long enough to negatively impact SNRF populations. Long-term habitat changes caused by fires acting in concert with increased temperatures and altered moisture regimes, would tend to add to tree mortality trends and permanently remove forested habitat as discussed below under Climate Change.

The Sierra Nevada Forest Plan Amendment (SNFPA) was adopted in 2004 largely in order to better address the potential for catastrophic wildfire by preventing build-up of fuels (USDA 2004, pp. 3–5). The SNFPA applies to national forests in the vicinity of the Lassen and Sonora Pass sighting areas. However, concerns regarding air quality and political impacts have limited prescribed burns, and dangerous fuel build-ups still exist within the portion of the SNRF range governed by the SNFPA (Lassen and Sonora Pass sighting areas) (Kolipinski 2015, p. 2).

Current and Future Impacts of Wildfire and Fire Suppression

Lassen Sighting Area: The “Reading Fire” burned approximately 11,331 ha (28,000 ac) within the Lassen sighting area over approximately 4 ½ weeks in July and August of 2012 (NPS 2012, p. 3). It was caused by a lightning strike at an elevation of approximately 2,134 m (7,000 ft), and was allowed to burn slowly over a period of two weeks in red fir habitat with relatively limited

ground fuels (*Id.* at 10). Decreasing humidity and fuel moisture allowed it to jump the Lassen National Park Highway and spread rapidly northwest through areas of heavier ground fuel accumulations (*Id.* at 3, 10–11, 22–23). It was contained on August 22 (*Id.* at 3). Impacts to SNRF were not estimated, but we expect impacts to available cover and prey base in the hottest burning portions of the burned area may have been substantial due to the extent and intensity of the fire.

Sonora Pass Sighting Area: In 2013, the “Rim Fire” burned 104,131 ha (257,314 ac) of forested habitat in the Stanislaus National Forest and Yosemite National Park, about 50 km (31 mi) southwest of the Sonora Pass sighting area (USDA 2013, p. 1; Sierra Nevada Conservancy 2014, p. 1). The fire burned from August 17 to October 24, 2013, and became the largest fire ever recorded in the Sierra Nevada Mountains (Sierra Nevada Conservancy 2014, p. 1). Although the sighting area itself was not affected, the intensity and size of the Rim Fire was made possible in part by past policies of fire suppression, and by vegetation stressed by lack of water (*Id.*). Such fire suppression policies have been applied generally throughout the Sierra Nevada Mountains (*Id.*), and water-stress is likely to increase in the future throughout the Sierra Nevada as well (see [Climate Change](#), below). Accordingly, the Sonora Pass sighting area may be at risk of impact from a similarly large or intense fire within 50 years (*Id.*). Such a fire would presumably reduce cover and habitat availability for several years at least.

Oregon Sighting Areas: SNRF in the Dutchman Flat sighting area have been detected at two locations on the site of a recent stand-replacing fire of 10,570 ha (26,119 ac) referred to as the Pole Creek burn (McFadden-Hiller and Hiller 2015, pp. 111–112). Impacts of the fire to SNRF are not known.

A 2011 fire called the “Dollar Lake Fire,” covering approximately 2,428 ha (6,000 ac) on the north side of the Mt. Hood sighting area (NWCC 2015, pp. 1–2) has been described as so intense, on such shallow soils with dense fuels, that it removed the vegetation almost completely, and left little vegetation even after two years (Dyck 2015, p. 1). Such fires, occurring at high elevations, can reduce available SNRF habitat for several years (*Id.*).

Wildfire and Fire Suppression – Discussion and Summary

Historical policies of fire suppression have increased forested areas at the expense of more open habitat (Perrine *et al.* 2010, p. 29), and have increased the risk of high-intensity fires by allowing accumulation of fuels (Miller 2003, p. 379; Truex and Zielinski 2013, p. 85). The loss of open habitat may have shifted the prey base in favor of more forest-adapted species, but we have no information to suggest such a shift would be detrimental to SNRF (Perrine *et al.* 2010, p. 29). There are also no reports of direct mortality to red foxes from fires, and smaller fires can improve habitat for red foxes by increasing production of new grasses and shrubs favored by certain prey species (Tesky 1995, pp. 7–8).

However, large, high intensity fires do remove vegetation for periods of several years or more, thereby lowering or eliminating the prey base in those areas. Large, high intensity fires have recently impacted the Mt. Hood and Lassen sighting areas, and came very close to the Sonora Pass sighting area. Accordingly, on balance we consider wildfire and fire suppression to

constitute a low-level impact both currently and into the future. This characterization does not account for the likelihood of long-term removal of forested habitat due to the combination of wildfires and climate change. See Climate Change, below, for further discussion of this impact.

Grazing

Inappropriate grazing regimes can alter riparian and meadow habitats in several ways. For instance, if managed inappropriately, livestock grazing in meadows and on stream banks can compact soils, which reduces water infiltration rates and the soil's ability to hold water, thereby increasing surface runoff rates into adjacent streams, downcutting streambeds, and lowering the water table (Meehan and Platts 1978, pp. 275–276; Kauffman *et al.* 1983, pp. 684–685; Kauffman and Krueger 1984, pp. 433–434; Bohn and Buckhouse 1985, p. 378; Armour *et al.* 1994, pp. 9–10). In some cases, excessive livestock grazing has resulted in the conversion of wet meadows into dry flats and in diminished perennial stream flows (Armour *et al.* 1994, p. 7). Livestock also directly consume forage that might otherwise be consumed by SNRF prey species (Grinnell *et al.* 1937, p. 398). Such habitat alterations can potentially lower the abundance of prey species available to SNRF, thereby lowering the numbers of SNRF that the habitat can support (Grinnell *et al.* 1937, p. 398; Kauffman and Krueger 1984, p. 433). In contrast, certain rodent prey populations (including pocket gophers (*Thomomys* spp) and Belding's ground squirrel (*Urocitellus beldingi*)) may also potentially increase due to favorable grazing practices, thereby benefitting SNRF (Perrine *et al.* 2010, p. 29).

Historical Impacts of Grazing

A recent conservation assessment of the SNRF identified reduced prey populations due to historical overgrazing, and predator eradication programs carried out in the past in support of grazing as significant sources of human-associated mortality (Perrine *et al.* 2010, pp. i, 17). In the 1930s, Grinnell *et al.* (1937, p. 398) considered overgrazing of alpine meadows by domestic sheep as “the greatest menace to the productivity” of SNRF. Additionally, in historical times, poisons such as strychnine were used on a widespread basis to control both livestock predators such as coyotes, as well as rodents (Perrine *et al.* 2010, p. 29). SNRF were directly susceptible to poisoned baits intended for livestock predators, and could also be indirectly exposed to rodenticides by consuming affected rodents (*Id.*). The widespread use of strychnine for grazing practices has since been outlawed (*Id.*). A single SNRF in the Sonora Pass sighting area, found in January 2011 on Highway 395 after having been struck by a vehicle (Sacks *et al.* 2015, p. 9), tested positive for rodenticide exposure (Clifford 2014, p. 2). Rodenticides are still used in public recreation areas to control rodent populations in response to potential plague outbreaks (Perrine *et al.* 2010, p. 29). They are also used in illegal marijuana cultivations, but these generally occur at elevations below 1,219 m (4,000 ft), and so would be unlikely to impact SNRF (Doerr 2014, p. 1).

Current and Future Impacts of Grazing

Lassen Sighting Area: In accordance with the conservation purposes of the National Park Service Organic Act (16 U.S.C. 1, *et seq.*), commercial grazing is prohibited in Lassen Volcanic National Park, and in all national parks (NPS 2006, sec. 1.4).

There are currently seven active cattle grazing allotments on the Lassen National Forest that have moderate to high value habitat for SNRF (USDA 2009, p. 510). However, grazing levels must adhere to utilization standards under the SNFPA designed to protect meadow hydrology and insure maintenance of adequate forage and cover for SNRF prey species such as meadow voles (*Microtus* spp.) and pocket gophers (*Thomomys* spp). We have no information to indicate grazing standards are not being met.

SNFPA grazing standards include minimum amounts of forage per acre to be left ungrazed at the end of a season, depending on condition of the range and precipitation received (USDA 2004, p. 56). Each grazing allotment has a management plan for carrying out the SNFPA guidelines. We consider these guidelines sufficient, when consistently applied, to maintain SNRF prey species, and to prevent changes to water tables and hydrological flows. For instance, a comparison of high-elevation allotments grazed under SNFPA guidelines, and similar allotments on which grazing had been suspended, showed no differences in the richness or diversity of meadow plant species, or in the frequency of soil stabilizing species (Freitas *et al.* 20114, p. 307). The comparison took place over a ten year time period on Inyo National Forest lands within the southern portion of the SNRF historical range (*Id.* at 302, 303).

Future actions by National Forest range managers include a proposal to revise the allotment management plan for the Feather River Grazing Allotment, consisting of about 5,386 ha (13,310 ac), about 8 km (5 mi) south of Lassen Volcanic National Park (USDA 2014d, p. 1). The proposed revision accounts for a loss of private grazing lands in the area by adjusting the remaining permitted limit for animal user months (AUMs) in order to meet SNFPA requirements and objectives (USDA 2014d, pp. 2, 10). The Draft Environmental Impact Statement (DEIS) for the project indicates that the proposed grazing plan revision may affect individual SNRF by impacting availability of prey species such as voles, but is not likely to cause a loss of viability for the subspecies (USDA 2014d, p. 52, 57–58). The DEIS notes that some prey species, such as pocket gophers and Belding’s ground squirrels, could increase in response to grazing (*Id.* at 58). If consistently followed, the adjustments proposed for the grazing plan revision appear likely to benefit SNRF in the area.

Sonora Pass Sighting Area: The Sonora Pass sightings lie partially in the Summit Ranger District of the Stanislaus National Forest, and partially in the Bridgeport Ranger District of the Humboldt-Toiyabe National Forest. We do not have information regarding grazing allotments in the Bridgeport Ranger District, but the Summit Ranger District has six active allotments (USDA 2014e, p. 41). Three of these are within approximately 16 to 32 km (10 to 20 mi) of the Sonora Pass sightings, separated by habitat suitable for SNRF, and at elevations ranging from 2,012 to over 2,743 m (6,600 to over 9,000 ft) (USDA 2014e, pp. 2, 41, 201–202). Thus, they are likely to contain habitat used by SNRF. The Forest Service is proposing to modify the boundaries of the three allotments (increasing the size of Eagle Meadow and Herring Creek, and aligning the bounds of Bell Meadow with natural barriers), as well as to update the allotment management plans to incorporate resource conservation measures and adaptive management options (not specifically for SNRF) (USDA 2014e, p. 8). The allotments currently contain 7,248 ha (17,911 ac) of habitat suitable for SNRF, and the Forest Service is proposing to add an additional 982 ha (2,426 ac) of suitable habitat to the existing allotments (USDA 2014e, p. 8). The Forest Service

has not yet assessed the habitat status for most areas within the allotment boundaries, but the habitat in the proposed additions is in good condition.

The status of various meadows in the three allotments was assessed in 2012, however, by the Central Sierra Environmental Resource Center (CSERC), a non-profit environmental protection group. They found that grazing had negatively affected hydrology and vegetation at some areas, resulting in meadow dehydration, streambank downcutting, and overgrazing of forage as compared to established grazing utilization standards (CSERC 2012, pp. 1–31). Such impacts could potentially reduce population sizes of SNRF prey species on the affected areas. We consider the resource conservation and adaptive management actions proposed by the Forest Service likely to improve conditions for SNRF on these allotments if implemented.

Oregon Sighting Areas: Commercial grazing is prohibited in Crater Lake National Park, and in all national parks, in accordance with the conservation purposes of the National Park Service Organic Act (16 U.S.C. 1, *et seq.*), (NPS 2006, sec. 1.4).

No grazing allotments occur near potential SNRF habitat in the vicinity of any of the four Oregon sighting areas north of Crater Lake.

Grazing – Discussion and Summary

Grazing on National Forest lands is conducted in the vicinity of two of the seven SNRF sighting areas: those at Lassen and Sonora Pass. The SNFPA establishes grazing standards for those locations, which if consistently met, would likely maintain habitat features required by SNRF prey species. Proposals for adjustments to certain existing allotments at both locations appear likely to improve habitat for SNRF prey species where applied. However, we have little information regarding the extent to which the Ranger Districts involved have been able to enforce grazing standards. A single independent review by CSERC found that in allotments near the Sonora Pass sighting area, some meadows had suffered no damage while others had been overgrazed, with potential impacts to ability to support SNRF prey. Even at this location, however, direct impacts to the SNRF prey base have not been demonstrated. Accordingly, based on the best available information, we find that grazing activities are not impacting SNRF, nor are they impacting habitat such that there will be effects to SNRF. Nor are they likely to do so in the future (within 50 years). We therefore conclude these activities are not stressors for the purposes of this evaluation.

