

Same Sky, Different Ground

*Reading the ecology of the Sunshine Coast, from
the reef to the range*

Daniel Addington

*Same Sky, Different Ground: reading the ecology of the Sunshine Coast,
from the reef to the range*

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While every care has been taken to ensure the accuracy of the information in this book, it is offered in good faith and for general interest only. The natural world changes, and access, conditions and regulations at the places described — including the sites in the field-companion chapters — change with it. Readers who go outdoors do so at their own risk and are responsible for checking current conditions and for their own safety.

Written with the assistance of AI tools, under the direction of the author; see "A note on this book."

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Acknowledgement of Country

This book is about, and was written on, the lands and waters of the Kabi Kabi (Gubbi Gubbi) people, the Traditional Owners and continuing custodians of the Sunshine Coast and its hinterland — a connection to Country recognised in the Federal Court’s determination of their native title in 2024, and reaching back many thousands of years before that. We pay our respects to Kabi Kabi Elders past and present.

This is a book about the ecology of that Country. It makes no claim to tell its cultural story, which belongs with the Kabi Kabi people themselves; where it touches on the long human history of the landscape — above all the shaping of the land by fire — it draws only on the published record.

Preface

Most people come to this coast for the beaches and take the rest of it for scenery — the low blue hills that are really the worn-down stumps of volcanoes, the scruffy roadside heath that holds one of the most remarkable floras in the country. This book is for anyone who has driven past all that and half-wondered what they were looking at. It is a guide to the reasons behind the landscape: to why this stretch of coast is arranged exactly the way it is, and how to read it for yourself. The rewards are larger than the view from the road lets on: at Cooloola, just north of Noosa, the sand itself keeps a calendar, and to walk inland over the dunes is to walk back through the better part of a million years.

The Sunshine Coast has a richer ecology than almost anyone living on it realises, laid out in such a clear, readable order that it makes an almost perfect classroom for how the living world is put together. It is also one of the fastest-growing regions in the country, and much of what makes it remarkable is being cleared and drained by people who do not know it is there. A landscape that is understood stands a better chance than one that is merely admired.

Its argument turns on a single chain of cause and effect, unfolded across the chapters in order and readable in either direction: read the rock and you can read the soil, the water, the fire, and finally the life and the history written on top of them. The aim is to make that reading a practical skill, so that by the last page a landscape that once looked like scenery has become a story you can read.

A few notes on how to use the book. The chapters build on one another and are best read in order the first time through, because each leans on the one before; but each also stands on its own, and the “Reading the country” section that closes most of them is meant as a quick field summary to carry away. The boxed sidebars are the tangents, the stories too good to leave out, and the final chapter is a companion for taking the whole skill outdoors, where it belongs. It is written for anyone curious about this place: the newcomer and the lifelong local, the student, the bushwalker, and the land manager who has to make real decisions about country like this.

This is popular science, which means it tries to be at once accurate and readable, and where those two pull against each other I have tried not to sacrifice the first to the second. The science here rests on the work of many researchers, named in the text and gathered in the references, and where it is still unsettled I have tried to say so plainly. Any errors that remain are mine.

Finally, as the opening pages set out more fully, this is an ecology book written on Kabi Kabi Country. It does not try to tell that Country’s cultural story, which is the Kabi Kabi people’s own; it keeps to the ecology and to what the published record will support. But it takes as its starting point something the science and the older knowledge agree on entirely: that this was never empty wilderness, that it has been read and tended for a very long time, and that learning to read it ourselves is the first step toward looking after it.

So let us begin where the book begins — with the country itself, and whose it is.

A note on this book

A word on how this book was made. It was written with the help of AI tools, used for drafting and for gathering the published research together. The author directed the work throughout, checked every fact against its sources, and did the editing. A reader is entitled to know how a book was made, and so it is set down here plainly.

I wrote it in the first place for myself, to learn to read the country I live in, and the writing of it has been most of the reward. If it proves useful to anyone else, so much the better.

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Chapter 1 • Country

Before it was a coast, a region, or a set of postcodes, this was — and remains — Country.

Stand on the long beach at the mouth of the Maroochy River, somewhere near the middle of the coast, and turn slowly all the way around. In a single sweep you take in almost the entire coast, from the reef offshore to the range behind. South along the coast, out of sight beyond the headlands, runs a chain of sand islands. At your feet a tea-coloured river slides out past dark ranks of mangroves. Inland, the coastal plain reaches away through cane paddock and suburb. And beyond it, blue and abrupt, stands a wall of forested range, with a scatter of strange, steep-sided peaks rising off the plain in front of it like something left over from another country. That one turn, from reef to range, is the subject of this book, and learning to read it is its single ambition.

This is the Sunshine Coast: a stretch of subtropical Queensland coast and hinterland an easy drive north of Brisbane, bracketed by the Glass House Mountains in the south and the great sand mass of Cooloola in the north, and reaching back from the beaches, in not much more than thirty kilometres, to the green volcanic tableland of the Blackall Range. Three short rivers, the Maroochy, the Mooloolah and the Noosa, drain it to the sea; a fourth, the Mary, rises behind the range and runs the other way, inland and north. It is, by Australian standards, a small and crowded place, its coastal strip now among the fastest-growing in the country. And yet packed into that short run from the surf to the range is almost every kind of country the eastern seaboard has to offer: reef and estuary, heath and swamp, open forest and rainforest, stacked in order up a single slope. Few places anywhere fit so much variety into so little ground, and fewer still lay it out so legibly.

It is a book about the ecology of that place. But before we read any of it, one thing has to be said plainly, because it is true and because everything else sits on top of it.

The Sunshine Coast is Kabi Kabi (Gubbi Gubbi) Country. The Kabi Kabi people are the Traditional Owners and continuing custodians of this land and its waters, a connection recognised in 2024, when the Federal Court of Australia formally determined their native title over a large part of the region. That determination put a legal seal on something that had never actually lapsed: a relationship with this Country reaching back many thousands of years, through a span of time so long that, as the next chapter will try to show, the entire period of European settlement is a single tick at the very end of the clock.

This book does not set out to tell the cultural story of that Country. That story is the Kabi Kabi people's own, to tell in their own way and their own time, and it is not mine to put on the page. What an ecology book *can* and must do, though, is refuse the comfortable old fiction that the landscape it describes was an empty wilderness before Europeans arrived. It was nothing of the kind. The country the newcomers walked into, the open, park-like forests they so admired, the abundance of game, the fine-grained mosaic of heath and woodland and grassland, had been actively shaped and tended for tens of thousands of years, above all with fire. Much of what we are about to read as “natural” ecology is, in truth, the legacy of one of the longest-running and most sophisticated land-management traditions on Earth. Where that history matters most to the ecology, and nowhere does it matter more than in the chapter on fire, this book notes it, drawing only on the published record. Otherwise it keeps its focus where the title promises: on the living landscape itself.



Figure 1.1 — The Sunshine Coast. From the Glass House Mountains in the south to the Coolooloola sand mass in the north, and back some thirty kilometres to the Blackall Range. Three rivers run to the sea; the Mary rises behind the range and runs the other way, north.

A landscape you can read

To a newcomer, the Sunshine Coast can look like a jumble, a pretty but random scattering of beaches, swamps, forests, farms and blue peaks, flung together by chance. It is not random at all. It

is one of the most legible landscapes in Australia, and reading it is a skill you can learn: not the botanist's trick of naming a tree from a single leaf, but the plainer, more useful knack of reading a whole slope at a glance. Red soil or bone-white sand, dense forest or open woodland, a tea-dark creek, the blue peaks standing off the plain — learn what those big, obvious signs are telling you and, more often than not, you will know roughly what you are standing in and why, and begin to see what the place has been through.

All of that reading turns on a single chain of cause and effect. The rock decides what kind of soil it will become; the soil, together with the water and the fire, decides what can grow; the living world arranges itself into an ordered procession of ecosystems; and people, for tens of thousands of years, and then very abruptly differently, reshape all of it. This country has been read, and tended, for a very long time; now it is our turn to learn how. The chapters ahead trace that chain in order, beginning where the landscape itself begins: an almost unimaginable time ago, with a continent on the move and fire rising from beneath the ground.

Chapter 2 · The making of the rock

The most peaceful-looking country often has the most violent past. It has simply had the time, since, to calm down.

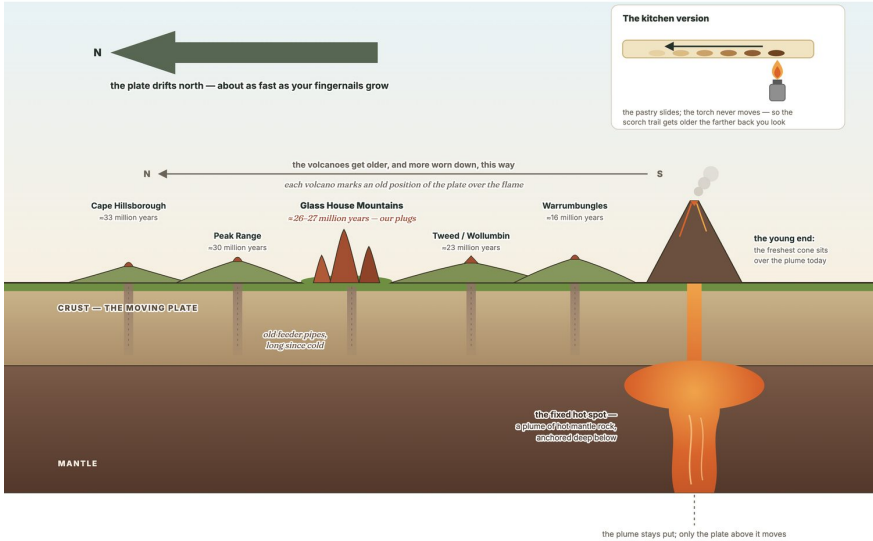
On a still morning the Glass House Mountains float blue and serene on the inland horizon, and nothing about the scene suggests violence. It looks about as old and settled a landscape as you could ask for, which, in a sense, it now is. But those calm blue peaks are the cooled stumps of volcanoes, the rich red soil of the hinterland is rotted-down lava, and the whole western skyline is the wreckage of a time when this quiet corner of Queensland sat over a furnace and burned. To understand anything that lives here, you have to begin with that fire, and with the almost unimaginable stretch of time that has passed since it went out.

But keep sight of where all this fire is heading. The red basalt of the ranges will become rainforest; the pale, starved old sand will become wallum heath, a low country of wildflowers and acid frogs breeding in water the colour of cold tea; and the slowly drowning eastern edge will become reef. Not a leaf or a frog or a coral of it will make sense until you know the rock beneath. That is why a book about living things has to begin in stone.

Geology writes the rules and the living world plays them out, and this chapter is about the moment the rules were written, in fire. So before we can read the living landscape, we have to try to think in deep time.

The hotspot track

One fixed flame, one slowly drifting continent — and a trail of volcanoes that doubles as a clock.



Schematic — not to scale; distances compressed. Ages after Wellman & McDougall (1974), Cohen et al. (2007) and Davies et al. (2015); the plume now lies off Australia's south.

Figure 2.1 — The hotspot track. The plate drifts slowly north over a fixed hot spot in the mantle, so the volcanoes it leaves behind grow older down the line — like pastry dragged across a blowtorch.

How to hold a number you cannot imagine

The volcanoes that built the bones of this region fell silent something like twenty-five million years ago, and twenty-five million years is not a number the human brain can hold. We are built to grasp a lifetime, a few generations, perhaps the few thousand years of recorded history; beyond that the zeros simply blur, and “twenty-five million years ago” lands in the mind as a vague synonym for “ages ago.” There is no shame in this; geologists feel it too. The only cure is to translate the number into something the body understands.

So try this. Squash all twenty-five million years of these volcanoes into a single twenty-four-hour day, midnight to midnight. On that scale, the volcanoes erupt and die in the first moment after midnight. The entire span of human presence in Australia, tens of thousands of years, occupies the last few seconds before the following midnight. All of European settlement, every town

and road and farm on the Sunshine Coast, happens in roughly the final *thousandth* of a second, the time it takes a camera to click. Everything you think of as the history of this place is that camera-click. Everything in this chapter is the other twenty-four hours.

Hold that ratio in your head, because it changes how you see the scenery. The peaks on the horizon are not a backdrop to the human story; the human story is a flicker against them. And the peaks themselves are not even permanent; they are halfway through vanishing. Deep time will be with us for the rest of the book, so you may as well get used to its company now.

The furnace beneath: a continent on the move

Now to the fire. Around twenty-six to twenty-seven million years ago, this stretch of the Queensland coast was volcanic country: no polite cone or two, but a whole wide region where magma shouldered its way up, in episodes spread over millions of years. *Why here, and why then?* The answer is one of the most elegant ideas in all of geology, and it involves the ground beneath your feet being a great deal less stationary than it feels.

The continents drift. Slowly, about as fast as your fingernails grow, but relentlessly, riding on the churning mantle beneath, and Australia has been drifting north for tens of millions of years and is drifting still. Now imagine that fixed in the deep mantle, far below the wandering plate, there sits a plume of abnormally hot rock: a “hotspot” that stays put while the continent slides over the top of it. Where the plate passes over the flame, the heat melts the underside of the crust, magma wells up, and volcanoes erupt. Then the plate carries that patch of crust onward, away from the flame; those volcanoes die; and fresh ones light up over the hotspot behind them. The result, over millions of years, is a *trail* of volcanoes laid down across the moving continent like a sheet of pastry dragged slowly across a blowtorch, oldest at one end, youngest at the other.

