Plague on the Prairie: The Fight to Save Black-Footed Ferrets from the West's Most Insidious Disease

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ABSTRACT

When a single remaining population of black-footed ferrets was discovered in Meeteetse, Wyoming in 1981, scientists had one last chance to save North America's only native ferret from extinction. Though the discovered population numbered over 100 individuals when it was found, ferrets began to die at an alarming rate just a few years after the rediscovery of the species. With their options running out, the United States Fish and Wildlife Service made the drastic choice of pulling every single surviving ferret into captivity. Thanks to decades of captive breeding and release efforts involving hundreds of people, there are now a few hundred black-footed ferrets back in the wild today. The black-footed ferret recovery effort has yet to overcome its greatest challenge, however: plague. Keeping ferrets alive in the wild is time consuming and cost intensive. Every wild ferret needs to be rounded up and vaccinated, and insecticides are sprayed over hundreds of thousands of acres each year to stave off the looming threat of a plague outbreak. To make matters worse, ferrets are becoming more inbred each year, making them even more susceptible to disease. Recently the black-footed ferret recovery effort has turned to cutting-edge genetic technologies to introduce more diversity into the ferret line, and, eventually, resistance to the plague. Some researchers think that such drastic measures might now be the only way for black-footed ferrets to ever have a hope of surviving on their own in the wild again.

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The first sign that the killer had arrived in Conata Basin was an eerie stillness. It was a crisp spring day on 12 May 2008, when a group of Forest Service biologists in Conata Basin, South Dakota noticed something was amiss.[i] They were gearing up for a day of field work: installing a cattle-proof fence around a portion of Conata Basin's expansive prairie dog colonies.[ii]

Overlapping with Badlands National Park, the Basin and its prairie dog colonies provide food (the prairie dogs themselves) and shelter (their burrows) to a dizzying array of wildlife. Fennec foxes, ground squirrels, burrowing owls, mountain plovers, and the park's pride and joy—black-footed ferrets—depend on the underground city for survival.[iii] But on this particular day not a creature stirred. No prairie dogs peeked from burrows or squeaked their signature alarm calls. Upon examination, the biologists noticed with mounting concern that the tunnel openings were caved in, covered with cobwebs, derelict with disuse. They were fencing in a ghost town.[iv]

"That's usually how it happens," says Travis Livieri, a field biologist who has worked on black-footed ferret conservation in Conata Basin for over 25 years. "All of a sudden, one day, all the prairie dogs are gone."[v]

The researchers abandoned the fence and scoured the landscape until they found what they were looking for. A single dead prairie dog, lying out in the open, untouched by predators. Alarmed, they bagged it up and FedExed the dead body to the Center for Disease Control for testing. They had to act fast. Once present on a landscape, the bacterial culprit they suspected could whip through prairie dog colonies like wildfire, killing nearly 100 percent of its victims. The test results came back with 24 hours: positive. The plague had arrived in Conata Basin.[vi]

Sylvatic plague is caused by the same bacteria responsible for bubonic plague. Once *Yersinia pestis* hits a prairie dog colony, the best way to combat it is to dust each and every burrow with the insecticide deltamethrin, frequently called "Delta Dust," which kills the fleas that carry it. This means teams of 10-12 people riding out on four-wheelers every day to stick tubes in half a million burrows to thoroughly coat the inside with a spray of insecticide. The method is labor-intensive and time consuming. At max capacity, the Conata Basin team could only dust up to 200 acres a day.

"It's like fighting a fire but you can only drive your truck so fast…and you've only got so much water," Livieri says. "So we had to make a decision about what to save, and what to…leave open to plague." By which he means, which animals to let die. By the time the Forest Service biologists found the first dead prairie dog in Conata Basin, the animals had vanished from over 3,000 acres—an area that holds an average of 48,000 prairie dogs. By the end of 2008, plague would hit at least another 8,000 acres.[vii]

The vanished dogs spelled disaster for Conata Basin's 350 black-footed ferrets, then the largest wild population of the species anywhere in the world. Black-footed ferrets are one of North America's most endangered mammals and rely almost exclusively on prairie dogs for their room and board. After being presumed extinct three decades prior, they were reintroduced to South Dakota in 1997 and Conata Basin had become the gold standard reintroduction site for one increasingly obvious reason: it was the only site within the ferrets' old range that wasn't already infected with plague.[viii]

