CROSSING THE LINE

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IMAGINE AN AIRPLANE flying north from Brisbane to Cairns. In just over two hours, it will cover nearly 1,400 kilometres of Australia's eastern coastline and add 340 kilograms of carbon dioxide to each of its passengers' personal carbon footprints.

The view from the plane's left shows the vast space of Queensland: bleached landscapes, tracks gouged through pink-dust earth, paddocks stippled with the shadows of thin trees. Further out, towards the state's centre, lies the Galilee Basin and all its coal – a huge foetal shape that covers 247,000 square kilometres of complex physiography. The 4.7 billion tonnes of greenhouse gas emissions associated with the largest mine planned for this place is equivalent to nine times Australia's overall emissions in 2014.

Nine times.

The view from the plane's right shows shapes beneath a palette of blues – aquamarine; turquoise; a thick, deep navy – with cays and islands breaking the water's surface. This is part of the Great Barrier Reef, which spans more than 340,000 square kilometres all the way up to Papua New Guinea. Home to, and built by, billions of tiny coral polyps, it's the world's largest structure made by living organisms. So big you can see it from space. A poster-child for conversations about climate, and now a clear casualty of so much change.

Four times in the past twenty years – in 1998, 2002, 2016 and 2017 – it's been hit by heatwaves. Researchers have reported 'catastrophic die-off' and 'post-bleaching mass mortality'. Worst-case scenarios for the summer of 2018–19 forecast bleaching that will extend, for the first time, the full length of the reef.

The damage isn't visible from up here – the dead coral, its less diverse regrowth, not to mention the other environmental stressors to which the reef is subject. Water acidification, run-off, overfishing, shipping, the famous crown of thorns starfish. Beyond the massive gesture of its size, you have to imagine the rest.

In mid 2016, Professor Justin Marshall, a marine biologist at the University of Queensland, declared the reef to be in a state of 'complete ecosystem collapse'. It was shocking to hear that phrase, to hear it said about this place. The terrific power in his last word, and the dreadful sense of what it meant. Climate collapse was not future anymore; it was here, and it was now. I stood and listened, sure that now, surely now, how we dealt with these issues would change.

It felt like very little did.

'I have, to be honest, been driven a little mad,' Justin Marshall tells me in an email two years later, 'swimming in the pus and decay during the ecosystem collapse of a billion beautiful animals.'

When we meet to talk about the reef, the climate, this möbius strip of a story, he shows me images from Lizard Island. 'These are corals that bleached while I was there – they died in two weeks – and disappeared… That's a short space of time. Which is pretty depressing.' If he makes a presentation to children or Indigenous people, he begins by apologising. 'Because I am sorry,' he says. 'We haven't done enough [to save the reef]. Which is hard.' By the end of our conversation, he's crying.

It feels, sometimes, like it's the only thing to do.

If I said that I've lived inside the story of climate change these past few years I could be talking about a novel I've been trying to write, set in a futuristic, climate-collapsed world. That would be true. I could be talking about non-fiction pieces I've written – about storms, trees, adaptation and vast ecological systems. That would be true too.

But it's nothing as personal or particular as that. It's the truth about every single one of us. We are all in this story, and this story is rolling on all around us, all the time. Not if or when, but now. When the Intergovernmental Panel on Climate Change (IPCC) released a special report on the impacts of global warming last October, it delineated the difference between 1.5 degrees and 2 degrees Celsius of global warming in terms of issues including sea-level rise, species loss and extinction, ocean temperature and acidity, reduced yield of cereal crops – including maize, rice and wheat – and increased water stress. 'Limiting global warming to 1.5˚C, compared with 2˚C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050,' it said, noting with 'high confidence' that an increase of 1.5 degrees would be achieved between 2030 and 2052. 'Some impacts may be long-lasting or irreversible, such as the loss of some ecosystems.' The Queensland Government's 2016 overview of climate change in this state forecasts changes including higher temperatures, hotter and more frequent hot days, more intense downfalls, and rising sea levels with more frequent sea-level extremes.

As the cultural theorist McKenzie Wark has pointed out in a discussion about our putative new geological age (the Anthropocene, with 'anthropo-' to underscore humanity's power and agency in it) and the narratives some now tag as 'cli-fi' (for climate fiction), all fiction is Anthropocene fiction now. Some of it just hasn't realised yet.

Back in 2003, Donald Rumsfeld, US Secretary of Defense, gave a famous departmental briefing, couching America's increasingly imminent war with Iraq in terms of 'known knowns, known unknowns, and unknown unknowns' – the things 'we don't know we don't know'. This tripartite prism has always seemed a useful one to apply to the complexity of climate change. There are mechanisms and consequences we can already see and understand. There are effects and impacts we can see happening without yet understanding why, or how they might impact each other. And then there are the 'unknown unknowns', the layers of knowledge about our planet's natural systems, their requirements, their reactions and interactions that we don't know we don't know about yet.

