INTRODUCTION

# THE PREDICTA MOTH

Over the years, coyotes ate many of Michael Soulé's cats. For most people, this might have been the end of the story, a nasty reminder of nature's darker proclivities. But Michael Soulé is not most people.

Soulé is a biologist. At the time, he was a professor at the University of California at San Diego, living in the chaparral canyons outside the city. He had grown up in the canyons, poking around in the leaf litter, catching lizards. When the boy became a biologist, he recognized that the chaparral was a unique ecosystem, with its own suite of interdependent plants and animals, the coastal sage scrub home to fox and bobcats, wrentits and spotted towhees, cactus mouse and California quail. But to real estate developers, the canyons were empty wasteland, waiting to be turned into homes. As he watched the progressive paving of the canyons, Soulé found himself even more distressed about the big picture, the loss of the ecosystem, than about the cats. Recent breakthroughs in biology had suggested that fragmentation of habitat inevitably threatened species. As developers carved the canyons into suburban lots, leaving behind islands of isolated brush, Soulé was alarmed enough to investigate that theory, and he sent students to compile data on the disappearance of birds from thirty- seven forlorn chaparral islands. He also had them collect data on local carnivores, to see if predation was a factor. After two years, as expected, data showed that the number of birds and other species in each patch was diminishing.[1]

But the data revealed something else, something counterintuitive. In canyons with coyotes, a greater diversity of birds survived. Canyons without coyotes supported fewer species. Having seen ample evidence that coyotes were responsible for his disappearing pets—cats flying through the cat door as if "chased by the devil"— Soulé had a theory: more coyotes meant fewer cats.[2] Fewer cats meant more birds. Coyotes were eating not only cats but also other midsized predators, such as foxes. Coyotes were acting as a control. Without that control, the midsized carnivores ran wild in an orgy of predation that Soulé termed "mesopredator release."[3] Another study confirmed it: one in five coyote scats contained domestic cat.

Before long, scientists were realizing that much of the country was suffering from a bad case of mesopredator release. The artificial absence of wolves and other large predators gave cats, dogs, raccoons, and foxes license to grow fat on wild birds from the beaches to the mountainsides. Soulé had observed just one manifestation of a crucial new scientific discovery: predators do not merely control prey. They control other predators, and by doing so, they regulate species with which they never directly interact. They regulate biological processes down the food chain. As scientists study the unbalanced and fragmented systems humans create as they alter the environment, they are realizing how interdependent species are. In a way, all of us are now living in a scientific experiment similar to that which San Diego developers created by carving up the canyons. We have unleashed forces we are still struggling to comprehend.

This global experiment is comparable to the one Americans unwittingly set in motion in the 1950s by sowing the land with toxic pesticides. In the fable that opens *Silent Spring*, Rachel Carson described a “strange blight” settling over a town.[4] Birds fell silent, bees vanished. There was no pollination, no fruit. “Everywhere,” she wrote, “was a shadow of death.”[5] Carson helped keep that pall from settling over the whole country by inciting a national debate that led to the banning of DDT.

But the shadow has fallen again. This time the problem is neither as concentrated nor as easily tackled as that of pesticides or pollution. This time the problem is the disappearance of nature itself.

The blight we are now experiencing, termed the “demographic winter,” is a result of human population growth, rampant development, and the destruction of ecosystems.[6] Together, these forces are acting to reduce the extraordinary diversity of plants and animals to a select, hardy few. Scientists estimate that this period of loss may last a millennium before tapering off and may bring about the elimination of millions of species of plants and animals. For biologists, the worst implication of the demographic winter is that by shrinking and isolating habitat, cutting wildlife populations to the bone, we may be erasing the process of evolution itself. No one can imagine the consequences of that. It seems unthinkable. But field biologists around the world are forced to think it, confronted with the evidence of empty forests and coral reefs reduced to slime. “It’s not death I mind,” Soulé once said. “It’s the end of life that bothers me.”[7]

