(brother of the novelist Kurt) then demonstrated that silver iodide was even more effective: cloud seeding had arrived. It would be deployed in US government programmes such as the 1962–83 Project Stormfury, which also drew on work by Simpson to control weather through the modification of hurricanes. Later, in the 1950s, a timber cabin on the grounds of the Woods Hole Oceanographic Institution in Falmouth, Massachusetts, became a hub for annual meetings where Simpson, meteorologist Jule Charney and other innovators teased out geophysical fluid dynamics. As Dry shows, imagination has been as important as mathematical skill in advancing planetary knowledge.

Today's hugely sophisticated climate models have fed off all these developments. The numerical general circulation model (GCM) was first established by US meteorologist Norman Phillips in 1956. Now, it relies on the world's most powerful computers to calculate how observed data respond to sets of physical equations that mimic climate processes. The GCM attempts to calculate all these processes across land, oceans and atmosphere, at different time intervals, to produce scenarios of future conditions.

Climate science is the study of change: the discovery of the climate system coincided with the emergence of methods for tracking climatic shifts. From the late 1950s, the advent of ice-core analysis revolutionized the field, as scientists such as Dansgaard and Wally Broecker read Earth's archives in the cryosphere. The extent and rate of human impacts on climate could be deciphered only once natural climate change — glaciations and warmer periods — was fully understood. With the entry of isotope analysis, ice cores and other palaeoclimate records have become invaluable yardsticks for checking future climate uncertainty.

Waters of the World demonstrates how impoverished science might become if stripped of the stories of the people who shaped it. As we live through a climate crisis of our own making, the book reveals how researchers, over more than 150 years, defined and measured the processes that got us here — and gave us the knowledge we need to curb their worst impacts. ■

Ruth A. Morgan *is a historian of science and the environment at Monash University in Melbourne, Australia. She is a lead author of the forthcoming sixth assessment report of the Intergovernmental Panel on Climate Change.*
e-mail: ruth.morgan@monash.edu

R.A.M. declares competing financial interests: see go.nature.com/2keyeiq for details.

ENVIRONMENT

Into the light: nature, culture, change

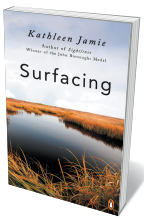
Kathleen Jamie's lens on human and planetary crises bends time and illuminates place, finds **Barbara Kiser**.

What are nature and culture on a planet we have exhaustively mapped and immeasurably changed? How are we ourselves altered in that process? In *Surfacing*, the poet and writer Kathleen Jamie explores this liminal space. Through 12 essays, she charts the passage of time in the environment and in us, examining ancient artefacts, dreamscapes and memories as they emerge into the light, and what they tell us about being human in a rapidly shifting world.

Surfacing ranges over Jamie's stints on archaeological digs on a Scottish archipelago and in the High Arctic; a sojourn in China; half-submerged familial memories. Seemingly disparate, the pieces are subtly entangled. There are echoes of Jamie's previous essay collections, *Findings* (2005) and *Sightlines* (2012). These established her unclassifiability as a writer, able to capture with equal depth a peregrine falcon intent on its prey, a Bronze Age burial, the feel of a dissected lymph node.

As in those books, there are no rhapsodies in *Surfacing*. There is a poet's economy with words, a stripped clarity.

Jamie begins in a cave in the West Highlands of Scotland, contemplating glaciations and climate change. Deep within it in 1995, divers discovered bear bones some 40,000 years old — a find like "reaching the memory of the hill itself". An aficionado of deep time (she has described her young self as a "teenage antiquarian, thrilled by standing stones"), she trawls museums on the east coast of Britain to view Arctic objects brought back by nineteenth-century whalers. Among narwhal tusks and taxidermied polar bears are beautifully worked Inuit relics, traded for guns.



Surfacing
KATHLEEN JAMIE
Penguin Press (2019)

One such visit leads her to archaeologist Rick Knecht, who runs a dig in a Yup'ik community in the Alaskan region of Beringia. There, fast-melting permafrost is exposing objects crafted from caribou antler, stone, wood and walrus ivory 600 years ago, before missionaries and hunters arrived from the south. 'In Quinhagak' records Jamie's time on the dig. But the essay shape-shifts. It becomes a compelling portrait of a culture recovering its resilience at a climate front line, where iceless winters and burning tundra are the new normal. And where the colonial legacy, not least addiction, is just a few villages away.

At Quinhagak, "light cascaded down from the whole sky. A ravishing, energising light." Under it, Jamie mingles with villagers amid long moments looking for bears on the tundra, or shifting mud on the site. In unearthed knife hafts shaped like seals, in villagers' stories of cranes and walruses, the human and natural coalesce.