The things that we cannot see coming.

When I write fiction, I hover in the space of what might happen next. I live, if you like, on the edge of uncertainty and revelation: what the next sentence may be, where a story might go. That's where we all live now: on the crest of a vast and breaking wave. In the 2016 Institute of Australian Geographers' presidential address, Steve Turton, an adjunct professor from Central Queensland University, wrote that we are 'now entering uncharted climate territory as a species – along with all the many millions of species that share our planet'.

Off the maps. Out of the known, to the unknown.

About a third of the way through that flight north from Brisbane lies the regional city of Rockhampton and the Tropic of Capricorn, the line that circles the earth at 23.5 degrees south of the equator to divide its temperate and tropical zones. Years ago, a sculpture was installed to mark this latitude. It used to sit precisely on that line but was relocated into Rockhampton proper in 1980. One story says this was after a highway deviation; another that it was to make it easier for tourists to see it.

Thanks to climate change that boundary, like its statue, is now mobile. Current calculations suggest the tropics are moving south at around eighty-five kilometres each decade. As a plane flies north, there's a slower corresponding shift in the other direction. Imagine temperatures, rainfall and myriad other climatic factors moving south, pulling different tropical species – flora and fauna – in their wake. Tropical cyclones are forming further away from their traditional zones – and while some models predict fewer of them in our future, those that do form are expected to be more intense. Temperatures are forecast to rise towards 'unprecedented thermal conditions'. How rainfall may change is still less well understood, but more extreme rainfall and other weather events are both predicted. The IPCC special report notes that 'countries in the tropics and Southern Hemisphere subtropics are projected to experience the largest impacts on economic growth due to climate change should global warming increase from 1.5°C to 2°C'.

By this century's end, that notional tropical line could have shifted as far as 850 kilometres south – that's more than the distance from Rockhampton to Brisbane. It would leave it hovering around Evans Head, below Ballina, on the New South Wales north coast. To head north to the tropics is to head towards the future, a future that's heading south to meet us all.

WE LAND IN Cairns. We rent a car. And we travel north again, the panorama of Australia from 10,000 metres up exchanged for a view that moves too fast for most sensory information to register: smells, sounds, textures. The country reduces to an up-close blur with wide panning-shots of landscape further out.

I see us from above, the white prism of our vehicle with me, my husband and our luggage of books, camping gear, billy cans, tiny battery-powered fans and dry ice packed inside. We have fifty kilograms of solid carbon dioxide in an esky in the boot, the equivalent of the emissions created by a car driving nonstop for just under two hours, or a forty-two-inch LCD television being left to run for twelve-and-a-half days. I imagine it as a future microclimate, as if we were transporting our own stash of increased parts per million of this abundant greenhouse gas. But it's not that; it's bait to catch mosquitoes. We have two reasons for making this trip. Mine is this essay, to think about an unknown and tropical future. My husband's is to search for a particular arthropod.

Put dry ice in a billy can; hang it up above the ground; switch on a tiny fan. The females of many mosquito species track towards the blood they need to consume in order to lay eggs by sensing the carbon dioxide we exhale as we breathe. In these traps, the carbon dioxide lures the mosquitoes to containers that hang beneath the billy cans of dry ice, where the suction from the fan draws them inside.

We're looking for a mosquito species that's also thought to be heading south: a cryptic sister species of *Culex annulirostris* that's common on the other side of the Torres Strait in Papua New Guinea. A cryptic species is a biologically distinct species that looks exactly the same as another one but cannot interbreed with it. Two mosquitoes might look the same but behave differently – in terms of what and when they eat, and any human pathogens they might transmit.

Cx. annulirostris is the most important endemic vector of human arboviruses in Australia: it can transmit Ross River fever, Murray Valley encephalitis, Japanese encephalitis (JEV) and Barmah Forest virus, and it's widespread across the continent. Fifteen years ago, my husband's lab found that a cryptic species of *Cx. annulirostris* existed throughout Papua New Guinea – and had been found in Australia, at the top of Cape York, in Bamaga, in 2002. This species transmits the deadly JEV in PNG. If this exotic insect crossed the Torres Strait and colonised Australia, we'd have the potential of two pests – two vectors – to worry about, and the potential of higher rates of JEV transmission in northern Australia. The Torres Strait is monitored for pests as small as varroa mites (that travel with Asian honey bees) and fruit flies, but this was evidence that the mosquito had snuck through. A changing climate might enable it to establish in different landscapes. As Queensland's Department of Agriculture and Fisheries puts it, the concern is that 'newly introduced mosquito vectors could carry [JEV] further south'.

