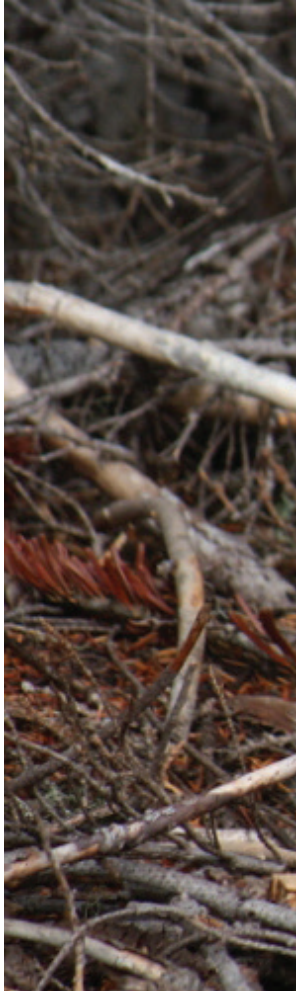

ECOLOGY & CONSERVATION

The Cascade Red Fox

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The fox padded lightly through six inches of new snow in the Gifford Pinchot National Forest, her nose leading the way to a cocktail of smells at the base of a mountain hemlock. She was so intent on the scented mixture of skunk, castor, and muskrat musk with undertones of chicken from the bait that she did not even hear the click of the camera that caught her image.

Later, on a dark winter afternoon in front of my computer, I sat flipping through thousands of photos that revealed the elusive residents of the Mt. Adams Wilderness: a nervous snowshoe hare, a stealthy bobcat, a gamboling trio of Pacific martens. But then I saw a critter I knew nothing about: a Cascade red fox, a rare mountain subspecies of red fox. This photo shifted the focus of my newly formed conservation initiative targeting wolverines in southern Washington—the Cascades Carnivore Project—to one that focused on the population status, community interactions, and ecological role of this rare and little-known forest carnivore.

Wildlife managers have only recently begun to appreciate the unique contributions the Cascade red fox makes to the fauna of the high Cascades. It is not, however, a simple story.

THE GLOBAL RED FOX

The red fox (*Vulpes vulpes*) has had a bum rap for as long as our civilization has been telling stories. Due to its omnivorous diet and innate curiosity, this small carnivore has been considered a trickster in folklore, and persecuted as a pesky chicken killer and a sly and devious predator. It is one of the most widespread carnivores on Earth and is considered an invasive pest in many areas. The species evolved in Africa or Eurasia from a now-extinct fox and is currently distributed throughout the Northern Hemisphere from deserts to temperate rainforests to tundra. The International Union for Conservation of Nature (IUCN) lists the red fox as a Species of Least Concern globally, i.e., one that is widespread and abundant. Before the advent of modern genetic techniques, subspecies divisions of red fox were based solely on geography and morphology, but the distinguishing features among all red fox are a white tipped tail, black tipped ears, and black stockinged feet. Coat color is highly variable. Although this historical subspecies classification scheme does not mesh perfectly with the genetic characteristics of these populations, there are three mountain and 11 lowland red fox subspecies, including a subspecies first described in 2010 that inhabits the Sacramento River valley. These 14 subspecies occupy a variety of habitats and coat colors from deep red to black and silver. Some of this biodiversity has been threatened recently by a lack of conservation concern for these unique red foxes, which are distinct in many important ways from their abundant nonnative cousins inhabiting the lowlands. In North America this has resulted in conservationists largely ignoring potential population declines in this rare and little-studied mountain fox, and making little attempt to understand how their populations, which occur in an archipelago of high-elevation habitat "islands," could be impacted by human activities, encroachment by potential competitors, and climate change. This begs the question: What factors could impact this animal, which is so far removed from people, and derived from a larger species considered well distributed and common?