Hunting and Trapping

Although hunting and trapping of SNRF is currently unlawful in California, it was legal historically across the range, and remains legal in Oregon (see below). We consider here the extent to which hunting and trapping may impact SNRF populations or the subspecies as a whole. Although we consider hunting and trapping together, we only have direct evidence of SNRF harvest due to trapping (Grinnell *et al.* 1937, pp. 396–397).

Historical Impacts of Hunting and Trapping

The SNRF has historically been hunted and trapped for its thickly-furred pelt, which was the most valuable of any terrestrial animal in California (Grinnell *et al.* 1937, pp. 396–397). In 1922, a trapper could get up to \$1,000 for a single pelt of a black phase SNRF (*Id.*). The more typical red phase was \$12 to \$30, however, and required substantial effort given the SNRF's high-elevation habitat. Consequently, trappers typically removed trap lines in response to lowered harvest levels in order to let local populations recover and serve as a continuing source of income (Grinnell *et al.* 1937, pp. 397–398). A typical number of SNRF harvested in California during a winter trapping season in the 1920s was 21 animals (Grinnell *et al.* 1937, p. 389).

By the 1940s and 1950s, the average yearly harvest in California over the 20 year period had decreased to 6.75 (Perrine 2005, p. 154). Most of these were likely taken during the 1940s, because SNRF were sighted only 19 times in California during the 1950s (Schempf and White 1977, p. 44). During the 1960s, the total number of sightings in California was also 19. The California legislature responded to this apparent drop in population numbers by banning the commercial harvest of red foxes throughout the state in 1974 (CDFG 1987, p. 4; Perrine 2005, p. 2).

Until recently, SNRF in Oregon were considered to be Cascade foxes; of the same subspecies that occupied the Cascades in Washington (Sacks *et al.* 2010, p. 1536). Information is not available regarding historical hunting and trapping pressures on foxes in the Oregon Cascades. Hunting and trapping of red foxes is regulated, but remains legal throughout the State of Oregon (except in National Parks).

Current and Future Impacts of Hunting and Trapping

Lassen and Sonora Pass Sighting Areas: Hunting and trapping of any subspecies of red fox is prohibited in California (14 California Code of Regulations (CCR) 460). Additionally, as discussed below (EXISTING REGULATORY MECHANISMS), the SNRF is protected as a threatened species under CESA (California Fish and Game Code 2050–2115.5; CDFW 2014, p. 12), which prohibits not only “take” by hunting or trapping, but also possession, sale, purchase, and export of the parts or products (such as pelts) of protected species (California Fish and Game Code 2080; 14 C.C.R. 783.1). Commercial and recreational trapping of certain other animals occurring within the range of the SNRF, such as coyote and gray fox (*Urocyon cinereoargenteus*), is allowed (14 C.C.R. 461, 472) but even in such cases, use of body gripping devices such as leg-hold traps, coniber traps, or snares is prohibited (14 C.C.R. 465.5(c)). Use of steel-jawed leg-hold traps is not lawful for any purposes other than in extraordinary cases to protect human health or safety (14 C.C.R. 465.5(e)). Accordingly, for SNRF to be incidentally trapped by legal methods, it would have to be in a non-lethal trap such as a net, cage, or box trap (14 C.C.R. 465.5(c)). Those must be visited at least once a day (14 C.C.R. 465.5(f), 14 C.C.R. 465.5(g)(2)), allowing the potential for an incidentally trapped SNRF to be released unharmed. Poaching and accidental shooting (possibly by people mistaking SNRF for gray fox), are possible, but are likely rare. No such incidents have been noted by researchers in any of the status reviews or investigations conducted on the subspecies to this point (Schempf and White

1977, entire; CDFG 1987, entire; Perrine 2005, entire; Perrine *et al.* 2007, entire; Perrine *et al.* 2010, entire; Sacks *et al.* 2010, entire; Statham *et al.* 2012, entire; Sacks 2014a, entire; Mohren 2014, entire).

Oregon Sighting Areas: Hunting and trapping of red fox has been governed by furbearer regulations since 1978 (ODFW 2011, p. 26). Those regulations allow licensed hunting and trapping of red foxes, including with use of dogs (635 Oregon Administrative Rule (OAR) 050-0045(1), 0045(8)). Since, as described above, high elevation red foxes in Oregon were recently determined to be SNRF, this applies to all SNRF sighting areas in Oregon except Crater Lake National Park, where hunting and trapping is prohibited. The Oregon Department of Fish and Wildlife (ODFW) maintains trapping records by county, without recording exact location or elevation, so harvest of SNRF cannot be distinguished from harvest of lowland fox subspecies (Turner 2014, p. 1). Numbers harvested were highest in Lane County (Willamette Pass sighting area), and second highest in Linn County (which overlaps part of the Mt. Washington sighting area). Across all eight Oregon Counties containing an SNRF sighting area, average harvest of foxes for the years 1989 to 2009 was 46.8 per year (or 5.85 per county per year). That dropped to 23 across all counties (2.875 per county) for the year 2010 to 2011, and dropped again to 10 across all counties (1.25 per county) for 2011 to 2012. The numbers of fox harvested per year thus appears to be undergoing a significant reduction, but we lack information to determine whether it is due to reduced hunting and trapping pressure (reduced effort), or reduced population levels of red fox. If the latter, we lack information to distinguish reduced levels of lowland red foxes from reduced population levels of SNRF. We have no information to suggest that current or future hunting and trapping of red fox will be different from the historical information provided above. Because it is not possible to determine from the records if SNRF are harvested or not, we assume that at least some of the red fox harvested are SNRF. Therefore, hunting and trapping may be acting as a low-level stressor on SNRF in all Oregon sighting areas except Crater Lake.

Hunting and Trapping – Discussion and Summary

Due to regulatory protections, hunting and trapping does not constitute a current or likely future stressor to SNRF populations in California or at Crater Lake in Oregon. In the other four Oregon sighting areas, low numbers of red foxes are being harvested, some of which are likely to be SNRF. Fox harvest rates have generally been low, however, and have been declining in recent years. Hunting and trapping is thus likely to impact individual SNRF in the four Oregon sighting areas, but in the absence of more definite information regarding SNRF population levels in Oregon, we do not consider such harvest levels likely to produce detrimental impacts to SNRF populations or to the subspecies as a whole. These activities therefore constitute stressors meeting the definition of low level impact. As neither the regulatory framework, nor hunting and trapping efforts appear likely to significantly change within a 50 year timeframe, we consider hunting and trapping to be a low level stressor both currently and in the future.

Salmon Poisoning Disease and Elokomin Fluke Fever

Salmon Poisoning Disease (SPD) is a bacterial infection that is typically fatal to canids (members of the dog family). Foxes are highly susceptible, as are domestic dogs and coyotes

(Cordy and Gorham 1950, p. 622; Headley *et al.* 2009, p. 1). The responsible bacterium *Neorickettsia helminthoeca*, is transmitted to canines when they eat infected fish (generally, but not solely, salmonids—trout or salmon), or infected Pacific giant salamanders (*Dicamptodon spp.*) (Headley *et al.* 2009, pp. 3, 4; Rikihisa 2014, p. 2). The fish (or salamanders) themselves become infected when the small, free-swimming larvae of a parasitic flatworm (*Nanophyetes salmincola*) burrow into the fish's tissues while carrying the bacterium inside their cells. The flatworm spends the first portions of its life in an intermediary host: a small freshwater snail *Juga plicifera* (Foreyt *et al.* 1987, p. 412; Headley *et al.* 2009, p. 3; CDFG 2010, p. 1; ITIS 2014, p. 1). The host snail has previously been referred to as *Oxytrema sillicula* (Sykes *et al.* 2010, p. 504) and as *Juga sillicula* (Rickman 2012, p. 5). *Juga sillicula* may also be a separate species from *Juga plicifera* (Rikihisa 2014, p. 2).

A similar disease, Elokomin fluke fever (EFF) is transmitted in the same manner (with the same flatworm vector and snail host) as SPD (Rikihisa 2014, pp. 1–3). It is caused by a related bacterium, *Neorickettsia elokominica*, and affects foxes and other canids in the same way as SPD (Rikihisa 2014, p. 3). However, it produces milder symptoms, and is fatal in only about 10 percent of untreated cases (*Id.*).

Likelihood of death in canids infected by SPD is high (Foreyt and Thorson 1982, p. 159; Perrine *et al.* 2010, p. 28). In California, the host snails are native to the Klamath and Eel River drainages in the northwestern portion of the State. SPD is now present in the upper Sacramento River as well, implying that either the host snail has extended its range (Rickman 2012, p. 3) or the parasitic flatworm has adapted to infect a different species of host snail (*Id.* at 5). The range of the disease (and thus presumably of the host snail) extends north from California (north of the Sonora Pass sighting area, but including the Lassen sighting area) through western Oregon (including the western slopes of the Cascades) to the Olympic Peninsula of Washington State (Headley *et al.* 2009, p. 2). SPD may also be carried to areas outside the native range of the host snail by stocking fish from infected hatcheries to various locations for recreational sport fishing. In California, the Darrah Springs, Mt. Shasta, and Crystal Lake hatcheries have all become infected with SPD (Rickman 2012, p. 1).

SNRF do not normally capture trout, but could conceivably ingest fish infected with either SPD or EFF by eating entrail piles left by anglers, trout killed during transplant operations, or trout killed during periods of low oxygen in late winter lakes (Rickman 2012, p. 1). Naturally occurring cases of SPD infection have been found in red foxes in the past (Todoroff and Brown 2014, p. 5), though never in SNRF. Additional future opportunities for ingestion of infected fish may occur in the Lassen sighting area, as improvements to Pine Creek allow infected Eagle Lake trout to spawn in headwaters of the creek within the Lassen sighting area (see below). Infected trout might also be killed by fire retardants used on National Forest lands to combat wildfires (USFWS 2008, p. 30), but that is unlikely. The aerial application of fire retardant by the U.S. Forest Service is governed by guidelines that provide for a 91-m (300-ft) buffer around all aquatic features (USDA 2011, p. 7). Additionally, based on calculations of misapplication over the past 3 years, there is a 0.42 percent chance of fire retardant being applied to aquatic features (USDA 2011, p. 104).

Historical Impacts of SPD and EFF

The first report of SPD infection (in domestic dogs) came from northwestern Oregon in 1814 (Headley *et al.* 2009, p. 1). In 1950, the range of the disease was considered to stop west of the Oregon Cascades (Cordy and Gorham 1950, p. 617); it is unknown if SPD has extended its range into the western slopes of the Oregon Cascades (and hence into the range of SNRF in Oregon). We have no direct information regarding historical impacts of SPD or EFF to SNRF, either in Oregon or California. We know of no confirmed cases of SPD or EFF in SNRF, either historically or in recent times.

Current and Future Impacts of SPD and EFF

Lassen Sighting Area: The Lassen sighting area is outside the historic range of SPD (Todoroff and Brown 2014, p. 6), and we have no information regarding presence of EFF at the location. However, rainbow trout from various hatcheries are stocked in the Lassen National Forest for recreational fishing (*Id.* at 15). Todoroff and Brown (2014, pp. 1, 7, 12) collected trout from across Lassen National Forest, and found that about half were infected by the parasitic flatworm (*N. salmincola*). However, only 5 out of 333 of those trout were also infected with SPD (*Id.* at 1, 14). Four out of 61 of those infected fish came from Eagle Lake, while the fifth came from the north fork of the Feather River (*Id.* at 14). EFF was not tested for.

A concern regarding potential impacts from SPD in the future involves efforts to restore historical spawning runs for Eagle Lake rainbow trout to the upper reaches of Pine Creek, which is within the current range of SNRF in the Lassen sighting area (Rickman 2012, p. 2). The Eagle Lake rainbow trout is a subspecies native to Eagle Lake and is currently dependent on hatcheries for its continued reproduction (77 FR 54550). A 2006 survey of veterinary clinics in the vicinity of Eagle Lake found that dogs with SPD had often consumed fish from the lake (Rickman 2012, p. 2). Restoration of the spawning run could thus allow infected fish to spawn and die within the Lassen sighting area, where they could be consumed by SNRF. Spawning runs were only possible historically during years with relatively high precipitation, however, and recent testing by Todoroff and Brown (2014, p. 14) found SPD infection in only 4 of 61 fish from Eagle Lake.

Sonora Pass Sighting Area: In order to prevent transmittal of diseases (including SPD and EFF), CDFW does not stock fish from Northern California south of the Feather River (Beale 2011, p. 1). Accordingly, the Sonora Pass sighting area is unlikely to be exposed.