'That's the kind of thing we need to pay attention to,' my husband says.

We drive and I glance in the car's side mirror, expecting to see a theatrical trail of thick white mist streaming out behind, a dark grey plume of mosquitoes following its Pied Piper allure. But the lid is tight on the esky. And you can't see a mosquito when you're driving at a hundred kilometres an hour.

The road climbs up from the coast and into the Great Dividing Range, these mountains that leap out of the ocean at the tip of Cape York like storybook dinosaurs and run down the eastern side of Australia to Victoria's Grampians. The ecology shows itself off as we drive: we're in eucalypt woodlands, with different stripes of differently greened trees making distinct bands across the hillsides. Ecologists could read stories in that banding; I see it more like collage or a work of art.

This is an old landscape. The Kimba Plateau, at the southern edge of the cape's delineated space, is thought to be the oldest continental drainage divide in the world. It's 180 million years old and still relatively intact. A significant proportion of its plants and animals occur nowhere else in Australia, and it's also home to more than one hundred Gondwanan relict species (species that predate Australia's final separation from Antarctica). It's the world's largest continuous tract of intact tropical savanna and was proposed, as far back as 2000, as having global significance as 'a baseline landscape…to monitor impacts in tropical environments of future climate change'. In the ultimate game of compare and contrast, as more of the world's landscapes change – through development; through climate change or any other stressor or impact; through any adaptation or mitigation – there's an increasing need for examples of unchanged places, the yardsticks against which new systems, new conditions, can be measured and assessed.

In this largely unaltered space, the road unrolls, long and incongruous; kilometre after kilometre of imposed bitumen with the steady march of poles-and-wire electrical infrastructure marching alongside. In some places, these two markers of development look as if they've been etched directly onto the land with a ruler – two lines drawn onto the earth. Power and transport, pushing on, as the road dips or curves. Sometimes there's a sign, often a name that belongs to colonial impositions: Spear Creek; Battle Creek; Double-Barrel Creek. These new names are written over those of the forty Indigenous languages that filled the Cape with their own stories, their millennia of describing being in and adapting to the cyclic changes of this wet-dry place. Talking about her work in Carpentaria (Giramondo, 2006), novelist Alexis Wright, from the Waanyi people in the southern Gulf of Carpentaria, has described her sense, as she looks at the land, of it combining 'all stories, all realities from the ancient to the new, and makes it one – like all the strands on a long rope'. I think of the battles, the weapons, the roads: all these stories woven into that hawser.

Now, this landscape holds banana plantations, mango orchards, coffee bushes. Bright-green sugar cane that's grown for biofuel: 'Green Energy for Far North Queensland'. A solar farm; a wind farm.

One flash of blue is a Ulysses butterfly; another is the underwing of a rainbow bee-eater. Then another: the wing of a sacred kingfisher.

At Bob's Lookout on the Desailly Range, 160 kilometres out of Cairns, the view unfurls so far it's as if we can see right out to the rest of Australia. The rest of Australia being 'there' – with its twenty-five million people – while we, two people, me and my husband, stand 'here'. It's the kind of place that opens our perspective. We breathe in the big sky before we go.

We reach Laura as the sun begins to set, the thick power wire turning off the main road as we do and splitting into lines like a musical stave. A group of galahs arranges itself as if to score the evening's birdsong, and then the stars are out, a shocking amount so far from any city's light-saturated night sky.

I've always been taken by the contrast of single searching scientists on one hand and the world's vast landscapes on the other. In Laura, as the sun sets, we're bitten by mosquitoes. We're bitten by mosquitoes as we set mosquito traps in the pub's backyard. ('You want to catch mozzies? Go for it,' says the publican. 'Most people want to catch fish.') The dry ice steams like a prop from a play. The fans whirr quietly in the suddenly come dark. We walk away, scratching at our itches.

It's early June: colder, drier – not the best time to find these creatures. Our plans to be here in late March were kiboshed by Cyclone Nora, her gale-force winds and flash flooding. My husband is pragmatic: 'We've come here when we can.' In the morning, we haven't caught a single mozzie. Not one mosquito has followed that thick white air to its source. 'Sometimes they need a synergy of different scents: they need to detect the lactic acid in sweat as well as the carbon dioxide from breath before they fly in,' says my husband as we pack the car.