Biodiversity loss is now lining up to be the greatest man-made crisis the world has ever known. Biologists call it the Sixth Great Extinction, or the Holocene extinction event, after our current geologic time period. (The five previous extinction events all came before the evolution of *Homo sapiens*, apparently triggered by a cataclysmic event or combination of events, such as a fall in sea level, an asteroid impact, volcanic activity.) Mass extinctions are different in kind from what specialists term “background” extinctions, the rare but regular loss of between one to ten species per decade. Two hundred and fifty million years ago, the most catastrophic, “the Great Dying” of the Permian age, wiped out over 90 percent of all species in the oceans and70 percent on land. It took tens of millions of years for life to recover.

The current extinction rates are alarming enough. Preeminent biologist E. O. Wilson believes we stand to lose half of all species by the end of this century.[8] Of the 45,000 species evaluated in the 2008 Red List, issued by the International Union for Conservation of Nature, 17,000, or nearly forty percent, may vanish.[9] Conservative estimates suggest that the extinction rate in the modern era has reached a hundred to a thousand times normal.

Climate change further exacerbates biodiversity loss, and each of these crises magnifies and intensifies the effects of the other. As the planet warms and dries in some areas, species are pushed out of niches they currently occupy. Some of them, including the emperor penguin in Antarctica and the polar bear in the Arctic, have nowhere to go. Worldwide, as water temperatures rise and ponds dry, exposing amphibians and their eggs to ultraviolet radiation and disease, a third of those species are threatened with extinction. As people burn forests for agriculture and grazing, as they replace native vegetation with mono-culture crops that discourage cloud formation, they alter the dynamic relationship between the earth's surface and the atmosphere, initiating further drying and warming, and further species loss.

Why do species matter? Why worry if some go missing? Part of the answer lies in the relationships coming to light between creatures like the canyon coyotes and the chaparral birds. After the nineteenth century's great age of biological collecting, when collectors filled museums to bursting with stuffed birds and pinned beetles, the twentieth and twenty-first centuries have proved to be an age of *connecting*. Biologists have begun to understand that nature is a chain of dominoes: If you pull one piece out, the whole thing falls down. Lose the animals, lose the ecosystems. Lose the ecosystems, game over.

Put another way, in this era of connection, we have learned that everything is interdependent. There are no spare parts. Predators regulate a constellation of other predators and prey; grazing animals regulate grasslands; grasslands and forests regulate climate. The physical world is like a big organic machine, an old car, for example, composed of interconnecting moving parts. Eco*systems*. You can lose inessential cosmetic elements, the bumper, the hubcaps, and it will still run, for a while. But eventually, if you lose enough critical parts, the machine will fail. When parts of an ecosystem are lost—predators, grazers, pollinators—the machine starts stalling, stuttering, failing. The processes of life grind to a halt.

This was the essential insight of conservation biology, a new scientific field launched with the determination to identify threats to ecosystems and to design the methods to deal with them. E. O. Wilson has called it "a discipline with a deadline."[10] The Society for Conservation Biology, founded in 1985, became one of the fastest-growing scientific organizations of its time, bringing together diverse specialties from ecology and population genetics to sustainable agriculture and forestry, revolutionizing the once sleepy field of natural history. Conservation biology and its epiphanies constitute a latter-day Copernican revolution. Just as Copernicus revealed that the earth was not the fixed center of the universe, so conservation biologists have found that *Homo sapiens* is not the independent actor he has imagined himself to be. With agriculture and livestock, we may have stepped outside the local habitats that rule other creatures' lives, making ourselves at home in places too cold or nutritionally marginal for any other primate. But we are still subordinate to natural forces. No species survives in a vacuum, including our own.