Oregon Sighting Areas: SPD is native in western Oregon, from the coast to the western slopes of the Cascades (Headley *et al.* 2009, p. 2). Fish raised in Oregon hatcheries commonly carried SPD in the 1980s and early 1990s (Green *et al.* 1986, p. 313; Rikihisa *et al.* 1991, p. 1929), although it is possible that they no longer do so (Niemela 2015, p. 3). Fish from Oregon hatcheries may be transplanted by the Oregon Department of Fish and Wildlife to high mountain lakes for recreational fishing purposes. Fish transplants to the Crater Lake area were stopped in 1941, but the descendants of those transplanted fish remain in the lake and surrounding streams (NPS undated, p. 1), and so may possibly remain vectors for SPD or EFF. Accordingly, we consider all five Oregon sighting areas subject to exposure. We also consider the likelihood of exposure to have remained constant in recent years, and expect that it will continue to do so.

SPD and EFF – Discussion and Summary

SPD and EFF are fatal to foxes, and commonly infect trout throughout the SNRF's current range, except at the Sonora Pass sighting area. However, we have no evidence of SPD or EFF infection of SNRF, currently or at any time in the past, and the only investigation of SPD infection rates in fish within an SNRF sighting area (Lassen) showed very low levels of SPD infection (5 of 333 fish) (Todoroff and Brown 2014, pp. 1, 14).

Future impacts are unlikely to change within 50 years at any sighting areas except Lassen, where planned hydrological improvements around Pine Creek are expected to allow Eagle Lake rainbow trout to spawn and die within the sighting area, thereby making them available for SNRF consumption. Since, even after improvements, spawning runs will only be likely during years with high precipitation, and since current infection rates are relatively low in Eagle Lake rainbow trout (4 of 61 fish), impacts to SNRF will likely be limited to occasional individuals, rather than a high proportion of the population. SPD and EFF can only be transmitted by consuming infected fish, so there is no danger of passing the infection from one SNRF to another. SPD and EFF are thus likely to impact individual SNRF in the future, but not entire populations.

Based on the lack of current impacts to SNRF, and on the fact that future impacts (within 50 years) are limited to individual SNRF, and are unlikely to have impacts that are population or subspecies-wide, we consider SPD and EFF to constitute a stressor with a low-level impact.

Other Diseases

Diseases most likely to have population-level effects on red foxes include sarcoptic mange, canine distemper, and rabies (Perrine *et al.* 2010, pp. 17, 28). Sarcoptic mange is a skin disease transmitted by a parasitic mite, that leads eventually to weight loss and death (Baldwin 2011, p. 1). Major outbreaks leading to losses or near losses of entire populations of red fox have been documented in Bristol, England in 1994 (Baldwin 2011, p. 1), and in northern Sweden in the late 1970s and early 1980s (Danell & Hornfeldt 1987, p. 533). The mite can be carried by coyotes and domestic dogs, in addition to red fox (Baldwin 2011, p. 13). Canine distemper is a highly contagious viral disease attacking the animal's central nervous system (Granberry 1996, p. 2). In addition to red foxes, it can affect dogs, coyotes, grey foxes, raccoons and skunks, and is 90 percent fatal to wildlife. Rabies is a viral disease of the central nervous system, usually transmitted by bite (CDC 2013, p. 1). Death rate for red foxes infected by rabies is high, even when receiving low dilutions of the virus (Black and Lawson 1970, p. 311).

Historical Impacts of Other Diseases

We have no information on the historical impacts of sarcoptic mange, canine distemper, or rabies to SNRF.

Current and Future Impacts of Other Diseases

Although the CDFW (2015, p. 2) has noted cases of rabies and distemper in Gray foxes (*Urocyon cinereoargenteus*) in Lassen County, to our knowledge none of the pictures available from camera traps, or direct examinations of foxes captured for radio tagging, have indicated impacts from these three diseases in any of the seven sighting areas. Perrine (2005, p. 154) noted that “we have no data on the impact of rabies, canine distemper, or other diseases upon mountain red fox in North America.”

Future impacts of such diseases on any given population are difficult to predict, but the low population densities of SNRF (Perrine *et al.* 2010, p. 9) should make transmission within a population or Sighting Area less likely except within family groups. The relative isolation of the Sighting Areas themselves should make transmission from one such area to another less likely, particularly for the Lassen, Sonora Pass, Crater Lake, and Mt Hood sighting areas, since those are the most physically separated from the sighting areas nearest to them.

Other Diseases – Discussion and Summary

Although sarcoptic mange, canine distemper, and rabies can produce population-level effects (medium impact level) in other subspecies of red fox, we have no information showing any such infections of SNRF, at either the individual or population level, now or in the past. SNRF also maintain unusually low population densities, making population-level impacts in the future less likely. Individual SNRF remain potentially susceptible to these diseases in the future, however, (within a 50 year timeframe).

Accordingly, because these diseases may affect individual SNRF, but are unlikely to produce population-level or subspecies-level impacts, we find these diseases constitute a stressor with a low-level impact.

Small Population Size and Isolation

Small populations may suffer from inbreeding depression, and experience proportionately greater losses from chance deleterious events such as storms or local outbreaks of disease or parasites (Gilpen 1987, pp. 132–134). Particularly small populations may also suffer reproductive decreases due to demographic stochasticity: a sex ratio heavily skewed by chance from 50:50 (Soule and Simberloff 1986, p. 28). High levels of genetic isolation (lack of interbreeding with members of other populations) exacerbate these problems. Inbreeding depression in highly isolated populations cannot be alleviated by genetic exchange with other populations, and depleted or extirpated populations cannot be replenished by migrants from other locations (Franklin 1980, p. 140; Gilpen 1987, p. 135).

Inbreeding depression results from the accumulation of deleterious alleles (gene variants) in the population (Soule 1980, pp. 157–158). This happens because alleles in general tend to be lost quickly from small populations due to the chance nature of reproduction (genetic drift) (*Id.*). When all the beneficial alleles of a given gene are lost by chance, and a deleterious allele is (by chance) the only variant of a given gene remaining in the population, then the frequency of that deleterious allele is “fixed” (meaning “affixed,” or “stuck”) at 100 percent, and the allele will be passed to all members of the population across subsequent generations (*Id.*). Because there are

many genes, there are many opportunities for deleterious alleles to become fixed in some of them, thereby producing deleterious effects. In larger populations natural selection can generally eliminate deleterious alleles before they become fixed, but in small populations the chance effects of genetic drift can overcome this tendency.

Inbreeding effects also occur because closely related individuals are likely to share many of the same deleterious alleles, and are thus more likely to pass two copies of a deleterious allele to their young, even if non-deleterious versions of the gene still remain in the population (*Id.*). Inbreeding depression typically results in abnormal sperm production, lowered reproductive success, and congenital abnormalities that can decrease survivorship (Soule 1980, pp. 157–158; O'Brien 2003, pp. 62–63). Loss of genetic variability also leaves the population more vulnerable to parasites and diseases due to depressed immune systems in individuals and genetically similar defenses throughout the population (O'Brien 2003, p. 63). Small isolated populations are also less adaptable to environmental change because the genetic variations that might have facilitated such adaptation are lost (Soule 1980, pp. 157–158).

An “effective population size” (the number of breeding individuals in a freely mixing population with equal numbers of males and females) of at least 50 individuals is generally considered necessary to avoid inbreeding depression and thereby provide for short-term population survival, while an effective size of 500 is necessary to allow for continuing adaptation (Shaffer 1987, pp. 74–75). Most populations are not freely mixing, and include individuals that fail to breed in a given year; so actual population sizes are typically larger than effective population sizes.

Historical Impacts of Small Population Size and Isolation

As discussed under SIGHTING AREA STATUS AND TRENDS above, the Lassen and Sonora Pass populations underwent recent population declines. We have no information clearly indicating those declines have yet resulted in inbreeding depression, however. Similarly, we have no information indicating inbreeding depression is affecting, or has affected, any Oregon populations or sighting areas.

Current and Future Impacts of Small Isolated Populations

Lassen Sighting Area: As discussed under SIGHTING AREA STATUS AND TRENDS (above), the effective size of the Lassen SNRF population is estimated at 21 breeding individuals. Since this is considerably less than an effective population size of 50, inbreeding depression may be an issue in the population, now or in the future (Shaffer 1987, p. 75). Potential inbreeding depression at the Lassen Sighting Area is also unlikely to be avoided through interbreeding with other populations. The nearest SNRF sighting area to the Lassen population is at Sonora Pass, but the distance between them (100 km (62 mi) straight-line distance) is greater than 95 percent of dispersal distances recorded for lowland North American red foxes (80 km (50 mi)) (Statham *et al.* 2012, p. 129). Genetic testing also provides no evidence of migration between the Lassen and Sonora Pass populations (Statham *et al.* 2012, p. 129). The population is thus both small and highly isolated from other SNRF.

The actual size of the Lassen population is likely to be somewhere between 21 and 63 individuals, depending on the number of nonbreeding individuals present (Sacks *et al.* 2010, p. 1536; Sacks 2015, p. 1). Such a small population is at risk from deleterious chance events, such as major storms or epidemics, that can harm or kill relatively large numbers of SNRF. We do not have information regarding how often such chance events occur, but consider at least one such event likely within the next 50 years.

Although no current impacts are clearly attributable to small population size or isolation, physiological examination of four adult female SNRF from the Lassen population, captured in 2000 for a radio telemetry study, showed they had not reproduced, either prior to the study or during its 2-year duration, despite the overlap of their ranges with a collared male (Perrine 2005, pp. 141, 164). Low reproductive success is a common result of inbreeding depression (Soule 1980, pp. 157–158; O'Brien 2003, pp. 62–63; Quinn and Sacks 2014, p. 15), although other possible explanations exist, such as low prey availability at higher elevations (Perrine *et al.* 2010, p. 5; Quinn and Sacks 2014, p. 15). However, see discussion of similar conditions at the Sonora Pass area, below.

The small size and high isolation of the Lassen population make future impacts likely from inbreeding depression or chance deleterious events. The population will remain vulnerable to such threats so long as it stays small and isolated, but based on observed reproductive output and on a lack of evidence for nearby SNRF populations, it appears likely to remain small and isolated for at least the next 50 years.

Sonora Pass Sighting Area: As discussed under SIGHTING AREA STATUS AND TRENDS, above, a rough population size estimate for SNRF in the Sonora Pass area is 14 breeding individuals, with a range of 10 to 20 (Quinn and Sacks 2014, pp. 2, 10). Since this is considerably less than an effective population size of 50, inbreeding depression may be an issue in the population, now or in the future (Shaffer 1981, p. 75). The Sonora Pass Population also appears to be highly isolated, since it is at least 100 km (62 mi) from the Lassen population to the north, with no known SNRF populations to the south. Genetic testing also shows a lack of migration between the Lassen and Sonora Pass populations (Statham *et al.* 2012, p. 129).

No current impacts on the Sonora Pass population are clearly attributable to small population size or isolation. However, low reproductive success in native SNRF observed within the Sonora Pass population (see SIGHTING AREA STATUS AND TRENDS, above) may be the result of inbreeding depression (Quinn and Sacks 2014, p. 15). Other possible explanations (such as low prey availability) are less likely in this instance, because when two nonnative (non-inbred) male red foxes entered the area under study, they mated with native SNRF females and produced a total of seven pups that same year (Sacks *et al.* 2015, p. 10).

The small size and high apparent isolation of the Sonora Pass population make future impacts from inbreeding depression and from chance deleterious events more likely. If the population is inbred, then the arrival of nonnative foxes, with alleles that are otherwise rare or missing from the population, may help alleviate that inbreeding depression. Their arrival could also lead to outbreeding depression, however, or to genetic swamping, as discussed below under Hybridization With Other Subspecies.

The population may also be subject to reduced reproductive success due to demographic stochasticity (chance changes in the male to female ratio). Of the eight adult SNRF identified at the study site, only two were clearly identified as male, and one of those died or dispersed from the area (Quinn and Sacks 2014, p. 14). However, two other adults from the study area could not be identified by sex, and other males may be in parts of the area that were not closely surveyed. We therefore do not consider that sufficient evidence exists to show current impacts from demographic stochasticity.