The biologists knew they had to take action if they weren't going to lose every single ferret. Livieri poured over his data from the last decade of black-footed ferret monitoring in Conata Basin and directed the dusters to where he thought the highest densities of ferrets were located. Federal agencies like the U.S. Fish and Wildlife Service, which runs the black-footed ferret recovery effort, spearheaded the dusting effort. Livieri, meanwhile, went out night after night, gathering and "like a madman."[ix]

"There wasn't a lot of time to reflect on the gravity of the situation. We just did it," Livieri says. "May 12, 2008 was the day that changed my life."[x]

In 2013, after years of intensive dusting efforts and vaccinations, Conata Basin's population of 350 black-footed ferrets had whittled down to just 50. Today, after over a decade of intensive management, the ferret population has crept up to just over 100 individuals.[xi]

Once plague is on the landscape, it's impossible to get rid of, devilishly difficult to detect, and highly lethal to a wide range of species. Only now, thanks to one of the most involved recovery efforts in the history of the Endangered Species Act, are we fully beginning to understand the toll it's taken on the Great Plains.

Black-footed ferrets' fates are intimately intertwined with plague. The story of this species, pulled back from the brink of extinction but still circling the drain, is about the havoc an infectious disease can wreak when we don't pay attention until it's too late. It's a story of the decades-long efforts of hundreds of people across the country to save one fierce little mustelid and recover an entire ecosystem in the process. It's a story about what happens when we fail a species, and what happens next.

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One to two million years ago, an enterprising group of Siberian polecats made their way across the Bering land bridge, leaving their home on the open expanse of the Eurasian steppe.[xii] They found a new continent full of creatures adapted to life on the plains. There were massive mastodons, vicious saber-toothed cats, giant camels, and great herds of bison that stretched for miles. But one animal was different from anything the polecat had encountered back home: prairie dogs. These social rodents—the perfect size for a polecat feast—would shape the pioneering mustelid's destiny in the new world.

Polecats are a tube-shaped animal over a foot long, with a cream-colored body, dark legs, a short, black-tipped tail, and a black bandit mask across their face. Everything about them is perfectly adapted to their fossorial, carnivorous lifestyle, where they spend much of their lives ambushing prey underground. Their short skull sports a ridge across the top, called a sagittal crest, which serves as an anchor for powerful jaw muscles housing 34 blade-like teeth. A flexible spine allows them to turn around in a tunnel just four inches in diameter.[xiii]

Back in Asia, there are no rodents that construct elaborate, underground cities. Rodents there are solitary, or live in smaller, spread out groups. Siberian polecats are likewise solitary, keeping to

themselves and opportunistically snacking on a diverse array of prey. In North America, however, they found something extraordinary in prairie dogs: the perfect food source, living in huge dense colonies that stretched for hundreds of miles, constructing burrows that were the perfect size for these mustelids to find shelter and raise kits. They had found a sort of ferret Promised Land. And their new home changed them.

The polecats became specialist hunters of prairie dogs. While they were active at all hours out on the steppe, in the Great Plains they learned to hunt their prey—typically larger and heavier than themselves—at night. Successful hunters learned to sneak up behind their quarry in their narrow, pitch black tunnels, delivering a quick strangling bite to the neck. By 800,000 years ago, the prairie dog towns had shaped those Siberian polecats into a new species, which we now know as the black-footed ferret. For tens of thousands of years, black-footed ferrets embedded themselves within their new environment, from Canada to Mexico, across the Great Plains to the Rocky Mountains.[xiv]

Remarkably, ferrets were at virtually no risk of ever running out of food despite a diet that consisted almost entirely of a single species. Prairie dog colonies stretched over an estimated 100 million acres of grasslands housing five billion of the rodents.[xv] Black-footed ferrets only eat about 100 prairie dogs a year, with each female ferret defending a territory containing an average of 900. Billions of prairie dogs comfortably supported about half a million black-footed ferrets for thousands of years.[xvi] It was the perfect setup—until it wasn't.

