

Island Fox Paradox

SHARON LEVY

Do species introduced by native people thousands of years ago deserve protection?

Five foxes sit in a polite row, waiting. As shadows grow long and the sun sets into the endless expanse of the Pacific, the foxes inch closer to the picnic table where students of the San Nicolas Island field school are sharing a barbecue dinner. If a scrap hits the ground, a fox will dart in, snatch it up, and resume its station. Bend toward one of the little



Channel Island foxes, long the top predator in their ecosystem, show little fear of humans. Wild foxes often accost visitors on San Nicolas, the island with the most abundant fox population in the island chain.

Photograph: David Butow.

animals, and it will lean forward, coming almost close enough to touch. It's forbidden to feed these foxes, members of a threatened species unique to the Channel Islands off the southern California coast. But archaeologists say these beasts evolved among native people; the island fox may belong right here, at the edge of a communal feast.

In the 1990s, a complex chain of events triggered by human actions brought foxes in the northern Channel Islands to the brink of extinction. The animals became the focus of intense and controversial conservation efforts. Now, archaeologists have new evidence that suggests foxes were carried to the islands by indigenous people thousands of years ago, and that humans shaped the evolution of the entire species. Entrenched conservation dogma assumes that we should strive to restore American ecosystems to the “pristine” state encountered by the first European settlers. The case of the island fox raises questions about just how we should go about protecting species whose history is entwined with our own.

Of foxes and men

René Vellanoweth, an archaeologist at California State University, Los Angeles, leads the excavation of an ancient settlement called Tule Creek Village, located on a San Nicolas bluff, which faces east toward the distant mainland.

On a sunny August morning, he and his colleagues probe with their trowels, preparing to uncover the skeleton of a ritually buried dog. Carefully arranged remains of dogs and foxes have been found clustered at the site, surrounded by hearths and valuable pieces of tool stone. It's clear that the prehistoric people of San Nicolas revered the island fox, and that both dogs and foxes played an important role in their lives.

The native people of the Channel Islands—the Chumash of the north, and the Tongva of the south—were forced out of their homes and relocated to mainland missions in the 1830s. Their fox-venerating practices soon died out, and little is known about those practices today. In their heyday, the Chumash performed a fox dance, wearing headdresses made of fox pelts. On Santa Cruz, at the northern, Chumash end of the island chain, early archaeologists found a child buried with two fox skulls; another burial site on the same island contained a man and a woman with a fox skull laid between them. A site on San Clemente Island—like San Nicolas, this was Tongva turf—contained six ritually buried foxes and six dogs.

As a graduate student in the early 1990s, Vellanoweth worked on an excavation at Viscaino Point on San Nicolas. Mixed with a hodgepodge of human artifacts, he found a 5000-year-old

bone from the inner ear of an island fox. The discovery pushed the known arrival of foxes in the southern islands back by about 2000 years. It also got Vellanoweth hooked on the creature's prehistory.

Each island population of fox has been designated a distinct subspecies on the basis of genetic differences. So when fox numbers on all three northern islands crashed in the 1990s, separate captive breeding programs were established for each population. Vellanoweth thinks biologists ignore a critical factor: the powerful human link to the fox. He believes native people not only carried the fox to the islands in the first place but that they also commonly moved animals from one island to another. "Humans and foxes evolved together," he says. "I honestly think, based on the archaeological data, that one of the best ways to keep these foxes going is to restart that relationship: Mix foxes from the different islands. That would increase their genetic diversity and help them recover."

Passage to the islands

Just a few mammals and reptiles managed to cross miles of open Pacific to reach the islands. The island fox (*Urocyon littoralis*), long the top terrestrial predator, has shaped its ecosystem. Foxes regulate numbers of endemic mice and skunks, limit the types of birds that nest, and control invasions by introduced rats. Most biologists and archaeologists agree that the fox plays a vital role in Channel Island ecosystems. Members of the two disciplines do clash over their very different visions of the origin of this charismatic beast and the best way to keep it thriving.

The island fox is less fearful and less nocturnal than its mainland ancestor, the gray fox. It's also much smaller, about the size of a house cat; it's common for species isolated on islands to shrink over generations in response to limited food resources. Just how long it took for the island fox to evolve its dainty physique and current bold nature is unclear. No remains of the mainland fox, *Urocyon cinereoargenteus*, have

been found on the islands. People first settled the northern Channel Islands as early as 13,000 years ago, leaving behind some of the most ancient human bones and artifacts in North America. The earliest known fox remains on the islands come from animals that lived long after the first humans came; they had already developed the unique characteristics that distinguish them from the mainland fox.