Oregon Sighting Areas: Surveys and incidental sightings conducted in 2012 and 2013 have produced 43 sightings from the area of Crater Lake National Park, 8 from around Willamette Pass, 2 from near Dutchman Flat, 13 from around Mt Washington, and 35 from near Mt Hood (Sacks *in litt.* 2014, pp 3–5; Cascadia Wild 2014, pp. 5–8 (att 1), 1–3 (att 2)). It is likely the number of individuals actually sighted is less than the number of actual individuals present in these sighting areas because the same individual may be sighted numerous times (Perrine 2005, pp. 147, 148). Distances between the five Oregon locations (Crater Lake, Willamette Pass, Dutchman Flat, Mt. Washington, and Mt. Hood) are 80 km (50 mi), 56 km (35 mi), 56 km (35 mi), and 101 km (63 mi), respectively. Thus, the two distances between the three middle locations are considerable, but less than the 95 percent dispersal range recorded for midwestern foxes (80 km (50 mi) (Statham *et al.* 2012, p. 129). (As discussed above under “Ecology,” dispersal distances specific to SNRF are not known). The most northerly and southerly Oregon locations are outside that 95 percent dispersal distance, however. Dispersal among the middle three locations is thus likely to be rare, while dispersal to either the northernmost or southernmost population (Crater Lake or Mount Hood) is likely to be particularly rare. It also remains possible that additional SNRF individuals, sighting areas, or populations could be present, since survey effort in Oregon may not have been sufficient to eliminate locations outside of the known sighting areas (Hiller 2015, p. 2).

Small Population Size and Isolation – Discussion and Summary

Populations at the Lassen and Sonora Pass sighting areas are small and isolated enough to be at risk of impacts from inbreeding depression and chance deleterious events. These are both population-level impacts, which do not necessarily affect the rest of the subspecies, so this potential stressor meets the definition of a medium level impact. The primary risk of such impacts is in the future (within 50 years), but evidence of low reproductive success in both populations suggests this may constitute a current impact of inbreeding depression. By contrast, reproductive success was not low for SNRF at the Sonora Pass population that bred with nonnative (non-inbred) males.

Population size estimates are not available for SNRF populations in Oregon. Isolation levels are likely relatively high for the populations at the Crater Lake and Mt. Hood sighting areas, based on their geographic distances from other sighting areas, but genetic data is lacking to help confirm such impressions.

Based on the best available information, we therefore find that “Small Population Size and Isolation” has, or is likely to have within 50 years, population-level impacts at the Lassen and

Sonora Pass sighting areas, but does not have subspecies-level impacts. We conclude that “Small Population Size and Isolation” is a stressor with medium-level impacts to SNRF.

Hybridization With Other Subspecies

Hybridization with non-SNRF red foxes can lead to outbreeding depression or to genetic swamping (Quinn and Sacks 2014, pp. 16–17). Outbreeding depression is a reduction in survivorship or reproduction caused by an influx into the population of alleles from other areas. Such a reduction can be caused by the loss of locally adaptive alleles, or by the breakup of coadapted gene complexes—groups of alleles that work together to provide a particular ability or advantage in the native habitat (Templeton 1986, pp. 106–107; Quinn and Sacks 2014, p. 17). Possible local adaptations in SNRF, subject to potential loss if hybridization occurs, could include changes to SNRF’s small body size, thick winter coat, and dense fur covering the toe pads (see SPECIES AND SUBSPECIES DESCRIPTION, above). These types of adaptations are normally maintained in a population by natural selection. But if early generations of hybrids have some compensating advantage (such as a lack of harmful characteristics related to inbreeding depression (as may be the case in the Sonora Pass population), or if the influx of nonnative alleles is large relative to the population size, then advantageous native alleles and allele complexes could be reduced in a population for many generations despite natural selection’s effects.

Genetic swamping occurs when continued influx of outside alleles cause the replacement of most native alleles, effectively turning what was once a native population into a population of some other subspecies or species. For example, genetic evidence suggests that a population of polar bears (*Ursus maritimus*) living on the Admiralty, Baranof, and Chichagof Islands near Alaska towards the end of the last glaciation (about 11,000 years ago) were genetically swamped by male brown bears (*Ursus arctos*) that entered the area and mated with the native females over several generations (Cahill *et al.* 2013, p. 4). The continued interbreeding caused the polar bear population to effectively transform into a brown bear population (*Id.*).

Historical Impacts of Hybridization With Other Subspecies

Genetic testing of SNRF at the Mt. Hood Sighting Area has found mitochondrial DNA normally associated with fur-farm stock in two individuals tested (Sacks 2014, pers. comm., p. 1). This could result from either modern or historical incidents of interbreeding (*Id.*). Information is currently lacking regarding negative impacts from such hybridization.

Current and Future Impacts of Hybridization With Other Subspecies

Lassen Sighting Area: The best available data do not suggest hybridization of SNRF with other subspecies is currently taking place at the Lassen sighting area, nor do the data indicate that hybridization is likely to occur in the future.

Sonora Pass Sighting Area: As discussed under SIGHTING AREA STATUS AND TRENDS, above, a recent study covering 20 to 50 percent of high quality habitat in the Sonora Pass sighting area documented interbreeding between female SNRF and two male nonnative red foxes

with fur-farm ancestry, resulting in six hybrid pups in 2013 (Quinn and Sacks 2014, pp. 2, 10). These pups were the only clear indication of successful reproduction in the area studied during the years 2011 through 2013 (*Id.* at 9–10), although SNRF could have reproduced in portions of the sighting area not covered by the study. If the nonnative males and the six hybrid pups stay in the sighting area and successfully breed with additional native SNRF, and if the low native reproductive success documented in the study area is indicative of the entire sighting area and remains low, then the resulting high production of hybrids relative to pure SNRF could cause the entire population to become hybridized to some extent within a few generations (Quinn and Sacks 2014, p. 17), potentially leading to outbreeding depression as discussed above.

Additionally, since no known populations of red fox within a reasonable dispersal distance (approximately 161 km (100 mi)) of the Sonora Pass sighting area could have produced the nonnative males, and since they did not arrive during the normal dispersal season, it is likely that they were introduced to the area by humans (Quinn and Sacks 2014, p. 17). If additional such introductions occur in the future, then it is possible that either the entire population or certain advantageous or unique alleles could be lost due to genetic swamping (*Id.*).

Oregon Sighting Areas: As discussed above, two individuals at the Mt. Hood sighting area show evidence of past hybridization with red foxes of fur-farm stock (Sacks 2014, pers. comm. , p. 1). Information is not available to determine whether such hybridization occurred recently, if it is likely to spread and cause outbreeding depression, or if additional introductions of nonnative red foxes are likely. Additionally, there is no information to suggest that hybridization is a current or future stressor at any of the other Oregon sighting areas.

Hybridization With Other Subspecies – Discussion and Summary

Hybridization is currently occurring at the Sonora Pass sighting area, and the production of hybrid pups constituted the entirety of reproduction observed on a study area at the site over a 3 year period. The Sonora Pass population is thus at risk in the future (within 50 years) for impacts from outbreeding depression and genetic swamping (Quinn and Sacks 2014, p. 2).

Hybridization has also occurred at the Mt Hood sighting area, but because the available evidence does not demonstrate such hybridization is ongoing, and because we do not know the size of the population at that location (and so cannot compare number of hybrids to number of pure SNRF), we do not consider hybridization to be impacting the population in that area.

Based on the best available information, hybridization is neither affecting nor likely to affect the other SNRF sighting areas within a 50 year timeframe.

Accordingly, based on the best available information, hybridization is not impacting SNRF at a subspecies level, but it is likely to produce population-level impacts at the Sonora Pass sighting area. Hybridization therefore meets the definition of a stressor with a medium-level impact.

Climate Change

Our analyses include consideration of ongoing and projected changes in climate. The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). The term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007a, p. 78). The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007a, p. 78).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system, substantial increases in precipitation in some regions of the world, and decreases in precipitation in other regions. (For these and other examples, see IPCC 2007a, p. 30; and Solomon *et al.* 2007, pp. 35–54, 82–85.) Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-twentieth century cannot be explained by natural variability in climate, and is “very likely” (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007a, pp. 5–6 and figures SPM.3 and SPM.4; Solomon *et al.* 2007, pp. 21–35). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011, p. 4), who concluded that it is extremely likely that approximately 75 percent of global warming since 1950, has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (e.g., Meehl *et al.* 2007, entire; Ganguly *et al.* 2009, pp. 15555, 15558; Prinn *et al.* 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the twenty-first century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007a, pp. 44–45; Meehl *et al.* 2007, pp. 760–764 and 797–811; Ganguly *et al.* 2009, pp. 15555–15558; Prinn *et al.* 2011, pp. 527, 529). (See IPCC 2007b, p. 8, for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation. Also see IPCC 2011 (entire) for a summary of observations and projections of extreme climate events.)

Most reports discussing downscaled or regional projections of climate change for California and the Pacific Northwest use a suite of climate models along with two different emissions scenarios. The exact suite of models and scenarios varies among reports, but the climate models generally encompass a range of sensitivities to climate scenarios, and the emissions scenarios usually

include a lower-emissions scenario along with a medium to high-emissions scenario. The differences between higher- and lower-emissions scenarios are minimal in the next few decades, but become increasingly pronounced after the mid-twenty-first century (Mote and Salathé 2010, p. 39; Cayan et al. 2009, p. 7). However, the current emissions trajectory is higher than any of the emissions scenarios used in climate projections for California and the Pacific Northwest (Hansen *et al.* 2013, pp. 1–2). Therefore, the projections we discuss here may underestimate the potential effects of climate change.

Historical records show increases in temperature over the last century across the SNRF's historical range (Bonfils *et al.* 2008, p. S49 and Fig. 1; Mote *et al.* 2010, p. 17; Littell *et al.* 2011, pp. 9–11; Mote *et al.* 2013, p. 28). Weather stations in the Pacific Northwest show a warming trend of approximately 0.8 degrees Celsius (°C) (1.4 degrees Fahrenheit (°F)) per century during the period from 1920–2000 (Mote *et al.* 2010, p. 17). All but two years since 1998 have had temperatures above the 20th century average (Mote *et al.* 2013, p. 28). In the Columbia Basin, which includes the northern portion of the Oregon Cascades, average temperatures rose by 1 °C (1.8 °F) between 1950 and 2006 (Littell *et al.* 2011, pp. 9–11). In California, average temperatures rose by 0.36 °C to 0.92 °C (0.65 °F to 1.7 °F) between 1950 and 1999, with several datasets showing no recent temperature change in the vicinity of Mount Shasta, but relatively large amounts of warming in the Sierra Nevada Mountains (Bonfils *et al.* 2008, p. S49 and Fig. 1).

All simulations project a larger increase in temperature across the analysis area over the twenty-first century than occurred during the twentieth century. Projections for temperature increases across the analysis area range from 1 °C to 3 °C (1.8 °F to 5.4 °F) by mid-century and from 2 °C to 5.8 °C (3.6 °F to 10.4 °F) by late in the twenty-first century (Mote *et al.* 2013, p. 34; Pierce *et al.* 2013, p. 844; Cayan *et al.* 2012, p. 4; Halofsky *et al.* 2011, p. 14; Mote and Salathé 2010, p. 41; Hayhoe *et al.* 2004, p. 12423). Some higher-emissions scenarios were not analyzed in these studies and would likely result in greater warming, outside the range reported above (Mote and Salathé 2010, p. 41). Summer temperatures are projected to increase more than winter temperatures (Pierce *et al.* 2013, p. 845; Cayan *et al.* 2012, p. 8; Mote and Salathé 2010, pp. 41–42; Salathé *et al.* 2010, pp. 65–66; Barr *et al.* 2010, p. 8; Koopman *et al.* 2010, p. 8; see Table 9). In all areas, heat waves are projected to increase in intensity and duration, especially under a higher-emissions scenario (Pierce *et al.* 2013, p. 848; Cayan *et al.* 2012, p. 10; Salathé *et al.* 2010, p. 69; Tebaldi *et al.* 2006, pp. 191–200; Hayhoe *et al.* 2004, p. 12423), and this effect may be especially pronounced in inland California (Pierce *et al.* 2013, p. 848; Halofsky *et al.* 2011, p. 15; Salathé *et al.* 2010, p. 69; Tebaldi *et al.* 2006, Fig. 3).

Historical Impacts of Climate Change on SNRF

SNRF are restricted to the upper elevations of the Sierra Nevada and Cascade Mountains because that is where their ancestors retreated at the end of the last glaciation (Aubry *et al.* 2009, p. 2679–2682; Perrine *et al.* 2010, p. 5; Sacks 2014a, p. 9–13). Rather than adapt to warmer temperatures in the lowlands, they remained adapted to boreal conditions and restricted their ranges to those areas in which such habitat remained. As discussed under Competition and Predation From Coyotes, below, this may have been due to the prevalence of coyotes at lower elevations. SNRF have remained restricted to high elevation areas, with the single exception of

an offshoot population that apparently managed to adapt to lowland habitat and evolve into a new and separate subspecies: the Sacramento Valley red fox (*Vulpes vulpes patwin*) (Sacks *et al.* 2010, 1533–1535).