When European settlers began to arrive on the Great Plains with their cattle, they became acquainted with prairie dog colonies themselves. They viewed them as a threat rather than an opportunity: another highly social mammal that served as competition for space and for resources. Farmers and ranchers declared war—a one-sided battle with millions of deaths. Prairie dogs were shot for sport, poisoned, killed by any means necessary. Their burrows were plowed over and converted into cropland. This animosity, and its devastating ecological impact, has continued to this day.[xvii] While only one to two percent of all prairie dog colonies remain, only one out of the five species is listed as endangered.[xviii]

"Prairie dogs are so hated in the West," says Kimberly Fraser, education specialist at the National Black-footed Ferret Conservation Center. "They're probably the most hated species in North America."[xix]

As a result, prairie dog colonies have been confined to smaller and smaller pockets, like fish in a slowly drying-up lakebed, left flapping and gasping in ever-shrinking pools. All the life that depended on prairie dogs for survival were suddenly in deep trouble—black-footed ferrets most of all.

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Unfortunately for both species, in the midst of these eradication efforts, another insidious threat was quietly extinguishing rodents with much less fanfare. In 1900, some black rats scurried onto the docks in San Francisco. The event caused quite a stir in our own species at the time, being as it was the very first plague outbreak on American soil. A man in Chinatown died of telltale

plague symptoms, and the whole area was promptly quarantined. Over 100 people in Chinatown died.[xx]

Meanwhile, those rats, and the fleas they carried, scattered around the city, and then the surrounding area. The fleas hitched a ride on ground squirrels, which spread them still further. By the 1930s, biologists had detected the presence of plague in a prairie dog colony. By 1955, plague had popped up in 15 western states. By 1988, it had reached the South Dakota border, and at least 76 species of mammal had tested positive for plague.[xxi]

Plague's range, to this day, nearly perfectly overlaps with the range of prairie dogs. While scientists are still unclear on the exact reason for such similar habitat preferences, one thing is clear: as was the case for black-footed ferrets, a city of rodents is a dream come true for *Y. pestis*.

The fact that *Y. pestis* and black-footed ferrets both thrive in prairie dog colonies is not a complete coincidence. Siberian polecats and the plague both evolved on the Eurasian steppe. Tens of thousands of years after black-footed ferrets made the split from their ancestors, *Y. pestis* branched off from its own close relative *Y. pseudotuberculosis.* The two bacteria remain genetically similar, but their strategies for infecting hosts are wildly different. *Y. pseudotuberculosis* is transmitted by water, and not particularly dangerous. *Y. pestis* is distributed by fleas and is one of the most virulent bacteria in the world.

Back on their home turf, polecats and *Y. pestis* seem to coexist relatively peacefully. Each is efficiently deadly, and each is a fairly undiscriminating rodent killer, taking a ground squirrel here, a pika there. Rodents don't gather in high densities on the Eurasian steppe, and even with plague's nearly 100 percent kill rate, no single infected individual can get far enough to do damage to an entire population before it dies. Plague's extreme virulence, in this environment, seems like more of a hindrance than a help. Most bacteria and viruses do not evolve to so effectively kill their hosts, because they are dependent upon their hosts to survive and spread.

"*Y. pestis* breaks the rules of epidemiology," says Dean Biggins, a field biologist with the U.S. Geological Survey who has been studying black-footed ferrets since 1981, and plague specifically for over two decades. "It functions more like a predator than a disease organism."[xxii]

As he explained, the virus doesn't seem to have a reservoir species, which is an animal that can act as a carrier without dying to spread the bacteria to a new host. It's deadly to most rodents—even the ones on its home turf. Biggins hypothesizes that plague might, in fact, be one of the reasons that no social rodents exist in Asia as they do in North America. By spreading out, animals ensure any one infected individual won't be able to spread the plague to many other before it dies. But in a packed-together prairie dog colony, a single sick individual can trigger an outbreak that spreads like wildfire.

Even when there isn't an obvious outbreak, plague appears to have a serious effect on the health of prairie dog colonies, and the black-footed ferrets that so heavily rely on them. When Biggins experimentally sprayed prairie dog colonies with the flea-killing Delta Dust, prairie dog survival jumped up to 45 percent in his study sites.[xxiii]

"That experiment was really revealing," Biggins says. "That was the clincher, that there was low-level plague that was very common." Common, but almost impossible to detect. During the same study, Biggins and his colleagues tried very hard to detect the plague. They tested thousands of fleas in the lab, and only got positive results a handful of times. When researchers test prairie dogs at sites with plague present in its background, or "enzootic," state they come back negative as well. Though they know it must be there.[xxiv]

Plague can also hide in a body, undetected, as it replicates. "By the time your body realizes that this plague bacterium is infecting you, it's already raging," Livieri says. "If it wasn't so devastating to our wildlife, you'd almost be impressed by it."[xxv]