The tremendous variety of species held in wilderness areas, particularly the tropics, is our bank and lifeline, our agricultural and medical insurance policy. Three- quarters of the world's food supply comes from twelve plant species, but those species are dependent on thousands of others: pollinators (insects, bats, birds), soil microbes, nitrogen-fixing bacteria, and fungi. The tropical rain forests contain a pool of genetic diversity for important food crops, a source for vital new strains that can be hybridized to fight pests and diseases. Botanists are combing the planet for wild ancestors of soybeans, tomatoes, hard wheat, and grapes, believed to contain valuable genes for drought tolerance and other characteristics, but much diversity has already been lost. Genetic engineering alone cannot replace what hundreds of millions of years of evolution have given us. Wild replacements for pineapples, pomegranates, olives, coffee, and other crops lie in biodiversity-rich areas that must be saved.

In terms of medicine, our most important modern pharmaceuticals, including quinine, morphine, aspirin, penicillin, and many other antibiotics, are derived from microbes, plants, and animals found in tropical and marine environments. The first comprehensive scientific treatise on our reliance on other species, *Sustaining Life: How Human Health Depends on Biodiversit*y, published in 2008, confirmed the importance of genetic variety, describing groups of threatened organisms crucial to agriculture and human medicine. Predictably, our close relatives, primates, make up a key group. Contributing to work on smallpox, polio, and vaccine development, primates allow research on potential treatments for hepatitis C and B, Ebola and Marburg viruses, and HIV/AIDS.[11]

The list of threatened plants and animals we rely on is weird and varied, including amphibians, bears, gymnosperms (the family of plants that includes pine trees), cone snails, sharks, and horseshoe crabs.[12] Cone snails, a large genus of endangered marine mollusks, inject their prey with paralyzing toxins that are prized in medical research for their use in developing pain medications for cancer and AIDS patients who are unresponsive to opiates. The blood of the horseshoe crab, which carries antimicrobial peptides that kill bacteria, is being tested in treatments for HIV, leukemia, prostate cancer, breast cancer, and rheumatoid arthritis; it also yields cells crucial in developing tests to detect bacteria in medical devices, and its eyes have allowed Nobel Prize–winning researchers to unravel the complexities of human vision.

Cone snails and horseshoe crabs are exactly the kinds of species that people tend to dismiss, seeing no utility in them, no connection to human need. This was the attitude expressed in 1990 by Manuel Lujan Jr., secretary of the interior during the George H. W. Bush administration, who asked in exasperation, “Do we have to save every subspecies?”[13] It was the attitude expressed in 2008 by presidential candidate John McCain, who repeatedly declared his opposition to the funding of research on grizzly bear DNA. He got a cheap laugh whenever he said, “I don’t know if that was a paternity issue or a criminal issue.”[14] Medical researchers were not laughing: bears, too, are essential to human medicine. Bear bile yields ursodeoxycholic acid, now used in treating complications during pregnancy, gallstones, and severe liver disease. Denning bears enter a period of lethargy during the winter and recycle body wastes in a process unique in mammals; this process is studied for insights in treating osteoporosis, renal disease, diabetes, and obesity.

If species are crucial to medicine, ecosystems are indispensable to the health of the planet. Ecosystems provide the most basic provisioning services— food, firewood, and medicines—along with the so- called regulating services of a fully functional environment, which include cleaning the air, purifying water, controlling floods and erosion, storing carbon, and detoxifying pollutants in soils. When ecosystems are lost, as they have been through felling of forests and conversion of landscape to agriculture on a vast scale, havoc ensues, triggering human and natural catastrophe on an unprecedented scale. When Americans plowed under the grasslands of the Great Plains, they set the stage for the Dust Bowl, violently exacerbating the effects of cyclical drought. The loss of that ecosystem plunged millions of people into misery and poverty, deepening the Great Depression. Australians sparked their own post–World War II dust bowl by burning millions of acres of native bush and planting wheat. Without eucalyptus and native bush cover to keep rainfall from entering aquifers below, without birds and native wildlife to propagate the bush, water saturated dry subsoil, mobilizing ancient salt deposits. Since then, 10 percent of the wheat belt in western Australia has turned to salt, with 40 percent more poised to follow in the next few de cades. In nearby towns, salt erodes buildings, literally exploding bricks in slow motion from within. While the cracks in North America's natural systems are slower to appear than in Australia, they are nonetheless appearing. In the southwestern United States, the water table has been driven to such historic lows that geologists are beginning to see visible subsidence: waves and cracks in the earth.