Heading north from Laura the bitumen runs out and we're onto fine, packed-down red dirt. The plants that line the left of the road are coated in this colour; the plants that line the right are coated in reverse by the traffic heading south. Like a lopsided colouring sheet. We drop our speed and the world becomes more tangible. We hear the birds, smell the air. We notice changes in the landscape: concentrations of xanthorrhoea, a stunning pond of waterlilies, the bread-and-butter-plate size of a eucalypt's leaves. We see a dingo, paused. A goanna, waiting. Kangaroos bounding away, and cows shepherding calves across the road.

What we can see; what we can't see; far away and up quite close. We're moving through a world that's vital. Everything's in play

IN EARLY 2018, a group of researchers led by William Laurance – a professor at James Cook University in Cairns, and the director and co-founder of ALERT, the Alliance of Leading Environmental Researchers & Thinkers – published a paper on the warning signals of biodiversity collapse in tropical forests, particularly those 'tipping points' where 'even small changes in environmental conditions will lead to large changes in the state of a system'.

'Our scientific capability to predict abrupt changes in nature…is limited,' the paper began, 'and this can have serious consequences for human wellbeing.' Understanding the warning signals of imminent biodiversity collapse 'could give conservationists time to act, thereby potentially lessening the extent of negative impacts on biodiversity'.

The study considered organisms including aquatic insects, mammals and birds from the Amazon, bats from Brazil's Cerrado forest, and mammals, birds and amphibians from South America's vast Atlantic Forest. While warning signals could be delineated for some creatures (such as the Atlantic Forest amphibians), they were not identified for others (such as the Atlantic Forest mammals). This 'lack of clear, ubiquitous warning signals' put paid to the idea of one 'ubiquitous mechanism' that signalled imminent collapse, and the research supported 'the general message that while reducing habitat loss should remain a top priority for conservation planners, the level of habitat loss at which communities can still be self-sustaining may be context and taxon-specific'. There is no blanket sign to warn us of what's coming.

We do know about some of the planet's tipping points in terms of climate change. In August last year, Will Steffen, a professor at ANU, and his colleagues published research describing 'a cascade of feedbacks that could push the Earth system irreversibly onto a "Hothouse Earth" pathway' where climate could not be stabilised and warming would continue 'even as human emissions are reduced'. 'If the threshold is crossed, the resulting trajectory would likely cause serious disruptions to ecosystems, society and economies.'

Ten bio-geophysical feedbacks were identified that could accelerate that trajectory, including the loss of Arctic and Antarctic sea ice, the dieback of forests, the weakening of our land and ocean carbon sinks, the rush of methane from our melting permafrost. Earth's systems were reacting quickly to two of these processes already, and others were expected to generate feedback by 2100.

Thirty years ago, researchers from the CSIRO started investigating the consequences of doubling the concentration of carbon dioxide in the earth's atmosphere. In 1988, specialists were invited from areas including agriculture, energy supply, transport, insurance and other national systems to present on its possible consequences. 'Most of the consequences that science then predicted would occur by 2030 we've already seen,' says Griffith University's Emeritus Professor Ian Lowe. 'And there are two reasons for that. We didn't know how rapidly greenhouse gas concentrations would rise. And there was genuine doubt about how rapidly increased levels of carbon dioxide would translate into warming.' Research now suggests a lag of decades between the cause of higher temperatures and their effect. The climate we experience today reflects our emissions of years ago; current emissions, higher now, will create the climate of decades hence.

What interests Lowe, alongside what he calls 'predictable changes – like Irukandji jellyfish moving south' are the 'nonlinear effects'. He describes a study of annual run-off in Perth's water supply system between 1910 and 2003, pointing out that Australia is not only the driest inhabited continent, but also the continent with the most variable rainfall. 'The difference between a wet year and a dry one in Europe is a factor of two or three. The difference in Australia is a factor of thirty.'

And the correlation between change in rainfall and change in run-off is now known to be nonlinear. Perth's rainfall has declined by around a quarter – as predicted more than thirty years ago – but run-off has declined by two-thirds of its pre-1975 levels. This is because, as Lowe explains, it's 'also hotter and drier when it rains, which means there's a more dramatic reduction in run-off'. Reduced run-off means less water can be collected; less water is available, even when it rains.

The impact of nonlinear effects is complicating in another way. If you're working with models or projections to anticipate change in the future, you can think about nonlinear effects, says Lowe, 'but you can't quantify them'.

In part, they lie – by definition – beyond anything that can be predicted by a model or a study. Models work on algorithms, and algorithms use data generated by events that have already taken place to project what might come next. The world we live in now is unprecedented in human existence. More and more, people will be living in environments 'for which there are simply no existing climate analogues,' as Steve Turton from Central Queensland University has said.