That is what happened here. The Sunshine Coast’s volcanoes are one stretch of a long track running down eastern Australia, growing younger toward the south; not far south of here, the great

Tweed Volcano, its eroded heart now standing as Wollumbin / Mount Warning behind the Gold Coast, is a younger, larger member of the same story. What stays with you is the sheer scale of the machinery: an entire continent, sliding over a fixed flame in the depths of the Earth, leaving a trail of fire hundreds of kilometres long and millions of years deep. The Glass House Mountains are one knot in that trail.

Sidebar — The longest scar on Earth. The volcanism that raised these peaks belongs to a far larger pattern. As Australia drifted north it dragged its crust across a zone of hot mantle for tens of millions of years, leaving age-progressive volcanic country strung down the eastern side of the continent. That belt includes the longest continental hotspot track known anywhere on Earth, the Cosgrove track, which runs for some two thousand kilometres through the inland. The Glass House peaks sit on the more easterly, coastal expression of the same long northward march, and they too are a kind of date-stamp: the volcanoes of eastern Australia grow steadily younger from north to south, so that, knowing roughly how fast the plate moves, you can almost read their ages off the map like distances on a ruler. It is fire written across half a country, and the Sunshine Coast's peaks are one bead in the line.

Thick lava and thin: the two fire-rocks

Not all of that fire made the same rock, and the difference matters enormously for everything that comes later.

Lava comes in two kinds that matter to this landscape, thick and thin, and the difference is mostly silica. **Silica-rich lava is stiff.** Viscous, barely able to flow, it clogs the volcano's throat and mounds into steep domes, cooling underground or only just above it into hard, dense rock: rhyolite and trachyte, the stuff of the plugs. Where it solidified in the vents and necks of the old volcanoes it formed knots of rock far harder than anything around them, and those knots are what is left standing today: the Glass House Mountains, Mount Coolum, Mount Tinbeerwah and the sharp spire of Mount Cooroora above Pomona. (Mount Ninderry

is the odd one out: its rock is the North Arm Volcanics, Late Triassic and some two hundred million years older than the rest, but it stands for the same reason — hard, unjointed rhyolite refusing to wear down.) The Glass House Mountains are the boldest of them: a cluster of sheer, separate towers rearing straight off the plain, each one the choked throat of its own vanished volcano. When you look at those peaks you are not looking at the volcanoes. You are looking at their frozen *plumbing*, the hard cores laid bare long after the volcanoes themselves rotted away.

Silica-poor lava is thin: runny, able to spread for kilometres before it stops. That is basalt. Rather than plugging a vent, it floods out across the country in broad sheets and cools flat. And the crucial part is this: basalt weathers, under high rainfall and enough time, into deep, fertile, chocolate-red clay. The basalt sheets of this region built the high tablelands — the Blackall Range of Maleny, Montville and Mapleton, and the rise of Buderim — and clothed them, eventually, in the richest soil the coast possesses. One kind of fire gave us the postcard peaks, the other gave us the farmland.

Sidebar — Why “Glass House”? The strange, steep-sided peaks that are the region’s signature carry an English name with an oddly industrial ring, and it comes from the very first European to sail past them. In May 1770, working his way up this coast, James Cook saw the peaks standing abruptly off the low plain, thought them like the glass furnaces (the “glass houses”) of the day, and set that name down on his chart; the resemblance, it is usually said, was to the glassworks of his native Yorkshire. It is a curiously apt piece of accidental geology: he was looking at the cooled insides of volcanoes and naming them for furnaces, with no idea that fire was exactly what had made them. The peaks had, of course, been named and known for many thousands of years before that, and carry Kabi Kabi names and meanings that are not this book’s to relate. But the newcomers’ name, at least, we can account for, and it turns out to be a better description than the man who coined it could possibly have known.

When the fires went out

And then, slowly, the fires went out. The continent drifted on, carrying this patch of crust away from the hotspot, and the volcanic country was left to face the only force more patient than deep time itself: the weather.

For something like twenty-five million years since the last fires, rain and river and chemical weathering have been gnawing at this rock, every single day, hauling it off to the sea. Entire volcanoes have been erased in that time. Not merely worn down: *erased*, every cubic kilometre of their cones and ash carried away, leaving only the hard inner plugs standing as the peaks we climb. The fiery landscape of twenty-five million years ago has been quietly disassembled; what we call the scenery is the rubble left behind, whittled by erosion into the shapes the next chapter teaches you to read.

The floor beneath the fire

The fire and its two rocks dominate the story of this region, but they were not even the beginning. The magma did not rise through nothing; it punched up through, and spread out over, rock that was already ancient: a floor laid down long before the first Sunshine Coast volcano ever lit.

Go deep enough, or find where erosion has stripped the country back to its oldest bones, and you reach the basement: hard, folded, fractured rock, the worn roots of far older mountains, welded together hundreds of millions of years ago when the eastern edge of the continent was still being assembled. Older by an order of magnitude than the volcanoes, this true foundation makes its own kind of country where it reaches the surface: the harder, poorer, more broken ground that the later forest chapters keep returning to as the “foundation rock” beneath the open eucalypt hills.

Over that basement, and under much of the modern coastal lowland, lies a younger but still venerable layer of sedimentary rock: sandstones, mudstones and thin seams of coal, laid down by rivers and swamps in the age of the dinosaurs, well over a hun-

dred million years before the volcanoes. It is these quiet rocks, and not the dramatic lavas, that underlie a good deal of the low, rolling country between the peaks and the sea; they make no post-cards and draw no climbers, but they are the workaday floor a great many of the coast's towns and farms actually stand on.

So the rock story has not two chapters but four, stacked in order of age: the ancient folded basement; the dinosaur-age sandstones laid across it; the volcanic fire, punched up through both; and, youngest of all, the sand. The fire and the sand catch the eye, because they throw the boldest shapes, but the older, quieter rock is there all along, underneath, holding up the middle of the picture.

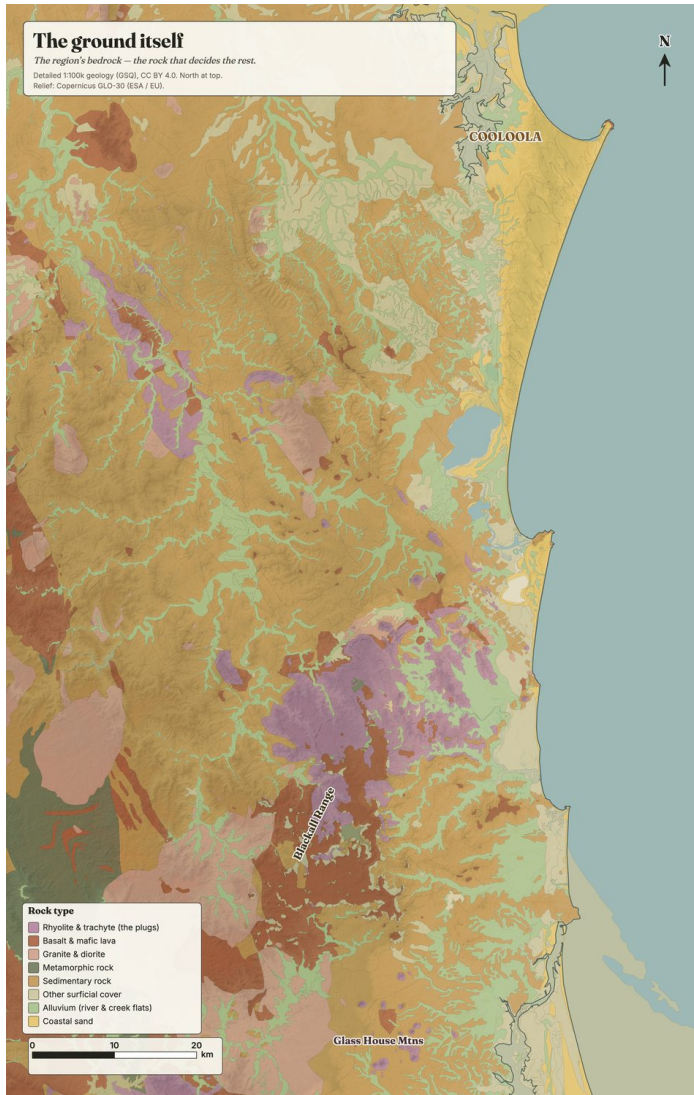


Figure 2.2 — The rock beneath. The region's real geology, from detailed state mapping: the Glass House felsic plugs, the Blackall Range basalt, the granite and sedimentary ranges, and the great apron of coastal sand — each a distinct rock, and the starting point for everything that grows.

The sand masses, made by water and wind

One part of the Sunshine Coast, though, the fire had nothing to do with. While the volcanic uplands are the oldest thing on the skyline, the sprawling coastal sand masses are among the youngest landforms in the country, built not by fire but by its opposites: water and wind, working in almost the present day.

The story of the sand begins far to the south. Rivers and surf grind the rock of distant coasts and ranges into quartz sand, and the tireless waves and currents of the eastern seaboard sweep it slowly *northward* in a vast conveyor. Where the coastline snags it, it piles up — prodigiously, on this stretch of coast — building the barrier islands and the immense dune fields of Cooloola, and carrying on north to raise K'gari (Fraser Island), the largest sand island on Earth. Wind then takes over from water, heaping the sand inland and, over the ice-age cycles of rising and falling sea level across the last seven or eight hundred thousand years, building dune upon dune in ranks marching back from the shore.

The contrast could not be starker, and it sets up one of the region's central tensions. The uplands are old, hard, fertile and made by fire; the sand lands are young, soft, almost sterile and made by water and wind. One was finished twenty-five million years ago and has been wearing down ever since; the other is still being built, grain by grain, by the next storm and the next tide. Same coast, two very different kinds of ground; and, as the chapters on soil and the wallum (the coastal sand-heath) will show, that contrast shapes what lives where.

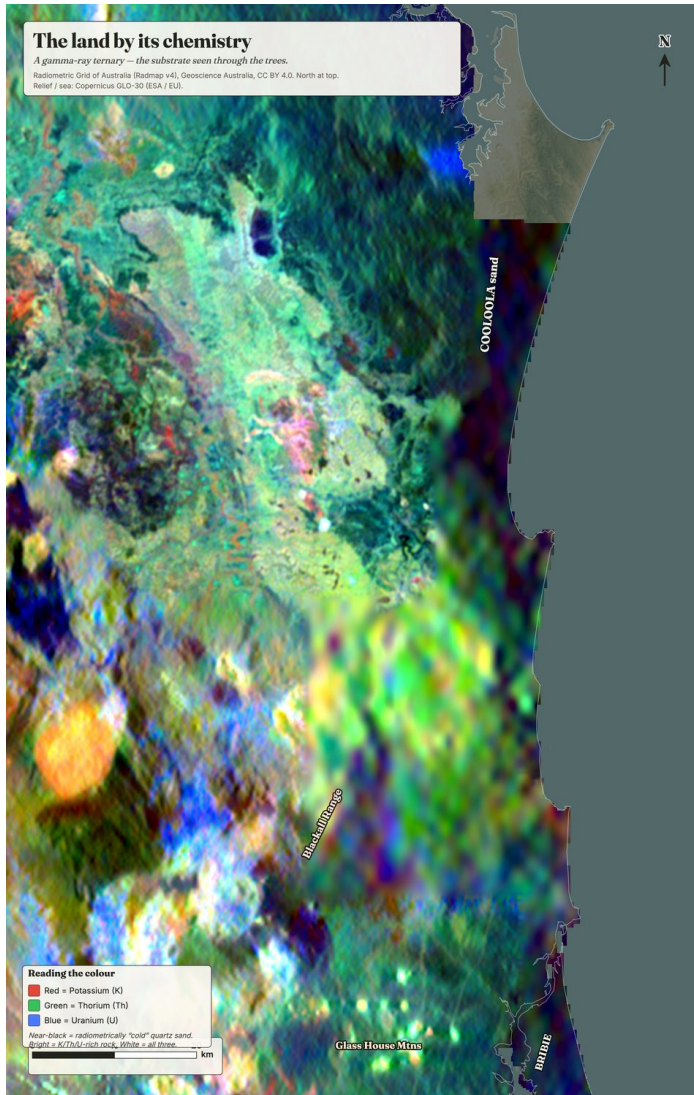


Figure 2.3 — The land by its chemistry. A gamma-ray view that sees past the vegetation to the ground: the quartz sand masses read radiometrically dead (near-black), while the basalt and felsic rock glow — the same geology, confirmed in a different language.

Sidebar — The young giant. It is a startling thought that rock twenty-six million years dead and some of the youngest land in the country sit within an hour's drive of each other. The trachyte of the Glass House Mountains was forged in volcanic fire before there were grazing animals on the Australian plains as we know them; the sand of the high Cooloolo dunes, just up the coast, is still being added to and reshaped by this winter's storms. We tend to assume that "the land" is all roughly the same age, that the ground is simply the ground, ancient and fixed. It is nothing of the sort. This one region is a layer cake of wildly different ages, and learning to see those ages — to know that this peak is a relic and that dune is practically new — is a large part of learning to read the country at all.