Gradually, we are realizing that the environment *is* the economy. The planet's rain forests currently function as a "giant 'utility,' " according to Andrew Mitchell, director of the Global Canopy Program.[15] He points out that the Amazon alone releases twenty billion tons of water into the atmosphere daily, providing free air-conditioning, free irrigation, free hydropower. With more tracts of rain forest lost every day, what will it cost to provide artificially the services we currently get for free? A recent study commissioned by the European Union calculates that those lost services, along with the massive release of carbon as forests go up in smoke (accounting for 20 percent of carbon emissions worldwide), add up to 7 percent of global GDP, or two to five *trillion* dollars annually—the equivalent of the total cost of the Iraq War every year.[16]

Signs of these costs are showing up everywhere, because ecosystem services are beginning to fail. After several record-breaking drought years, the Amazon is approaching a tipping point when its "rain machine" may malfunction, putting South American agriculture in peril. Australia's rice and wheat crops are failing due to drought, sending worldwide wheat prices to a ten-year high. Emerging diseases are being unleashed as forests are cut. Honeybee colonies are vanishing, leaving commercial crops from avocados to oranges unpollinated. Water shortages, food riots, failed crops, the worldwide collapse of pollinators: this is only the beginning. Welcome to the demographic winter, the new hot season in hell.

But what if we had a choice? What if we could slow or even stop the Sixth Great Extinction? What if conservation could save us from the demographic winter?

It can. Conservation biologists have developed a number of methods for restoring the balance between ourselves and nature, for saving biodiversity. The most exciting and promising of these methods is rewilding.[17] Proposing conservation and ecological restoration on a scale previously unimagined, rewilding has become a principal method for designing, connecting, and restoring protected areas—the ultimate weapon in the fight against fragmentation.

Michael Soulé and a colleague, Reed Noss, formulated the essence of the new discipline in a 1998 paper, “Rewilding and Biodiversity: Complementary Goals for Continental Conservation.”[18] In it, they boiled the requirements down to three words: “Cores, Corridors, and Carnivores.”[19] Core protected areas had long been a feature of conservation design, but Soulé and Noss described national parks and wildlife refuges as only the beginning, the kernels from which larger, mightier protected areas must grow. Cores, they argued, must be continental in scale, preserving entire ecosystems: mountain forests, grasslands, tundra, savannah. Corridors were necessary to reestablish links between cores, because isolation and fragmentation of wilderness areas erode biodiversity: They enabled wildlife to migrate and disperse. And carnivores were crucial to maintaining the regulatory mechanisms keeping ecosystems healthy, harking back to those chaparral canyons. Because large carnivores regulate other predators and prey, exercising an influence on the ecosystem far out of proportion to their numbers, their protection and reintroduction is crucial. Because predators need large areas to survive, “they justify bigness.”[20]

Over time, the definition has been broadened and refined by a host of experts. Cores are to be expanded and strictly protected, and their natural fire and flood regimes restored, wherever possible. Corridors are only one type of connectivity, which may take forms other than simple linear strips of land, including patches, or stepping stones, of habitat. Both cores and corridors may require restoration of degraded habitat to achieve large-scale connectivity; carnivores may need to be reintroduced. The category of carnivores has now been joined by “keystone species,” creatures that interact so strongly with the environment that they wield an outsized influence. The damming of beavers—altering the course of streams, opening meadows within forests, and creating pond ecosystems—elevates them to a keystone species. The grazing and browsing of elephants, who act as forest engineers, pushing over trees and keeping vast grasslands like the Serengeti open, makes them keystones.

