Camille Parmesan

Where the wild things were

Georges Fabre was a forester in late-nineteenth-century France. In the region known as the Cévennes, villages were doing well: the silk and chestnut industries were booming, and shepherds banded together to make the yearly 'transhumance,' bringing thousands of sheep up to the rich pastures of Mont Aigoual in springtime. Life was good – too good.

Clearing of the land for pasture and crops had been going on for at least five thousand years, but population booms in the late 1700s greatly overtaxed the land. Clearing and cutting trees for pastureland and firewood had denuded the old forested lands. Whole mountainsides were barren. By 1856, the normal heavy rains of this region caused abnormal floodwaters. When rains came, the now loose soil became mudslides pouring down into the valleys and towns below. Once bountiful fresh springs and clear streams became silted and undrinkable.

"On the 4th of October, 1861," wrote Fabre in his diary, "clouds from the southeast, which had amassed for three days on the high summits of the Aigoual, burst suddenly and poured into the valley such quantities of water and stones that all the roads were cut off and the lands silted up . . . . On [the] 28th of October 1868, the disaster reoccurred . . . local people were astonished. Flood water from the Herault [river] had never before been so sudden nor so strong; it reached second stories."

In 1875, the French National Forestry Commission gave Fabre a monumental task: to repair the environmental problems in the Cévennes. Over the next thirty years, Fabre, with the help of botanist Charles Flahaut, restored some 3,500 hectares, reaching 11,800 hectares by the time the Parc de Cévennes was created. To recover a working watershed, these two unintentional environmentalists argued the need to restore the land as it was before the clear-cutting. This was not an easy task: they had to win over angry locals, who feared the loss of pastureland for their sheep. They

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poured over diaries and interviewed the elderly – the ones who had been there Before. They figured out which hillsides had been beech woods; which live oak, cherry, and chestnut; which swathed in pines and firs. Flahaut started an arboretum – to experiment with trees from around the world – finding which species would do well in this harsh environment, with its poor soils.

Fabre and Flahaut were ahead of their time. They designed a new forest that included exotic Scots and Black Austrian pines, but they also made an effort to nurture the few remaining stands of native beech forest, as well as the native sweet chestnut and cherry groves. This was not conservation in its strictest sense, but these actions were also far from the response of many modern foresters to similar circumstances: planting acres of a single species of nonnative but fast-growing pine, which culminates in a 'forest' that is devoid of flowers, insects, and birds. Such a sea of green is in reality a biologically sterile wasteland.

It wasn't until one hundred years later that the Cévennes area became a park, officially guiding and limiting activities. When one walks through the Parc de Cévennes now, it appears as wild and untouched as can be. On the hike to the Cascade D'Orgon, one can see Cirque eagles lazily gliding on a spring thermal, seeming to be just enjoying the sheer fun of it after a long cold winter. Peacock and tortoiseshell butterflies bask on the rocks. The beech woods are a fantasy land – all silver gnarled trunks rising from deep copper floors. Later, toward summer, one can spot Cleopatra and speckled wood butterflies flitting from heather to basket-flower to mint to thyme. Only the wild roses are ignored, full of scent but no sweet nectar. Local black honeybees and bumblebees and giant dragonflies join the dance in the air. It appears to be as it always has been.

The Society for Ecological Restoration was founded in 1988 – recognition that many areas had been degraded to the extent that preservation alone would not be enough, that time and energy needed to be put into recreating the landscape and the native biodiversity to restore the system back to health. Fabre and Flahaut's restoration of Cévennes biodiversity might be the first large-scale, successful ecological restoration project. Even now, most restoration projects are miniature compared to the scale of the 'Aigoual Epic' some 130 years ago. Scale, however, is not what is most notable about his project. The mark of these two men was in realizing that man and nature are not separate. Fabre was a visionary for recognizing the dependence of humans on what we now call a 'stable, functioning ecosystem.'

In practice, much of modern society, even now, clings to the misconception that human culture is separate from nature. This fallacy is an overriding theme in many cultures, but it is perhaps most obvious in the urban cultures of industrial nations, where water is well known to come from a tap. Even within the conservation community, this view often unconsciously pervades conservation planning. The catholic nature of this attitude makes for strange bedfellows. Consider a staunch capitalist viewing nature as something to harness and tame to serve Man, alongside an environmentalist viewing nature as a treasure to be preserved for its own sake. Underlying both views is the tacit assumption of nature as something separate from humans – interacting in either positive or negative ways, but acting as separate entities.