Plague's impact on prairie creatures went largely unnoticed for almost the entire 20th century. It evaded detection due to its insidious nature in part, but also because most researchers just weren't looking for it. "The interest [in the plague] has not seemed to spill over into understanding the ecology of this organism," Biggins says. "The interest in humans and black rats has kind of led us astray."[xxvi]

While there were a couple of surveys that tracked its march east, no one realized how much havoc *Y. pestis* was wreaking, how many deaths had gone unnoticed. By the 1970s, black-footed ferrets were presumed extinct. At the time, biologists suspected the culprits were a disease called canine distemper—a viral infection related to measles and spread by dogs—and habitat loss.[xxvii] Then a single remaining ferret population was discovered one fall in in Meeteetse, Wyoming.

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On September 26, 1981, the Hogg family was about to sit down to breakfast at their family ranch in Meeteetse, Wyoming, when Lucille Hogg, the family matriarch, noted that she had heard their dog Shep raising a commotion the previous night. Suspecting Shep had picked a fight with a porcupine, she sent her husband John out to investigate. But the tube-shaped animal he saw lying on the ground was a creature he had never seen before. Perplexed, John took the animal inside and laid it out for his wife and kids to see.

Lucille announced that she liked the exotic look of it, and wanted to have the creature stuffed and mounted for her mantle. So, when the family drove to town to run errands later that day, John put the strange animal in a sack and threw it in the truck. After they visited the post office, the family walked across the street to the local taxidermist.[xxviii]

Upon seeing the contents of the sack, the taxidermist got a strange look on his face, and rushed to the back of the shop to make a call. When he returned, he informed them that his suspicions had been confirmed. The Hoggs had brought in a black-footed ferret, a species that was presumed extinct and last seen alive in the wild seven years prior and 500 miles away.[xxix] He informed the Hoggs he would have to confiscate the animal immediately. Lucille never did get that ferret mounted on her mantle.[xxx]

It didn't take long after the town taxidermist made his call to the Wyoming Game and Fish Department for biologists to descend on Meeteetse. Where had this ghost ferret come from? Were there others? After expanding their search, they struck gold. A prairie dog town on the neighboring Pitchfork Ranch was harboring over 100 black-footed ferrets.[xxxi] Wildlife biologists were ecstatic. Against all the odds, they'd been given one last chance to save the species. The Wyoming population, they would later learn, was saved by its isolation, having been cut off from other black-footed ferrets for perhaps thousands of years.[xxxii] This isolation would come to be a blessing and a curse.

Once the biologists found live ferrets, it was time to take the effort national, and they called upon the U.S. Fish and Wildlife Service. Dean Biggins was doing field work in nearby Shereton, Wyoming at the time. Looking back, he says, it seems inevitable that he was called in. Ferrets' nocturnal, underground, anti-social lifestyle makes them particularly tricky animals to directly observe in the wild. Biggins' research at the time involved radio telemetry, in which researchers trap and radio collar animals, then use the collar to follow their movements.

The very first ferret captured at Pitchfork Ranch was radio collared, and Biggins was called in two days later. All of the biologists were highly motivated to get as much data on black-footed ferret ecology and biology as possible, as quickly as possible. They knew they might never get another chance.

Over the next couple of years, radio telemetry work at Meeteetse "pretty much became my full-time job," Biggins says.[xxxiii] For several years after the 1981 discovery, he and other biologists intensively studied the ferrets in their natural habitat. In 1984, a survey of the population came back with 124 healthy individuals.[xxxiv] But in 1985, a plague outbreak hit the prairie dog colony and ferrets began dropping dead.

"We were losing prairie dog colonies right and left, a lot of acres," Biggins recalls. Biologists thought the ferrets were dying from the double blow of canine distemper and loss of their food source to the plague. But that hypothesis didn't quite square with what they were seeing.

"The ferrets seemed to precede the decline in prairie dogs, and we were scratching our heads, going 'well, they're supposed to be resistant [to plague], but they sure don't look like it'," he says. "We have a lot better picture now of what was probably happening back then."[xxxv]

In hindsight, it might seem absurd that biologists assumed black-footed ferrets were immune to the plague. But ferrets were hard to study, and by the time researchers began to try to understand them in earnest, they were already nearly extinct. Biologists had to rely on indirect evidence. Most predators, like coyotes and badgers, seemed to be immune. And when researchers injected domestic ferrets with plague bacteria to simulate a flea bite, they were similarly unfazed.[xxxvi] Plague was considered a rodent disease, first and foremost, and not even the Meeteetse disaster was enough to push scientists to question that basic assumption.