GOING BACK TO THE PLEISTOCENE ICE AGES (OR GETTING TO KNOW THE MOUNTAIN FOXES)

Red foxes have a unique evolutionary history in North America that was elucidated by United States Forest Service (USFS) biologist Dr. Keith Aubry and his colleagues in recent decades. The colonization of North America by red foxes

Paradise Valley Road female, Oct. 9, 2015.

was shaped by two waves of migration from Eurasia. Half a million years ago, during the Illinoian Ice Age, red foxes first colonized North America from Asia over the Bering LandBridge, which became established due to the lowering of sea level by the formation of continental glaciers. When the glaciers melted and the Bering Strait was reestablished, red foxes became isolated on separate continents. These foxes swept south and east across the boreal forest. Then, during our most recent glaciation (the Wisconsin Ice Age), the Bering LandBridge formed again and a second wave of red foxes migrated to North America from Asia, which resulted in limited genetic exchange between the Eurasian and North American red foxes. During this last glaciation, the earlier fox migrants were pushed by the ice sheets into the vast, windswept plains and relatively low-elevation forests of the western and central United States, south of the ice. Here they presumably adapted to the colder, glacial climate, which lasted for the next 100,000 years. Once the ice sheets had receded, these foxes moved up into the mountains of the West where habitat conditions were similar to those they occupied during glacial times, leaving the thawing plains of the American Midwest devoid of red foxes. This long separation from their ancestors in the Old World allowed time for their DNA, shaped by chance and environment, to diverge. North American red foxes have now been separated from Eurasian populations for 300,000–600,000 years, and are genetically different from other red foxes. University of California at Davis molecular ecologist Mark Statham and his colleagues recently suggested that all North American red foxes be reclassified as a distinct species, *Vulpes fulva*—the North American red fox.

The descendants of those early Illinoian Ice Age migrants comprise the three mountain subspecies (*V. v. cascadensis, necator, and macroura*) that now inhabit the Cascade Range, the Sierra Nevada, and the Rocky Mountains, respectively (with the exception that red foxes in the Cascade Range of Oregon are now believed to belong to the Sierra Nevada subspecies). The valley bottoms are generally assumed to be inhabited by invader foxes that originated on the East Coast and were brought west for fur farming and hound hunting. The mountain foxes live at high elevations year-round in relatively open forests and subalpine parkland. Mountain foxes are typically smaller in size and exhibit a greater variation in their coat colors than lowland red foxes. These are not just the red-coated foxes of fairytales and wildlife calendars; mountain foxes occur in coat colors ranging from straw yellow to red to black and silver. There is also a relatively common "cross" variant whose name is derived from the cross formed by a thin black stripe that extends over the shoulders and crosses one along the backbone. More importantly, the mountain foxes are ecologically unique, feeding exclusively on alpine and subalpine prey such as snowshoe hares, white-tailed jackrabbit, pocket gophers, voles, winter-killed mountain goats, ground-nesting birds, and high-elevation plants. Molded by two ice ages, they have become well adapted to the cold. They rarely occur in the western hemlock and silver fir forests that cover lower elevations of the Cascade Range. They do not leave their snowy abode during the harshest blizzards of winter nor interbreed with red foxes in the valleys. They are finely tuned for life at altitude.

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A FOX BY ANY OTHER NAME

Throughout the year, the Cascade red fox relies heavily upon high-elevation meadows and tree copses to forage for small mammal and lagomorph prey. The eastern slope of the Cascade Range contains relatively dry and open mountain hemlock, subalpine fir, and whitebark pine forests and krummholz copses, as well as ragged pinnacles of rock that support mountain goats, whose carcasses are an important source of food. Like most furbearers, the Cascade red fox has suffered significant declines in abundance and distribution as a result of trapping and poisoning over the last century. Despite the absence of these activities for many decades, Cascade red foxes appear to have experienced range losses recently, perhaps due to the shrinking of high-elevation parklands and meadows from climate change, the loss of subalpine conifers to drought, fire, and disease, or the expansion of coyotes (*Canis latrans*) into the high-elevation habitats that Cascade foxes rely on. Historical patterns of land use during the past 100 years, including timber harvest, recreational use, and road building, continue to influence habitat conditions at various spatial scales and affect the ability of native wildlife to survive and reproduce.

WHAT'S IN A PH.D.?