How does the human as an animal fit into this paradigm? *Homo sapiens* first

appeared about 1.5 to 1.8 million years ago. Many groups hold dear to the idea that our emergence was somehow special – that we are fundamentally different from every other species on Earth. Perhaps it is easy to believe this now, given that no other species appears to inhabit our niche. We are able to mold our local environments to fit our needs on a scale that dwarfs what any other species currently around us is able to do. However, at our inception, perhaps we did not appear so special. There were several other primate species that walked on two legs; made and used tools for hunting; gathered fruits, nuts, and vegetables from the land; and lived in social, family clusters. From the perspective of our use of resources and interactions with our environment, we weren't special by any means. We were simply the ones that survived. There is even some evidence that we hastened the extinction of our main competitors: the occasional skeleton of Neanderthal Man sporting an injury to the head that appears to have been inflicted by a heavy weapon. We are animals; and as animals, we are just as dependent upon, and connected to, nature as any other wild animal on this planet.

This recognition underlies a new vision that has swept through the conservation community – that there is, in fact, no dichotomy of worlds. This idea was not new in society – the pantheistic movement so beautifully encapsulated by the works of Thoreau, Wordsworth, and others had at its core the oneness of Man, God, and Nature. What conservation science did was to specify and quantify the ways in which the very existence of human culture and society relies on goods and services supplied by nature.

The evidence that man depends on and is affected by the health of natural ecosystems is incontrovertible. Likewise, it is clear that human beings have managed and shaped natural ecosystems since the dawn of time. The invention of a hunting tool efficient enough to take down big game appears to have allowed human tribes to hunt to extinction many of Earth's large mammals, at least as far back as twelve thousand years ago. This vision – that humans and nature are not two domains but one – has been more recently joined by environmental economists, driven by Herman Daly, Richard Norgaard, and others.

One planet. One system with finite resources. Sustainability of human society relies on the sustainability of nature. This has formally been accepted in theory, if not in practice, by 189 nations who have signed and ratified the Convention on Biological Diversity (CBD).[1] The goal now clear, the question becomes how to achieve it. In nations that have had high human impact for thousands of years – much of Asia, Africa, and Europe – it is clear that preservation, through creation of parks systems and hunting bans, will not successfully maintain biodiversity. Perhaps paradoxically, active management of natural ecosystems shaped by prolonged human contact must go along with the restoration and preservation of wilderness. An extremely clear example of this can be found in Europe.

From Great Britain to Sweden to Switzerland to France, the highest diversity of flowering herbs, birds, and butterflies is found in traditionally managed meadows. The natural state over much of Europe is forests. Small meadows must have occurred naturally before man, perhaps because conditions were slightly too wet or the soil too thin for trees. But, generally, forests advanced as glaciers retreated some twelve thou-

1 Convention on Biological Diversity, United Nations Environmental Program, www.cbd.int.

sand years ago. Man soon followed, and immediately began clearing small patches of woodland to create pastureland for their domestic animals and farmland for crops. Over thousands of years, the native flowers, birds, and butterflies colonized and flourished in these man-made meadows. Native species are now so dependent upon these man-made meadows that if the land were not managed, and reverted to its natural, forested state, then these species would go locally extinct.

Stability of these exceptionally diverse systems depends on human management. To preserve these habitats, the historical means of keeping this land from reverting to forest must be maintained. Meadows must be either grazed for a brief period or cut for hay once or twice during the year. Strict 'preservation' – putting up a fence and keeping man out – results in natural reforestation: woody shrubs and trees taking over within a few years.

Similar active management is becoming more commonplace in the 'wild' areas of North America, necessitated by spillover from human activity degrading these areas. Many systems are adapted to a particular regime of fires – they need fires of the right temperature at the right time of year at a particular frequency. Fire suppression can kill off native fire-dependent species and create shrubby undergrowth in place of open forest. Nitrogen pollution from industry and automobile emissions lead to streams clogged with green algae and can completely alter which species dominate the landscape. Exotic plants and animals transported across the world can destroy the land outright or outcompete natives and take over. To keep natural systems intact, various forms of ongoing management usually must intervene to keep these human-caused degradations from fundamentally altering the natural system being preserved.