Reading the country

This is where the reading begins, before soil or water or a single living thing. The western skyline of sharp blue peaks is fire and deep time made visible: the hard hearts of vanished volcanoes, twenty-five million years dead and halfway through disappearing. The green tablelands behind them are the other kind of fire, runny basalt rotted to red wealth. The low, rolling country in between, where most of the towns and farms sit, is quieter and much older stuff: dinosaur-age sandstone and the ancient basement beneath it, the floor the fire erupted through. And the bright dunes along the coast are something else entirely: astonishingly young, built yesterday by water and wind and still under construction. Four grounds, then, and an abyss of time between them.

The fire, though, was only the beginning. Making the rock is one thing; carving it into the country you can actually stand in is another, and that is the patient, twenty-five-million-year work of the next chapter: rain and rivers sculpting this raw volcanic wreckage, with exquisite slowness, into peaks and plateaus and valleys. The fire wrote the rules. Erosion drew the map.

Chapter 3 • Reading the rock

The hills are not where the land was pushed up. They are where it refused to wear down.

Fly into the Sunshine Coast on a clear day and the landscape below you looks suspiciously deliberate, as though somebody sat down with a plan and a steady hand: a long wall of green range standing guard along the west, a scatter of lone peaks planted across the middle like chess pieces left mid-game, and a wide, flat coastal plain unrolling to the sea. It is a tidy, almost designed-looking arrangement, and nobody designed any of it. Every peak, plateau and plain you can see is simply a record of an argument the land has been having with the weather for tens of millions of years: which rock could stand its ground, and which could not. Learn to read that single quarrel and the whole region falls open in front of you, like a map that has finally had its legend pinned to the corner.

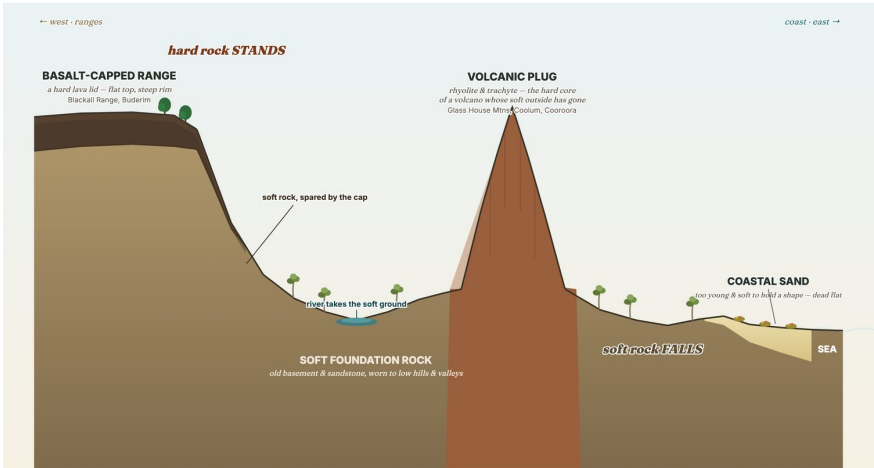
The last chapter told you how all that rock arrived; this one is about what happened *after* the fireworks stopped: the long work of rain, river and weathering that carved the raw material into country you can actually stand on. And the first thing to swallow sounds wrong: the volcanoes did not build the Glass House Mountains. Erosion did. Those peaks are what was left behind when everything softer around them was carried out to sea.

The one rule that explains everything: hard stands, soft falls

Every hill on the horizon hangs off a single principle: **in a wet climate, given enough time, a landscape is shaped above all by what wears down, far more than by what was lifted up.** Rain, rivers and chemical weathering set about every exposed surface, indifferent and unhurried: soft, soluble or cracked rock surrenders quickly and becomes valley and plain, while hard, dense, unfractured rock holds out and is left marooned as the ground around it is lowered.

Hard stands, soft falls

Rock hardness decides the shape of the land: the hard rock stands up high, the soft rock wears down low.



Read the shape and you have read the rock: the hard plug and the basalt cap stand tall as high ground, while the soft foundation and the sand are worn away to valleys and flats. Schematic west-to-east cross-section; heights, spacing and depths not to scale.

Figure 3.1 — Hard stands, soft falls. The whole chapter in one profile: the hard volcanic plug and the basalt cap have stood their ground as high country, while the softer foundation rock and the young coastal sand were worn away beneath them into valleys, low hills and flats — read the shape and you have already read the rock.

The Sunshine Coast happens to be a near-perfect classroom for this, because it was dealt three very different kinds of rock that have eroded at hopelessly unequal speeds.

The first is the **volcanic plug rock**, the rhyolite and trachyte. It is among the hardest, least-fractured rock in the region, and it has held so stubbornly that, while the ground around it was stripped back by hundreds of metres, the plugs barely budged. They stand now as the signature peaks of the coast: the Glass House Mountains rising sheer and improbable off the flat plain, Mount Coolum hunched domelike against the sea, Mount Tinbeerwah, and the sharp spire of Mount Cooroora over Pomona. Mount Ninderry, behind Yandina, stands the same way on rock some two hundred million years older: Late Triassic, from a quite separate volcanic episode. Call them mountains if you like, but nothing here was folded or collided or thrust up: they have been *exhumed*,

that frozen volcanic plumbing we watched form, finally out in the weather. The textbook name is a volcanic neck; the honest one is a stump that flatly refused to rot.

The second kind is **basalt**, the runny sheet-lava of the last chapter. It is hard enough to shield whatever sits beneath it, but weathers down from the top into deep, rich, red clay. So where a basalt sheet still caps the land it builds a **plateau or tableland**: a wide, flat-topped upland with steep edges where the protective lid finally fails. This is the Blackall Range (Maleny, Montville, Mapleton), the green wall of the hinterland, and the same story plays out at Buderim, a basalt-capped rise standing head and shoulders above the coastal lowland. Stand at a Maleny lookout with the world dropping away at your toes, and understand what you are looking at: not a cliff that was heaved upward, but the cut edge of a lid being quietly undermined.

The third kind is the **softer foundation rock**, the ancient basement and dinosaur-age sandstones we met earlier, wearing their local names here: the folded marine sediments of the Amamoor and Booloumba Beds in the Conondale Range country, and the Early Jurassic Landsborough Sandstone that floors much of the coastal lowland. Weaker, more shattered and more easily worn, it does the precise opposite of the plugs: it slumps into **low rolling hills and broad valleys**, the ground the rivers have had the easiest time chewing through. Most of the settled coast, from the Maroochy valley to the low country around Caloundra and Landsborough, is written on this softer foundation: the ground that gave way, and the ground most of us live on.

And draped over the lowest, youngest country of all comes the fourth material, hardly rock at all: **unconsolidated sand**, the great coastal drifts. Having no hardness to call on, it forms the flattest land there is: the coastal plains, the barrier islands, the dune fields of Cooloola. Its shape owes nothing to resistance and everything to wind and water, both still at work on it as you read this.

Sidebar — Why the Glass House Mountains are mountains at all. Whatever their shape suggests, the Glass House Mountains were never built up into the sky at all. Chapter 2 told the plug story; the point worth adding *here* is what erosion did next. The land surface around the peaks was lowered instead — hundreds of metres of it, carried off grain by grain to the sea. Tibrogargan and Beerwah stand tall today only because everything that once stood as tall beside them, but softer, has gone. Give erosion a few more million years and even these hard cores will follow.

Why hard is hard, and soft soft

The rule invites a further question: what makes one rock hard and another soft, when both are built from much the same minerals? The answer is only partly the rock's own toughness; far more of it comes down to a humble thing: cracks.

Rain does not attack a rock evenly, all over at once. It gets in wherever there is a way in — along the joints and fractures that split almost every body of rock, the planes of weakness left by cooling or by the flexing of the crust. Once inside, water works less by brute force than by slow chemistry, rotting the minerals along the crack walls into clay and carrying them away dissolved. A rock laced with joints is riddled with doorways and crumbles from the inside out; a rock with almost no joints — dense, unfractured, cooled slow and solid deep in a volcanic throat — offers the weather nowhere to grip, and simply endures. So the plugs stand not only because their rock is hard but because it is *whole*; the soft foundation gives way not only because it is weak but because it is broken, the weather already inside it everywhere at once.

You can watch this happening, paused mid-act, in one of the most recognisable sights in the bush: a jumble of great rounded boulders heaped on a hillcrest, as though a giant stacked them there. Nobody did. They are corestones — the last, unrotted hearts of what was once a single mass of jointed rock. Water crept in along the joints and rotted each block inward from every crack until only a rounded kernel of sound stone was left in a matrix of its own weathered remains; wash the soft matrix away, as rain and

slope eventually do, and the cores tumble together at the surface, stone spheres that were never round when they formed. Every such boulder pile is a working diagram of how this country wears away: at the cracks first, always, and the sound rock last.

Sidebar — The cracks that come built in. Some of the joints that let the weather in were there from the rock's very first day, made in the act of its own cooling. When a thick sheet or plug of lava cools and hardens it shrinks, and shrinking rock, like drying mud, cracks. Sometimes it cracks into a remarkably regular set of tall, many-sided columns, the “columnar jointing” of the great organ-pipe basalt cliffs seen the world over, and visible on the harder volcanic rock of this region too. The most striking local example is the tall trachyte columns on the north face of Mount Beerwah, known, aptly, as the Organ Pipes. It is a small marvel of physics: molten rock, cooling, spontaneously dividing itself into neat polygonal pillars. It is also, in the long run, a set of ready-made doorways for water, splitting the rock into blocks before erosion has lifted a finger. Cooling builds the cracks; the weather, over the following millions of years, moves in through them. Even the way a rock will one day fall apart was, in some measure, decided at the moment it was born.

Reading a landform without leaving the car

Once the rule is properly in your hands, you can do something smugly useful: look at a hill and name its rock before you have so much as touched it. The *shape* gives the game away, because each kind of rock erodes into its own silhouette, as recognisable as handwriting.

A **steep-sided, lonely peak with a sharp summit or a bare rock face** is almost always a volcanic plug, too hard and unbroken to round itself off into anything gentler. The Glass House peaks, Coolum, Cooroora and Ninderry all announce themselves this way from a kilometre off.

A **broad, flat-topped upland with a distinct steep rim** is a basalt cap: the flatness is the old lava surface lying where it cooled, the rim the eroding edge eating inward. The Blackall Range and Buderim both read this way. The clincher is underfoot — basalt weathers into that deep chocolate-red, clay-rich soil, the richest in the region, which is precisely why these uplands carried rainforest first, and dairy farms and avocado orchards later.

Low, rounded hills and open valleys are the telltale mark of the softer sedimentary and metamorphic basement: with no single resistant layer left to hold a sharp edge, the land relaxes into gentle curves, like a face going soft with age. This is the open eucalypt-forest country of the foothills.

And **dead-flat ground close to the coast** is sand, or river-laid alluvium, too young and too soft to have grown any shape of its own just yet.

You can often begin reading all this before you have named a rock, because the living cover draws the same map. Forest pours into the soft-floored gullies and crowds the deep-soiled basalt, while the hard, bare ridgelines carry only a wiry scatter that seems to hang on out of sheer obstinacy. Why soft ground should grow such lavish forest and hard ground so little is a story the next few chapters will tell in full; for now, notice that the plants obey the rock as faithfully as the shape does.

This is why the drive described at the start of Chapter 7 works as reading rather than mere sightseeing. The cool, red-soiled rainforest at the top sits on basalt; the open eucalypt slopes below it on the softer foundation rock; the flat cane country on river alluvium; and the bright, bleached heath at the bottom on sand. Learn the rock, and the rest of the drive reads itself.

Sidebar — Two soils, two worlds, one rainfall. Drive from a Maleny lookout down to a Glass House foothill and the country changes utterly: one patch grows lush rainforest, the other dry, grassy woodland. The range is the wetter of the two (it is the wettest ground on the coast), but nowhere near wet enough to account for that on its own, and the whole of the remainder lives in the rock. The basalt of the range rots down into deep, water-holding, nutrient-rich clay; the harder rocks and sandstones of the lowland yield only a thin, hungry, free-draining soil that lets everything run straight through it. For the cleanest proof, take a single hillside. On Mount Ninderry, behind Yandina, the thin dry soil of the exposed slopes grows open, grassy, fire-loving forest, while a few steps away in the gullies, where deeper soil collects and the air stays damp, the very same hill grows tall wet forest edging toward rainforest. One hill, one sky, one rainfall, two worlds — and the ground deciding which is which. This is the single most consequential thing rock ever does: it decides what kind of soil it will become, and the soil, in its turn, decides very nearly everything else that follows.

Why the rivers run where they do (and one that runs the wrong way)

The drainage of the region is the rock's signature too, written in water rather than stone. Rivers are not the free spirits we imagine; they are opportunists, threading along the softest, most fractured ground they can find and steering meekly around anything hard. The Maroochy, the Mooloolah and the Mary all trace the grain of the older, weaker foundation rock and the joints in the volcanic country: the plain reason their valleys lie where they do and not somewhere else.