In founding the Cascades Carnivore Project, I am following in the footsteps of two inspiring scientists. Dr. Keith Aubry, an emeritus scientist with the U.S. Forest Service's Pacific Northwest Research Station, began the first field study of mountain foxes in 1978 (the year I was born) in Mt. Rainier National Park and the Crystal Mountain area in Washington. This study provided important baseline information about the evolutionary and distributional history of both mountain and lowland red foxes, as well as seminal findings on the ecological relations of the Cascade red fox. Dr. Ben Sacks, Director of the Mammalian Diversity and Conservation Lab and my supervising professor at the University of California at Davis, where I am a graduate student, is an expert in wild dog genetics and conservation. The groundbreaking work of these scientists and their collaborators on the evolutionary history of the red fox in North America showed not only how unique mountain foxes are among the red foxes, but also that the Cascade red fox is the most genetically distinct of the mountain foxes, and occurs only in Washington state.

My research aims to develop a better understanding of how environmental changes in the western mountains impact the conservation of this rare mountain carnivore. I have been working with volunteer wildlife biologists and citizen scientists to conduct non-invasive surveys throughout the year at high elevations

For the conservation of the Cascade red fox, its unique genetic makeup may be a double-edged sword. On the one hand, we hypothesize that its unique genetic history confers adaptations that have allowed the fox to thrive where others could not. On the other hand, such specialized adaptations can make it more difficult for the fox to adapt to changing habitats and climates.

Left: Photo: Bob Rae. Right page: Photo: Tony Carado.

within the National Forest and National Park systems in the Cascades. We have deployed hundreds of remotely triggered wildlife cameras and walked, snowshoed, and skied endless miles collecting hair, scat, and urine from which DNA can be extracted to determine where Cascade red foxes live and where they don't. I am concerned that the distribution of the Cascade red fox may be largely restricted to a few isolated, high-elevation areas of the Cascades. By examining if and how well fox populations are connected, and how this connectivity is predicted to change with climate change, we can begin to understand the long-term prospects for this unique carnivore. I am investigating whether the low number and fragmented distribution of the Cascade red fox is sufficient for them to successfully reproduce and maintain adequate levels of genetic diversity. For conservationists, genetic diversity is important for predicting how likely a species is to persist over the long term. With a diverse complement of genes, a population is more likely to include at least some individuals that can survive future environmental changes, such as the introduction of new diseases or parasites or rising global temperatures. The process by which such initially exceptional individuals survive and contribute their genetic characteristics to the next generation is known as natural selection, and results in the continuing evolution of species to their changing environment. The farther one travels to find a mate, the more likely that mate will be genetically distinct from oneself, resulting in more diverse offspring contributed to the population's gene pool. Cascade red foxes may be scattered across a vast mountain landscape with huge distances and major barriers between them. My work suggests their strongholds are Mt. Adams, Mt. Rainier, and the Goat Rocks Wilderness. They seem to have been gone from Mount St. Helens since the 1980 eruption. There have been some foxes detected in the William O. Douglas and Norse Peak Wildernesses. They may occur in the Alpine Lakes Wilderness and their presence in the North Cascades is largely unknown.

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A WARMING WORLD

How does climate change affect the Cascade red fox? The reality is we do not know yet. But there are some strong hypotheses worth testing. Impacts of climate change in the alpine environment have been well documented. Two key measures of climate change are temperature and precipitation patterns. In the mountains, changes manifest as rising temperatures and precipitation falling increasingly as rain, rather than snow, resulting in shorter, warmer, wetter, and less snowy winters. So what is the relationship between these climatic changes and Cascade red fox conservation? The Cascade red fox is strongly associated with high-elevation mountain habitats and is well adapted for life in snowy conditions. Compared to lowland red foxes, mountain foxes have much more fur lining the soles of their feet, which helps them function as snowshoes, and a smaller body size, which allows them to move with greater ease in deep, powdery snow. The Cascade red fox may use the mountain biome to escape predation from the coyote, which is a lowland-adapted species. Coyote abundance has been on the rise since the extirpation of the gray wolf in Washington in the 1920s and state and federal restrictions on lethal predator control. In addition, Cascade red foxes rely

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Photo: Unknown.