Current and Future Effects of Climate Change on SNRF

Over the past 50 years, warming temperatures have led to a greater proportion of precipitation falling as rain rather than snow, earlier snowmelt, and a decrease in snowpack throughout the western United States (Kapnick and Hall 2010, pp. 3446, 3448; Halofsky *et al.* 2011, p. 21). The consequent lengthening of summer drought and associated increases in mean annual temperature have, in recent decades, caused increased tree mortality rates in mature conifer forests in the range of the SNRF (van Mantgem *et al.* 2009, pp. 522–523). Tree mortality rates in the western United States have doubled over the past 17 to 29 years, depending on region, due in large part to drought stress and increased outbreaks of pathogens and insects such as bark beetles (ISAB 2007, p. 23; van Mantgem *et al.* 2009, p. 523; Griswold 2015, entire). These trends are likely to continue (Cayan *et al.* 2012, pp. 20–21; Littell *et al.* 2011, p. 60; Salathé *et al.* 2010, pp. 66–68; Hayhoe *et al.* 2004, p. 12423).

Climate change is also contributing to increased tree mortality in forests of the western United States due to an increase in large wildfires (Westerling *et al.* 2006, p. 940). In the mid 1980's the incidence of wildfires larger than 400 ha (988 ac) in western forests nearly quadrupled compared to the previous 15 years, while the total area burned by such fires increased by a factor of over six and a half (*Id.* at 941). These increases are most pronounced at elevations ranging from 1,680 to 2,590 m (5,512 to 8,497 ft) (*Id.*), which is within the range in which SNRF have been found at all sighting areas. The increases are highly correlated with earlier timing of spring snowmelt, associated with climate change (*Id.*). Warmer temperatures and drier fuels resulting from drought stress and pathogen and insect outbreaks (as discussed above) tend to increase both ignition incidents and fire spread (Field *et al.* 1999, pp. 22, 35). Western forests with greatest vulnerability to moisture deficits produced by earlier spring snowmelts include those the Sierra Nevada and Cascades ranges (Westerling *et al.* 2006, p. 942, figure 4).

Water deficit from climate change is also expected to decrease seedling establishment and tree growth in many currently forested areas, thereby affecting forest regeneration and altering tree species distributions into the future (Littell *et al.* 2013, p. 112). Montane scrub communities, which require less water, are likely to increase at the expense of losses in forested areas, thereby decreasing and isolating areas of appropriate habitat, and leading to greater competition and predation from coyotes, which are better adapted to drier and warmer conditions (see Competition and Predation From Coyotes, below). Forest communities are unlikely to respond to climate change by simply moving to higher elevations, because soils at such elevations are shallower, and thus less able to hold moisture (Fites-Kaufman *et al.* 2007, pp. 457–458).

SNRF use forested areas for cover, to facilitate movement in deep snow, and for day-rests (Benson *et al.* 2005, p. 128; Perrine *et al.* 2010, p. 29), so decreases in such habitats would likely tend to decrease movements and increase exposure to predators and weather. However, the likely extent of such decreases in forested habitats over the next 50 years remains unclear. We

therefore consider habitat loss from climate change to constitute a medium level impact at all sighting areas.

Lassen Sighting Area: Potential climate change impacts to SNRF in the Lassen sighting area include loss of habitat and reduced snowpack (see above). The reduced snowpacks may increase the future risk of competition from coyotes (see Competition and Predation From Coyotes, below). SNRF have been sighted in the area at elevations ranging from 1,410 m (4,626 ft) to 3,130 m (10,269 ft) (Perrine 2005, p. 162). This is a wide range compared to other sighting locations, but it extends up to nearly the highest elevation in the area: Lassen Peak is 3,189 m (10,463 ft). Accordingly, as climate change causes losses to snowpacks and forested ecosystems, the preferred habitat for SNRF will tend to shrink. SNRF at Lassen have also demonstrated the strongest affinity for mature closed-canopy forests (during the winter) (Perrine 2005, pp. 67, 74, 90), and so may be particularly impacted by forest losses due to climate change (as discussed above).

Sonora Pass Sighting Area: Potential climate change impacts to SNRF in the Sonora Pass sighting area include loss of habitat and reduced snowpacks (see above). The reduced snowpacks may be currently resulting in increased risk of competition from coyotes (see Competition and Predation From Coyotes, below). With the exception of the female killed on Highway 395 at about 2,250 m (7,200 ft) (CDFW 2015, p. 4), SNRF in the Sonora Pass area have been sighted at elevations ranging from 2,473 m (8,114 ft) to 3,495 m (11,467 ft) (Sacks *et al.* 2015, p. 11). The high end of this range involved an SNRF sighted at the summit of Sonora Peak (*Id.*). Other peaks in the area (such as Leavitt Peak, elevation 3,527 m (11,572 ft) are of similar elevations. SNRF in the area thus currently appear to be occupying a relatively narrow elevational range at the upper limit of the area. The extent of high quality habitat in the area surveyed is roughly 2 to 5 times the size of the area sampled by Quinn and Sacks (2014, p. 14), or approximately 260 to 650 km² (100 to 251 mi²), which is relatively small given that average home range size in the area is 9.1 km² (3.5 mi²) (*Id.* at 10–11).

Oregon Sighting Areas: Potential climate change impacts to SNRF in the Oregon Sighting Areas include habitat loss and reduced snowpacks (see above). The reduced snowpacks may increase the future risk of competition from coyotes (see Competition and Predation From Coyotes, below). The Crater Lake area has the highest-elevation Oregon sightings; ranging from 1,835 m (6,020 ft) to 2,377 m (7,799 ft) (Sacks 2014, p. 3). It also has the least area available above that range, and so may not allow SNRF to shift to higher elevations where coyotes may continue to be excluded by high snowpacks. The highest elevation sighting from the other Oregon areas is 1,879 m (6,165 ft) at Mt. Hood (Akins 2014, p. 2). All Oregon sighting areas except Crater Lake also include one or more peaks extending to much higher elevations, thus potentially are able to continue to provide suitable habitat for SNRF into the future. These include Maiden Peak (2,384 m (7,822 ft)) in the Willamette Pass sighting area; Mt Bachelor (2,764 m (9,068 ft)) in the Dutchman Flat sighting area; Mt Washington (2,376 m (7,795 ft)) in the Mt Washington sighting area; and Mt. Hood (3,429 m (11,250 ft)) in the Mt Hood sighting area.

Reduced snowpacks in the Sonora Pass sighting area due to climate change may currently be resulting in increased competition and predation from coyotes (see Competition and Predation From Coyotes, below). This effect is likely to increase over the next 50 years, and to have population-level effects on SNRF in the future. Other SNRF sighting areas are likely to experience similar decreases in snowpack and increases in coyote competition in the future as well. However, SNRF at the four Oregon sighting areas north of Crater Lake may be able to move upward in elevation to areas with higher snowpacks. This will be less likely for SNRF at the Crater Lake, Lassen, and Sonora Pass sighting areas, as these populations already appear to be at or near the highest elevations in their respective areas.

Climate change is also causing increased wildfires, and loss of forested habitat resulting from wildfires, drought stress, and pathogen and insect outbreaks. These losses will likely continue over the next 50 years throughout the SNRF range, likely resulting in medium-level impacts at all sighting areas.

Competition and Predation From Coyotes

Both coyote and SNRF are opportunistic predators with considerable overlap in food consumed (Perrine 2005, pp. 36–37). Although no direct documentation of coyote predation on SNRF is available, coyotes will chase and occasionally kill other North American red fox subspecies, and are considered important competitors of red fox generally (Perrine 2005, pp. 36, 55; Perrine *et al.* 2010, p. 17). Red foxes consequently tend to avoid areas frequented by coyotes (though not necessarily to the point of complete exclusion) (Perrine 2005, p. 55). For instance, Sacks *et al.* (2010b, p. 17) identified several instances in which Sacramento Valley red foxes had apparently been excluded by coyotes from areas they had previously occupied. This interspecies competition and habitat avoidance may therefore be an important factor restricting SNRF to its comparatively small and less productive range at the highest elevations studied (Perrine 2005, pp. 84, 105). In particular, as avoidance of an area is more difficult when raising pups, coyote competition may be a primary reason why SNRF pup rearing appears restricted to high-elevation subalpine habitat (Perrine *et al.* 2010, p. 15; Quinn and Sacks 2014, p. 2), even if adult SNRF are at lower elevations just prior to mating and pup rearing season in the spring (Perrine 2005, pp. 78–79).

Perrine's (2005, pp. 73–74) investigations at Lassen found coyotes were present at all elevations during the summer months, and that a positive correlation actually existed between SNRF and coyotes during those times (*Id.* at 83). Since the correlation was only evident at broader scales, however, he considered it a likely artifact of their common affinity for roads (*Id.*). Even during snow-free months, however, Perrine found coyote population density to be greater at lower elevations, thus producing an elevational separation between most coyotes and the SNRF population (*Id.* at 192).

During the winter season, Perrine (2005, pp. 30, 78) found that both SNRF and coyotes descended to lower elevations, where mule deer (*Odocoileus hemionus*), (and more specifically in the case of SNRF, mule deer carrion) became important components of their diets. However, SNRF tended to stay at higher elevations than coyotes, thereby reducing potential for

competition (*Id.* at 74). Perrine (*Id.* at 80–81) attributed the elevational descent of both species to very deep snow packs at higher elevations. SNRF are better able than coyotes to live in areas of relatively deep snow, however, and thus tend to remain at higher elevations where coyotes are less common during winter months. SNRF may also potentially benefit from the presence of coyotes during winter by scavenging deer carcasses killed by coyotes (Perrine 2005, p. 31). Mule deer carrion may be more important to SNRF in the Lassen sighting area than in other locations due to the lack of mid-sized winter prey such as snowshoe hare (Perrine 2005, p. 30). Mule deer was a relatively minor dietary component of Cascade foxes in Washington and of red foxes in Maine, where snowshoe hares were more available (*Id.* at 30–31). Even in the Lassen sighting area, Perrine (2005, p. 24) found that the main food source of SNRF during the winter remained small rodents rather than deer.

SNRF from the Sonora Pass area were not found to descend to lower elevations during winter as did the SNRF at Lassen (Statham *et al.* 2012, p. 130). Statham *et al.* (2012, p. 130) speculated that this might be because the individuals followed in Perrine’s (2005) study of the Lassen population were non-breeders, and so were attempting to disperse to new home ranges. It may also result from a greater availability of mid-size prey items such as snowshoe hares at high elevations at Sonora Pass but not at Lassen (Perrine 2005, p. 29, 30). A third possibility is that snowpacks have not been high enough in recent years to force SNRF, and possibly even some coyotes, down to lower elevations. Typically, deep snows in the Sonora Pass sighting area tend to keep coyotes below 2,743 m (9,000 ft) (Rich 2014, p. 1). However, snow packs in the area during the winters ending in 2013 and 2014 were so low that snowmobile use at the Bridgeport Winter Recreation Area (see Vehicles, below) was largely discontinued, resulting in a lack of snowmobile monitoring reports for those years (USDA 2010, pp. 17–20; Rich 2014, p. 1).

Historical Impacts of Competition and Predation From Coyotes

The general tendency of red foxes to avoid coyotes has likely been an important factor determining red fox distribution, often relegating red foxes to suboptimal habitats (Perrine *et al.* 2010, p. 20; Sacks *et al.* 2010b, p. 17). As Perrine (2005, pp. 84, 105) suggested, competition and predation from coyotes is thus likely a primary reason why the range of SNRF is restricted to such high elevations. However, such competition likely varies in intensity with prey availability, such that at least in the Lassen area studied, it is stronger in winter. We therefore consider coyotes a likely determining factor of the historical lower elevational range of the SNRF.

Coyotes were rare or nonexistent in the Oregon Cascades prior to about 1930, but their numbers increased after that time due to the extirpation of gray wolves (*Canis lupus*) in the area (Toweill and Anthony 1988, p. 507). Coyote populations also benefitted from clearcutting, which left numerous forest openings in which productivity of berries and prey species was increased (*Id.* at 511).

Current and Future Impacts of Competition and Predation From Coyotes

Lassen Sighting Area: Although, as discussed above, competition and predation from coyotes may be an important factor restricting the lower elevational range of the SNRF, we lack evidence to show that such competition has been increasing in recent years at Lassen, or the extent (if any)

to which it may be responsible for recent declines in SNRF population numbers (as described by Sacks *et al.* 2010, p. 1536). However, as climate change progresses, snowpacks are expected to diminish (Kapnick and Hall 2010, pp. 3446, 3448; Halofsky *et al.* 2011, p. 21). The greater disadvantage of coyotes relative to SNRF in deep snow is likely the primary reason the two species segregate elevationally during the winter (Perrine 2005, p. 81). As snowpack depths decline, coyotes are likely to stay longer and return earlier to higher elevations, eventually becoming resident there. SNRF raise their pups in the spring, while snowpacks are just beginning to recede (*Id.* at 192). This is also the time of greatest resource scarcity (*Id.* at 193). Food availability is important for successful reproduction (*Id.*), so additional competition and predation from coyotes during this time would likely lower reproductive success. Examinations of four female SNRF radio collared and followed for 2 years in the Lassen region showed that none had successfully reproduced (*Id.* at 113, 116), so reproductive success already appears to be low. Increased competition and predation from coyotes due to climate change is thus likely to put the population at greater risk over the next 50 years.