The original proponents of rewilding were careful to propose it as a “complementary” method to those being implemented by nongovernmental organizations like the World Wildlife Fund. Some of those methods are similar to rewilding in their focus on large-scale conservation. “Representation,” for example, is one large-scale strategy, focused on preserving representative areas of every identifiable ecosystem, such as savannah, tropical moist forest, tundra, desert, coral reef. The WWF’s “eco regions” program favors representation.[21] Another model, “hotspots,” is designed to save unique areas of high endemism, places like the Galápagos Islands, where many species of plants and animals found nowhere else in the world have evolved.[22] The large-scale continental reserves envisioned by rewilding might neglect island hot-spots like Madagascar or Java. Likewise, a single-minded focus on hotspots might shortchange areas like the African savannah, which is low in endemic species but enables mass migration.

But rewilding's unique triple focus on protecting and restoring cores, connectivity, and carnivores (or keystones) sets it apart from other large-scale conservation methods and projects. The goals of reintroducing carnivores where extirpated and restoring connectivity— even if it means replanting or regrowing bushland or forest between reserves— make rewilding more ambitious than even the most visionary conservation plans of the past.

Over the last two decades, extraordinary progress has been made. Many landscape-scale rewilding projects have been launched, aimed at restoring "megalinkages" throughout and between continents: Yellowstone to Yukon, Algonquin to Adirondack, and Baja to Bering in North America; Paseo Pantera in Central America; the Terai Arc in Asia; Gondwana Link in southwest Australia; the transboundary peace parks in Africa.

In line with these goals, many countries have moved to place more land under protection. Only a thousand protected areas existed in 1962, representing 3 percent of the earth's surface. Now there are over a hundred thousand protected areas worldwide, expanding conservation to over 12 percent. According to the United Nations' World Conservation Monitoring Center, protected areas now represent "one of the most significant forms of land use on the planet." While not all protected areas are devoted to rewilding, some of the largest reserves in the world, including the transboundary protected areas in Africa, are. Ecological restoration has worked wonders in Nepal's Terai Arc, where monsoonal lands are recovering from intensive human use as people are persuaded to manage forests for conservation and supplement their income with ecotourism and sustainable native crops. In northern Kenya, a privately owned rhino reserve is guiding communities that are rewilding former grazing lands at the same time as it fosters lucrative tourism facilities in a region once devastated by poaching. Native forests and bushlands are being painstakingly regrown in Costa Rica and Australia.

To be sure, daunting challenges loom. Many parks around the world are still "paper parks," without adequate funding or protection. Issues that threaten to stall or derail rewilding have included everything from poaching to the opposition of people living in or around protected areas, which were often proposed or planned without their input. Restoration itself is a flash point for organizations that fear it might undermine protection and encourage environmental depredation. While transboundary parks—stretching across national borders between neighboring countries—seem thrillingly idealistic on paper, implementing them has proven to be fraught, as planners pick apart political and legal knots while local people grow impatient.

As rewilding has entered the mainstream, increasingly accepted by international organizations, it has had to negotiate an uneasy expansion from a scientifically based conservation method into an ambitious social program. The institutions that fund major conservation and rewilding projects, including the United Nations and the Global Environment Facility, have pressed for greater sensitivity and attention to human rights, insisting that projects with a strict focus on biological conservation be expanded to encompass human aid, in the form of so- called community conservation projects. This has been controversial for biologists; scientists have reluctantly found themselves acting as social engineers, trying to design new economic opportunities for traditional pastoralists, changing the way people live on the land. Conservation organizations have rapidly evolved into groups practicing poverty relief on the side, installing biogas facilities in villages in Nepal or providing seed money for microfinance loans to poor women. In consequence, poverty relief has become bitterly disputed in conservation, with some biologists insisting that it is an ineffective and even counterproductive means of habitat protection.