Paul Collins, curator of vertebrate zoology at the Santa Barbara Museum of Natural History, developed a widely accepted model of the island fox's origin and evolution, which he published in 1991. His scenario is based on the pattern of fox remains found at sites throughout the island chain—all of which are associated with human artifacts except for a single specimen from Santa Rosa—and on differences in cranial characteristics between fox populations on each island. During some long-ago ice age winter, he believes, floodwaters filled rivers on the adjacent mainland and hurled debris into the Pacific. A few gray foxes, or perhaps a single pregnant female, were caught up in the flood and rafted out to the northern islands on heaps of flotsam. (Foxes are poor swimmers, and it's unlikely they could ever have swum the distance between the mainland and the islands.) Over time, fox descendants adapted to the new habitat, where they became the dominant predators. Unlike their cautious mainland kin, foxes on the islands had nothing to fear: They became bold, moving by day, approaching any creature that caught their interest. They colonized the three northern islands of San Miguel, Santa Cruz, and Santa Rosa, which would have been connected as a single landmass when ice age glaciers were at their peak.

The absence of island fox remains in the oldest archaeological sites on the southern islands of San Nicolas, Santa Catalina, and San Clemente suggests that foxes arrived there well after native peoples. Most researchers agree that foxes made the journey from the northern islands in Indian canoes. It's clear that by the time the first foxes



Whether carried by native people or washed offshore by floodwaters and transported aboard flotsam, foxes first arrived in the northernmost Channel Islands. Later, after the island fox had evolved the unique characteristics that distinguish it from its mainland ancestors, people carried it to the southern part of the island chain. Map: Lencer.

reached the southern islands, they'd become tightly woven into the lives of Channel Islands people.

One fox skull from Santa Rosa Island, thought to be about 22,000 years old, was interpreted by Collins and others as strong evidence that foxes crossed to the northern islands long before people arrived. Recently, Vellanoweth pooled resources with a group of archaeologists, led by Torben Rick of the Smithsonian Institution, to fund carbon dating of this skull, along with a few other fox remains thought to pre-date human settlement. The Santa Rosa specimen proved to be less than 2000 years old; some of the bones turned out to be even more recent, from animals that lived in historic times. The oldest, found on San Miguel Island, dated to about 6300 years ago, millennia after people had arrived. These earliest island fox bones are about the same age as the oldest remains of domestic dogs on the islands. Rick and Vellanoweth see this as support for their vision of the island fox as a human-made species, the descendants of mainland foxes carried to a new land by people. In their model, foxes first reached the northern islands in Chumash canoes, rather than on rafts of flotsam.

Worldwide, prehistoric peoples brought wild and domestic animals with them when they colonized

islands. It's easy to imagine why seagoing explorers would bring dogs, pigs, chickens, and goats. Rats and mice often traveled as stowaways, but other untamed creatures were moved on purpose: Ancient people carried red deer to the islands of Corsica and Crete, the northern cuscus (a member of the opossum family) from New Guinea to the island of New Ireland, and the red fox to Cyprus. The reasons for these animal transplantations remain mysterious. It's possible that the Chumash carried gray foxes with them to the Channel Islands, but since no remains of the larger, mainland fox have ever been found there, it's impossible to know for sure when, or how, the ancestral foxes first arrived.

Before the fox

The fossil record from the prehuman era contains evidence of birds, mice, shrews, and pygmy mammoths. (Ice age mammoths could have swum to the islands and, like the gray fox, shrunk over the course of time.) Though these ancient bone deposits have yielded no fox remains, Rick believes they still hold important clues to the fox mystery.

On San Miguel Island, paleontologist Dan Guthrie has studied deposits of eggshell fragments from nesting colonies of two extinct seabirds, Dow's puffin (*Fratercula dowi*)

and a flightless scoter (*Chendytes lawi*), that once inhabited remote, rocky shores on the Channel Islands and southern California mainland. Both ground-nesting birds would have been easy prey for foxes, and they seem to have stopped breeding on the open shores of San Miguel after the fox arrived. *Chendytes* survived and was hunted by the Chumash for thousands of years after the fox

appeared, but the birds abandoned open beaches for small islets and rugged cliffs inaccessible to foxes.

