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IN A few weeks, tourists will start appearing in Glacier National Park in Montana. With cameras whirring like insect wings, they will jostle for a glimpse of Rocky Mountain peaks jutting into the sky, ridges covering behind thick ice and meadows flashing with yellow lilies. But all is not well amid this splendid scenery: every year, Glacier has a little less glacier.

In 1850, there were about 150 thick glaciers in the park. Today only 37 remain and they, too, are melting away. At this rate, says Daniel Fagre, an ecologist at the US Geological Survey, all the glaciers could disappear by 2030.

It's not just the scenery that'll suffer. Below the peaks, park streams are getting less summer snow melt, thanks to changing precipitation patterns. As a result, some streams will warm, threatening some invertebrates that form the bottom of the food chain for fish such as the imperilled cutthroat trout. Others could dry up entirely by midsummer, becoming little more than seasonal pools that come and go with the rains. Park wetlands, too, are in danger of shrinking, stranding the voles that live among soggy wetland plants and leaving the birds, bears and other animals that dine on voles to look elsewhere for meals.

The shifting climate at Glacier National Park is just a snapshot of the challenges facing conservation biologists everywhere as global warming takes hold. Across the world, a patchwork of national parks, nature reserves and wildlife refuges offers safe haven to ecosystems packed with animals and plants. Can the parks continue to do their job as temperatures rise, storms increase and species decide to move?

"Climate change sets new ground rules for park planning," says Daniel Scott, a research scientist at Environment Canada in Ottawa, Ontario. According to one analysis by Dutch government scientists, almost a fifth of the world's large nature reserves could transform into significantly different landscapes over the next 30 years. And a report this March in the journal *Science* pegged climate change as one of the 21st century's top threats to biodiversity.

Canada, in particular, may be in for a hard time. Its weather suits cold-loving animals, from caribou to polar bears. As temperatures creep higher, these creatures could be in for an unpleasant surprise. What's more, Parks Canada has been carefully setting aside a national park within each of the country's 39 types of natural areas—one park includes boreal forest, for instance, while another covers prairie grassland. So far, the agency has designated parks in 24 such areas, says Scott. But the biome boundaries may well shift with the climate, leaving the parks protecting vastly different ecosystems. "Over time, what you were trying to protect may be located elsewhere," says Scott.

Similar problems could crop up worldwide (see Diagram). Not only are glaciers melting, protected marshes are disappearing under rising tides and meadows shrinking beneath invading trees. In Costa Rica's Monteverde Cloud Forest Preserve, cloud-forest birds and amphibians have vanished as the moisture-giving clouds shift higher up the mountain or even lift off the peaks altogether (New Scientist, 8 May 1999, p 32). Global warming threatens to tear some protected ecosystems completely apart as species invade, flee, breed at odd times or go extinct because they cannot adapt.

"This is going to be a huge issue for land managers," predicts Deborah Jensen, vice-president of



Enlarge image
National parks at risk from climate change

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conservation science at The Nature Conservancy near Washington DC. "It's our job to save these areas. As the globe warms, what on earth are we going to do about it?"

So far, nobody has done much of anything. It's more than 15 years since scientists began to worry about the fate of protected ecosystems in a warmer world. Yet for land managers struggling to cope with today's troubles, such as the invasion of non-native species and runaway fires, climate change seems like someone else's problem—a decades-long challenge that looms on some distant horizon. Given lukewarm political will and the scientific uncertainty about just how different regions will be affected, it's easy to see why global warming hasn't hit the radar screen of government agencies and other wildlife organisations.

Fossil clues

But not all scientists and conservationists are blind to the problem. To find clues to the future, some are peering into the past, gleaning information about the many previous climate changes from animal fossils, tree rings and other leftovers. Others have begun charting the changes already afoot in national parks. And a few are even trying to find solutions, from finding better ways of designing nature reserves to forming partnerships with landowners outside those protected areas.

To get a sense of just how fast habitats can change, it helps to go hiking through New Mexico's Jemez Mountains with Craig Allen, an ecologist at the US Geological Survey. While most climbers in the area barely glance at the scratchy green stands of juniper and piñon trees, perhaps stopping just to shake the sand out of a shoe, to Allen these trees reveal the forest's past. Just fifty years ago, ponderosa pines outnumbered the piñons and junipers.

Yet in just five years—1951 to 1956—a stretch of the forest rearranged itself. It was an unusually dry time: in 1956, the weather station at Bandelier National Monument recorded a mere 150 millimetres of rain. As scores of ponderosa pines died from thirst or greedy bark beetles, junipers and piñons seized the opportunity offered by the newfound sunlight, scaling the mountainside and quickly filling in the gaps in the canopy. "It's a cautionary tale for how fast ecosystem edges can change with the climate," says Allen.

Indeed, the past offers plenty of cautionary tales. For one thing, ecological communities don't simply march northward—or skyward, in the case of mountains—in a neatly choreographed trot to wetter, cooler conditions. Instead, climate change is often more like a burst of fireworks: ecosystems smash apart and their animals and plants scatter in different directions, depending on their individual needs.