Controversial or not, the unflinching message of conservation biology is that rewilding is not only a scientific necessity but also an ethical responsibility. Biologists no longer shrink from the overtly moral argument that humanity has an obligation to protect and restore wilderness. That responsibility, they contend, goes beyond any utilitarian argument. Noteworthy biologists from E. O. Wilson to Jared Diamond have pushed their colleagues to enter the political arena in the fashion of groups like International Physicians for the Prevention of Nuclear War, while religious leaders have encouraged their fl ocksto consider the moral implications of destroying creation. Biologists and clergy are being radicalized by the same shared belief, a sign that we find ourselves on the brink of committing irrevocable acts.

Conservation, like the ecosystems it seeks to restore, has also suffered from isolation. Too often dismissed, too often relegated by governments, media, and decision makers to the bottom of priority lists, beneath scores of other pressing social and economic crises, conservation has only recently begun to be perceived as a critical component of any effort to restore a nation’s health and revitalize its agriculture, natural resources, and economy. A wider social recognition of our global ecological interdependence has lagged behind. As a result, the response to the Sixth Great Extinction has been slow in coming, weak in urgency, and disorganized in focus. To remedy that, rewilding— the great project of conservation in recent years—needs sustained consideration and scrutiny. Scientists and activists on virtually every continent have been working for de cades to advance the science and promote the agenda, pressuring governments to accept the need for it. As science has been transformed into actual projects, there have been mistakes, trials and errors, grandiose claims, and dead ends: that is, of course, how science works. My purpose is to examine rewilding as a central, pivotal enterprise and to find, amid those successes and failures, a sense of its progress.

Far from being a quixotic, utopian quest for a lost Edenic wilderness of the past, rewilding is a necessity, economic and existential. Along with alternative energy, the emerging professions of ecological restoration and management will help to drive the economy in the future. Already thousands of jobs in developing countries have been created in ecotourism, law enforcement, and agroforestry. From design to implementation, rewilding projects create jobs for a host of specialities—soil assessment, land system mapping, wildlife surveys and management, fire management—and for people in the construction and landscaping fields. Already projects are being designed to store carbon over decades in newly planted native vegetation, to restore connectivity and biodiversity in large-scale protected areas, and to train workers in restoring and maintaining wetlands and removing invasive species. Such projects could constitute the centerpiece of a global jobs program in developing and developed nations alike, training workers in environmental science and carbon sequestration.

Most important, rewilding can play a crucial role in addressing climate change. While it cannot stop the crisis by itself—only systemic changes in government policies and corporate practices can accomplish that—expanded core reserves and restored connectivity between them can stabilize and revitalize forests, protect biodiversity, reestablish the crucial balance between predator and prey, and restore the health of coastlines, prairies, deserts, oceans, and river systems. In this sense, rewilding holds the potential to stabilize far more than natural areas in peril: it can enhance and protect national security by sequestering carbon and safeguarding fresh water, fertile soils, cleaner air. It is a Marshall Plan for the planet.

Famously, Charles Darwin predicted that an extraordinary white night-blooming orchid found only in Madagascar—an orchid with a nectary so deep that only an impossibly long implement could penetrate to the pollen within— necessitated the existence of a night-flying pollinator, probably a moth equipped with a nearly foot-longproboscis.[23] No one had ever seen such a creature. Forty years later, a night-flying subspecies of moth with a nearly foot-long proboscis was found feeding from the flower. It was named *Xanthopan morganii praedicta*, the Predicta moth. Nature itself is like that orchid—unique, fragile, locked in a relationship with a transient being on which it is utterly dependent: ourselves. We flew away for a while, thinking we could leave the natural world behind. But our destinies evolved together. We will survive only in a world as complex and biodiverse and interdependent as the one that created us.