Rick thinks that relics of abundant ground-nesting birds can be used to clock the approximate arrival of foxes on the islands. Evidence to support that idea comes from very recent times. In 2000, the San Miguel population of island fox dwindled to only 15 animals, and all of them were removed from the wild and held in pens as part of a captive breeding program. With the island's top dog out of the picture, ground-nesting birds—including northern harriers, western gulls, and Brandt's cormorants—claimed territories and raised young all over the island. At the same time, populations of the island deer mouse exploded and began fluctuating between extremely high and low densities, a pattern never seen while foxes patrolled San Miguel. Black rats, which, unlike foxes and deer mice, were introduced in relatively recent times and have not naturalized on the islands, expanded out from a thin strip of habitat at the beach's edge and invaded the main island. On nearby Santa Cruz and Santa Rosa, numbers of the island spotted skunk (a species absent from San Miguel) boomed as the local population of foxes dwindled. All this demonstrates the fox's powerful role in structuring island ecosystems.

Other findings underscore the long-standing bond between foxes and humans. Fossil bones preserved in ancient bald eagle nests from the prehuman era contain no trace of fox, though more recent nests hold a smattering of fox bones among collections dominated by fish and sea bird bones. (The last bald eagles in the Channel Islands disappeared in the late 1950s, poisoned by DDT [dichlorodiphenyltrichloroethane]. The pesticide was released to the Pacific from a chemical factory in Los Angeles, contaminating the marine food web that supported the big birds.) Even the foxes' parasites may tell a tale. The mainland gray fox carries about 50 different species of flea, but the island fox has only a few. The dominant variety is *Pulex*



Archaeologist René Vellanoweth pauses on the beach below Tule Creek Village on San Nicolas Island. At the village site, he and his colleagues have excavated ritual burials of island fox and domestic dog. Both canids played an important role in native ceremonies, and both traveled to the southern Channel Islands in Indian canoes. Photograph: Sharon Levy.



Two dog skeletons were part of a three-dog burial site excavated at Tule Creek Village. The burial dates to the 13th century ACE. Photograph: Courtesy of René Vellanoweth.

simulans, the same flea that infests people and their dogs.

Managing island fox populations

The dramatic collapse of fox populations on the northern islands followed a complex series of actions by modern people. These included the 1850s settlement of the islands by ranchers, whose sheep overgrazed native shrubs, transforming the vegetation to a nonnative grassland that offered little cover. Ranchers also left thriving populations of feral pigs behind on Santa Cruz and Santa Rosa. Foxes coexisted with the pigs for more than a century, but wild piglets, by attracting a new and deadly predator, eventually helped to bring foxes to the edge of oblivion.

Golden eagles had been persecuted for decades by ranchers in the western United States, even after the Bald and Golden Eagle Protection Act of 1940. Golden eagle populations did not begin to rebound until the 1990s, when they colonized the Channel Islands for the first time. Gary Roemer, now an ecologist at New Mexico State University, witnessed the result on Santa Cruz Island, where he radio-collared numerous foxes. For the first few months of his study, he didn't track a single fox

mortality. Then, in the spring of 1994, he found the carcass of a fox killed by a large raptor. The only candidate predator was the golden eagle. Soon fox survivorship on the island plummeted, while the number of eagle sightings grew. On the way to his study site one day, Roemer watched a golden eagle feeding on a distant hillside. After the bird flew off, he hiked to the site of the kill and found an eviscerated piglet.

Using empirical observations and mathematical models, Roemer showed that feral pigs—fecund animals that produce many young per litter and breed any time of the year—formed a bountiful food source that made it possible for golden eagles to nest successfully on the islands. Adult pigs are too large for an eagle to tackle, so pig populations remained robust while supporting heavy predation. The island fox reproduces at a relatively slow rate, each female producing just one or two young per year. Because a fully grown adult weighs only about 2 kilograms, foxes remain targets for hungry eagles throughout their lives. Island foxes alone could not support a population of golden eagles, but eagles that relied on piglets as a staple food often took foxes, too. The northern islands lack any significant cover to shelter foxes

from an aerial predator. On the mainland, with its many predatory hazards, gray foxes move cautiously, by night. But thousands of years in a predator-free environment had transformed the island fox into an easygoing creature, rambling the arid hillsides in sunlight. The fox became easy prey.