All they knew was that black-footed ferrets were slipping through their fingers yet again, and if they let this population die, the species would finally be well and truly extinct. With no viable

alternative, USFW approved the roundup of every remaining ferret in the Meeteetse population.[xxxvii]

"In the black-footed ferret program, sometimes we make bad decisions," says Livieri. "Not because we are bad decision makers, but because we have no other decisions to make."[xxxviii]

By the time USFW made the desperate call, it was already nearly too late. Searchers found just 18 ferrets, several of which promptly died in captivity. It was not at all evident whether the drastic call had been the right one. "There was a lot of strife and a lot of arguing," Biggins says. "We were on pins and needles for a while wondering if we had contributed to the extinction of the species."[xxxix]

It would take years to grasp the full significance of that moment. Biggins' entire career has been spent grappling with the ramifications of that singe decision. A young field technician at the beginning of this saga, Biggins' face is now lined from age and sun, his hair and mustache a dignified silver. He speaks matter-of-factly, in an amiable Western drawl. While he's semi-retired, he's still personally involved in fieldwork and weekly calls with the black-footed ferret recovery program he helped shape.[xl]

After his radio telemetry work, Biggins was thrown into captive breeding research, helping the effort to grow just seven ferrets into a captive population of 200 by 1991. That year, USFW chose Shirley Basin, Wyoming as the first release site, and Biggins was tasked with figuring out how to teach captive ferrets to survive in the wild and chase down prairie dogs. The first release attempts went poorly. With no experience of the outside world, most of those early releases were promptly eaten by coyotes, badgers, and even a golden eagle.[xli]

Biggins spent the better part of a decade developing a pre-release bootcamp for young ferrets to increase their chances of surviving in the wild, using pens built at an old military facility in Pueblo, Colorado.[xlii] It was during this phase of his career that a devastating accident helped uncover the truly existential threat plague posed to black-footed ferrets.

To supply the prairie dogs for his studies, Biggins employed a man who captured and killed prairie dogs for ranchers. The man would bring in live prairie dogs, which were quarantined and tested. He'd also bring in dead prairie dogs for the center to test for various diseases. The two groups of prairie dogs were stored in separate freezers.

Then, in the summer of 1995, there was a personnel change. The dead prairie dogs brought in for testing were instead fed to 30 of the center's captive ferrets. The ferrets began to hemorrhage internally, and their lungs filled with fluid. Twenty-seven ferrets died. Two of the prairie dogs had been infected with plague.[xliii]

"At the time, it was probably the lowest point in my career. It was a total disaster," Biggins says. "That was a real kick in the head for us."[xliv]

The incident followed another that had happened at a research facility in Sybille, Wyoming the previous year, and quietly written up in a journal article. In February 1993, a lone male slipped

out of his enclosure. After a search, he was captured two days later, seemingly in good health, and put in quarantine as per standard procedure. The lab technicians on duty anesthetized him to run some tests, and noted that when he woke up, he didn't seem particularly interested in his dinner.

When they returned the next day, he was dead. Red foam coated the ferret's nose, and a post-mortem revealed that his lungs were full of white froth. The paper notes that "it is possible" that black-footed ferrets could be more susceptible to plague than domestic ferrets.[xlv]

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It is very difficult to detect plague before it is too late, which is why the best way to protect against plague is keep it from infecting an animal in the first place. Not unlike a ferret winding its way through a prairie dog burrow waiting for the opportune moment to strike, *Y. pestis* remains hidden within its hosts' body until just before it issues its death blow.

Once *Y. pestis* has infected a flea, ideally (for the bacteria), the next few days go something like this: the bacteria begin to form a biofilm in the space between the flea's probing mouthpart and its gut. Once the biofilm has closed off this space entirely, the flea's attempts to feed are in vain—no blood can reach its stomach. The blood instead hits the biofilm, mixes with plague bacteria, and is regurgitated back into the new host. The flea dies of starvation within five days. *Y. pestis*, meanwhile, travels through its' host's bloodstream to the lymph nodes, where each bacterium multiplies and causes swelling (called a "bubo," thus, "bubonic plague"). But here's the trick: the host's immune system is none the wiser.

