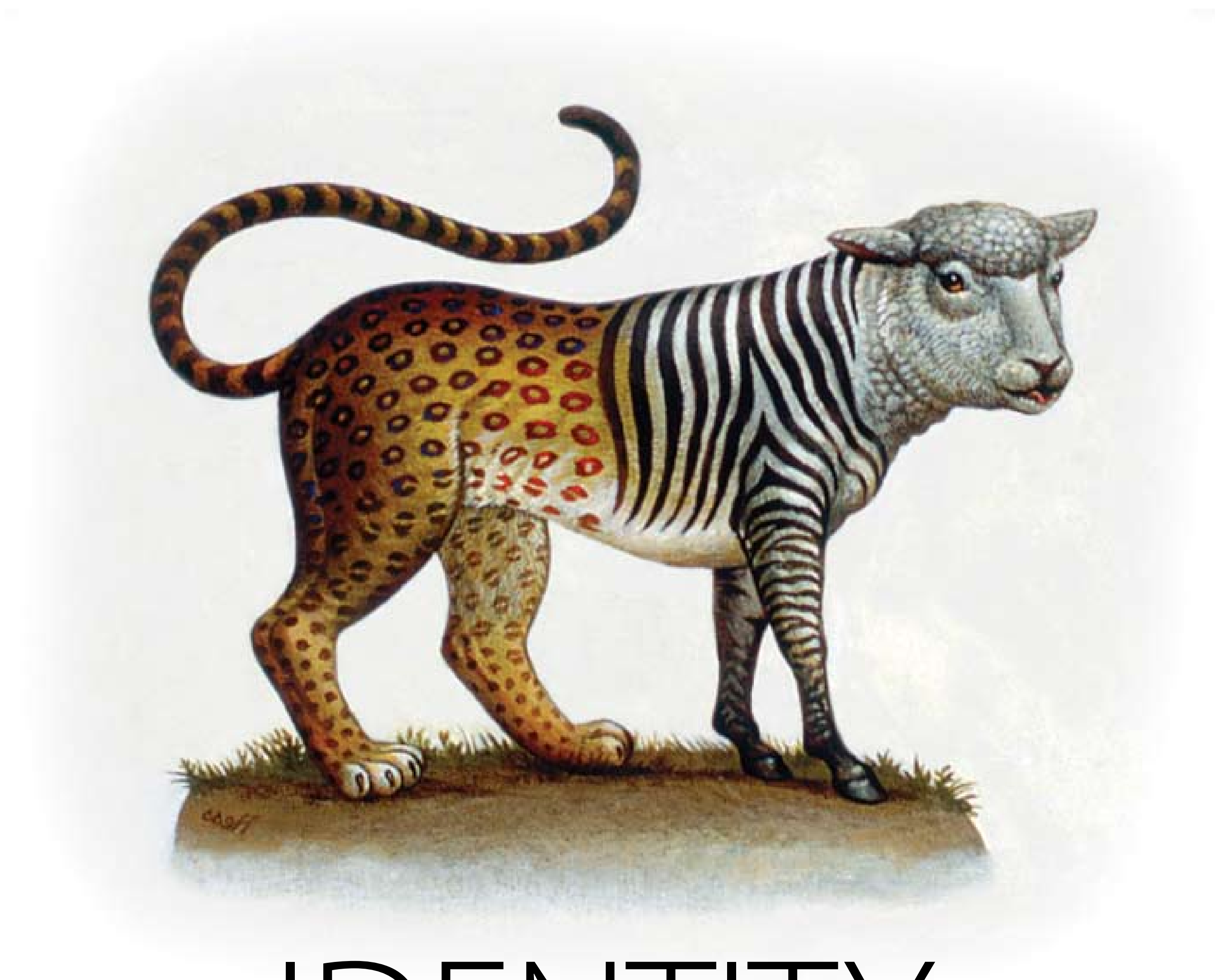

IDENTITY CRISIS

BY DOUGLAS FOX

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FEATURE

● ● ● **Hybridization** can be both a creative and a destructive force. And it's on the rise. Should we embrace it or quash it?