Sonora Pass Sighting Area: Coyotes are present in the Sonora Pass area at the same elevations as SNRF during the summer months, although the average elevation for coyotes appears to be lower than average elevation for SNRF (Quinn and Sacks 2014 pp. 11, 35). Coyotes also appear to outnumber SNRF in the area (*Id.* at 12). From 2011 to 2013, genetic tests of scats found in the study area (a subset of the entire area considered potentially capable of supporting SNRF) identified 31 individual coyotes, but only 10 total SNRF (along with 2 nonnative red foxes and 6 hybrid red foxes) (*Id.* at 2, 12). Four coyotes were present for a year or longer, and were therefore likely resident in the area (*Id.* at 12). Several of the coyotes were related to each other, suggesting they were establishing territories and raising pups (*Id.*). One such breeding pair was located in early April 2013 (during SNRF pup-rearing season) at an elevation of 3,000 m (9,843 ft). This may have been unusual, as the snowpack in 2013 was low and coyotes are more typically found below 2,743 m (9,000 ft) due to deep snow (Rich 2014, p. 1). The situation is likely to become more common in the future, however, as snowpacks decline due to climate change (Kapnick and Hall 2010, pp. 3446, 3448; Halofsky *et al.* 2011, p. 21).

Oregon Sighting Areas: Coyotes are fairly evenly distributed across Oregon, except for the northwestern corner of the state (ODFW 2014, p. 2). One was genetically identified from scat found in late October, 2013 at the Mt. Hood sighting area at an elevation of 1,879 m (6,165 ft); higher than any SNRF identifications in the area (Akins 2014, p. 2 (“CALA” indicates *Canis latrans*)). Another coyote was identified in the same sighting area by camera trap at 1,768 m (5,800 ft) (Sacks 2014, p. 5). Coyotes were also detected at four camera trap stations in the Willamette and Deschutes National Forests where SNRF were also detected (McFadden-Hiller and Hiller 2015, pp. 112–113). Although the specific sighting locations weren’t identified in the report, the stations were located in the three central sighting areas in Oregon (Willamette Pass, Dutchman Flat, and Mt. Washington) (*Id.* at 3). Coyotes are present year-round in both the Willamette and Mt Washington sighting areas, and have been photographed at eight camera stations that also photographed SNRF, with intervening time periods ranging from 10 days to 5.5 hours (USDA 2015, pp. 3–4).

However, a single pack of wolves has now become established in the southern Oregon Cascades about 24 km (15 mi) south of the Crater Lake sighting area (ODFW 2015, p. 13). Restoration of

wolves to the Cascades in sustainable populations would likely tend to lower coyote population numbers or exclude them from higher elevation forested areas, thereby facilitating the persistence of nearby SNRF populations (Levi and Wilmers 2012, p. 926). The wolves themselves would be unlikely to compete heavily with SNRF because they tend to take larger game (ODFW 2015, p. 8). ODFW's conservation objectives for the wolf include establishment of seven breeding pairs in western OR for three consecutive years (ODFW 2010, p. 17). Accordingly, we consider it likely that the current wolf population will expand over the next 50 years to effectively overlap the Crater Lake sighting area, and possibly the Willamette Pass, Dutchman Flat, and Mt. Washington sighting areas as well (Niemela 2015, pp. 3, 4). We therefore consider coyote competition with SNRF unlikely to grow over the next 50 years at the Crater Lake sighting area, and less likely at the three more northerly sighting areas mentioned.

Competition and Predation From Coyotes – Discussion and Summary

Coyotes chase and kill red foxes generally, and compete with them for prey. Although the ranges of SNRF and coyotes overlap, SNRF are more common at higher elevations where coyotes are less common. SNRF also appear to restrict pup-raising to these high-elevation areas. SNRF are particularly vulnerable to such interactions during pup rearing season, since they must capture sufficient prey to feed their pups and are less free to move from the area of the den site. It is thus likely that SNRF are restricted to areas with high elevation and low primary production in part because of competition and predation from coyotes.

During the winter, coyotes typically move to lower elevations to avoid deep snowpacks. Climate change is expected to reduce snowpacks throughout California and the Pacific Northwest. This may allow coyotes to stay at high elevations longer, or become resident throughout the winter, thereby increasing competition and aggressive interactions with SNRF. Such increased overlap of coyotes with SNRF appears to have already begun in the Sonora Pass sighting area, where a breeding pair of coyotes was documented on a high-elevation territory in early April (SNRF pup rearing season) of 2013, a year of unusually low snowpacks. Current impacts on SNRF from the presence of coyotes in the area was not documented, however.

We expect that climate change will increase coyote competition at the Mt. Hood, Lassen, and Sonora Pass sighting areas in the future, as snowpacks diminish. However, that competition is likely to be checked at the Crater Lake sighting area by the establishment of wolf populations, which may also decrease coyote competition at the Willamette Pass, Dutchman Flat, and Mt. Washington sighting areas. SNRF at the four Oregon sighting areas north of Crater Lake may also be able to avoid coyote competition by moving upward in elevation to areas with higher snowpacks. Such upward movement will be less likely for SNRF at the Lassen, and Sonora Pass sighting areas, as these populations already appear to be at or near the highest elevations in their respective areas. Accordingly, based on the best available information, we therefore expect increases in coyote competition to have population-level impacts to populations at the Sonora Pass and Lassen sighting areas within the next 50 years, but not to have impacts that are subspecies-wide. We therefore consider competition and predation from coyotes to constitute a stressor with a medium-level impact for SNRF.

Predation by Domestic Dogs

SNRF are most likely to interact with domestic dogs at recreational areas such as ski lodges or national parks within their sighting areas, and in the course of being hunted with dogs in any of the Oregon sighting areas other than at Crater Lake. As discussed under Hunting and Trapping, above, Oregon state law allows red foxes to be hunted using dogs. We consider predation by dogs in the course of hunting to be an impact related to hunting, but our information does not separate foxes taken by hunters from those taken by trappers. In this section, we consider predation of SNRF by domestic dogs in situations not involving hunting.

Historical Impacts of Predation by Domestic Dogs

We have no information regarding instances of predation of SNRF by domestic dogs prior to 2000. However, SNRF exhibiting begging behavior were noted at the Lassen Peak parking lot, in the Lassen sighting area, in 1970, 1977–1980, 1987, 1989, and 1997 (Perrine 2005, p. 150). Such behavior can increase risk of attack by dogs (*Id.* at 151; see also *Lassen Sighting Area*, below).

Current and Future Impacts of Predation by Domestic Dogs

Lassen Sighting Area: Of five SNRF radio-collared by Perrine in 2000 (2005, p. 135), one died due to a dog attack (*Id.* at 141). That SNRF, a female known for having previously exhibited begging behavior (*Id.* at 148), was killed in October, 2002, within 175 m (574 ft) of a ski chalet (*Id.* at 141). Her body was intact and in good condition, indicating the dog had attacked the SNRF and then let go without attempting to eat it. This is the only documented case of SNRF predation by dogs of which we are aware. Dogs and other pets are allowed on roads, parking lots, campgrounds and picnic areas, but not on trails (NPS 2015a, p. 1). They must be kept on leash (*Id.*).

Sonora Pass Sighting Area: We are not aware of any issues involving actual or potential predation of SNRF by domestic dogs at this location.

Oregon Sighting Areas: We are not aware of any instances of predation on SNRF by dogs at any of the Oregon sighting areas. Of those areas, we consider dogs more likely to interact with SNRF at the Crater Lake and Willamette Pass sighting areas. Four trails have recently been opened to dogs on leash at Crater Lake National Park (NPS 2015b, p. 1), while the Willamette Pass sighting area is near a ski lodge and other high-use recreational areas.

Predation by Domestic Dogs – Discussion and Summary

We are aware of only one documented example of dog predation on SNRF. That occurred in 2002 in the Lassen sighting area. Because predation by dogs is impacting individual SNRF, but is not producing population-level or subspecies-level effects, it meets the definition of a stressor with low-level impacts.

Vehicles

Potential stressors related to vehicles (including cars, trucks, snowmobiles, and other off-highway vehicle (OHV) equipment) include direct impacts, disturbance from noise, and disruption of prey such as rodents living below the surface of the snow. Vehicles may also provide some benefits to SNRF by providing roads and compacted snow trails for travel, and occasional roadkilled animals for scavenging.

Historical Impacts of Vehicles

The only known incidents of vehicle impacts with SNRF are relatively recent. Since 2010, five SNRF have been reported killed by vehicles, including within the Sonora Pass sighting area (California State Hwy. 395), the Crater Lake sighting area (main Park road near administration building), two in the Mt. Washington sighting area, and one near Silver Lake, Oregon, about 80 km (50 mi) west of the Crater Lake sighting area (Statham *et al.* 2012, p. 124; Sacks 2014, p. 1; Doerr 2015, p. 11; Wolfer 2015, p. 1).

Current and Future Impacts of Vehicles

Lassen Sighting Area: SNRF in the Lassen sighting area commonly use roads to travel on (Perrine 2005, p. 85), so the extent to which a given road is beneficial or detrimental may depend on traffic, particularly during dusk, dawn, and at night when SNRF are most active (Perrine 2005, p. 110).

In accordance with the requirements of the Sierra Nevada Forest Plan Amendment (SNFPA), the Lassen National Forest prohibited wheeled vehicle travel except on designated routes and limited OHV use areas (USDA 2009, pp. iii, 461). The Forest maintains two areas for OHV use but these do not have suitable SNRF habitat or known sightings of the subspecies (USDA 2009, p. 510). They specifically analyzed potential impacts to SNRF of adding some additional roads to those approved for use, and concluded such impacts would be negligible based on proximity to known SNRF sightings and projected levels of use (USDA 2009, pp. 510–511).

Sonora Pass Sighting Area: In 2009, the Omnibus Public Land Management Act of 2009 (16 USC 460vvv) established a 2,833 ha (7,000 ac) snowmobile recreation area in the Stanislaus and Humboldt-Toiyabe National Forests. The resulting Bridgeport Winter Recreation Area (BWRA) directly overlaps the majority of SNRF sightings from the Sonora Pass sighting area. Typically, about a dozen snowmobilers per day travel over California State Hwy. 108, at the north end of the BWRA, while slightly fewer use the recreation area itself (Rich 2014, p. 1). This may be because Hwy. 108 is groomed twice a week while the BWRA is not (*Id.*). Snowmobile use in the BWRA is not limited to trails or to daytime use (*Id.*).

Researchers are currently investigating potential impacts to SNRF in accordance with Standard 32 from the SNFPA (requiring activities near verified SNRF sightings to be analyzed to determine if they have a potential to affect the subspecies) (USDA 2004, p. 54; Rich 2014, p. 1). Results are not yet available, in part because the snowpack has been low during the last two winters (those ending in 2013 and 2014) and therefore the area has not been available for snowmobile use (Rich 2014, p. 1).

The Department of Defense (DOD) is currently operating a 243 ha (600-ac) Mountain Warfare Training Center for the U.S. Marine Corps within the Sonora Pass sighting area. The Mountain Warfare Training Center is a training site for Marines preparing to serve in mountainous regions, with an emphasis on training for cold weather and high altitudes. Training activity primarily involves limited personnel pedestrian activities, helicopter landing and deployment sites, and vehicle exercises on established roads. Training operations include military readiness activities on adjacent Humboldt-Toiyabe National Forest lands via a temporary special use permit with the Forest Service that is renewed annually (Lowden 2015, p. 1). Possible stressors from training exercises include collision with vehicles and disturbance from helicopters (Lowden 2015, p. 1; Sierra Nevada Red Fox Working Group 2015, p. 3). We have no further information with which to analyze the likely extent of these potential impacts.

Oregon Sighting Areas: All Oregon Sighting Areas include roads and snowmobile trails, though the relative areas devoted to such use differs, as discussed below. The only records of vehicle-related injuries or deaths of SNRF in Oregon are the two incidents discussed above at the Crater Lake and Mt. Hood sighting areas.

Roads within Crater Lake National Park are generally open to the public. There are some service-only roads that the public is not allowed to use. Only one portion of the Park (northwest) is open to snowmobiles; SNRF sightings have not been reported from this area.