To escape detection, *Y. pestis* deploys a number of stealth proteins. Plasminogen activators destroy blood clots and clear the way for the bacteria to spread through the bloodstream. F1 antigens—gel-like capsules the surround the bacterium—stave off white blood cell engulfment. And when the bacteria move on from lymph nodes to the liver and spleen, V antigens act as an anti-inflammatory immunosuppressants, sending the host's cells a signal that everything is fine and under control even as the organs lose function. When the organs are fully destroyed, the bacteria spill out into the bloodstream and sweep through the entire body. Death soon follows.[xlvi]

From the moment the black-footed ferret was listed as an endangered species to the unfortunate instances in the mid-1990s, researchers were sure that this attack from within was only affecting prairie dogs. They thought ferrets were simply more vulnerable to the prairie dogs' disappearance. But the mishaps prompted researchers to directly test the impact of plague on black-footed ferrets for the first time.

By 2000, studies of black-footed ferret susceptibility to plague were well underway. The prognosis was as bad as it possibly could have been. Not only were prairie dogs hyper-sensitive to plague, but so were black-footed ferrets. And they could catch it directly, from fleas, or indirectly, by eating infected prairie dogs.

Tonie Rocke, a research epidemiologist with the Unites States Geological Survey, was called upon to figure out whether a plague vaccine developed for the U.S. army would work for black-

footed ferrets. In a rare stroke of good news, the vaccine worked perfectly, though it was most effective after three doses. This "F1-V" vaccine contains its namesake proteins, which teach the immune system to detect them as a threat and develop antibodies.[xlvii] In a follow-up to the experiment in which Biggins tested prairie dog survival in colonies sprayed with Delta Dust, researchers compared survival of vaccinated and unvaccinated ferrets on captive release sites. The results were even more striking. When vaccinated ferrets were released onto prairie dog colonies, their survival increased by 240 percent.[xlviii]

But there is still a frustrating amount that researchers don't understand about plague. "It's just very complicated," Rocke says. "It's a really really complicated disease with lots of different vectors and different mammals that can be infected with different routes of transmission." And the challenge of studying it is compounded by the fact that the plague's favorite prey has a penchant for burrowing. "It's not so easy to understand the dynamics of the disease when you can't follow them underground," she says.[xlix]

Livieri echoes this frustration. The success of vaccinated ferrets, even in areas with no obvious plague outbreak, prove that plague has a big impact on this species at all times. But how is it possible that something that seems so obvious and deadly can hide so well?

"The million-dollar question is where does it hide," Livieri says. "We know that plague is present in low levels in the background all the time. Where does it hide in that background low-level period? We don't know. What are the conditions that allow it to re-emerge? We don't know."

Livieri grew up in Wisconsin and had never been west of the Mississippi before he happened to get a job working with black-footed ferrets for the National Park Service in 1995, fresh out of his degree in wildlife biology. "Ferrets are so charismatic. They grab you pretty quick," he says. "Once you begin to understand the concept of restoring an ecosystem by restoring this one species, you feel the obligation."

In 2001 he formed his own non-profit called Prairie Wildlife Research dedicated to ferret and prairie dog conservation. His commitment to the ferrets' survival, and the survival of the prairie ecosystem, made the appearance of plague in Conata Basin particularly devastating. After plague hit in 2008, the ferret population in the area struggled to rebound, creeping closer and closer to zero. In 2013, there were just 50 ferrets left, and halfway through the field season, a massive snowstorm hit the area.

"It wreaked havoc," Livieri says. "The ferret population is at its lowest and I can't get out there and help find them and vaccinate them." He pauses and sighs. "That…that was the hardest season."[l]

Luckily, the ferrets survived another year, and have been slowly rebounding since—though they're nowhere near the previous high of 350 individuals. And Rocke is currently developing another vaccine, one that ideally gets to the plague one step sooner by targeting prairie dogs.[li]

“It's very different than the vaccine that's been used in ferrets so it can be orally administered,” Rocke says. “Because we're not going to round up tons of prairie dogs.”

After years of development, she is now confident that the oral vaccine is effective, but all the logistical hurdles are still being worked out. How do you ensure the prairie dogs eat the baits? How do you distribute them? Studies have found peanut butter-flavor vaccine pellets to be the most tempting to the prairie dogs, “Some locations we got as high as 90 percent uptake, so we thought we did pretty well there,” Rocke says.