The Mary River takes this to a perverse extreme. It runs, for a coastal river, almost defiantly the *wrong way*: north, away from the sea that sits right there beside it, before finally reaching the coast far up at the Great Sandy Strait. You might wonder what it thinks it is playing at. The answer is that it has no choice in the matter. The high basalt and volcanic country of the hinterland

raises a divide the river simply cannot climb over, so it does the only thing water ever does: it gives up on the short, hard route and takes the long, soft one, following the lower, weaker ground all the way around. A river that appears to be defying geography is obeying it to the letter.

Over millions of years, this same opportunism is how the post-card scenery gets made. A river cutting down through a basalt-capped plateau carves a gorge, the hard cap left hanging waterfalls at the lip; the celebrated falls of the Blackall Range hinterland, which every visitor dutifully drives up to admire, are nothing more mysterious than the points where a stream is sawing through the resistant basalt edge. Each waterfall is the leading edge of erosion working backwards into the plateau, shaving it smaller year by year. The scenery we travel an hour to photograph is, in plain truth, a freeze-frame of the land caught in the act of wearing itself away.

How long all this took

The hardest idea to hold steady here is the timescale, the one Chapter 2 squashed into a single day. The volcanoes fell silent something like twenty-five million years ago, and everything since — the stripping away of whole mountains of softer rock, the exhuming of the plugs, the carving of every valley and gorge, the lowering of the surface by hundreds of metres — is the patient work of erosion across all that time, too slow for any human eye to catch, yet grindingly relentless against deep time.

This is why geologists call it old, stable country, and mean it almost fondly: no great recent uplift, no continents colliding to throw up fresh mountains, no glaciers grinding it into shape — just rock of different hardnesses, left out in the weather for an immense span and wearing down at its own rates. The landscape is not a thing once made and then finished, like a building, but a process caught in the middle of happening, and every peak, plateau and plain around you measures two things at once: how far the wearing-away has got, and how stubborn each piece of rock turned out to be when its turn came.

Reading the country

The next time you find yourself standing somewhere on the Sunshine Coast, look first at the shape. A lone sharp peak is a hard volcanic plug, the survivor of a vanished mountain. A flat-topped green range with a steep rim and red earth is a basalt lid still holding the line, the richest soil in the region under your boots. Rolling hills and open valleys are the softer foundation, worn gentle; dead-flat coast is young sand, still being arranged and re-arranged by the sea. Four shapes, four rocks, and behind them one absurdly simple rule: hard stands, soft falls. Hold it, and every hill on the horizon suddenly has a reason.

The next chapter follows the handover from rock to soil, and why the soils of the Sunshine Coast, from the deep red clays of the range to the bottomless bleached sands of Cooloola, hold the real key to everything that grows here.

Chapter 4 • Soil

Everything that lives on land lives, in the end, off the few centimetres where rock has learned to hold life.

A few kilometres apart, under the same sky and the same rain, the Sunshine Coast grows towering rainforest on one soil and a riot of wildflowers on little more than bare sand on the next. The whole of that difference is held in the thin living skin where rock meets air: soil, the most overlooked presence in this landscape and the most decisive. Learn to read the soil and you can read the country, and one stretch of coast just north of Noosa is among the best places anywhere to learn how.

The last chapter ended on a handover, the most consequential one in the region: rock decides what kind of soil it will become, and the soil decides very nearly everything after that. This chapter follows that handover down into the ground. It is, by some distance, the most internationally celebrated science the Sunshine Coast has to offer, though you will search the tourist brochures in vain for it, because hidden in plain sight here is a natural experiment so clean that scientists have flown across the world to stand in it. It has taught us how soils are born, grow up, grow old and finally fail, and why, in flat defiance of common sense, the very poorest soil can carry the very richest life.

How a dune's soil ages — and why the forest on it rises, then shrinks.

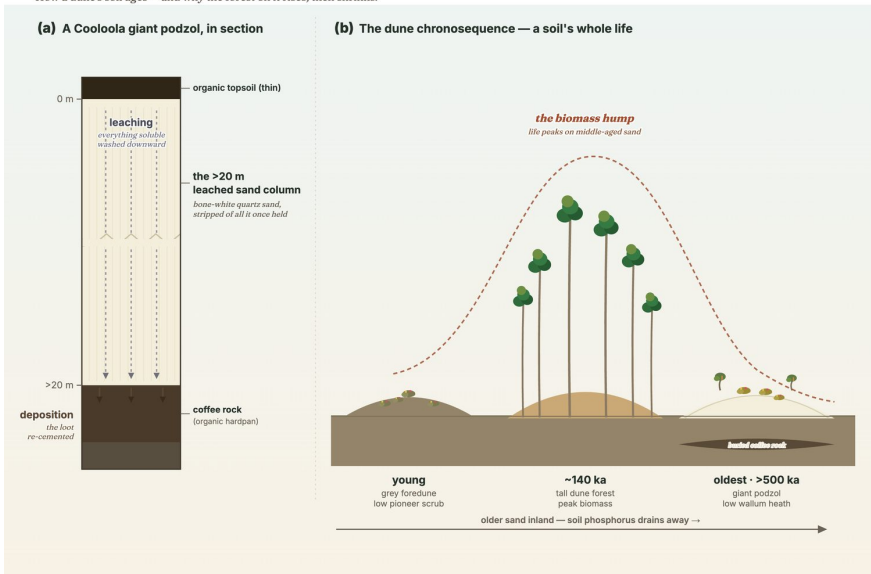


Figure 4.1 — The giant podzol and the dune chronosequence. The bleached column is quartz sand stripped of everything soluble; walk inland onto older sand and the forest itself shrinks as the phosphorus drains away.

How rock becomes soil

First, clear up a misunderstanding, because almost everyone has it. Soil is not crushed-up rock; it is rock that has been taken to pieces, chemically rebuilt, blended with the dead and the living, and sorted into layers, a slow and patient collaboration between weather, water, time and an enormous cast of organisms, most of them too small to see. Rain and acids dissolve the soft bits and carry them off. What stubbornly resists becomes the mineral skeleton. Plants and microbes pile on carbon, knit it all into crumbs and clods, and pump nutrients up from below and in from the air. The end product is layered, like a slightly grubby cake: dark, living topsoil over paler, leached subsoil over weathering rock. Read those layers and you read the soil's entire biography.

Two properties decide most of what a soil can do, and both will follow us the rest of the way. The first is **texture**, clay or sand, which decides how the soil holds water and air. Clay clings to wa-

ter and nutrients with a miser's grip; sand lets both run straight through as though through a sieve. The second is **fertility**: how much nutrient the soil holds, above all nitrogen and phosphorus.

And here we arrive at the asymmetry on which the whole Cooloola story swings: **nitrogen can be replaced from the air, but phosphorus can only come from rock**. Certain microbes and plants can haul nitrogen straight out of the atmosphere and bank it in the soil; nothing whatsoever can do that for phosphorus. Once the original rock's phosphorus has weathered out and washed away to sea, that is the end of it — no resupply, no second delivery, not ever. Hold on to that one fact and you can predict the fate of any soil on Earth given enough time, which, fortunately, is the one thing soil has in abundance.

The region's soils, in four families

The rock map of Chapter 3 becomes a soil map almost without translation. There are, near enough, four families.

On the **basalt** of the Blackall Range, Buderim and Mapleton, the old lava rots down into deep, red, well-structured clay, the soils a scientist calls a Ferrosol and your grandfather called a krasnozem. They are red for the same reason rust is red: iron, oxidised. They hold water, they hold nutrients, and they are the most fertile ground in the region by a wide margin. This is precisely why the basalt uplands carried the original rainforest, and then, once that was felled, the dairy farms, the small-crop country and today's avocado and macadamia orchards. Rich rock, rich soil, rich growth: the most intuitive story in the region, and almost the only one.

On the **softer sedimentary and metamorphic basement** of the foothills, the soils are thinner, mixed and resolutely middling: often a sandy or loamy topsoil sitting on a clay subsoil. This is the open eucalypt-forest country: not poor enough for heath, not rich enough for rainforest, and so getting on with being neither.

On the **floodplains**, where the rivers have spent millennia laying down silt and clay, the alluvial soils are fertile and easy to plough, which is exactly why this is the most thoroughly cleared land on the coast, handed over long ago to sugar cane and small crops.

And then there are the **coastal sand masses**, the wallum and the great dune fields of Cooloola, where the soil is sand essentially all the way down: bottomless, bright, acidic and astonishingly, almost comically, poor. These are the soils that hold the famous science, and they have earned the rest of the chapter to themselves.

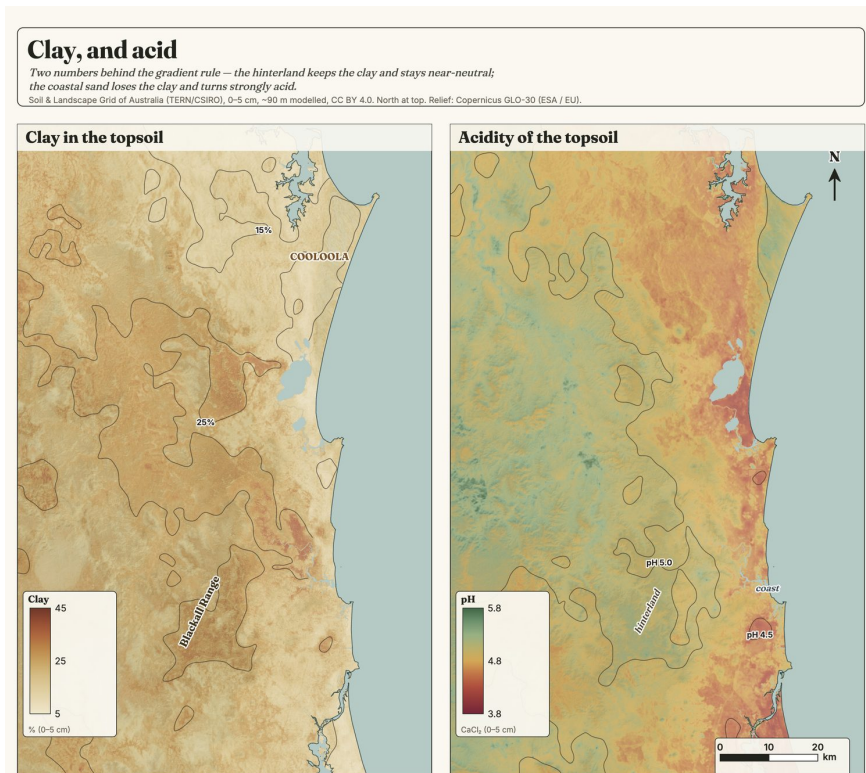


Figure 4.2 — Clay and acid. The gradient rule written in the soil: the basalt hinterland holds clay and stays near-neutral, while the coastal lowland thins to near-pure sand and turns strongly acid — the sour ground of the wallum.

The nutrient arc: young, middle-aged, old

In 1976 two soil scientists named Walker and Syers published a model of what happens to a soil over very long spans of time, and it has since become one of the bedrock ideas in the field. Boil it down and it is a story in three acts, and every act turns on that asymmetry between nitrogen and phosphorus.

A **young** soil — fresh sand, fresh volcanic ash, fresh river silt — arrives with a decent stock of phosphorus locked up in its minerals but next to no nitrogen, because nitrogen has to be built up, slowly and biologically, out of thin air. Young soils are therefore short of nitrogen: add some and everything grows faster. Over centuries, nitrogen-fixing organisms steadily bank it into the system, and the soil's fertility climbs toward a peak. So far, so cheerful.

A **middle-aged** soil has plenty of nitrogen in the bank, but its phosphorus is now draining away, leached out in water, and locked, molecule by molecule, into chemical forms that no root can prise open. The balance of power tips.

An **old** soil has been so comprehensively stripped of reachable phosphorus that it runs short of it for good, and because phosphorus cannot be replaced from the air, this shortage only ever deepens. On the most ancient soils the system itself goes into reverse, a melancholy process ecologists call retrogression: it loses productivity as the last accessible phosphorus vanishes. This is the part people find hardest to accept. Soil does not improve forever, like a wine. It matures, then it ages, then it winds down to almost nothing.

To *test* an idea like that, you would need a row of soils identical in every respect, the same parent rock, the same climate, the same vegetation history, differing in one variable only: age, ideally across hundreds of thousands of years. Such a thing has no business existing anywhere on Earth. It exists at Cooloola.

Cooloola: a time machine made of sand

Just north of Noosa, the coast has been quietly building itself out of sand for an extraordinarily long time. Wind and sea threw up dune after dune, and, this is the magical part, they did it in order, like tree-rings laid out flat: the youngest dunes nearest today's beach, progressively older ones marching inland, the oldest set right back perhaps seven or eight hundred thousand years. Everything else about them barely changes. Same quartz sand, same rainfall, same mild coastal air. The only thing that varies as you walk inland is **time**.

Stop and let that sink in, because it is one of the wonders of Australian science. Walk from the beach toward the hinterland and you walk *forward* through several hundred thousand years of soil development, reading the entire life story of a soil in a single afternoon's stroll. There are vanishingly few places on the planet where deep time is laid out this tidily and this legibly, and scientists come to read it like a manuscript.