'The Australian Academy of Science report on climate change in 2013 charted two scenarios,' says Lowe. 'In the first, the world gets the message, carbon dioxide emissions peak in 2020 and the world decarbonises by 2100. In the second, it's business as usual. Each graphs the range of scientifically credible estimates for that course of action and what that means in terms of global temperature.' The first band tracks a course for an increase of between 1.5 and 3 degrees – if the world decarbonises. The second ranges upwards from 4 degrees to 'off the scale for the upper limit – which reflects the fact that we don't know what will happen'.

'We're doing an uncontrolled experiment,' Lowe says. 'Of course, in the fullness of time, we'll know what happens next.'

To give another example: while climate science had indicated that warming would be greater at the poles than in temperate regions, and greater in temperate regions than in the tropics, what was not foreseen was a disruption of the circumpolar circulation resulting in cold Arctic air flowing down over North America. Alaska and Siberia were projected to have warmer winters – and this has happened. But New York has also endured unexpectedly colder winter weather: in recent winters, temperatures have been around minus 10 degrees Celsius, rather than their usual plus 3 degrees. 'That was not foreseen,' says Lowe.

So an ice shelf melts; storm seasons surge. The Earth moves closer to those self-reinforcing feedbacks that could push its systems towards the planetary threshold that triggers 'Hothouse Earth'. Ecosystem collapse has already been charted in a variety of Australian environments, including kelp forests, floodplain forests, Gondwanan refugia forests, alpine forests – and the Great Barrier Reef.

'If Australia was more like Indonesia,' says Justin Marshall, 'and 60 per cent of our protein came from the reef, and the reef was now a quarter of what it used to be – which is what it is – we'd be more scared.'

CHARLIE VERON HAS a different phrase for the world's unknown unknowns: he calls them 'wild cards', and points out that they 'almost dominate the system'. Veron was employed by James Cook University as the first full-time researcher on the Great Barrier Reef in 1972 a marine biologist who famously never attended a lecture in marine biology, who applied for the position from a background in herpetology and entomology – and got the job. (His was the only application.) In the early 1990s, he spent eighteen months in France reading 'a crate full' of publications about climate change: 'You could Google it today but then you couldn't, and I had a lovely library. It only took me about a day to say, *oh my God*.'

One of the first things he realised as he entered the world of climate science and its communication was that the UN's Intergovernmental Panel on Climate Change (IPCC) could 'only examine criteria that were statistically examinable, and that wiped out all the wild cards…those things couldn't even be submitted.' At a conference in the US in the mid 2000s, he met some glaciologists who thought that Greenland's ice would melt 'not just by the sea eating away its perimeter, or absorbing heat over its high zone, but that it would form sink holes all over the continent.' He pauses. 'It was a crazy idea – and ideas like that couldn't be used by the IPCC. [Something] has to be statistically testable – if it's not, it's an opinion, and they can't include it…you can't put something like a notion in an algorithm. But that's what bloody well happened.'

In 2009, Veron addressed the Royal Society in London. 'Is the Great Barrier Reef destined for death row?' he asked and answered: 'Yes.' The concentration of carbon dioxide in the atmosphere the day that Veron spoke at the Royal Society was 387 parts per million. Hold that level steady 'with a magic wand', he said at the time, and 'the GBR would gradually, slowly decline – it's upper area to a depth of ten metres would gradually become rubble.' Increase carbon dioxide levels to 400 parts per million 'in the great global experiment we're conducting now', he continued back in 2009, and 'it would cause major weather events…and severe bleaching, mainly during El Niño years'.

And here we are: the highest concentration of carbon dioxide recorded so far at the Mauna Loa observatory in Hawaii peaked at 412.63 parts per million in April 2018.

A ROAD TRIP is a kind of meditation. Time and space stretch a little and you pay different attention to the landscapes you move through. I clock the termite mounds, round and orange-yellow in the south; more jagged, greyer-orange further north. Further north again, they're more like tombstones – and there are actual tombstones, sometimes, too: memorials of more recent losses. Bright pink, bright white, glistening silver.

Old systems; new systems. Our smartphones don't work in most places, so we're standing in phone boxes and scrounging coins to call our son. He's been reading the Narnia books this year, and I think of the voice, the animation, the rights of Narnia's forests, its creatures, its streams. I think about the reawakened forest in Prince Caspian, the trees beginning to move in the moonlight, 'in and out through one another as if in a complicated country dance'.

There's something about the way children cleave to the idea of talking animals, animated worlds. Perhaps it's something we all need to remember. To stand still and let the world speak to us again; to let its organisms exercise their own agency; act independently of humans in their landscapes.

It was the American biologist EO Wilson who coined the term 'biophilia' for the love of nature, Justin Marshall tells me. 'He knew we need a connection to the Earth to feel human, and we're losing that. Australians do still love their environment and they still like going camping and going surfing. So we're a bit more connected than most. But most people are definitely more focused on what they get out of their phones than on watching a bird in a tree while they're waiting for a bus.'