Jamie is struck by the Yup'ik habit of attentiveness, and the cohesion it nurtures. She finds her own vision sharpening as she scans the land, and sees herself in some way as scanned by it. In the village, she "noticed that people notice", surmising that the "whole place must be in constant conversation with itself, holding knowledge collectively". When elders handle and name the long-buried artefacts — antler-scrapers, root-picks — she feels she is listening to the language of landscape, and to a people coming home.

Half a world away, she reflects on another dig. But this community, on Westray in the Orkney archipelago, moved on five ▶

GRAEME WILSONVV

Kathleen Jamie in Orkney, UK.

MARK RALSTON/AFP/GETTY

Melting permafrost near the town of Quinhagak, Alaska.

millennia ago. The Neolithic and Bronze Age dwellings at Links of Noltland have been exposed over decades by ferocious winds. Now the site is threatened by erosion — and funding issues. The excavations are something of a sprint.

When not scraping through layers of time and materiality, Jamie explores the store of finds — the biggest assemblage of Neolithic objects found in Britain. She is beguiled anew by worked bone and stone, from putative tattooing implements to the 'Westray Wife': a tiny sandstone figure with intent eyes, "ancestral and watchful". But when Jamie imagines which object might be sent into space as an emissary to alien cultures, she opts for a Neolithic stone ploughshare. Ugly and functional, it marks the start of how we've tamed and trashed the wild under "the weight of our stuff".

In the 1980s, Jamie travelled widely in remote regions of Asia: her 1992 book *The Golden Peak* recounts her time in northern Pakistan. A journey from that era — to Xiahe, a culturally Tibetan town in Chinese territory — unfolds in *Surfacing*. To reconstruct those weeks at a borderland fraught with uncertainty, Jamie turns domestic archaeologist, burrowing into piles of notebooks and photographs. Through them, she re-enters the "womb-like otherworld" of a temple at Labrang Monastery, meets Chinese students eager to build cultural bridges and joins a gaggle of fellow travellers escaping oppression in Europe. They have arrived, however, only to witness Tibetan culture besieged. The parallel with Yup'ik history is clear.

Surfacing is rich in such mirrorings and mergings. Spirals — carved into the Westray Stone, a magnificent tomb relic — crop up on a ceramic sherd in a newly ploughed field. The motif, she notes, symbolizes how unrelated events can "wheel back into proximity". And so they do, in the life trajectories of Jamie, her daughter and her father, and in the rise and fall of human settlements. Blazing moments light the way: an eyeful of eagle over a Scottish road, sockeye salmon in an Arctic stream "like silk slashes in a Tudor sleeve".

At one point, Jamie is midway through a forest somewhere in Scotland, grappling with how to frame the wars and environmental destruction that crowd our collective consciousness. She realizes she is lost. I found myself thinking of Dante Alighieri, coming to himself at life's midpoint "in a dark wood" as *The Divine Comedy* opens. But this is a book shrugging off literary allusions. Jamie comes to things openly, listening and looking. And as she shows throughout this astonishing work, it is in looking — attuning ourselves to nature and culture, past and present — that we find our compass. ■

Barbara Kiser *is* Nature*'s senior editor for Books and Arts.*

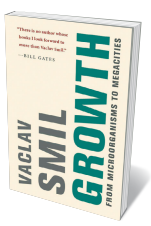
RESOURCES

The energy crunch

Vaclav Smil's latest book computes the cost of growth on a finite planet. **Melanie Moses** praises the result.

In 70,000 years, *Homo sapiens* has grown from thousands of hunter-gatherers teetering on the brink of extinction to a global population of 7.7 billion. In *Growth*, Vaclav Smil explains how we have peopled the planet through our growing capacity for harvesting energy from our environment: food from plants, labour from animals and energy from fossil fuels. Civilization has developed by dominating Earth's resources. Smil, whose research spans energy, population and environmental change, drives home the cost of growth on a finite planet. It is high: polluted land, air and water, lost wilderness and rising levels of atmospheric carbon dioxide.

He argues that most economic projections predict growth by ignoring the biophysical reality of limited resources. Economists emphasize that efficient use enables growth without pumping up energy consumption. Smil does not deny that energy efficiency has increased. For example, he details how agriculture now extracts ten times as much food energy from each parcel of land as it did a century ago. But the 10-fold increase in yield has been driven by a 90-fold boost in energetic inputs — caused by fossil-fuelled farm machinery, and electricity for irrigation and fertilizer production. When this complexity is accounted for, the story of efficiency is turned on its head: we now put more fossil-fuel energy in for each unit of food we get out.



Growth: From Microorganisms to Megacities
VACLAV SMIL
MIT Press (2019)

On a crowded Earth, we mostly address this challenge by eating up more land. A 2019 report from the Intergovernmental Panel on Climate Change, called *Climate Change and Land*, shows that we are in danger of running out of space: humans shape more than 70% of ice-free terrain, much of it for crops and livestock. As grasslands and forests are converted to