Taking management actions to maintain biodiversity were great leaps for the conservation community. These actions signaled acceptance that pure preservation – putting a fence up around a patch of land – was no longer enough. Instead, the community recognized that conservation of biodiversity often meant managing the land through controlled burns, weeding out invasive species, and bringing grazers and browsers in to eat off excess plant material resulting from nitrogen enrichment. Sometimes it has meant restoring the land completely from the bottom up, as Fabre did. The community rallied. New cohorts have been trained in this mindset. Long-term conservation planning has laid out guidelines for dynamic management and restoration of old and upcoming preserves. The community has become invigorated with a 'can-do' proactive attitude.

Then came climate change.

Climate change presents an unprecedented challenge. It cannot just be added to the long list of degrading pressures with which managers must deal. Climate change truly is fundamentally different: different impacts, different actions needed to mitigate future impacts, and different suites of adaptation to help current reserves continue to preserve biodiversity. Few of the conservation community's existing tools, techniques, technologies, and strategies are effective against a globally changing climate.

What is it about climate change that makes it so insurmountable? First is its global nature. We're seeing impacts of current warming on every continent and in every ocean. We're seeing its effects in every type of plant and animal that has been studied – from butterflies in Finland to fish in the North Sea, from foxes

in Canada to trees in Sweden, from birds in Antarctica to starfish in Monterey Bay, California.[2] Second, climate change is conducting the most massive relocation of species since the last ice age. Forty percent of wild species are showing changes in their distributions – shifting their ranges north and south toward the poles and up mountains. An astonishing 62 percent are showing changes in their seasonal timing: spring is earlier and fall is later. Birds arriving for their spring migration, butterflies emerging from wintering, trees leafing out after winter dormancy, and flowers blooming for the first time are all about two weeks earlier than they were thirty years ago across the northern hemisphere. Globally, we have estimated that recent, human-driven climate change has affected half of all wild plants and animals in some form or another.[3]

Each species has a range of climates within which it can survive and reproduce. Temperatures and rainfall/snowfall that fall outside the 'climate envelope' for that species mark geographic areas in which that species cannot live. As Earth warms, the climate envelopes for many species are shifting their locations. About 40 percent of wild plants and animals are relocating accordingly, attempting to track their climate envelopes across land and sea. Species unable to move are becoming endangered, as the climate around them is no longer suitable for them. The obvious result of this process is that many preserves will no longer contain the climates required by the very species for which they were founded. In another hundred years, a nation's carefully planned reserve system won't work as intended. There is no accepted active management scheme that will keep the integrity of biodiversity within a preserve intact in the face of climate change.

Even worse, it is the 'wildest' landscapes that are being hit hardest by climate change. Though Earth is dominated by humans, there are still a few places that even the most cynical ecologist considers relatively untouched. A few PCBs and traces of DDT notwithstanding, the harsh landscapes of the boreal tundra, the bizarre life that thrives on ice-covered polar seas, the craggy peaks of the Grand Tetons, Mt. Whitney, and Mt. McKinley: these are places that still evoke a sense of time before man – places we still think of as 'wild.' These areas – the few remaining nearly pristine areas – are being strongly affected by anthropogenic climate change. Warming has been strongest at the poles – up to 4°C increase in annual mean temperature (compared to a 0.7°C global increase). As sea ice gets thinner and shrinks in area, so too shrink animal populations for which ice is their home: from the polar bear and the ringed seal in the Arctic, to the Adelié and Emperor penguins in the Antarctic. These animals are retreating toward the poles, and are rapidly reaching the end of the Earth as they know it.

The other havens for cold-adapted species – on mountaintops around the world – are also showing signs of warming stress. The Cévennes is again among the first in the world – this time the first to show clear signs of mountain species being pushed up and off the mountains. The elegant glide of the Apollo butterfly – its alabaster wings only occasionally revealing bright dots of red – can no

2 C. Parmesan, "Observed Ecological and Evolutionary Impacts of Contemporary Climate Change," *Annual Reviews of Ecology and Systematics* 37 (2006): 637 – 669.