'In Australia, quite a lot, children are explaining to their parents what climate change is about,' says Charlie Veron. 'That's shutting the gate after the horse is out, but so is everything we do.'

We go on, further up, and farther in; that's another line from Narnia. We camp at Archer River, dismantling our still-empty traps the next morning as people pack up their overnight camps to move on. The Archer River roadhouse is cut off for several months each year in the wet and its owners hunker down and settle in, adaptive and prepared. I watch the campers fill their water bottles, pack up their portable solar panels. We call it holidaying, but what if it speaks to how we might live in a more adaptive future? I watch the campers drive away to look at something new.

Driving here is like driving through old-fashioned souvenir sand bottles – stripes of red, orange, pink, grey, brown, white earth. The grasses along the roadside run from deep maroons and rusts at the top, through blond-golds into lush greens. And the eucalypts: different barks and colours of leaves, and all of them amped up somehow, as if they were more enlarged or more alive. The eucalypts give way to mallees and melaleucas and palm trees – a different kind of lushness. There are white herons everywhere. One station has a cleared paddock facing the road and the cows congregate in the corner where there's one big tree.

The greens change, the species change, the elevation rises and dips back down to the cape's western coast. I watch jabiru at the Weipa tip while my husband puts out his packets of solid carbon dioxide. I imagine crocodiles in the creek at Putts Palms as he hangs up more billy cans.

The afternoon light turns Albatross Bay to quicksilver. Duyfken Point, site of the first recorded European contact with this continent in 1606, is on the other side. When the sun sets, layers of opalescence linger on the water's surface long after the daylight has gone. It's a strange orange-plum colour; 'The colour of the earth,' suggests my husband.

This evening, in Weipa, mosquitoes are following the lure of our dry-ice bait. These mosquitoes will be frozen, fixed in ethanol, ground down, and sent to Korea for sequencing – the micro of one arthropod; the macro of globalised science. This genetic snapshot: 'We'll know if our mozzie's staying put or moving south,' says my husband, 'or if the ones we saw in 2002 were just a freak occurrence.'

We're inside one tiny unknown unknown, grateful for the insects who've picked up on our carbon dioxide in Weipa and followed it into the traps.

And then we start the journey south again through serried rows of saplings that flicker like the lines in a flip book; striations of dark and light and shadow. At this slower, dirt-driving speed they look like they're about to resolve into an image of something else altogether, as if they're on the edge of revelation.

‘You know, Darwin was reading economics when he was thinking about evolution,’ says my husband. ‘He was reading about limits to growth.’

A night at Merluna Station; a night at Laura; then we’re on the sealed road back to Cairns. At Bob’s Lookout, an hour or so after sunrise, there’s a sense of the day and the world both unfolding. Out of nowhere I think of this line: ‘Too big to fail.’ Is that our secret belief, our secret hope about our planet?

The cape’s western coastline is somewhere way off to my right. Over there, between Karumba and the Roper River, more than a thousand kilometres of mangroves died between late 2015 and early 2016 – another case of ecosystem collapse. The mangroves of the gulf are less looked at than the reef, and it took some time for the die-off to be reported: a local fisherman thought the trees near where he lived had been coppiced and rang to alert MangroveWatch.

Researchers from this citizen-science interface checked satellite images and immediately saw something was wrong – and much further afield. The trees had endured higher temperatures and drier conditions – including a twenty-centimetre sea-level drop thanks to wind patterns altered by that year’s El Niño – and the effects of this were later compounded by shoreline erosion, sea-level rise and humidity. These mangroves had been cooked, starved of water then flooded again.

‘Mangroves die and regrow all the time,’ says MangroveWatch’s Jock Mackenzie. ‘But this was different. And we don’t know what’s going to happen next – we’re in new territory.’ The extent of the die-off was also unprecedented: the distance from Brisbane to Sydney. Imagine that, the trees’ lush green reduced to an arid monochrome that went on and on, that far.

I turn my head towards the east, trying to visualise that stretch of space. And then I keep turning, north-east, and I visualise a very different scale.

In 2013, biologist Conrad Hoskin from James Cook University travelled to the small sky island of Cape Melville. Sky islands are isolated mountain tops that hold flora and fauna completely distinct to the landscapes around them. Cape Melville’s tiny plateau measures just six kilometres by three. This one expedition has revealed one new plant so far, a ‘funky little snail’ that turned out to be an entirely new genus, and five altogether new vertebrate species: three skinks, a leaf-tailed gecko and a frog. ‘It’s a rocky, complicated landscape,’ Hoskin has told me. ‘Species can hide away there over time. It’s a fairy-forest – it’s beautiful. And most of what you’re seeing is unique.’