What they find is the Walker-Syers arc made flesh. On the young foredunes the sand is grey, faintly fertile, and the plants are limited by nitrogen. Move inland and the soils take on the unmistakable architecture of a **podzol**: dark, organic-stained sand at the top; then a band of pure, bleached, bone-white sand beneath it, the part that pulls first-timers up short; then, sometimes many metres down, a dark, coffee-coloured, cemented layer where everything the rain stole from above has finally come to rest. On the oldest dunes these podzols are simply enormous, the bleached column plunging more than twenty metres down — a six-storey building's worth of white sand, among the deepest soils of their kind anywhere on Earth, and important enough to be written up in the journal *Nature* back in 1981. And the phosphorus, the nutrient that cannot be replaced? Measured along the sequence, the available phosphorus falls away, dune by dune, until only a small fraction of the young dunes' modest stock is left. The most ancient Cooloola soils are, in nutrient terms, about as close to nothing as a soil can be while still, against all odds, holding up a forest.

Sidebar — What white sand is trying to tell you. That dazzling white sand under the wallum is not clean because someone washed it. It is white because it has been *robbed*. Rain trickling down through the surface litter picks up organic acids, and those acids go to work like solvent on every grain, stripping off the microscopic coatings of iron and aluminium, and with them the colour, and carrying the loot, along with dissolved organic matter, down into the depths. What is left near the surface is naked quartz, bleached to the bone. The stolen goods are dumped far below as that dark, rusty, sometimes rock-hard layer the locals call coffee rock. The act of larceny has a name, podzolisation, and it is the unmistakable signature of an old, leached, profoundly poor soil. So the next time a stripe of brilliant white sand surprises you in the bush, read it correctly. You are not looking at a beach that lost its way and wandered inland. You are looking at the fingerprint of a crime: a soil that has had everything useful leached out of it over tens of thousands of years.

A walk through half a million years

So take the walk the sequence invites, inland from the beach, and watch not just the soil but the whole living world age along with it, now with an eye to what grows on each dune as much as to what lies beneath it.

Start on the young grey sand just behind the beach. The soil here is barely a soil at all: pale grey, thinly organic, still carrying a modest dose of the phosphorus the sand arrived with, and short mainly of nitrogen. The plants match it: low, salt-hardy pioneers on the front, and a little inland a scrub of coastal she-oak and banksia, quick colonisers of raw ground. Young soil, young vegetation, everything still on the way up.

Walk on, onto dunes a hundred and forty thousand years old, the biggest ridges in the whole field and nowhere near the oldest, and the country does something that startles anyone who expected poverty to mean bareness: it grows *tall*. On these middle-aged sands, with nitrogen now banked up by generations

of wattles and enough phosphorus still within reach, stands the tallest, densest forest of the whole sequence — high eucalypts, a closed canopy, real timber standing on bottomless sand. This is the summit of the arc, the moment a soil is old enough to be rich in nitrogen and still young enough to be solvent in phosphorus. Knowing nothing of what came before or after, you would call this the best country of the lot.

Then keep walking, onto the older dunes, and watch the forest begin, almost imperceptibly, to come down. The giants thin and shorten; the canopy opens; the understory hardens and closes in. You are walking down the far side of the arc now, into retrogression, written in a forest slowly losing the height it can no longer afford.

And at the far end, on the oldest dunes of all, the ones whose bleached podzols plunge twenty metres and more, the forest has given out altogether. What stands on the most ancient sand is not forest but the wallum: low, wiry, hard-leaved heath, knee- to head-high, growing on ground so stripped of phosphorus that a tall tree can no longer be built on it. It looks, at a glance, like the poorest and most defeated country on the entire walk. It is very nearly the richest. The two arcs have crossed: the *mass* of the vegetation peaked back on the middle-aged dunes and has fallen away to almost nothing, while the *variety* of it has climbed, dune by dune, to its maximum here on the oldest, hungriest sand. In one walk you have watched a soil, and the forest riding on it, born, grow up, grow rich, grow old, and run down at last to a low, brilliant, threadbare heath — the entire life of a landscape, laid out in order along a few kilometres of sand.

Sidebar — A clock made of sand. How can anyone possibly know that the oldest of these dunes is seven or eight hundred thousand years old? The answer is one of the neater tricks in modern science, and it turns each grain of sand into a tiny clock. A buried grain of quartz sits in a faint, steady drizzle of natural radiation from the sand around it, and that radiation slowly knocks electrons loose inside the crystal, where a few become trapped in its flaws and build up, year on year, like charge accumulating in a battery. The crucial part is that sunlight empties the trap: expose the grain to daylight and the stored charge drains away to zero. So the last time a grain saw the sun, the very moment the wind flipped it up into the growing dune and buried it in the dark, its clock was wiped to zero and began filling again. In the laboratory, under safe light, a scientist stimulates the grain with light and measures the faint glow it gives back, which is proportional to the dose it has soaked up since it was buried; divide that by the known rate of the local radiation drizzle, and out comes the time since the grain last saw daylight. The method is called optically stimulated luminescence, and it is how the dunes of Cooloola were read, grain by grain, into a calendar. Every dune is, quite literally, full of buried clocks, each one stopped on the day it was covered over.

Why the poorest soil grows the richest flora

Now for the paradox promised at the very start, and the deepest lesson Cooloola has to teach anyone. Common sense insists that the rich red basalt should carry the greatest variety of plants and the starved white sand the least. Common sense, here, has it almost exactly backwards. The wallum heath on the oldest, poorest sand is one of the most species-rich plant communities in the entire region — banksias, grevilleas, peas, boronias, wildflowers, ground orchids, glittering carnivorous sundews — while the rainforest on the richest soil, for all its cathedral grandeur, runs on a comparatively short cast of large trees. The poor ground is the crowded one, and the reason is worth chasing down.

The first half of the answer is competition, and it is almost a parable. Where soil is rich, a few fast, greedy plants grab the abundant nutrients, shoot up, and shade and crowd everyone else into oblivion; abundance, perversely, narrows the field to a handful of bullies. Where soil is desperately poor, *no* plant can grow fast enough to lord it over the others, so the door is thrown open to hundreds of specialists, each scratching a living a slightly different way. Poverty is a great leveller and a greater diversifier.

The second half is the more astonishing. As the soil grows poorer, the *number of different tricks plants use to find nutrients* goes **up**, not down. Work on long, ageing dune chronosequences has shown that nutrient-acquisition strategies multiply as phosphorus dwindles, and that this very diversity of strategies is a large part of why the diversity of species runs so high. The tricks are worth knowing one by one, because you can collect the full set on a single morning's walk through the wallum:

- **Striking deals with fungi.** Most plants here run their roots in partnership with mycorrhizal fungi, which vastly extend their reach into the soil and trade scarce nutrients for plant sugars, a sort of underground barter economy. Different plants strike different fungal deals, each tuned to a different sliver of the soil's meagre stores. One neat local study grew the wallum scribbly gum beside a pampered, fertile-country relative and found that what decides how hard a tree leans on its fungi is not which tree it is but what ground it stands in: on wallum sand both depended heavily on the partnership, on rich soil neither much bothered.
- **Mining the soil by chemistry.** The banksias, grevilleas and hakeas (the Proteaceae) grow dense brushes of so-called "cluster roots" that flood a patch of soil with acids and enzymes, prising loose phosphorus that is chemically locked away from almost everything else. It is the botanical equivalent of dissolving the safe to get at what is inside.

- **Eating animals.** Where the ground simply cannot supply enough nitrogen, some plants get it from meat. The sundews glittering in the wet heath, and the bladder-worts lurking in the swamps, trap and digest insects, a direct and slightly sinister end-run around the poverty of the soil.
- **Pulling nitrogen out of the sky.** The many native peas and wattles partner with bacteria that fix nitrogen straight from the atmosphere, banking the one major nutrient the air is willing to hand over for free.

The thread tying every one of these together is the hard, tough, long-lived leaf, the “sclerophyll” leaf that gives this whole style of Australian vegetation its name. Think about it from the plant’s point of view: if you have spent precious, near-irreplaceable phosphorus building a leaf, you cannot possibly afford to throw it away after a single season. So you make it tough as old boots, defend it grimly against being eaten, and keep it for years. Poverty, in the plant world, breeds ingenuity, and ingenuity breeds variety. That is the engine humming away beneath the wallum, and Cooloola, with its bottomless podzols and its long slide into phosphorus poverty, is one of the places the world has learned to read it.

Sidebar — The most valuable worthless real estate in ecology. Cooloola is freakish, and here is exactly how. To compare soils of different ages anywhere else on Earth, a scientist has to hunt down sites that differ in age but match in everything else, and climate, rock and history almost never cooperate; they are forever changing more than one thing at once, which is the bane of anyone trying to run an experiment. Cooloola hands it all over for nothing: a clean sequence spanning the best part of a million years, same sand, same sky, only time changing. Which is the lovely irony. A stretch of “useless” coastal scrub, twice fought over by sand miners who could see nothing in it but the heavy minerals in the dunes, turns out to be one of the most scientifically precious landscapes in the country. The land that looks worthless by the measure of a paddock is very often the most irreplaceable by every other measure there is.

Reading the ground

Add soil to the short list of things you can now read at a glance. Deep red earth on a basalt range tells you the richest soil going, rainforest and orchard country; thin, mixed soil on rolling foothills means open eucalypt forest; dark, fertile flats beside a river are cleared floodplain. And bright, bleached, bottomless sand is the oldest and poorest ground of all and, wonderfully, against every expectation, often the most diverse, where sheer poverty has bred a thousand specialists. Same sky, different ground, different world; and the ground, under that sky, is the reason why.

There is one element we have so far treated only as a villain: the water that strips the phosphorus, fills the swamps, and stains the wallum streams the colour of strong tea. Water is the next great force to understand: the rivers, estuaries, dune lakes and hidden aquifers that seep through these soils and bind the whole gradient together.

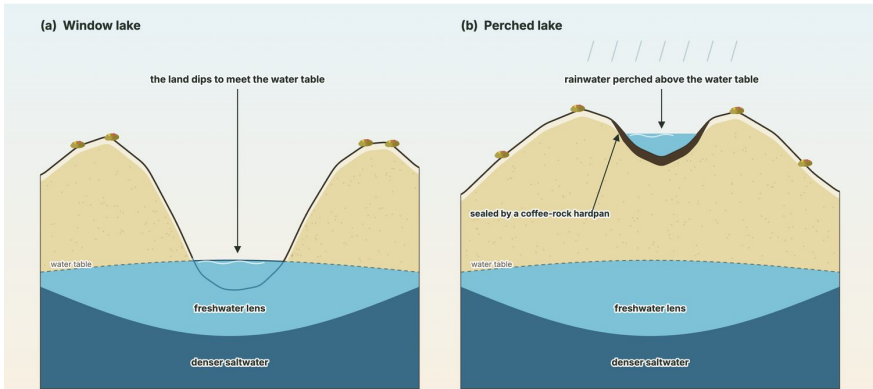
Chapter 5 • Water

Rock decides the shape of the land and soil decides what will grow on it; water decides how the two are joined.

The rock beneath this landscape has sat here for twenty-five million years, and the soil takes hundreds of thousands of years to age; water does its whole job in an afternoon's rain, and never stops moving. It carries the range's rain down to the sea, strips the phosphorus from the dunes, fills the swamps and stains the streams the colour of strong tea. And, strangest of all, it hides a vast freshwater store beneath the driest-looking sand you can find. To finish reading the physical stage, you have to stop looking at the scenery and follow the water.

We left water, at the end of the last chapter, with something of a bad reputation. It was the thief: the agent that trickles down through the sand, picks the pocket of every grain — its iron, its nutrients, its colour — and makes off with the lot, leaving behind the bleached, bottomless poverty of the wallum. All true. But it is a slander to leave it there, because larceny is only one item on water's very long résumé. Water is also the great connector of the gradient from reef to range, the medium in which the whole cross-section is dissolved and shunted about. This chapter follows it through four disguises: the rivers, the estuaries where they hand themselves over to the sea, the hidden aquifer locked inside the sand, and the tea-dark lakes and streams of the wallum.

Fresh water floats on salt inside the sand — a lake either reaches down to it, or perches above it.



Schematic cross-sections; the freshwater lens floats on denser saltwater in the manner of Ghyben-Herzberg. Not to scale.

Figure 5.1 — Dune lakes: window and perched. Two ways to hold a lake in a heap of sand — dig down to the water table, or seal a basin above it with a pan of coffee rock.

Water as the courier

Begin with the simplest picture. Rain falls; gravity takes it to the sea. End of story. Except that the part that matters is not *that* the water gets to the sea but *how*, because the route it takes on the way down decides very nearly everything it does.

On the basalt range, rain lands on deep clay soil that holds it like a sponge and lets it go grudgingly, a little at a time. This is why the hinterland stays green through the dry, why its gullies run clear and cool, and why rainforest can afford to live there at all. On the thin foothill soils the water is in much more of a hurry: it runs off fast and the country dries hard between rains. And on the coastal sand it does something different again. It sinks more or less straight down, vanishing from the surface into the body of the sand mass, where it may wander underground for *years* before it troubles a stream. The same rainfall, falling on the four grounds of Chapter 3, takes four entirely different roads. Learn where the water goes and you have read, in advance, what is allowed to live there.

The Sunshine Coast catches a generous share of that rain in the first place, most of it in a warm-season wet, roughly summer into autumn, with a drier winter and spring to follow. And the wet comes down hardest against the ranges, which block the moist onshore air and wring it out like a flannel as it is forced to climb. So the high country is at once the wettest part of the region and the birthplace of most of its rivers.