Palaeontologist Anthony Barnosky at the University of California at Berkeley has found evidence for this in fossils from Porcupine Cave in the Colorado Rockies. Between 400 000 and 800 000 years ago, squirrels, lemings and other small mammals living in the cave faced a fickle climate, as the Earth grew and then shed massive coats of ice, according to long-term temperature changes. During warm periods, some of the species extended their range far north, into Canada. Others were much less ambitious, settling in the nearby Great Basin region. The end result? Climate change splintered the cave community in unpredictable ways.

These changes weren't all bad, says Barnosky. In fact, repeated reshuffling of the ecological deck is one of the reasons the Rockies support such a diverse flora and fauna today. But the next reshuffling will be very different from all the previous ones. In the past, species could roam across whole continents in search of wetter, cooler, drier or warmer stomping grounds. Today, farms, fences and cities pen wildlife into nature reserves. "A moose finds it difficult to run through downtown Toronto to reach better habitat on the other side," notes Scott. And if species have nowhere else to go, says Barnosky, they could be in trouble if climate change affects their safe havens in parks.

Some conservationists say there's a way around this problem: wildlife corridors, strips of habitat that connect nature reserves (see *New Scientist*, 20 August 1994, p 30). Similarly, in Europe, there's talk of a "reserve network" that would link reserves with scattered patches of habitat that could serve as steppingstones for wildlife on the move. In Israel, conservationists have even suggested making use of the land beneath the power lines that snake across the country. So far, though, few of these ideas have moved from the drawing-board into the real-world battle of politics and landowners' interests.

One exception is The Nature Conservancy, which has begun working with landowners outside public natural areas, and outside some of its own 1300 nature reserves, to keep the perimeters open as a welcome mat for wandering animals. In Salt Lake City, Utah, just outside Canyonlands National Park, the conservancy bought the sprawling Dugout Ranch from a ranching family—and hired a family member to manage it. In Mexico and Wyoming, the conservancy has co-managed slices of land with local ranchers. "It's becoming a normal way for us to do business," says Jensen. "Ranchers in the southwestern US got really excited when the [endangered] jaguar made a reappearance, and in some cases they are very willing to manage land in a conservation-compatible way."

Programmes such as these offer some hope, but it seems clear that some parks will no longer protect the species and habitats that are their reason for being. The problem for conservationists is that it's not clear which parks these will be. Current climate models are too coarse to be useful for a given park or nature reserve, cautions Lesley Hughes, an ecologist at Macquarie University in New South Wales, Australia. "And even if we could predict outcomes for certain species, based on their physiology and current distribution, it may be the changing nature of interactions between species that will be most important—and these are much harder to predict," says Hughes.

Mountain hideaways

That leaves conservationists grappling with the job of protecting their home turf. History offers some help, by showing park managers what kind of change they may be in for. During a warm period about 13 000 years ago, for example, Fraser fir and red spruce trees on low summits in the southern Appalachian mountains died out. But a few trees on the coolest, highest peaks survived. And since then, as the climate cooled again, the survivors' progeny have marched back down the mountains.

Could this sort of thing happen again? Quite possibly, say Paul and Hazel Delcourt, ecologists at the University of Tennessee, Knoxville, who have analysed published information on plant fossils from the Appalachians. "The challenge," says Paul Delcourt, "is to manage parks as dynamic, changing landscapes,

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not static, postage-stamp-sized populations." And if conservationists can learn how nature reinvents itself, they might be able to help the process along.

For instance, says John Peine of the University of Tennessee, one way to save the Fraser fir might be to collect seeds to plant in more favourable locations, should the trees' home grow too hot. Other endangered plants could also be saved in this way, but it would be far harder to truck teams of writhing animals to new homes. And who's going to bother with moving earthworms, snakes, prairie dogs and countless other charisma-challenged animals critical to ecosystems?

So if some species are hard to move, can reserves be designed so they can move themselves? One strategy, says Scott, is to choose lands that run on a north-south-rather than east-west-axis, giving animals room to move into cooler grounds if the area warms. In recent months, Parks Canada has discussed creating a new national park around the eastern arm of Great Slave Lake in the Northwest Territories. But as currently proposed, the park runs on an east-west axis. Perhaps, says Scott, the agency should consider adding lands to the north and south.

In much the same way, lands with a mix of higher and lower ground would give some species a chance to climb into slightly cooler, and possibly wetter, territory. Scott and his colleagues are urging conservationists to keep principles such as these in mind when considering new reserves. "Our point is that to date, climate change has not been one of the factors taken into consideration for park planning," says Scott. "From now on, it should be."

Indeed, unless such action is taken, the decades of hard work put into establishing and running reserves around the world could be undone. Instead of preserving rich slices of nature for posterity, they could become barren monuments to our failure.

"We put aside these areas because we wanted to keep them, and maybe we can't, because of our own actions," says Fagre. "That's a wake-up call."

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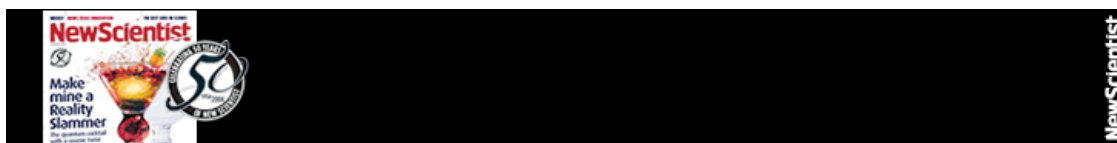
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