In any conversation about tipping points and feedbacks, about unknown unknowns, in any conversation about the environmental crisis that we live in, the word ‘extinction’ always comes into play. Our impact on the biosphere is perhaps greater than our impact on the atmosphere, and extinction rates continue to ramp up. Yet it’s also estimated that we’ve catalogued and classified only a third of all the species living in Australia while we continue to lose species at an unprecedented rate. Losing them sometimes before we know what they are, how they work, what they do – and how they interact. It is, says Ian Lowe, like throwing away the bricks that build a house without knowing what the loss of each one means. Or which one’s removal will cause the whole edifice to collapse.

‘Environmental Jenga,’ says Justin Marshall.

I think of these new 'bricks' added in from Cape Melville against the ones we've already thrown away. 'There should be a sense of urgency about climate change, but there should be more of a sense of urgency about biodiversity loss,' says Lowe. 'Back in the 1990s, an ecologist made the salient point that with concerted will and action you could stabilise the global climate and return it to a pre-industrial level – over about 200 years. But biodiversity loss is permanent. It's irreversible. Every time we lose a species there's a whole range of unpredictable effects on the whole system,' he says, 'and we're cosmically ignorant of what it might mean if the long-footed potoroo disappears, or the Lord Howe woodhen, or whatever the species might be.'

Unintended consequences: when Mao Zedong sanctioned the eradication of sparrows from China in 1958 as one of 'four pests' (because they ate seed), he inadvertently triggered a locust plague (because sparrows also eat insects). More than twenty million people starved to death.

LIKE MANY NOVELISTS, I'm seduced by the idea of a correlation between reading and empathy – the powerful act of imagining yourself into someone else's life. In stories of climate change and place, what's needed is the capacity to imagine not only a different who, but a different where and when: how things might be different; how some things already are. The body weight of some birds is already changing, and so is the time taken for some butterflies to emerge from their cocoons. These are just some of the adaptations Australian species are making to climate change, adaptations that the planet's other species have no choice but to make. They adapt, or they fail.

Fifteen years ago, the environmental journalist Bill McKibben edited an issue of *Granta* called The Overheating World. He wrote, in his introduction, not only of our fatal lack of fear of global warming – 'hardly anyone…has fear in their guts' – but also of the protective way in which we allow our awareness that the world will change to be 'muted by the future tense'.

We are in the future now, well and truly, with extinctions and collapses on the one hand and, still, discoveries and adaptations too. Justin Marshall cries and Charlie Veron says he wishes that he'd 'never heard of climate change. But I think the plight of the Great Barrier Reef is waking people up, which is why I spend so much time talking with journalists… I hate it, every time I talk about the future of the GBR, my children; I get more and more depressed and miserable. But I'm not going to give up because I can't – I'd let the reef down.'

The Permian-Triassic extinction event – the 'Great Dying' – occurred some 252 million years ago and wiped out more than nine-tenths of all species. A paper published in 2011 suggests that the rate of recovery for marine and terrestrial ecosystems after that happened was in the order of five to eight million years.

That's an awfully long time.

'Life is resilient,' says Justin Marshall, 'and it will be resilient beyond humans.' But it's humans he wants to focus on now – rather than science. CoralWatch, the citizen-science engagement tool he helped establish seventeen years ago, monitors reefs in seventy-nine countries and offers its classification system in 137. Marshall sees this as 'community-building, trying to rebuild the reef one polyp at a time – but the polyps are people. And if we can do that…' He pauses. 'I'm hoping something will go viral or take off like a pyramid scheme. You tell one person, you tell two people, you tell four, and so on. Grains of sand on a chessboard – that sort of stuff… I think that's the way to do it, to have the conversation with as many people as possible. I've got no idea how to engage a million people, but I'm trying.'

He says this just before he starts to cry.

The latest interim IPCC report, released in October 2018, insisted greenhouse gas pollution must reach zero by 2050 for the world to have any chance of capping temperature increases at 1.5 degrees. And a 2-degree Celsius rise impacts more than three times as many planetary landscapes as a 1.5 degree rise. Up it goes, exponentially, again – like Justin Marshall's pyramid scheme.

And that's when I see it. That's when I understand what the real wild cards are. The unknown unknowns in all of this are each and every one of us: what we purchase, what we vote for and what we insist on, as much as how we live. 'I've been saying this for a long time,' says Ian Lowe. 'The only grounds for having any kind of cautious optimism is recognising that human systems are nonlinear, that they can change very rapidly from one state to another.' Remember how one prime minister went from being unassailable to unelectable in six months in 2007, he says. Remember how the country used to regard same-sex marriage. Remember further-back historical things like apartheid or slavery. 'Things can change, and if you reflect on the biggest changes, they've happened because a small group of determined people persuaded their friends, their neighbours, their colleagues that the old way is not appropriate.'