3 C. Parmesan and G. Yohe, "A Globally Coherent Fingerprint of Climate Change Impacts in Natural Systems," *Nature* 421 (2003): 37 – 42.

longer be seen on plateaus that reach only to 850 meters; these populations have all perished with warming winters. To catch a glimpse of this French treasure one must be on a mountain of more than 900 meters – where proper winters still exist.

Deep in the cloud forests of Central America, it has become harder to find their local treasures – brightly speckled amphibians that truly are jewels of the clouds. Many of these frog species have served as poster children for the preservation of tropical cloud forests. Ironically, now that many sites have successfully been protected, global warming has crept in from behind and staked its claim. The golden toad of Monteverde Preserve in Costa Rica has the dubious honor of being the first species believed to have been driven extinct by global warming.[4] Among a group of species called 'harlequin' frogs for their clown-like colors, seventy-four species have gone extinct in the past thirty years – all in areas that still appear to be excellent cloud forest habitat. Their loss is still a mystery, but the fact that most extinctions were within one narrow elevational band suggests the influence of a changing climate.[5]

At the other end of spectrum, systems that we associate with hot beaches, bath-warm waters, and cold drinks – species that we might think would be hot-adapted – are also suffering. Sixteen percent of tropical coral reefs worldwide were killed off by heat during the single extreme El Niño of 1997 and 1998. A coming threat is the increasing acidity of the oceans, caused directly by increased atmospheric carbon dioxide. The pH of tropical waters has already dropped from 8.2 to 8.1, as carbon dioxide is absorbed and converted to carbonic acid. As pH continues to drop, the ability of animals to construct hard shells will decline dramatically. Some coral biologists fear that 'business as usual' projections could lead to tropical corals being unable to build and maintain reefs as early as 2050.[6]

We're entering an age of vanishing wilderness, when the wild places were. To have any hope of preserving our biodiversity in the face of climate change, we need, like Fabre and Flahaut, to be futurists, pragmatic but farsighted. It is time for radical notions.

One such notion is to transplant species that otherwise have no hope. While several conservation scientists have broached this idea in publications and meetings, it clearly is anathema to many applied conservation biologists – for whom the thought of intentionally introducing an exotic species into an area in which it never lived goes against their most fundamental ethics. Huge amounts of time and money are being spent on keeping exotics *out* of preserves, for invasive exotics are one of the prime causes of endangerment of many native species.

Should we, then, consider moving the polar bear to Antarctica, which currently is losing sea-ice habitat at a slower rate than is the Arctic? With little thought, the clear answer is no. Antarctica already has its own fauna – with loads of tasty bear treats all dressed up in their best tuxedos. Penguins have never evolved

4 J. A. Pounds, M. P. L. Fogden, and J. H. Campbell, "Biological Response to Climate Change on a Tropical Mountain," *Nature* 398 (1999): 611 – 615.

5 J. A. Pounds et al., "Widespread Amphibian Extinctions from Epidemic Disease Driven by Global Warming," *Nature* 439 (2006): 161 – 167.

6 O. Hoegh-Guldberg et al., "Coral Reefs Under Rapid Climate Change and Ocean Acidification," *Science* 318 (5857) (2007): 1737 – 1742.

defenses against large terrestrial predators, for none have existed. Introducing polar bears would mean a high risk of extinction for several penguin species. The known cost is far greater than the unknown good.

But consider as well the case of the American pika, which is less clear-cut. Paleological records show that it lived in the lowlands during the last ice age. As the ice retreated, the once continuously distributed pika gradually shifted upward – an easy move. Now, it survives in isolated mountaintop 'islands' on various mountain ranges throughout the western United States. Populations below about seven thousand feet are rapidly going extinct, with past physiological studies suggesting thermal stress is the cause.[7] Do we watch this species gradually go extinct on all but the highest mountains? Or do we move the American pika to more northerly mountains, where it doesn't now exist? Is this an acceptable suggestion if the new habitat doesn't have any other pika species, but unacceptable if such obvious competitors exist? What about the case of no other pika species, but other small mammals that could potentially use similar niches? Where do we draw the line?