Short, steep, and one river that won't take the hint

The region's rivers are, with a single celebrated exception, short and steep and in a tearing hurry. The Maroochy, the Mooloolah and the Noosa all rise in the ranges nearby and reach the sea within a few tens of kilometres, which means they fall fast, flood fast, and turn tidal a surprisingly long way inland. They are coastal rivers in the truest sense: more estuary than river for much of their length, their lower reaches a slow, salt-tinged dawdle through floodplain and wetland rather than a brisk dash for the coast.

Why they run where they run is the rock's signature again, told in Chapter 3: rivers are opportunists, exploiting the soft and fractured ground and going around the hard. The Mary River makes the point on a grand scale. Rather than taking the short cut east to the sea, it sets off *north* for more than two hundred kilometres, walled off from the nearest coast by the high basalt of the range, and reaches the ocean only far to the north, at the Great Sandy Strait behind K'gari. A river apparently fleeing the nearest sea looks like a blunder until you remember the one rule water never breaks: it cannot climb. It can only find the lowest line the rock will permit.

The character of these rivers also changes as you travel down them, and that change is the whole gradient performed in miniature. The upper reaches are freshwater, often clear and cool where they drain the ranges. The middle reaches slow down, warm up, and pick up the tea-coloured stain of the lowlands. And the lower reaches turn tidal, then brackish, then frankly marine, which is the moment a river stops being a river and becomes an estuary.

When the water comes all at once

Short, steep rivers do not merely run fast; they flood hard, and flooding is not an aberration in this country but one of its basic settings. Because the catchments are small and steep, and the wet season delivers its rain in heavy warm-season downpours, a river like the Maroochy or the Mary can climb from a quiet stream to a brown, bank-topping torrent inside a day, spread out across its floodplain, and fall away again almost as quickly. Every few years the rain is heavier still: the drenching rain of a tropical low or ex-cyclone sliding down the coast, or an East Coast Low reaching up from the south. The flat lower valleys of these rivers are floodplains for the plainest of reasons: they are the ground the river has flooded again and again, and will flood again.

It is tempting to read a flood as pure disaster, and for anyone living on the floodplain it certainly can be. But in ecological terms the flood is not the catastrophe; it is the point. A great deal of the life of a lowland river depends on the water leaving its channel from time to time and spreading out across the flat. The flood pulse, as ecologists call it, does in a few days what nothing else does at all. It carries a load of nutrient and sediment out onto the floodplain, refills the swamps and lagoons and soaks the paperbark forests of the next chapters, connects the river to a scatter of off-channel waters that fish and waterbirds crowd into to feed and breed, and tops up the shallow groundwater the floodplain lives on through the dry. Many of the region's fish and waterbirds take their cue to breed from the flood itself; the wetlands that store and filter the water are built and kept open by it. A floodplain that is never allowed to flood — walled off, drained, built over — quietly loses the wetlands, and the life, that the flooding sustained.

So the flood is the floodplain's counterpart to the fire of the chapter after this: a periodic disturbance that looks like destruction and is in truth a renewal. The difficulty, as ever, is the collision with us, because the flat, fertile, well-watered floodplain is also precisely the ground we most want to farm and to build on.

That is why so much of the region's flood story becomes, in the end, a story of levees and drains and the wetlands lost behind them, a thread the later chapters take up.

Where river meets tide: the estuary

The estuary is the hinge of the entire gradient, the place where freshwater and saltwater, river and ocean, land and sea are stirred together twice a day by the tide. It is also among the most productive habitat anywhere on Earth. The Sunshine Coast's estuaries (the Maroochy, the Mooloolah, the Noosa, the Pumicestone Passage tucked behind Bribie Island) are the nurseries on which the region's fisheries and much of its birdlife ultimately depend.

That world — the mangroves standing up to their ankles in salt, the saltmarsh and seagrass, the extraordinary daily traffic of fish and birds — belongs to Chapter 8. This chapter cheerfully hands it over. But let us fix the principle here, because it is a *water* principle. An estuary works because the tide and the river between them deliver a constant subsidy of nutrients and fine sediment, and because the mixing of fresh and salt sets up a gradient of saltiness that sorts living things into zones as sharply as altitude sorts them up the range. The estuary is where the land's water finally puts down its cargo, and all that richness is built from what it carried.

The sponge beneath the sand

Now to the least visible of the region's waters. Go and stand on the dry, dazzling sand of the wallum, or on the high dunes of Cooloola, in the middle of a proper drought. It will seem the least watery place you could possibly choose. You would, in fact, be standing on the lid of an enormous freshwater store.

A coastal sand mass behaves like a colossal sponge. Rain sinks straight in and gathers as a great lens, a dome, of fresh groundwater held within the sand, floating, because fresh water is the lighter of the two, on the denser saltwater that creeps in from the sea below. In the bigger sand masses this freshwater store is huge and slow: water that enters at the surface may take years, even dec-

ades, to work its way through. And because the sand hoards that water and releases it slowly, the streams, swamps and lakes of the sand country do not pack up and dry out the moment the rain stops. They are fed from below, by groundwater seeping steadily out of the sponge, all year round.

Ecologists have a name for the habitats that live off this hidden supply, **groundwater-dependent ecosystems**, and they are the quiet foundation of the wallum. Recent work on the Cooloola sand mass (Dyring and colleagues, 2025) has mapped just how tightly the wetlands, lakes and perennial streams there are bound to the level and quality of the groundwater beneath them. It is a sobering finding, because it means these ecosystems can be undone by anything that draws the water table down or fouls it: heavy extraction, drainage, the wrong kind of development. The water that keeps the wallum alive is mostly underground, out of sight, and dismayingly easy to wreck without anyone noticing until it is too late.

Sidebar — Why the wallum doesn't die in a drought. By rights, a heath growing on near-sterile sand, in a climate with a long dry season, ought to shrivel up and die every single year. It does no such thing, and the reason is the sponge. Beneath the surface lies a freshwater store so large and so slow that it works as a buffer against the seasons, dribbling water into the roots, streams and swamps long after the last rain has been forgotten. The plants of the wallum are not so much drought-defying as quietly plumbed into a hidden reservoir they did nothing to fill. Lower that reservoir, and the toughness evaporates with it.

The two kinds of dune lake

The sand masses hold the region's most photographed water, the dune lakes, and there are two quite different sorts, told apart entirely by how they relate to that buried store.

A **window lake** is exactly what the name promises. It is a place where the land surface dips down far enough to slice into the top of the freshwater lens, so the lake is simply a window thrown

open onto the groundwater. Its level rises and falls with the water table, and it is part and parcel of the same body of water as the aquifer all around it.

A **perched lake** is the stranger and frankly more wonderful of the pair. It sits *above* the water table, perched, sometimes startlingly high in the dunes, with no groundwater feeding it whatsoever. What holds it up is a basin sealed at the bottom by a layer of organic hardpan: the very same dark, cemented “coffee rock” of Chapter 4, the place where leached humus and iron came to rest, here doing duty as a watertight floor. A perched lake is filled by precisely nothing but rainwater, caught and cupped on this seal. That gives it an almost unearthly purity: very few dissolved nutrients, very little sediment, often glass-clear or stained a clean tea-brown. That also makes it terribly fragile, because everything in it arrived as rain and the only thing keeping it there is an organic layer that took millennia to lay down. Lake Poona, in the Cooloola sand mass, is a classic perched lake of exactly this kind; the larger and more famous examples lie on K’gari (Fraser Island) just to the north, the same sand system carrying on.

A dune lake is the whole sand country shrunk to a single basin: what looks permanent is on loan, and it rests on a structure, a hardpan or a water table, that can be broken in an afternoon and not remade in ten thousand years.

Blackwater: the colour of tea

Anyone who has paddled the upper Noosa River or waded a wallum creek knows the region’s signature water on sight: clear, but deeply stained, the colour of black tea or weak coffee, so dark and still in places that the banks hang upside down in it like a mirror. This is **blackwater**, and it is perfectly clean. It is one of the defining features of the sand country, and it is made of just two ingredients: tannins and acid.

The grandest expanse of it, the still, tea-dark reaches of the upper Noosa that go by the name of the Noosa Everglades, gets a proper visit in Chapter 10.

The tannins are dissolved organic compounds leached out of the leaf litter of the wallum and the paperbark swamps. They are the very same family of compounds that browns the tea in your cup, and they get there in exactly the same way: water steeping slowly through dead leaves. Because the sand holds almost no clay or nutrient to bind them up or break them down, the tannins simply pile up in the water and stain it brown. And that same poverty makes the water **acid**, too: with no clay and no carbonate on hand to neutralise anything, the organic acids from the litter, together with the acids thrown off by the leaching of the sand itself, are left to run the show. They drive the pH of wallum streams and swamps down to somewhere around 3.5 to 4.5, roughly as sour as orange juice, and acidic enough to kill most freshwater life elsewhere in Australia.

Most freshwater life, but, gratifyingly, not all. The acid waters of the wallum are home to a small club of specialists found almost nowhere else, the most celebrated being the “acid frogs”: a handful of species that have learned to breed in water too sour for their competitors and their predators, and so find sanctuary in conditions that everything else reads as poison. Their full story belongs to the chapters on the wallum and its animals (Ch 9 and Ch 16); the peculiar chemistry of this water is a habitat in its own right, not a defect to be pitied. Just as with the poor soils of Chapter 4, the harsh condition does not empty the system out; it filters it, and hands what is left to the few that can take it.

Sidebar — Reading water by its colour. Colour is to water what shape is to a landform: a first, fast reading of what a thing is and where it came from, free of charge, from the nearest bridge. Water that runs clear and cool off a green range is basalt water, filtered through deep clay and relatively rich. Brown and turbid after rain, hauling suspended clay and silt along with it, is floodplain or foothill water, loaded with sediment and racing. And the clear-but-tea-stained kind, dark and acid and still, is sand-country water: blackwater, steeped in litter, leached of nutrient, the unmistakable fingerprint of the wallum. Three waters, three origins, and you can very often tell them apart at a glance before you have even got out of the car.

Reading the water

So add water to the short list of things you can now read at a glance. Clear cool streams off a green range mean basalt country, rich and reliable; brown rivers heavy with sediment, the soft foothills and the floodplain. A bright dry heath that somehow never quite dies in the drought is sitting on a hidden freshwater sponge beneath the sand, and a lake perched impossibly high in the dunes is rainwater cupped on a seal you could break with a backhoe. Then there is dark, still, tea-coloured water, as acid as it is beautiful: the blackwater of the wallum, leached and specialised and found almost nowhere else. The same rain falls on the coast; what splits it into these separate worlds is the route it takes afterwards: down a basalt creek, out to sea through an estuary, or into the sand to sit for a human lifetime before it sees daylight again.

Water shapes this landscape by being present. The last of the great physical forces shapes it by arriving and then leaving: the dry season and the drought that come in behind the wet, drying the litter and the heath until they will carry a flame. Where the water recedes, the next chapter begins — fire, which has burned through this country for longer than people have walked it, and which the people learned, in their turn, to take up and wield.

Chapter 6 • Fire

This is a country that learned the language of fire, struck a bargain with it, and in a great many places can no longer live without it.

Of the four great forces in this opening section — rock, soil, water and fire — three seem to belong together, and one seems an intruder. Rock, soil and water are the patient, building, life-giving kind. Fire is the one that arrives roaring and leaves everything black. It is tempting to file it under disaster, an accident that befalls the bush from time to time and that the bush survives in spite of itself. That instinct is almost entirely wrong, and unlearning it is what this chapter is for. Across most of the Sunshine Coast, fire is one of the things the vegetation is *made of*, as much a part of how these plants live as rain or sunlight, and a great deal of what grows here would simply vanish without it.

The last chapter ended with the water receding, the wet drawing back into the dry season, the litter and the heath drying until they will carry a flame. Australia is one of the most flammable continents on Earth, and it did not become so by accident: tens of millions of years of drying climate, nutrient-poor soils, and a flora that took to oil and tough leaves have together built a landscape primed to burn, and a cast of plants that have gone beyond surviving fire to actively *summoning* it. To finish reading the physical stage, you have to understand the flame that runs across it.

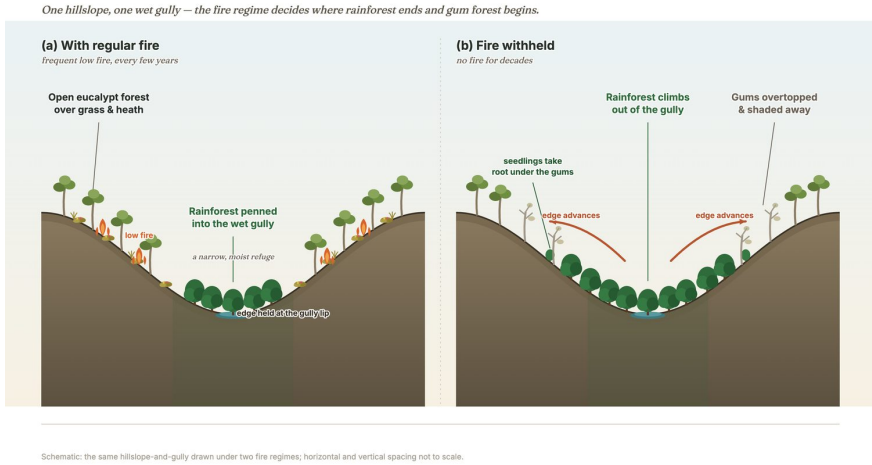


Figure 6.1 — Fire draws the line. Burn often and rainforest hides in the wet gullies; hold the fire back and it climbs out and shades the gum forest away.