Red Fox, continued from previous page

upon the subnivium for preying on winter-active small mammals. Unpredictable changes to the space that forms between the ground and deep snowpacks could have significant consequences for the Cascade red fox. Warming conditions can alter the insulating qualities of snow due to decreased depth and increased density, which is predicted to lower the temperature of this stable environment and reduce the abundance of small mammal prey. In addition, these foxes prey on small mammals in winter by pouncing through the snow to catch them as they move within this protected habitat. However, once the first winter rains fall on the loosely compacted snow, the snow pack hardens and may prevent foxes from accessing the subnivium for periods of time. This pattern is expected to become more prevalent as rain becomes increasingly common in the mountains. Hardening of the snowpack may also have the adverse effect of encouraging new predators and competitors to invade alpine and subalpine areas from which they would normally be excluded due to their reduced ability to travel in soft, deep snow. This encroachment may be the single greatest proximate threat to the Cascade red fox as it could result in competition during winter scarcity as well as increased mortality rates at the paws of predators such as the coyote.

There are two primary environmental alterations associated with a warming climate that could potentially impact the Cascade red fox. The first is the encroachment of meadows by shrub and tree species. Climate change is causing tree line to shift upward in elevation, reducing the extent of the alpine meadows upon which the fox relies. The invasion of shrubs and conifer saplings into subalpine meadows has been well documented on Mt. Adams in photographs of particular locations taken 50 years apart. Subalpine meadows and their small mammal communities provide the primary foraging grounds for Cascade foxes throughout most of the year. The second is the increased spread of plant diseases and pests. Fungal and beetle infestations are decimating the subalpine forest. The loss of whitebark pines from warming temperatures and increases in disease are becoming more and more prevalent on the dry eastern slopes of the Cascade Range where mountain foxes are most likely to live. The Cascade red fox relies upon copses of these high-elevation pines and firs to hunt for snowshoe hares and white-tailed jackrabbits during the winter months, and for cover to use as daybeds and rest sites during the harshest winter blizzards. Finally, recent wildfires have severely affected some of the subalpine parklands and upper elevation forests that the Cascade red fox calls home on Mt. Adams and throughout the Cascades. This year, wildfires in the Cascades were the largest and most destructive on record. Wildfires are a natural part of ecological cycles but modern blazes burn so intensely due to the huge fuel loads that were created by 100 years of forest fire suppression and drought.

AN UNPREDICTABLE FUTURE

What can we do to ensure that Cascade red fox populations will remain viable? A primary goal should be to continue systematic surveys over the long term and in the North Cascades to establish baseline conditions and monitor changes in their abundance and genetic diversity. Increasingly, occurrence records obtained by citizens are becoming an essential part of this process. Such records enable scientists to identify new areas of current presence and may encourage the establishment of new ecological studies, which will be essential for the effective conservation of this unique and intrepid little fox. Research investigating habitat selection at multiple spatial scales, movement patterns, predator-prey relationships, and home-range ecology is desperately needed to fill many key knowledge gaps about the conservation needs of this species. In addition, we should protect denning sites. This is especially important in preventing unnecessary pup mortalities when they emerge from their dens. The next phase of the Cascades Carnivore Project aims to investigate microhabitats most important to the Cascade red fox and determine how the essential components of their habitats will be affected by future changes to the composition and climate of the landscapes they occupy in their mountain home. Ultimately the fate of all alpine species lies within our ability, or inability, to care for our unique alpine landscape, and to address the potential threats to their persistence. The Cascade red fox has been evolving its unique character for hundreds of thousands of years in North America. With a little more attention from scientists, resource managers, and the public, I am hopeful that we will find a way to help our mountaineering friend persist well into the future.

Report your mountain red fox sightings to cascadescarnivore@gmail.com

This research on the Cascade red fox is generously funded by the Mazamas, the Mammalian Diversity and Conservation Laboratory (University of California, Davis), Gifford Pinchot, Mt. Hood, and Okanagan-Wenatchee National Forests, Mt. Rainier National Park, the Mountaineers, Norcross Wildlife Foundation, Oregon Zoo Foundation, The Wildlife Society Washington, WDFW Aquatic Lands Enhancement Account, Washington Foundation for the Environment, Washington's National Park Fund, and the tireless efforts of many citizen scientists, wildlife biologists, and laboratory genetics interns at the University of California, Davis.