On a crisp February morning, several hundred hunters and spectators dressed in camouflage, Carhartts, and flannel mingled outside a metal-roofed shed in Frenchville, Pennsylvania, for the final hours of the seventeenth Annual Mosquito Creek Coyote Hunt. As spectators watched and children stomped about in the snow, 177 coyotes—brought down over the weekend—were hoisted by the hind legs and weighed, one by one, on a digital scale dangling from the ceiling of the shed. But there was something odd about these animals. They weighed 20 pounds more than their western coyote cousins, with the top six beasts tipping the scale at 45 pounds or more. And instead of the usual short gray-brown fur, the second-place critter sported a peculiar reddish shaggy coat.

These curious coyotes amaze outsiders, and they have prompted a quiet debate about their true identity. "You see animals like this, and you wonder if they're hybrids with dogs or wolves," says Roland Kays, mammal curator at the New York State Museum in Albany, who attended the Mosquito Creek tournament to collect samples. Much like wolves, these stocky northeastern brutes often prey on deer, and genetic and morphologic studies suggest that they do indeed carry the last shreds of the New England wolf gene pool—but hopelessly blended with coyote DNA. After hunters and farmers exterminated all but a few New England wolves in the nineteenth and early twentieth centuries, the smaller, lither coyote wandered into the void. These immigrants mated with their few remaining wolf cousins, blending the two species into a medium breed: bigger than a coyote, but smaller than a wolf. Robert Wayne, who studies wolf, dog, and coyote genetics at University of California, Los Angeles, rather vaguely calls them "the New England canid."

Whatever you choose to call them, one thing is certain. These oddballs interfere with wolf conservation. They fall short of wolfhood, and yet their very presence dooms any effort to restore authentic New England wolves that once lived here. If we brought these wolves back to New England, they would interbreed with coyotes, causing us to lose it all over again, says Wayne—a tiny sugar cube of wolfdom dissolving in an ocean of blended canid genes.

Similar stories are playing out around the world. Human activities, from road building to deforestation to transporting invasive species, are tearing down the geographic barriers that once kept species separate—all too often prompting them to merge into a genetic melting pot. Like a child's set of overmixed watercolors, human-triggered hybridization could run together the colors of much of Earth's biodiversity into drab brown.

But the outlook isn't entirely dismal. What makes hybridization such a tricky conservation problem is its alter ego. On the one hand, hybridization merges friends with enemies, mixes despised invasives with cherished endemics, and steamrolls biodiversity. But on the other hand, it creates new biodiversity by aligning genes into new constellations. And some of these newcomers might just do well in a warmer, human-dominated world.

Many managers have a habit of shooting hybrids, poisoning hybrids, and ripping them out of the ground when they find them mingled with one of their favorite pure-blooded species. The problem people have with hybrids reflects a fundamental disconnect between how biologists have sliced, diced, and taxonomized organisms since the time of Linnaeus and how they *actually* exist in real life.

Taxonomy has shifted over the past several decades from the language of morphology to the language of molecules—and that shift has revealed the world to be a messy place. Consider the case of the red wolf. It once roamed the southeastern U.S. from Texas as far north as Pennsylvania. But when hunting and habitat destruction devastated the population, coyotes moved in from the west and mated with remaining wolves. In a last-ditch preservation effort in the 1970s, biologists rounded up 400 wild red wolves and captive-bred 14 of them that they identified as pure. The idea was to produce a population that could be reintroduced into the wild.

But then in 1992, Wayne dropped a bombshell. He published a genetic analysis suggesting that "pure" red wolves were themselves hybrids between gray wolves and coyotes. This threw into question whether they even deserved protection. The answer depended on whether the hybrids were the bastard sons of human interference over the last 150 years—or whether they hybridized thousands of years ago and might reasonably be considered a bona fide species. Geneticists continue to debate the exact relationship between red wolves, gray wolves, and coyotes—and in the absence of a clear answer, the red wolf still enjoys protection.

The story of westslope cutthroat (WCT) trout in Montana and Idaho sounds a similar note of confused identities leading to confounded priorities. Stocking rivers with rainbow trout has caused widespread hybridization between rainbows and endangered WCT trout. U.S. Fish and Wildlife has so far declined to protect WCT trout; its surveys—based on morphology—show sufficient populations of pure WCT

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trout to sustain the species. Yet genetic studies reveal substantial hybridization, even in populations that morphology studies have supposedly shown to be pure. That finding prompted Montana state conservation authorities to protect genetically pure WCT trout.