Snowmobiles are used extensively within the Willamette Pass sighting area. Snow groomers also work the slopes for skiers visiting the Willamette Pass Ski Area. Willamette Pass is a high use recreational area at all times of the year. The effects to the local SNRF population are unknown at this time.

The Dutchman Flat sighting area is bisected by two major highways: Oregon State Hwy. 242 in the north, and County Hwy. 46 in the south. There are also numerous snow-parks, with many miles of snowmobile trails within the area. OHV trails also exist in the area, and an extensive complex of mountain bike trails run for dozens of miles throughout the Dutchman Flat area. Effects of this exposure to vehicle traffic are not known at this time.

There are many miles of snowmobile trails and OHV trails throughout the Mt. Washington sighting area which increases the potential for collisions with vehicles and noise disturbance; effects to SNRF of this exposure are unknown. We have confirmed reports of two collisions resulting in deaths of high-elevation red foxes along highway 20 within the past few years (USDA 2015, p. 3; Wolfer 2015, p. 1).

Much of the Mt. Hood sighting area is designated wilderness, but a few OHV trails do occur within the general range of the SNRF sightings, at lower elevations (around 1,524m (5,000 ft). Effects of this exposure to SNRF are unknown.

Vehicles – Discussion and Summary

All of the SNRF sighting areas have moderate to extensive opportunities for OHV, snowmobile, and on-road vehicular traffic. Although no studies have been completed, the mere location of the SNRF sightings in these areas suggests that the SNRF are able to adjust to the noise involved, and that sufficient SNRF prey remain in such areas.

Five SNRF have been found killed by vehicle traffic along roads; four in Oregon and one in California (Statham *et al.* 2012, p. 124; Sacks 2014, p. 1; Doerr 2015, p. 11; Wolfer 2015, p. 1). Additional such strikes are likely to occur occasionally over the next 50 years. Vehicle strikes off roads are also possible, particularly at the Sonora Pass sighting area where snowmobiles may run over a wide area, off trails, at any time of day or night. However, we have no evidence that vehicle strikes are likely to occur at any sighting area with great enough frequency to rise to a population-level impact, even given the low population numbers estimated for the Lassen and Sonora Pass sighting areas.

Since vehicles occasionally kill or injure individual SNRF, without rising to the level of affecting entire populations or the subspecies as a whole (now or in the future), we consider vehicles to constitute a stressor with a low-level impact on SNRF.

Cumulative and Synergistic Impacts of Potential Stressors

Certain combinations of stressors may result in cumulative or synergistic impacts that go beyond what might be expected from simply adding the impacts of each individual stressor. We review such cumulative and synergistic effects here.

Cumulative and Synergistic Impacts from Small Population Size

When a population is small, the relative importance to the population of each potentially reproducing individual is increased. Thus, potential stressors that directly result in death or loss of reproductive ability for individual SNRF can have greater relative impacts on small populations than on larger ones. Potential stressors meeting this description include: “Hunting and Trapping”, “Salmon Poisoning Disease”, “Other Diseases”, “Competition and Predation From Coyotes”, and “Vehicles”. Of these, only “Hunting and Trapping”, and “Vehicles”, are known to have directly caused SNRF deaths. However, in the case of “Hunting and Trapping”, the sighting areas (in Oregon) most likely to suffer individual losses of SNRF from this potential stressor are not the same sighting areas (in California) known to be small. In the case of “Vehicles”, the number of deaths caused by vehicles (one each for the Sonora Pass, Crater Lake, and Mt. Hood sighting areas) is not sufficient to raise the impact level of this potential stressor from “low.”

For “Salmon Poisoning Disease”, and “Other Diseases”; because we lack information regarding any current impacts, and because available evidence does not show that future impacts are likely to be serious enough to affect the size or growth of a population (even a small population such as at the Lassen sighting area) we consider impact level for these potential stressors to remain low.

Impacts from “Competition and Predation From Coyotes”, as discussed above, are considered moderate due to potential population-level impacts, particularly at the Sonora Pass and Lassen

sighting areas. These impacts account for the fact that the Sonora Pass and Lassen populations are likely small. Since we do not have clear evidence of population size for the Oregon populations, cumulative or synergistic impacts of population size do not raise the impact level of “Competition and Predation From Coyotes” from moderate to high.

“Hybridization With Other Subspecies” also has the potential for cumulative or synergistic impacts with “Small Population Size,” since the same amount (in absolute numbers) of hybrid pups produced will have proportionately larger impacts on smaller populations. We accounted for this in our discussion of the topic, however, since it primarily applies to the Sonora Pass population, which is known to be small.

Cumulative and Synergistic Impacts from Climate Change

The cumulative and synergistic impacts of climate change with both wildfires and competition and predation from coyotes has been discussed under the relevant sections, above. Climate change is expected to increase the incidence and extent of wildfires, leading to loss of forest habitat. Climate change will also lower snowpacks, leading to increased competition and predation from coyotes throughout the SNRF range.

Cumulative and Synergistic Impacts – Discussion and Summary

The potential stressors most likely to produce cumulative or synergistic effects with other potential stressors are “Small Population Size” and “Climate Change”. The most important cumulative or synergistic effects involve the interactions of these potential stressors with “Competition and Predation From Coyotes”. Any cumulative or synergistic impacts that may be significant have been addressed above in the sections on the relevant potential stressors. We have thus accounted for such cumulative or synergistic impacts when assigning impact levels for the potential stressors involved.

Table 2: Summary of Potential Stressors to the Subspecies

Potential Stressor	Current Impacts by Sighting Area	Projected Future Impacts	Overall Impact Level
Logging	None for all sighting areas. Minor, well regulated habitat impacts such as fuel treatments, unlikely to affect SNRF.	None, based on consistent regulatory timeframe of 50 years.	None
Wildfire and Fire Suppression	Recent intense fires at Mt. Hood, Dutchman Flat, and Lassen, and near Sonora Pass.	Similar fires likely in future. May contribute to long-term habitat losses covered below under Climate Change.	Low
Grazing	None for all sighting areas. Minor habitat impacts in Sonora Pass, but SNRF impacts such as prey reduction not shown.	None, based on consistent regulatory timeframe of 50 years	None
Hunting and Trapping	Loss of individuals in Oregon. None in California.	Based on apparent trends and consistent regulatory timeframe, losses likely to remain at low levels into indefinite future (50 yrs).	Low
SPD and EFF	No evidence of current impacts.	Occasional losses of SNRF at Lassen sighting area possible after improvements to Pine Creek allow spawning runs of infected Eagle Lake trout within 50 years.	Low
Mange, distemper, rabies	No evidence of current impacts.	Low impacts likely for at least one area within 50 yrs. Medium impacts possible but unlikely given low population densities, lack of historical losses.	Low
Small population size and isolation	Medium impacts to reproduction from inbreeding likely at Sonora Pass, possible at Lassen. None shown elsewhere.	Potential serious impacts to Sonora Pass or Lassen populations within 50 years due to inbreeding or chance events.	Medium
Hybridization	Reproduction at Sonora Pass limited to hybrids in 2012, 2013, but no impacts to population yet shown. Some past hybridization likely at Mt. Hood sighting area, but extent unclear and no impacts shown.	Current trends at Sonora Pass sighting area make outbreeding depression or genetic swamping reasonably likely within 50 years. Either would constitute a medium (population-level) impact.	Medium

Potential Stressor	Current Impacts by Sighting Area	Projected Future Impacts	Overall Impact Level
Climate Change	Reduced snowpack may have increased coyote competition at the Sonora Pass sighting area (see below).	Over next 50 years: (1) Medium impacts from habitat loss at all sighting areas. (2) Medium impacts from increased coyote competition (see below).	Medium
Competition and Predation From Coyotes	Reduced snowpack may have increased coyote presence and competition at the Sonora Pass sighting area. No evidence of direct impacts.	Medium impacts from increased coyote competition within 50 years due to reduced snowpack at Sonora Pass and Lassen. Impacts unlikely within that time at Crater Lake due to establishment of wolves. Impacts unlikely at remaining Oregon sighting areas due to possible establishment of wolves and/or likely ability of SNRF to move up elevation.	Medium
Predation by Domestic Dogs	One documented predation in 2002 at the Lassen sighting area. No other documented incidents.	Continued rare losses of individuals over next 50 years.	Low
Vehicles	Low impacts due to loss of individuals at Crater Lake, Lassen, Sonora Pass. Impacts from noise stress possible but no direct evidence.	Continued occasional losses of individuals over next 50 years.	Low

EXISTING REGULATORY MECHANISMS

Existing regulatory mechanisms that affect the SNRF include laws and regulations of the Federal government, and of the State governments of California and Oregon. Such laws and regulations address potential stressors from several sources, and are discussed in this document under the headings of the stressors they address. We provide here a general overview and summary of the Federal and State regulatory frameworks

Federal Regulations

There are a number of Federal agency regulations that pertain to management of SNRF or its habitat. Most Federal activities must comply with the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. §§ 4321 *et seq.*). NEPA requires Federal agencies to formally document, consider, and publicly disclose the environmental impacts of major Federal actions and management decisions significantly affecting the human environment. NEPA does not regulate or protect SNRF, but requires full evaluation and disclosure of the effects of Federal actions on the environment. NEPA does not require or guide potential mitigation for impacts.

U.S. Forest Service

The USFS policy manual (USDA FS 2005, section 2670.22) allows for designation of sensitive species of management concern. The SNRF has been identified as a sensitive species where it occurs on National Forests in California (U.S. Forest Service Region 5) since 1998, and is expected to be identified as a sensitive species where it occurs on National Forests in Oregon (U.S. Forest Service Region 6) in June 2015 (USDA 2015, p. 4). The Sensitive Species Policy is contained in the USFS Manual, section 2670.32 (USDA FS 2005, section 2670.32) and calls for National Forests to assist and coordinate with other Federal agencies and States to conserve these species. Special consideration for the species is made during land use planning and activity implementation to ensure species viability and to preclude population declines that could lead to a Federal listing under the ESA (USDA FS 2005, section 2670.22). Proposed programs and activities must be analyzed for their potential effect on sensitive species. For example and at this time, proposed activities that occur within the applicable national forests will include measures to avoid or minimize project-related impacts to SNRF and its habitat. If species viability is a concern, impacts are avoided or minimized; if impacts cannot be avoided, a further analysis of the significance of potential adverse effects is required; the action must not result in loss of species viability or create significant trends toward Federal listing (USDA FS 2005, section 2670.32).

National Forest management is directed by the Multiple-Use Sustained-Yield Act of 1960, as amended (16 U.S.C. §§ 528 *et seq.*) and the National Forest Management Act of 1976, as amended (NFMA) (90 Stat. 2949 *et seq.*; 16 U.S.C. §§ 1601 *et seq.*). NFMA specifies that the Forest Service must have a land and resource management plan (LRMP) to guide and set standards for all natural resource management activities on each National Forest or National Grassland. Current LRMPs were developed under the 1982 planning rule (47 FR 43026, September 30, 1982, pp. 43037–43052), which required the Forest Service to maintain viable populations of existing native and desired nonnative vertebrate species.

The Forest Service has recently revised their NFMA planning rules (77 FR 21162, April 9, 2012), which will apply to future LRMP revisions. The revised NFMA planning rules require the Forests to use an ecosystem and species-specific approach in their LRMPs to provide for the diversity of plant and animal communities and maintain the persistence of native species in the plan areas. This includes contributing to the recovery of federally listed threatened and endangered species, conserving proposed and candidate species, and maintaining viable populations of species of conservation concern (77 FR 21162, April 9, 2012, pp. 21169–21272). Directives for implementing the revised rules have not been finalized, so it is unclear how this change will affect SNRFs and their habitat, but the SNRF will likely become a species of conservation concern under the new policy in all the National Forests in which it occurs (Chatel 2015, p. 1).

Northwest Forest Plan: The Northwest Forest Plan (USDA and USDI 1994, entire) was adopted by the Forest Service in 1994 to guide the management of over 9.7 million ha (24 million ac) of Federal lands (USDA and USDI 1994, p. 2) in portions of western Washington and Oregon, and northwestern California within the range of the northern spotted owl. The NWFP amends the LRMPs of National Forests and is intended to provide the basis for conservation of the spotted

owl and other late-successional, old-growth forest associated species on Federal lands. The NWFP is important for SNRFs because it creates a network of late-successional and old-growth forests that help meet the SNRF's habitat requirements, discussed above, at four of five Oregon sighting areas (i.e., Willamette Pass, Dutchman Flat, Mt. Washington, and Mt. Hood Sighting Areas).