The continent that learned to burn

Start with a question that sounds simple and is not: why does anything burn here so readily in the first place? Plenty of the world's forests are wet enough, or cold enough, or simply too well-fed to catch alight more than once in a century. Australia is none of these things, and the eucalypts that dominate it are, frankly, a fire hazard with leaves on.

Consider what a eucalypt is actually carrying around. Its leaves are loaded with volatile oils, the very oils that scent the bush on a hot day and hang as a blue haze over the ranges, and oil, as anyone who has cooked with it knows, does not take much persuading to ignite. The tree sheds vast quantities of litter, all of it slow to rot on poor soils and piling up into ready-made kindling. Many species hang on to long streamers of loose, fibrous bark that carry flame up from the ground into the crown like a wick. Put it all together and you have a tree that does everything but strike the match. The uncomfortable conclusion, which ecologists arrived at slowly and reluctantly, is that the eucalypt is closer to an arsonist

than a victim — a plant that has made itself flammable on purpose, because fire clears away its slower, softer competitors and leaves it holding the ground.

That only makes sense, of course, if the eucalypt can walk away from the blaze it encourages, and here is where the real genius shows. The fire-country plants of the Sunshine Coast carry an armoury of tricks for surviving, and often profiting from, a fire that would be the end of almost anything else.

- **Bark as a fire blanket.** Many eucalypts wrap themselves in thick, insulating bark that lets the trunk char on the outside while the living tissue beneath rides out the heat unharmed.
- **Buds in hiding.** Beneath that bark, and deep in the wood, eucalypts keep dormant “epicormic” buds tucked away from the flames. Within weeks of a fire that has stripped a tree to a black pole, these burst out all along the trunk in a green fuzz of new leaves — one of the most hopeful sights in the Australian bush, and one of the strangest the first time you see it.
- **A bank vault underground.** Many shrubs and smaller trees grow a swollen woody base called a lignotuber, a buried store of buds and energy, so that when fire takes the plant above ground it simply resprouts from the rootstock, as though nothing much had happened.
- **Seed that waits for fire.** The banksias, hakeas and grevilleas of the wallum lock their seed inside hard, woody fruits and hold it there, sometimes for years, releasing it only when the heat of a fire cracks the fruit open, so the seed falls onto a freshly cleared, freshly fertilised ash-bed, its competitors burnt away and its moment perfectly chosen. Others keep their seed in the soil and germinate only when they taste the chemicals in smoke, a cue that says, in effect, *the coast is clear and the neighbours are gone*.

- **Flowering on cue.** The grass-trees — the *Xanthorrhoea* that everyone recognises and almost nobody can name — will often throw up their tall flower spike most spectacularly in the season after a burn, as though the fire had flipped a switch.

These are not the tricks of a plant gritting its teeth through a disaster. They are the equipment of one that has folded fire into its life cycle so completely that to remove the fire is to remove something it lives by. For much of this country, fire is the gardener, not the enemy.

The truce fire keeps

Fire's deepest work on the Sunshine Coast has nothing to do with killing plants or releasing seed. It is to settle, again and again, the long-running border dispute between the rainforest and the eucalypt forest.

These two worlds are opposites, and they want opposite things. The eucalypt forest, as we have seen, promotes fire and thrives on it. The rainforest does the reverse, defending itself by denying fire a start rather than by resisting it: a patch of rainforest keeps its own interior dark, damp and still, its litter moist and slow to ignite, so that fire approaching from the dry forest outside falters at the green wall and goes out.

This sets up one of the great balancing acts of Australian ecology, and the Sunshine Coast displays it beautifully. Where fire comes often enough, the eucalypt forest and the heath hold the ground, and the fire-sensitive rainforest is penned into the gullies and gorges too wet to burn. But let the fire stop for long enough, and the rainforest begins to advance. Its pioneer trees creep out from the damp gullies into the eucalypt forest, their shade thickening, their moist litter smothering the grassy understorey, until the country is too damp to carry a fire at all and the eucalypts, unable to regenerate in the gloom of their own usurped forest, are slowly shaded into local extinction. The rainforest does not need to defeat the eucalypts. It only needs the fires to stop, and time.

So the boundary between these two forests, which looks on a map like a fixed line, is nothing of the sort. It is a frontier held in place by fire, advancing or retreating with how often the flame comes through. Get the fire regime right and you keep both worlds; get it wrong in either direction and you lose one of them.

Sidebar — The forest that puts itself out. A forest whose chief survival strategy, in one of the most flammable landscapes on Earth, is to be too wet to burn sounds like a contradiction. Yet that is exactly the rainforest's method, and it works through sheer architecture. The closed canopy blocks the sun and the drying wind; the air beneath stays humid; the deep, fast-rotting litter never gets the chance to dry into kindling. A fire that would race through the eucalypt forest next door reaches the rainforest edge and simply runs out of fuel, like a match dropped into a damp pocket. The catch is that this defence is all or nothing. A rainforest cleared, fragmented or dried at its edges — by logging, by a road, by a single fire that breaches the wall in a bad year — loses its own humid microclimate, dries out, and becomes, for the first time, able to burn. And a rainforest that burns does not come back as rainforest. The wall, once breached, tends to stay down.

One landscape, many fires

There is no such thing as the “right” amount of fire for the Sunshine Coast, because the coast is not one place. Each world along the gradient wants something different from the flame.

The rainforest wants no fire at all, and is harmed by any. The wet eucalypt forests of the better soils want fire occasionally, enough to keep the rainforest at bay but not so much that it cooks the bigger trees. The dry, grassy woodlands of the foothills want fire fairly often and fairly gently, a light burn every few years that keeps the grass fresh, the understorey open and the woody shrubs in check. And the wallum heath on the poor sand is the most fire-hungry of all: many of its banksias, peas and wildflowers positively depend on a burn every so often to release their seed and clear the rank old growth; for the peas and boronias it is

the spring flowering that makes the heath such a spectacle, while the banksias hold up the autumn and the cold months. Leave the wallum unburnt too long and it stops being a wildflower garden; it grows leggy, woody and tired, and the diversity that made it remarkable drains away.

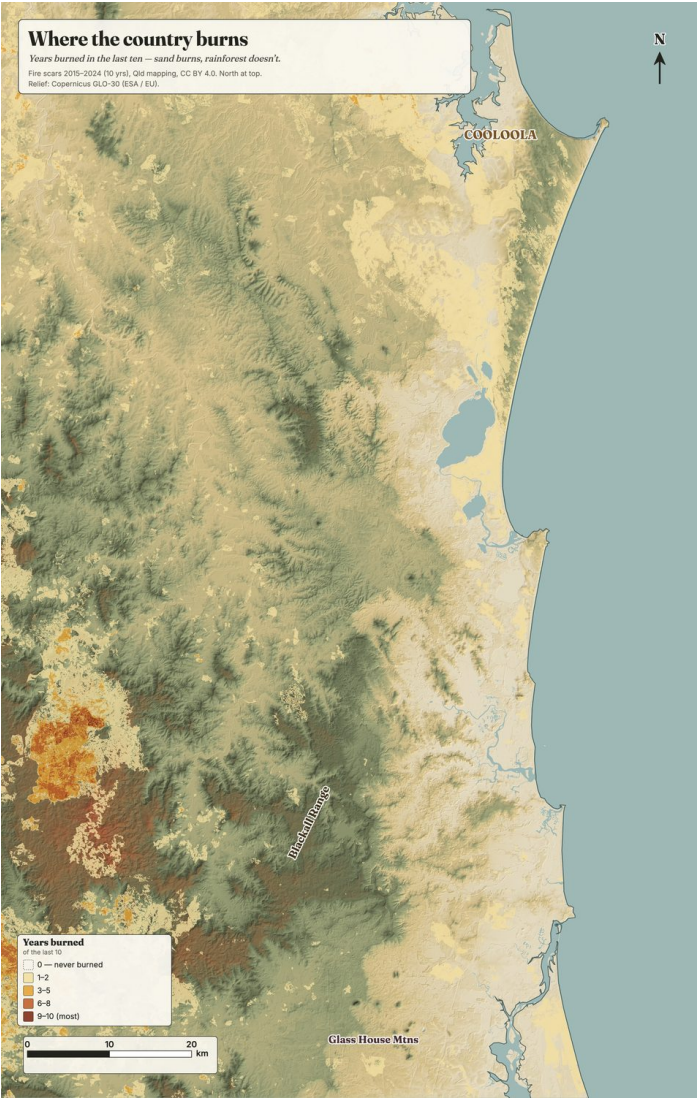


Figure 6.2 — Where the country burns. Ten years of fire scars: the sand, wallum and dry eucalypt country burns again and again, while the rainforest and wet gullies barely burn at all — fire draws the boundary and holds it.

Even the paperbark swamps of Chapter 10 play a hand, sitting as a damp brake on the system, too wet to burn in a normal year but able to carry fire in a drought.

Fire, then, is less a single tool than many: frequent and cool here, rare or excluded there, every few years and patchy somewhere else. The art lies in matching the fire to the ground beneath it. Same flame, different country, different outcome.

How a fire moves

To manage fire, or even to talk about it sensibly, you have to grasp one more thing: that “a fire” is not a fixed quantity. The very same patch of bush can carry a gentle flame you could all but step over, or an unstoppable wall three times the height of the trees, and the difference between the two has little to do with the bush and almost everything to do with three things working together: fuel, weather, and the lie of the land. Fire scientists call them the fire-behaviour triangle, and every burn, cool or catastrophic, is decided by them.

The first leg is **fuel**: how much dead leaf, bark and twig is lying about, how dry it is, and above all how it is arranged. Straight after a fire there is little on the ground to carry a flame. Over the following years the litter piles up and, more to the point, a thick connected understorey grows into the gap between the ground and the canopy, and it is that continuous ladder, rather than the depth of litter alone, that lets a fire climb and run.

What the fuel does not do is pile up for ever. This is where the folk version goes wrong, and the real answer is more interesting. Measured across several thousand sites in eucalypt forest and woodland, overall fuel hazard turns out to be *highest* six to twelve years after a fire, and *lowest* in country that has not burnt for a century, because frequent burning holds the understorey in a young, shrubby, well-connected state, while a long absence of fire lets those shrubs age, thin and fall apart, taking the ladder with them. Fuel accumulates and then declines. That is an uncomfort-

able finding for anyone who wants a single number for how often to burn, and it is the reason this chapter keeps arriving at a spread of ages across the country rather than one right interval.

The second leg is **weather**, and it is the wild card. On a still, cool, humid day a fire crawls, low and patchy, easy to walk beside and easy to put out. Add heat, drought and, above all, wind, and the identical fire transforms: the wind bends the flames forward, drives them into fresh fuel, and hurls burning bark and embers ahead to light new fires far in front of the main one, turning a manageable burn into a firestorm in minutes. It is why fire crews watch the forecast far more anxiously than the forest, and why the weather and the season in which a fire is lit matter every bit as much as whether it is lit at all.

The third leg is **the slope**. Fire runs uphill fast, because its flames lean into the ground ahead and dry and preheat it; a fire climbing a steep gully can move several times quicker than one on the flat, which is part of why the rugged, gully-cut country of the ranges is such awkward ground to burn safely.

Put the three together and you have the most important distinction in the subject: the gulf between a cool burn and a catastrophic one. A cool burn — light fuel, mild weather, gentle ground, lit in the cooler months — is the gardener's fire, low enough to spare the big trees, the soil, and the animals that can shelter or outrun it. A catastrophic fire — heavy fuel, savage weather, steep ground, in the worst of the summer heat — is a different creature altogether, killing what a cool fire would have spared and inflicting damage a landscape may take decades to undo. It is the *same fire* in name only. Which of the two you get is set by the three legs of the triangle, and the entire craft of living with fire is the craft of choosing the days when the triangle is on your side.

The first fire managers

None of this was discovered by science. It was known, in the deepest and most practical way, for tens of thousands of years before the first ecologist set foot here. For almost all of human history on this continent, the fire that ran across this country was lit by people, on purpose, and with great skill.

Aboriginal people across Australia used fire as their primary tool for tending the land: frequent, low, patchy, cool burns, lit in the right season and the right weather, that cleared undergrowth, flushed fresh growth to draw game, opened paths, protected the fire-sensitive patches, and stitched the country into a fine-grained mosaic of recently burnt and longer-unburnt ground. This was management of extraordinary sophistication, a continent gardened with fire. The historian Bill Gammage made the case at book length in *The Biggest Estate on Earth*, arguing that the open, park-like landscapes the first Europeans so admired were the deliberate product of this careful burning rather than any wild accident; as with any big idea, the detail has been vigorously debated since, and the picture varies from one part of the country to another. The ecologist David Bowman, writing in 1998, set Aboriginal burning squarely at the centre of how the Australian vegetation came to be the way it is. And today a living movement of cultural-fire practitioners, among them the work gathered in Victor Steffensen's *Fire Country* and the Firesticks Alliance, is carrying that knowledge back onto Country.