But the decision to protect genetically pure WCT trout has triggered another debate. What levels of genetic mixture deserve protection? And what levels risk contaminating the population even further and should be exterminated? "We went around in circles for years on that," says Robb Leary, a fish conservation geneticist with Montana Fish, Wildlife, and Parks in Missoula. The state currently considers only 100-percent WCT ancestry to be genetically pure, but at times the debate has teetered toward lowering the threshold to 95 percent, 90 percent, or even

85 percent. "The problem for me is that any level you choose below 100 percent is strictly arbitrary," says Leary. "What's magical about 90 percent versus 89 percent?"

The dilemmas facing red wolves and WCT trout spring from a common scenario: Co-occurring species that diverged less than a couple of million years ago may have separated into different ecological niches but haven't yet evolved reproductive barriers. In fact, much of the world's biodiversity exists as clusters of evolutionarily young species. So when human interference causes ecological barriers to come tumbling down, the love flows freely—and so do the genes. Some worry that this spells trouble for biodiversity.

Ole Seehausen, an evolutionary geneticist at the University of Bern, Switzerland, has coined a name for the problem: reverse speciation. Seehausen has been watching the phenomenon unfold for the last 15 years in one of the most Technicolored biodiversity hotspots on earth. In East Africa's Lake Victoria, hundreds of colorful cichlid species are gradually—but literally—merging their colors back into that bland watercolor brown.

Victoria's army of cichlid species has long amazed biologists. Root around in the lake's waters, and you'll come up with every imaginable adaptation. Some groups of cichlids carry mouth parts specialized for stripping scales off their prey. Other groups carry forward-pointing teeth adapted to vacuum-sucking the young fry out of brooding mothers' mouths. Yet others have adapted to ramming into brooding mothers from below, jolting them into spitting out the young fry, which they protect in their mouths and which the bumper-car aggressor then devours. Within each of these tribes, you'll find a bouquet of distinct species with fussy mating preferences based on color patterns—say, velvety black, or blue with orange fins, or red with yellow bellies.

By the time Seehausen made his first several visits to Lake Victoria between 1986 and 1993, the number of cichlid species in the lake was rapidly falling, with a few species disappearing between each visit. Most people attributed this decline to the voracious appetites of Nile

Left Page: the sympatric species pair *Pundamilia nyererei* (top) and *P. pundamilia* (bottom) from a clear-water site in Lake Victoria. **Above**: wild hybrid phenotypes from a fully admixed population in a turbid-water site in Lake Victoria. © Ole Seehausen perch, which were introduced into the lake for commercial fishing. But as Seehausen mapped the distribution of cichlid species in 1993, he noticed something strange: the numbers of species seemed to correlate with how murky the water was in any given locale. In spots with clear water, cichlid species maintained their tribal wardrobes of metallic blue with red fins, yellow with red bellies, or red with yellow flanks. But in places where farming, sewage, and nutrient runoff had clouded the water, the number of species had collapsed. "You get six or seven species coexisting in the turbid sites and 35 to 40 species in clear-water sites," says Seehausen. "The ones in turbid water are less colorful and typically intermediate between several species that live in clear water."

Seehausen continued to investigate the cichlid collapse, and in 1997 he published a paper in *Science* (1) which suggested that cichlid diversity was collapsing due to rampant hybridization between species—and that this hybridization arose, in part, from cloudy water. It turns out that these young species of fish maintained their distinctiveness by picking a mate based on color. They hadn't had time to evolve any other major reproductive barriers. But eutrophication changed the equation. Unable to discern color in cloudy water, fish sidled up to one another in a less discriminating manner—the aquatic equivalent to a smoke-filled fern bar on Thursday night, where the standards of mate selection temporarily slip to a lower common denominator. In Lake Victoria, it caused dozens of species to collapse within a decade or two.

Lake Victoria is anything but unique, says Seehausen; he points to similar implosions of diversity that have occurred elsewhere in the world. In a paper published in *Molecular Ecology* in January 2008 (2), Seehausen, Gaku Takimoto of Toho University in Japan, and colleagues extrapolated from a handful of examples to what they call a universal phenomenon: human activities homogenize natural environments by clouding the water, leveling typography, or planting monocultures. In each case, says Seehausen, the removal of niches promotes hybridization and reversal of speciation.

Seehausen suspects that many cases of reverse speciation have gone unnoticed. Based on the observation that species pairs younger than 2 million years often hybridize without difficulty, he and Takimoto estimate that reverse speciation could affect up to 40 percent of the world's freshwater fish species and 25 percent of mammals.