The NWFP establishes several land use allocations, with differing levels of standards and guidelines for managing forest resources. Reserved lands (consisting of Congressionally Reserved Areas such as Wilderness Areas, Late Successional Reserves, Administratively Withdrawn areas, and any additional reserved areas identified by the LRMP for the National Forest in question) are managed to protect and enhance conditions of late-successional and old-growth forest ecosystems (USDA and USDI 1994, C-8, 11; USDA 2015, p. 4). Habitat manipulation activities in LSRs must be preceded by management assessments with specific requirements, including monitoring and evaluation of the actions effects. LSRs were established in part to maintain habitat for the northern spotted owl. Vegetation management activities such as thinning and understory removal of vegetation that lead to the development of late-successional forests or reduce the risk of large-scale stand-replacement disturbances may occur in LSRs.

Matrix lands are areas in which scheduled timber harvest is permitted (USDA and USDI 1994, p. A-4). Protections for occupied northern spotted owl sites and other species also overlay Matrix lands, further reducing the area available for timber harvest (USDA and USDI 1994, p. C-10). Riparian Reserves overlay all land allocations and emphasize protection of riparian dependent resources from a minimum of 30 to 91 m (100 to 300 ft) wide on each side of the stream, depending on the water body (USDA and USDI 1994, pp. C-30 – C-31). Timber harvest is restricted in riparian reserves to vegetation management activities that are consistent with Aquatic Conservation Strategy objectives (USDA and USDI 1994, pp. C-30 – C-31).

The annual volume of timber offered for sale in the NWFP area has been greatly reduced since 1990, in part due to implementation of the NWFP. The annual probable sales quantity (PSQ or targeted timber volume) under the NWFP is just over 800 million board feet, only 18 percent of the volume annually offered in the 1980s by Federal agencies in the NWFP area (Grinspoon and Phillips 2011, pp. 3, 5). The actual effect on the ground is even less because actual harvested timber sales from inception of the NWFP through 2008 have averaged 469 million board feet per year, or 58 percent of PSQ (Grinspoon 2012p. 1). Thus, the impacts associated with habitat loss from forest management activities on Federal lands within the NWFP area (including the Willamette Pass, Dutchman Flat, Mt. Washington, and Mt. Hood Sighting Areas) has been substantially reduced.

SNFPA: Forest Service lands in California outside of the NWFP areas (a portion of lands within the Lassen and Sonora Pass Sighting Areas) operate under LRMPs that have been amended by the Sierra Nevada Forest Plan Amendment (SNFPA), which was finalized in 2004 (USDA 2000, volume 3, chapter 3, part 4.4.1, pp 2-18; USDA 2001, entire; USDA 2004, entire). The SNFPA requires fire and fuels management projects in most areas to retain at least 40 percent (preferably 50 percent) canopy cover within a treatment unit, and effectively requires retention of trees 63.5 cm (25 in) dbh in most treated areas (USDA 2004, pp. 3, 50). This is close to the preferred

winter habitat characteristics discussed above for the Lassen Sighting Areas (60 cm (23.6 in) dbh and 40 percent or greater canopy closure). Areas near buildings and other human development (commonly referred to as the wildland urban interface) receive less protection: trees of 76 cm (30 in) dbh or greater are retained, and there are no canopy cover requirements. However, the SNFPA also requires managers to minimize fragmentation of old forest habitat (USDA 2004, pp. 53–54).

SNFPA Standard and Guideline #32 requires the Forest Service to conduct an analysis to determine whether activities within 8 km (5 mi) of a verified SNRF sighting have the potential to affect the species (USDA 2004, p. 54). It also mandates a limited operating period of January 1 to June 30 as necessary to avoid adverse impacts to potential breeding, and it requires two years of evaluations for activities near sightings that are not associated with a den site.

Omnibus Public Land Management Act of 2009 (OPLMA): The OPLMA (PL 111-11, p. 1059) establishes the Bridgeport Winter Recreation Area, consisting of about 2,833 ha (7,000 ac) in the northern portion of the Sonora Pass siting area on Forest Service land (USDA 2010, p. 4). The OPLMA states that the winter use of snowmobiles is allowed in the Recreation Area, subject to terms and conditions established by the Secretary of Agriculture. Prior to passage of this act, the area had been under consideration for designation as wilderness, although snowmobile use had been allowed in the area since 2005 (USDA 2010, pp. 3–4). The Forest Service has completed a management plan that calls for monitoring of impacts to wildlife (USDA 2010, p. 9), and is proceeding with evaluations of impacts to SNRF in accordance with SNFPA Standard and Guideline #32 (above).

National Park Service

Statutory direction for the National Park Service lands that overlap the SNRF's range is provided by provisions of the National Park Service Organic Act of 1916, as amended (16 U.S.C. §§ 1 *et seq.*) and the National Park Service General Authorities Act of 1970 (16 U.S.C. §§ 1a-1). The purpose of national parks, monuments, and reservations is to, “conserve the scenery and the natural and historic objects and the wild life [*sic*] therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (16 U.S.C. §§ 1 *et seq.*). More specifically, natural resources are managed to, “preserve fundamental physical and biological processes, as well as individual species, features, and plant and animal communities” (NPS 2006, p. 26). Land management plans for the National Parks do not contain specific measures to protect SNRFs or their habitat, but areas not developed specifically for recreation and camping are managed toward natural processes and species composition and are expected to maintain SNRF habitat. Prescribed fire is often used as a habitat management tool by the Park Service. The effects of these burns on SNRFs have not been directly studied, but there are no reports of direct mortality to red foxes from fires (Tesky 1995, p. 7), and fuels reduction through prescribed fire will likely benefit SNRFs in the long term by reducing the threat of SNRF habitat loss (Truex and Zielinski 2013, p. 90; Zielinski 2014, pp. 411–412). Hunting and trapping are generally prohibited in National Parks (16 U.S.C. § 127). Park Service policy allows these activities on Park Service lands if the actions do not unacceptably impact Park resources or natural processes (NPS 2006, pp. 46–47); however, they are not currently allowed in Crater Lake, Lassen Volcanic, or Yosemite

National Parks. Hunting and trapping is also prohibited in Sequoia and Kings Canyon National Parks (which are not known to contain current populations, but are in the SNRF's historical range).

U.S. Department of Defense

Sikes Act Improvement Act of 1997 (Sikes Act) (16 U.S.C. 670a): The Sikes Act required each military installation that includes land and water suitable for the conservation and management of natural resources to complete an integrated natural resource management plan (INRMP) by November 17, 2001. An INRMP integrates implementation of the military mission of the installation with stewardship of the natural resources found on the base. Each INRMP includes: (1) An assessment of the ecological needs on the installation, including the need to provide for the conservation of listed species; (2) a statement of goals and priorities; (3) a detailed description of management actions to be implemented to provide for these ecological needs; and (4) a monitoring and adaptive management plan. Among other things, each INRMP must, to the extent appropriate and applicable, provide for fish and wildlife management; fish and wildlife habitat enhancement or modification; wetland protection, enhancement, and restoration where necessary to support fish and wildlife; and enforcement of applicable natural resource laws. We consult with the military on the development and implementation of INRMPs for installations with listed species.

The U.S. Marine Corps' Mountain Warfare Training Center (MWTC) has lands within the Sonora Pass sighting area. Some MWTC lands were recently acquired, and although the total DOD-owned acreage (approximately 243 ha (600 ac)) is below the Sikes Act criterion, the MWTC has initiated preparation of an INRMP (Norquist 2014, p. 2). Because the INRMP is not yet finalized, we cannot evaluate its adequacy as regulatory mechanism.

State Regulations

California

California Hunting and Trapping Regulations: The State of California classifies red foxes as a furbearing mammal that is protected from commercial harvest (14 C.C.R. 460), and provides protection to SNRFs in the form of fines between \$300 and \$2,000, and up to a year in jail for illegal trapping (114 C.C.R. 465.5(h)). Body-gripping traps are also generally prohibited in California, so accidental harvest of SNRF incidental to legal trapping of other species is unlikely (see Hunting and Trapping, above). Between 2000 and 2011, approximately 150 trapping permits were sold annually in California (Callas 2013, p. 6); thus, the effects of legal trapping to all species combined are probably low. Licensed trappers must pass a trapping competence and proficiency test and must report their trapping results annually. Scientists who are trapping SNRFs for research purposes must obtain a Memorandum of Understanding from the State (California Fish and Game Code, Sections 1002 and 1003, and Section 650). Additionally, strict trapping and handling protocols must be adhered to by researchers to ensure the safety of study animals.

California Endangered Species Act (CESA): CESA (CA Fish and Game Code (CFGF) 2050 *et seq.*) prohibits possession, purchase, or “take” of threatened or endangered species without an incidental take permit, issued by CDFW. SNRF were designated as a threatened species under CESA in 1980 (CDFW 2014, p. 12).

Oregon

Oregon Hunting and Trapping Regulations: SNRF in Oregon may be hunted and trapped, including with use of dogs (635 OAR 050-0045(1), 0045(8)). As discussed above (Hunting and Trapping), actual impacts to SNRF are difficult to determine because of record-keeping conventions, but likely to be relatively low.

CURRENT MANAGEMENT AND CONSERVATION

As indicated under EXISTING REGULATORY MECHANISMS, above, the SNRF has been identified by the U.S. Forest Service as a sensitive species in California, but not in Oregon. This requires the Forest Service in California to analyze its activities for the potential effect on the SNRF. The report produced by Quinn and Sacks (2014, entire) on SNRF at the Sonora Pass Sighting Area is largely a result of funding and manpower contributed by the Forest Service as a result of the SNRF’s sensitive species status (*Id.* at 5).

The SNRF is also protected from hunting and trapping by California fish and game laws, and from any manner of “take” by CESA. CESA also prohibits possession, sale, purchase, or export of SNRF parts or products, such as pelts.

The SNRF also benefits from Late Successional Reserves (LSRs) established under the Northwest Forest Plan (NWFP), primarily for the benefit of the northern spotted owl. Forests are managed to promote old-growth characteristics within the LSRs, thereby likely benefitting SNRF, which showed a preference for mature, closed canopy forest at the Lassen sighting area (Perrine 2005, pp. 67, 74, 90). As discussed under *Logging and Vegetation Management*, above, LSRs and other reserved forest lands such as wilderness areas have considerable overlap with the lower elevational portions of habitat at the four Oregon SNRF sighting areas outside of Crater Lake National Park.

CHANGES SINCE 90-DAY FINDING

As discussed under **Current Distribution**, above, the five Oregon sighting areas were discovered after publication of our 90-Day Finding, and consequently were not considered in that document. The five Oregon sighting areas are: Crater Lake, Willamette Pass, Dutchman Flat, Mt. Washington, and Mt. Hood. The addition of this area significantly increases the known range of the SNRF. Additional information on these sighting areas is summarized in Table 1 and Map 2, above. Additionally, the arrival of nonnative red foxes at the Lassen and Sonora Pass sighting areas, and the production of 11 hybrid offspring at the Sonora Pass sighting area (see [Hybridization With Other Subspecies](#), above), had not taken place by the time we published the 90-day finding.

OVERALL SUMMARY

The SNRF is a red fox subspecies adapted to snowy, high elevation habitats. It was originally considered restricted to the Sierra Nevada, Trinity, and Cascade Mountains of California, but its range is now considered to also include the Cascade Mountains of Oregon. No recent sightings are known from the Trinity Mountains. A total of seven sighting areas (two in California and five in Oregon) are known in which SNRF have reliably been located. All such sighting areas are in National Parks and National Forests in the Cascade and Sierra Nevada Mountains. The sighting areas are summarized in Table 1 and Map 2, above.

SNRF populations at the Lassen and Sonora Pass sighting areas (both in California) have been estimated at 21 and 14 breeding individuals, respectively (with potential upper limits of 63 and 50 adults, respectively) (Sacks *et al.* 2010, p. 1532; Quinn and Sacks 2014, pp. 2, 10, 14). Populations sizes for the Oregon sighting areas are unknown.

The most serious stressors impacting SNRF or its habitat are: Small population size and isolation; hybridization with non-native red fox; climate change; and competition and predation from coyotes. Based on information available at this time, these stressors are of greatest concern at the Lassen and Sonora Pass sighting areas because the populations in those areas are known to be small, near the elevational limits of their respective ranges, and (in the case of the Sonora Pass sighting area) shows evidence of hybridization with nonnative red foxes.

Population sizes and trends remain unknown for the Oregon sighting areas, as does degree of isolation. Hybridization may be an issue at the Mt. Hood sighting area, but additional information is needed to determine if it is ongoing or took place years ago. Competition and predation with coyotes is also likely to be less of a stressor in Oregon, particularly in the Crater Lake sighting area, due to the likely re-establishment of overlapping wolf populations within the next 50 years. SNRF in Oregon sighting areas other than Crater Lake may also be able to migrate up-elevation to stay in areas of heavy snow, as coyotes tend to avoid such areas. Loss of forested habitat and increased wildfires due to climate change are thus likely to be the most significant stressors on the Oregon sighting areas.

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