I TAKE THE train from Cairns back down to Brisbane. I tell myself it's because I want to see the changes in the landscape as I travel. I want to understand exactly how far north one place is from the other. I want to see the detail of the places in between, not their aerial overview. In truth, I think it's that I don't want this story to end. I can't write you the southern seep of a bioregional zone. I can't write you the bleaching of a reef, the suffocation of a mangrove, the startle of seeing a new species for the first time, the thickness of so much long-dead life pressed into so much dark black coal.

What I can do is try to pay attention. This trip, and all these stories are a kind of witnessing of what is going on, a way of saying, even gently, see this place? See how it is this moment? With the extent and rate of change we've locked in now, you won't see it like this again – not in your lifetime.

Here comes the purple flare of tibouchina, the Seussian shapes of sprawling pawpaw farms. A man walking across an empty field spraying something from a jerry can as three big dogs bound at his heels. Here comes the highest peak in Queensland and the turn-off to Abbott Point. These nothing and everything points.

A line of trackside markers counts the distance back to Brisbane – 1,592, 1,476, 1,367, 1,339 – and the train's speed lets me notice tiny things. A falling leaf, a single pebble. For twenty-four hours and twenty minutes, I try to hold the idea of so much change and adaptation at the forefront of my mind. Through the window, now, a shimmer of butterflies – ones with wide white wings and smaller yellow ones. The trees change. The soils change. But I can't see what's happening beneath that. I can't see heat or rhizomes or dewpoint or carbon uptake. I can never see those growing, growing, growing parts per million in the air.

I can only imagine bearing witness to these things.

At one in the morning the train reaches Rockhampton, the latitudinal line of demarcation between what's tropical and what's not. I open my eyes as the forward motion slows and realise that the tracks here run along the middle of the street. It's a disconcerting thing, to glide along a suburban thoroughfare in a train, as if the carriages have jumped the safety of their fenced and confined tracks and are sneaking directly into town.

Here come the shops, the red-lit crossings, and the Rockhampton Musical Union Choir Hall – it's as surreal as a dream – and then the huge, wide-platformed station. 'I've got to get out,' a lady cries behind me – unaware or unconcerned that most of the passengers are asleep. 'I've got to get a picture; I was born here in Rockhampton.' It's not clear who she's saying this for. But she snaps her image the old-fashioned way, looking out to this place that has some resonance for her; not looking back onto herself.

There's nothing to suggest the presence of the Tropic of Capricorn nearby, nor the fact that the tropics are already inching south. As the train pulls out again, I turn on my phone to idle round its maps app and try to spot the tropics' relocated marker somewhere there.

The screen flares in the darkness, Rockhampton's streets snapping into their grid. But the blue dot that should pinpoint exactly where I am is jumping all over place – four streets north, three streets east, a great lunge west. I frown, not knowing why it would do this. It makes me feel as if I might have disappeared.

I glance through the window to check that I'm still somewhere. And there it is, not far from the now-enclosed train line: the slightly kitsch concrete needle designed to mark the intersection of the Tropic of Capricorn with the surface of the earth itself. As if it might have manifested just exactly where I'd see it. Like the one specimen of Papua New Guinea's cry ptic Cx. annulirostris mosquito that did fly into our trap in Putt's Palms in Weipa: a sliver of evidence that that organism, too, is heading south.

The train continues to move down from the north, returning from the future. That tropical line heads south as well. At one in the morning – any time you like – on the reef, in the Melville Ranges or in Weipa, in Karumba, in the Galilee Basin, things are moving and they're changing. Adapting and surviving or running up against their end.

You'll have to imagine all those unknowns. You'll have to imagine what's coming next.

Notes

Information on historical and current CO2 emissions is available from the NOAA: https://www.esrl.noaa.gov/gmd/ccgg/trends/data.html

Emissions estimates are based on information available from the Carbon Fund: https://carbonfund.org/individuals/?gclid=EAIaIQobChMIjv7dueuH3gIVjgYqCh0Xhg9jEAAYAiAAEgKQzPD_BwE

Emissions estimates are based on information available from YouSustain: http://www.yousustain.com/footprint/howmuchco2?co2=50+kg

Information on Cape York languages available from: https://glottolog.org/resource/languoid/id/pama1251

The latest Australian State of the Environment report (2016) at the time of writing is available online at: https://soe.environment.gov.au/theme/overview

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