Just as climate shapes vegetation, so can vegetation shape climate. A clear-cut can be up to 2°F hotter and 30 percent dryer than the adjacent forest interior. Thus forestation or reforestation will tend to make the local climate cooler and wetter – that is, if it's in the temperate or tropical zones. In the boreal zone, shrubs and trees create a dark surface above the snow in winter. Whereas tundra creates a landscape of unbroken snow, reflecting the sun's energy, and hence cooling the climate, dark trees absorb the sun's energy, locally warming the climate. Do we use this knowledge to modify climate locally? Do we create novel vegetation structure – the ultimate in species' invasion – for the sake of small, local climate modification?

These are not scientific questions; they are ethical ones. Science can project which species will be most at risk of extinction, but it cannot help with how that information should be used. Once we accept the premise that there are no more wild places, it becomes easier to emulate Fabre and Flahaut.

Every system is disturbed or managed by mankind: it is only the degree that varies. Many species will go extinct because of climate change. It is up to mankind to decide whether to let that process play out, or to intervene. If action is the chosen course, then when and how, and for whom?

The most obvious action available would actually alleviate many of the impending ethical dilemmas – to reduce greenhouse-gas emissions drastically and prevent the worst-case scenario from becoming reality. The global climate system has a long memory. Global temperature will continue to rise, for the carbon dioxide now in the atmosphere will continue to affect earth's climate and continue to cause rising seas for a few hundred years. The choice is not whether to stop climate change, but whether to cut emissions drastically now so that we warm 'only' another 2°C by 2100, or whether to continue with business as usual and allow Earth to reach a climate it hasn't seen in a few million years – some four to six degrees warmer than it is now.

7 A. T. Smith, "The Distribution and Dispersal of Pikas: Influences of Behavior and Climate," *Ecology* 55 (1974): 1368 – 1376; E. A. Beever, P. F. Brussard, and J. Berger, "Patterns of Apparent Extirpation among Isolated Populations of Pikas (*Ochotona princeps*) in the Great Basin," *J. Mammal* 84 (2003): 37 – 54.

Mitigation (preventing damaging climate change from happening in the first place) is easier, cheaper, and ultimately more successful than adaptation (coping with change after it comes). But this philosophy seems neither to have pervaded the minds of individuals nor the hearts of most governments. Having participated in ten years of meetings, reports, and policy sessions (all with similar recommendations), followed by pathetically slow changes in governmental policy and even less real reduction in emissions, I'm pessimistic that drastic emission reductions will come in time.

Thus we return to the ethical dilemmas that continued climate change will impose. If we act decisively and globally and make major reductions in greenhouse-gas emissions, then our ethical choices may be relatively painless. Inaction will create choices on a grander scale, involving more areas and more species. We are coming up against such choices now – conservation groups are hesitating to buy habitats on barrier islands that are currently in good shape, but that are likely to be undersea in a hundred years. Such decisions have to be made now, not in the future. As global warming increases, the choices will become harder. Which species will we be willing to sacrifice because of overriding costs, potential loss of other species, unknown ecosystem consequences, or simply because the money in hand could be spent on projects with more certain conservation returns? Do we save the charismatic polar bear while ignoring the unglamorous Houston toad?

How do we think about the future? Do we preserve and restore habitat for a particular bird species that all projections say cannot live there one hundred years from now? This is the reality with which the conservation community is grappling. Even if one accepts the extinction of one bird, the answer isn't obvious. One may argue to preserve the habitat because it will allow one more generation to experience this particular bird, which may have a particularly melodious song. There is also the hope that a given preserve will continue to be good habitat for other native species – perhaps those less beautiful but also less vulnerable to climate change, and perhaps for new species that will enter as they themselves are forced from their former homes. Preservation and restoration cannot be a bad thing, even if we may not be able to divine how the return on investment will play out over the centuries.

Perhaps that is the message – to continue to aid nature in ways we know how, in hopes that Nature will eventually recover. Species *will* disappear from our parks. Species will go extinct. The unknowns are the extent, the when, and the where – not the fundamental process. The greatest challenge facing conservationists will be in letting go of conservation in the narrow sense, and setting conservation goals that more fundamentally preserve the essence of what we mean by 'biodiversity.' This will mean that difficult decisions will have to be made, such as who to save and who to let go, when to fight and when to give up. There may be no true wilderness left – but let us hope that a new generation of conservation futurists will preserve a world where wild things still live.