Carried to their logical conclusions, Seehausen and Takimoto's ideas suggest that even pristine areas could suffer the brunt of human-triggered hybridization. Consider the likely effects of climate change on biodiversity hotspots such as the Cape Floristic Region in South Africa, where hundreds of species of flowering protea plants exist—often within a kilometer of one another. Climate niche models devised by Guy Midgley of the South African National Biodiversity Institute in Cape Town suggest that, as temperatures warm over the next century, protea species will shift southward by dozens of kilometers. This means that species which aren't in close proximity now could be brought together within several decades—with the potential for a wave of new hybridization.

So how do we respond to this sort of crisis? That depends on our goals. If we're trying to protect the purity of species that existed before human interference, then we may have to maintain taxonomic segregation in a landscape that no longer enforces it. People working with red wolves have taken this approach—and so far it has required heavy-handed management with no end in sight.

To avoid hybridization with coyotes, wildlife managers reintroduced the red wolf on a single peninsula along the North Carolina coast in the late 1980s, and have since enforced a coyote-free buffer zone along the trunk of the peninsula. They monitor canids in the buffer zone by genetically testing pups and analyzing fecal DNA. Coyotes and coyote-red wolf hybrids found in the zone are sterilized or removed. The growth of healthy wolf packs with a stable social fabric may eventually reduce the tendency of wolves to settle for coyote mates, but for now the task falls to humans.

But what if we aim for something other than purity? In the fragmented landscapes of New York, Pennsylvania, and southern New England, some people suggest letting go of the long-lost New England wolf (*Canis lycaon*) and embracing the motley crew of large and sometimes shaggy coyote-wolf hybrids that live there now. "Do you take this very typological viewpoint that we've got to restore what was there historically according to some kind of baseline?" asks Wayne. "Or do we allow evolution to sculpt a solution to the environments that have changed, thereby allowing a new kind of animal, maybe a hybrid, to predominate?"

His point is that New England has changed since the New England wolf last lived there. Even if thousands of *Canis lycaon* could be reintroduced, they might not thrive in the patchy New England of today. On the other hand, hybridization's bastard son, the New England canid, has adapted well to areas that are now inhabited by humans or paved with farms—a niche that pure wolves generally won't touch. "They're playing an ecological role—if not exactly like the wolves did, then similar to it," acknowledges Kays. "They're the top predator, probably the only predator eating deer, and they eat a lot of rabbits, too."

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Embracing the New England canid appeals to the dual nature of hybridization—its ability to not only obliterate biodiversity but also create it by connecting the genetic dots in new ways. "Hybridization really does allow the evolution of useful adaptations," says Loren Rieseberg, an evolutionary biologist at the University of British Columbia in Vancouver. Rieseberg's own experiments, published in *Science* in 2003 (3), show how two wild sunflower species hybridized over the last 200,000 years to create several new species which were able to adapt to extreme conditions in desert dunes and brackish marshes. This sort of creative force might also allow lineages—if not exactly the species we know today—to dance, bob, and weave around the unexpected curve balls tossed out by climate change.

Managers often exterminate hybrids when they threaten to swamp an endangered population. That approach is easy to understand when you consider that many of the regulations around which conservation has been built demand that a protected organism be discrete, easily defined, and unchanging.

But what we call a distinct species may simply represent a snapshot in time, a single frame captured from a system in flux. Populations change not only over geographic area but also over time—and hybridization drives that process.

Frank Landis of the Catalina Conservancy in California has chosen to recognize the potential value of hybrids. Landis manages the precarious future of the seven remaining members of the Catalina mahogany, which grow in a single gully on Catalina Island off the coast of California. They stand at the brink of melting away into the encroaching horde of the much more numerous island mountain mahogany—a closely related species which readily hybridizes with Catalina mahogany. Landis could easily justify yanking the 70-odd hybrids surrounding those seven remaining pure-sapped trees, but instead he sees those hybrids as an evolutionary hedge in an uncertain world. "I see no reason to say that evolution shall not take place after this point, that as this species existed in the 1980s is where it shall be henceforth," says Landis. These two species naturally occur in proximity, and Landis sees no evidence that hybridization is caused by humans. With the looming uncertainty of climate change, hybridization might not be such a bad thing. Hybrids might just thrive in a future where their parent species might not. "If the hybrids have some value," says Landis, "they'll prove it." ❧

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