As for distribution, pellet shooters attached to drones and four-wheelers seem to do the trick. But the oral vaccine has still only been tested on a small scale, and widespread use is still a ways off. “I don’t really see us getting away from vaccinating ferrets directly in any short period of time,” Rocke says.[lii]

As Rocke, Livieri, and Biggins continue to battle the plague on the plains, others in the black-footed ferret recovery effort have turned their attention to trying to give captive-bred ferrets the very best shot at survival in the wild by focusing on what they can control in captivity: genetics.

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Researchers think the inevitable inbreeding in the black-footed ferret program plays a role in how exceptionally susceptible black-footed ferrets are to plague and other diseases. Ever since a handful of Meeteetse ferrets gave birth to the first captive-born kits, captive breeding facilities has been acutely aware of the looming threat of genetic decline.

As a result, black-footed ferrets have become something of a poster child of captive breeding techniques and a pioneer of reproductive technologies in conservation. Since the recovery plan was first conceived in 1988, it has produced over 9,000 ferrets, nearly 5,000 of which have been released into the wild.[liii]

“People put a lot of effort into making sure that this time we got it right,” says Tara Harris, director of conservation at the Phoenix Zoo, which is one of the five captive breeding facilities involved in the recovery effort. “Nobody wanted to fail after the population had been rediscovered. It’s a ton of pressure to get it right.”[liv]

Multiple facilities ensure that if something goes catastrophically wrong somewhere, most ferrets will still be safe. But no matter where they’re located, they have a similar setup: a sterile, bio-secure room (or series of rooms) with individual cages aligned in neat rows. These have metal bars and a plastic floor, with a black tube in the corner and a dark hole in the center. The hole leads to another black tube, which runs down into a metal box on the floor that acts as the ferrets’ “burrow.”[lv]

Ferret pairings are based entirely on genetics. Every year in the fall, the facilities swap ferrets between themselves to ensure the best matches. Each potential pairing is assigned a numerical rating called a Mate Suitability Indicator by a software program called MateRx. Numbers range from 1 to 6, with 1 being a “very beneficial” pairing and 6 being “very detrimental.” The rating

is determined by factors like the expected changes in genetic diversity resulting from the offspring produced, the rarity of each individual parent's genetics, and the "proportion of unknown pedigree." The Smithsonian Conservation Biology Institute's studbook keeper, Paul Marinari, assigns each kit a studbook number, which helps breeding facilities keep track of pedigree and which ferrets are "good breeders."[lvi]

But the program's biologists have always been acutely aware that relying on the Meeteetse descendants alone won't cut it forever. In the 1990s, a woman named JoGayle Howard who worked at the Smithsonian pioneered artificial insemination in the ferret recovery effort, first experimenting on domestic ferrets, then moving on to Siberian polecats and finally to black-footed ferrets themselves. By artificially inseminating females with the sperm of ferrets with no offspring, Howard found that she could introduce more genetic variability into the ferret line. To date, over 120 black-footed ferrets have been produced using artificial insemination technology.[lvii] And the techniques she developed were applied to other species at the Smithsonian—like the zoo's pandas and snow leopards.[lviii]

But with the threat of plague looming outside the sterile confines of the captive breeding facility, the black-footed ferret recovery effort is motivated to push breeding technologies even further. Scientists gathered together to form a "black-footed ferret recovery implementation team" in 2014, consisting of three subcommittees. The "genomics group" is using next-generation technology to assess the genome of the black-footed ferret. Another sub-group determines which ferret tissue samples might be valuable to try to preserve for future use. And the third sub-group focuses on cloning.

Intra-species cloning has been done before. Scientists have cloned a dog from a dog and a sheep from a sheep. "That happens all the time," says Sam Wisely, a conservation geneticist at the University of Florida and member of the recovery implementation team. What the black-footed ferret program wants to do is *inter*-species cloning—using a domestic ferret surrogate to give birth to a black-footed ferret clone.

Interspecies cloning has also been done in a very limited capacity, "but no one has incorporated that into a conservation program," Wisely says. "Black-footed ferrets would be the first endangered species to do it. If we did it."[lix]

That's still a big if. In 2018, a small non-profit based in Sausalito, California called Revive & Restore received their first permit to go ahead with the petri dish stage of cloning research.[lx] Revive & Restore is perhaps most famous for its bold ambition to bring iconic species like mammoths and passenger pigeons back from the dead, but in more recent years they have begun to set their sights on species that aren't yet extinct (just very nearly gone). The non-profit is currently testing the feasibility of cloning black-footed ferrets from sperm preserved from two ferrets in that original Meeteetse population that didn't survive to reproduce.[lxi]

This might seem like a drastic measure, but everyone who has worked with black-footed ferrets over the last several decades seems to agree it's a necessary one. Or at the very least worth a shot, given the grim reality in the wild.