On San Miguel, the number of foxes dropped from 450 adults in 1994 to 15 in 1999. The Santa Cruz population dwindled from 2000 adults to about 50; on Santa Rosa, only 14 foxes survived by 2000. Captive breeding programs were established on each of these islands. For the San Miguel and Santa Rosa fox subspecies, inbreeding was a real concern, and pairs were carefully selected to maximize the genetic variability of their young. Today, feral pigs have been killed off and golden eagles relocated to northeastern California. The San Miguel island fox has returned to its previous abundance, and populations on Santa Cruz and Santa Rosa are recovering. Captive breeding of island foxes ended in 2008, when it became clear that survival in the wild was high, and that the animals were reproducing more successfully on their own than under human supervision.

Vellanoweth readily admits he's not qualified to make wildlife management decisions, but he thinks the archaeological evidence should not be ignored. He believes it would be easy and truer to the long-term history of the species to broaden fox gene pools in the northern islands by bringing in some of the abundant foxes from San Nicolas or San Clemente.

For most biologists who've worked with island foxes, that idea is anathema. Fox populations on the northern islands are recovering despite their low genetic diversity. Collins says the unique DNA markers and morphological characters that have been identified for each fox population show that the animals on each island have been genetically isolated for a significant stretch of time, probably much longer than the 180 years since native people were driven away. There are minor but clear physical differences,

too; Collins can reliably distinguish a fox's island of origin on the basis of cranial measurements and the shape of its nasal bones. Mixing animals from such distinct populations could lead to the loss of unique traits that fit each subspecies to its home environment, a phenomenon known as outbreeding depression. Although deliberate cross mating has worked to counter some extreme cases of inbreeding in endangered species—the Florida puma, for example—this approach is considered a desperate last resort.

However, the conventional approach ignores the fact that we ourselves set the definitions of what is different enough to constitute a distinct subspecies, and that these definitions are often based on our belief in a clear barrier between wild nature and human tampering. “That distinction is easy to make in modern society,” Rick says, “but when you go back in the past, it’s a very blurry line at best.” The Chumash and Tongva people traveled often between islands, trading snail shell beads, tool stone, sea otter pelts, and, perhaps, half-tame foxes. Fox remains are nearly as common as dog remains in their ancient villages. Then as now, island foxes must have stayed close to human settlements, cruising for scraps and approaching people. It’s easy to imagine people making pets out of these appealing little creatures.

Seeking answers in ancient DNA

Rick hopes to resolve the debate over the island fox's origins by studying DNA from ancient bones collected across the island chain. Over the past few years, research on ancient DNA has progressed rapidly, yielding insights into the population biology of such long-extinct creatures as the short-faced bear, woolly mammoth, and cave lion. Prehistoric DNA may help reveal the true extent of humanity's prehistoric influences on the island fox. How long ago did the island fox diverge from its mainland ancestor, and how long have populations on each island been genetically isolated? This information could guide the future conservation of the species.



This fox skull was buried near the whole skeletons of three domestic dogs. Ceremonial burials of both domestic dogs and island foxes have also been found on Santa Cruz and San Clemente islands. Photograph: Courtesy of René Vellanoweth.

Some biologists worry that the ancient link between humans and the island fox may be used as an excuse to take away the species' protected status. That issue has come up in the past: Soon after Collins published his evidence that people had brought the fox to the southern islands, members of the US Navy command that owns San Clemente Island seized on the finding as a rationale for stopping expensive fox conservation efforts. Biologists countered that tactic with studies that demonstrated consistent genetic differences between the fox populations on each island. Whatever the first island foxes' origins, and however long their fates were interwoven with native peoples', the populations on each island now seem to be on distinct evolutionary paths. Under the Endangered Species Act, this means each population deserves protection.

When the first foxes reached the islands, they likely decreased the bio-

diversity there, as many newly introduced species do. Today they play an important role in structuring and sustaining the living communities of the islands. Yet the fox's close and longstanding ties to native people can make it harder for modern conservationists to set ecologic baselines. If the goal is to return one or more of the islands to its pristine prehuman state, one could argue for wiping out island foxes, tipping the balance back in favor of skunks and ground-nesting birds. But that's not what the archaeologists want to see happen. “If native people did introduce the fox to the islands,” says Rick, “I don't think that should change their conservation status at all. To me, it makes these animals even more unique and important.” What Rick hopes to see is not a slacking off in protection of the island fox but an incorporation of prehistoric insights into its future management.

Visit these sites for more information:

www.nps.gov/chis/naturescience/island-fox.htm

www.islandfox.org

Sharon Levy (levyscan@sbcglobal.net) is a freelance science writer and author of Once and Future Giants: The Fate of Megafauna in a Human World, to be released soon.