“Plague, I think, is the number one thing preventing a speedy and rapid recovery,” Wiley says. “The sooner we can get self-sustaining populations back in the wild, the sooner we can stop captively breeding them.” In Wiley’s opinion, if it weren’t for plague, cloning wouldn’t need to be a consideration.[lxii]

“The black-footed ferret [recovery effort] has been an incredibly innovative and successful program,” says Ben Novak, the Revive & Restore black-footed ferret project leader. “You can say, oh, well, God, there’s no hope for the ferrets without solving plague and it looks bleak, when in truth the narrative is, there’s absolutely hope for the ferrets. We just have to overcome this one problem.”[lxiii]

Revive & Restore is hoping to have a viable black-footed ferret clone within two years, if they get approval to move on to live animal testing.[lxiv] They’re also looking into a longer-term genetic solution to plague. Novak says that black-footed ferrets do seem to have the genes that would help them resist plague, but they aren’t “kicking on” in time to save the ferrets that have been infected. Studies in mice have indicated that the resistance could potentially be turned on permanently, with some genetic tweaking.

“We’re several years away from actually testing something like this in black-footed ferrets,” Novak says. “But I do believe that there is a future for black-footed ferrets in which they are a self-sustaining species that no longer requires vaccination.”[lxv]

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The black-footed ferret recovery effort has in many ways been a success story. “I can’t think of a recovery plan that has more people dedicated to saving this species. It just has a lot of people rooting for it,” Wisely say. “They’re kind of the flagship for prairie conservation.”

But it also offers a dire warning. Much of the tireless work of hundreds of people around the country to keep black-footed ferrets alive wouldn’t have been necessary if we hadn’t avoided facing the problems ferrets faced on the prairie until it was nearly too late. “The black-footed ferret program is the perfect case study of don’t let species get that rare,” Wisely says.[lxvi]

Livieri has dedicated years of his life to vaccinating ferrets and aiding in prairie dog oral vaccine studies and is hopeful about cloning as another potential tool to help save the species. However, he says, “what this represents is we failed. We failed to preserve them in the wild and now we are dealing with the consequences of that failure. You shouldn’t normally have to do this.”

The black-footed ferret program has been a story of hindsight being 20-20, of crises narrowly averted. Livieri hopes that ferrets can serve as a lesson to programs that aren’t yet so desperate, but might someday find themselves in this position in the future. Even if cloning works for black-footed ferrets, for instance, there are only two ferrets with tissue that has been well enough preserved to clone.

“With a species now, take as many samples as you can. If you can, bring a few individuals into captivity and figure out how to breed them,” Livieri says. “Figure this out now. It’s all about preparing yourself for the eventuality of a species being pushed to the brink of extinction. How are you going to get back out of that hole?

“When you think about black-footed ferrets, we got all the way down the drain. If you’re down at the bottom of the drain, you’re going to have to do some really drastic things.”[lxvii]

Meanwhile, there is still a startling amount we don’t know about how plague is affecting other species across the American west. Biggins believes it could be having a dramatic effect that reaches far beyond ferrets and prairie dogs. “[Ferrets] taught us a really important lesson,” Biggins says. “That spurred our interest in plague.”

He worries that by only focusing on dramatic, obvious cases of plague, researchers are still missing the bigger picture. Wildlife disease ecology is still a relatively new field, in part because diseases can be so tricky to study—even ones that are far less evasive than plague. New technologies can provide quicker, more satisfying solutions, but they’re often treating a symptom rather than root causes.

"As each new disease comes along, one by one, we’ve been saying we can solve this with our technology and then business as usual. For some reason—I think it’s human arrogance—we think our technology can solve everything,” Biggins says.[lxviii]

But ignoring a problem because it’s challenging, or because we wish it weren’t there, doesn’t keep it from causing harm. Cloning could indeed help save the black-footed ferrets, or at least buy them a little more time. Meanwhile, plague has started moving east again. It’s still spreading, though no one knows how. No matter how many ferrets researchers clone, plague will still be out there, causing ripples of disappearances across the West, just waiting for us to take notice.

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