The upshot for the Sunshine Coast is plain enough from the published record. The mosaic of heath and forest the first colonists met here was a worked landscape, and fire was the principal tool that worked it. The “natural” Sunshine Coast was already, in the deepest sense, a tended one.

What happened when the burning stopped

When that long tradition of careful, frequent, knowledgeable burning was broken, as it was across the region within a generation or two of colonisation, the fire did not simply go away. The bargain the country had struck with fire was still in force; only the party that had kept it for millennia had been removed.

What followed was not one problem but two opposite ones, often in the same district. In some places fire was actively suppressed, put out and fought and kept away from farms and houses and growing towns, and the long-unburnt country responded exactly as the rules predict. The rainforest pushed out of the gullies into the eucalypt forest; the open woodlands thickened with woody scrub; the wallum grew rank and lost its flowers; and, most dangerously, the uneaten fuel banked up year upon year until the eventual fire was no longer a cool gardener's burn but a furnace hot enough to do real and lasting damage. In other places the opposite happened: country was burnt too often, or too hot, or at the wrong time of year, grinding down the diversity that a gentler rhythm had maintained. Either way, the lesson is the same, and sobering. This is not a landscape you can leave alone and expect to stay as you found it. Doing nothing is itself a decision, and usually the wrong one.

The fires to come

There is a further reason all of this now matters more than it ever has, and it is the climate. This country's fire was calibrated to a particular climate — a particular rhythm of wet and dry, a particular envelope of heat and drought — and that climate is now shifting beneath the landscape's feet. South-East Queensland is projected to grow hotter through this century, with longer, more dangerous fire seasons and deeper droughts, which means more of the extreme days on which the fire-behaviour triangle turns against us, and fewer of the mild ones on which safe burning can be done.

The consequences are no longer hypothetical. In recent drought years fire has reached places it is barely supposed to reach: the wet floor of a rainforest gully, the damp heart of a sand island. When even that fire-sensitive country will carry a flame, the old comfort that it can always look after itself no longer holds.

Sidebar — The fire that reached the rainforest. In the drought-stricken summer of 2019–20, the season that came to be called Black Summer, fire reached places it is barely supposed to reach, including stands of subtropical and temperate rainforest, some of them Gondwanan remnants, that had not burned in a very long time and are not built to burn at all. Closer to home, the great sand islands of this coast burned at a scale that alarmed everyone watching: a fire on K’gari, just to the north, burned across a large part of the island through the second half of 2020, and the Cooloola sand mass has seen serious fires of its own. A rainforest gully or the wet floor of a sand island carrying a flame is a contradiction the old rules never had to reckon with — and it is the plainest sign yet that the climate the country struck its bargain under is no longer the climate it lives in.

Getting fire right was always difficult; a warming, drying climate is making it harder, and the cost of getting it wrong steeper. The country still needs its fire: the wallum still needs its burn, the woodland its cool flame. But the window in which that fire can be delivered safely is narrowing, even as the fuel, wherever burning has lapsed, keeps steadily building. It is precisely the wrong combination, and it is why putting the right fire back into this landscape, deliberately and skilfully, has become not a heritage exercise but one of the most pressing tasks of caring for the country at all.

Reading the fire

Putting fire back, deliberately and well, is now one of the central tasks of looking after this country, and it is a hard one, because the right fire for the rainforest edge is the wrong fire for the wallum, and the prescription has to change with every step down

the gradient. Land managers today distinguish, roughly, between hazard-reduction burning (cool fires lit to reduce the fuel that feeds dangerous ones) and ecological burning (fire lit to maintain the health and diversity of an ecosystem), and the real skill lies in serving both aims at once without sacrificing either.

This is where the long, patient work of local science earns its keep, because the only way to know what a particular fire regime really does to a particular patch of bush is to try it and watch, for years. A long-term prescribed-fire experiment in the region's heath and woodland (Dooley, Lewis and Schmidt, 2023) has done exactly that, manipulating how often the country is burnt and tracking what it does to the plants over many years. It confirms in hard local data what the gradient implies: that fire frequency is a master switch on diversity, and that no single setting suits everything. It is unglamorous science, conducted with drip-torches and quadrats and a great deal of patience, and worth more to the future of this country than almost anything flashier.

So add fire to the things you can read at a glance. Straight-trunked eucalypts standing over open grass have been recently and lightly burnt; a wall of green rainforest in a gully is fire's refuge, kept unburnt by accident or design; a heath blazing with spring wildflowers is answering a burn with everything it has. And where woody scrub is closing over what was once open woodland, or rainforest pioneers are stealing into the eucalypts, you are looking at country that has gone too long without the flame it was built around.

That conversation, between the country and the fire, completes the physical stage. We now have the rock, the soil it becomes, the water that moves through it, and the fire that runs across it: the four forces that between them set every rule the living world must play by. The rest of this book is about the living world itself, the plants and animals and the whole ordered procession of ecosystems those four forces produce. It begins, in the next part, with the single idea that ties them together: the great gradient from the reef to the range.

Chapter 7 • The Great Gradient

None of this was ever empty wilderness. It had been shaped, and tended with fire, for a very long time before we came.

Here is a forty-minute drive that doubles as a time machine and a field guide. Point the car down the hill from Maleny to Mooloolaba and, before your coffee has gone cold, you will have crossed more than three hundred million years of rock and passed through every major ecosystem the Sunshine Coast holds. Most people make this drive thinking about lunch. Learn to read it instead, and you will have understood the entire place, because hidden in that one unremarkable commute is the single idea that everything else hangs on.

Start at the top, on the Blackall Range, in the deep green hush of Mary Cairncross. The air up here is cool and wet, the kind of air that fogs your sunglasses when you step out of the car. Strangler figs throw their buttresses across the path like the flying ribs of some half-built cathedral; a piccabeen palm leans into a shaft of light; somewhere off in the gloom a whipbird cracks the quiet like a snapped elastic band. The soil under your boots is a rich, chocolate red. Take a good look at all of it, because you are about to watch it disappear.

Point the car downhill and within minutes the rainforest thins and surrenders to tall eucalypt forest, the canopy lifting and opening, light pouring in, grasses pushing up between the trunks. Lower still, the country flattens into the old floodplain: cane paddocks now, with the occasional lonely forest red gum left standing in a field like the last guest at a party nobody told it had ended. Cross the Maroochy River, slip past the last low hills, and the very ground changes its mind and turns to sand: paperbark swamps in the hollows, flower-strewn heath on the rises, then the dunes, and finally the mangroves and the open water of the river mouth, where the tide breathes in and out, twice a day, forever.

Six worlds, one short drive. To a newcomer they look like six unrelated places, each with its own cast of plants and animals, flung together by accident like passengers on a delayed train. They are nothing of the kind. They are a single, ordered sequence, a *gradient*, and once you can see the logic that lines them up in that order, the Sunshine Coast stops being a pleasant jumble of scenery and becomes something you can actually *read*. The trick is that the sequence falls out, link by link, from a handful of rules so simple you could write them on a napkin. So let us write them on a napkin.

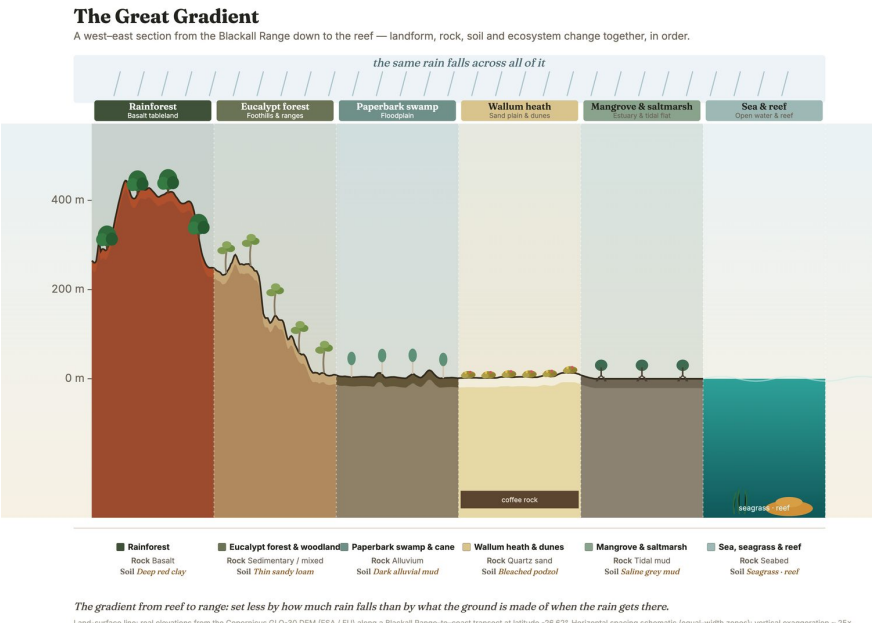


Figure 7.1 — The great gradient. Landform, soil and ecosystem change together in a predictable sequence — set less by how much rain falls than by what the ground is made of when the rain gets there.

The one rule that runs the whole show

Everything else is a footnote to this: **geology writes the rules, soils translate them, living things live them out, and people change them.**

The bones of the region are volcanic. Somewhere between twenty-six and twenty-seven million years ago, as the Australian plate drifted slowly north over a fixed hot spot in the mantle (picture a sheet of pastry being dragged across a stationary blowtorch), magma forced its way up toward the surface. In a few places it never quite made it, cooling underground into hard plugs of rhyolite and trachyte that erosion has since stripped naked and stood up on the skyline: the Glass House Mountains, Mount Coolum, the improbable spire of Mount Cooroora at Pomona; and, on far older Triassic volcanic rock, Mount Ninderry behind Yandina. Elsewhere a runnier basalt lava spread itself out, sat in the high rainfall for a few million years, and rotted down into deep red clay. And along the coast, over hundreds of thousands of years, the sea and the wind built and rebuilt vast fields of sand.

Three rocks, then, and three quite separate destinies. Rich basalt on the cool, wet ranges grows rainforest. Hungry sand on the warm, dry coast grows heath. And between them, on mixed sedimentary and alluvial ground, grows the open eucalypt forest that nine people in ten picture the moment you say “the Australian bush.” The rainfall, you will notice, barely gets a vote; most of the gradient gets a decent drink. The decisive thing is not how much water falls on the country but what the country is *made of* when the water gets there: how deep the soil runs, how many nutrients it holds, and where the water sits or slips away. Get those three things straight in your head and you can predict, with startling confidence, what will be growing before the car has rolled to a stop.

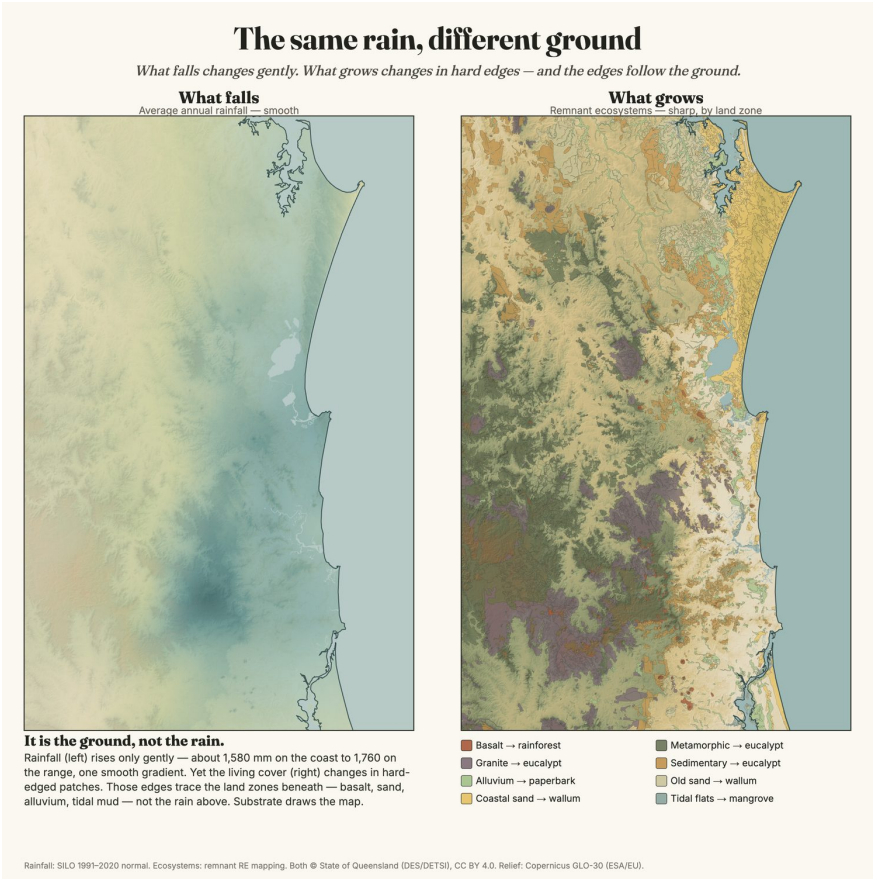


Figure 7.2 — The same rain, different ground. Rainfall (left) changes only gently across the country; the ecosystems (right) change in hard-edged patches — and the patches follow the ground beneath, not the rain above.

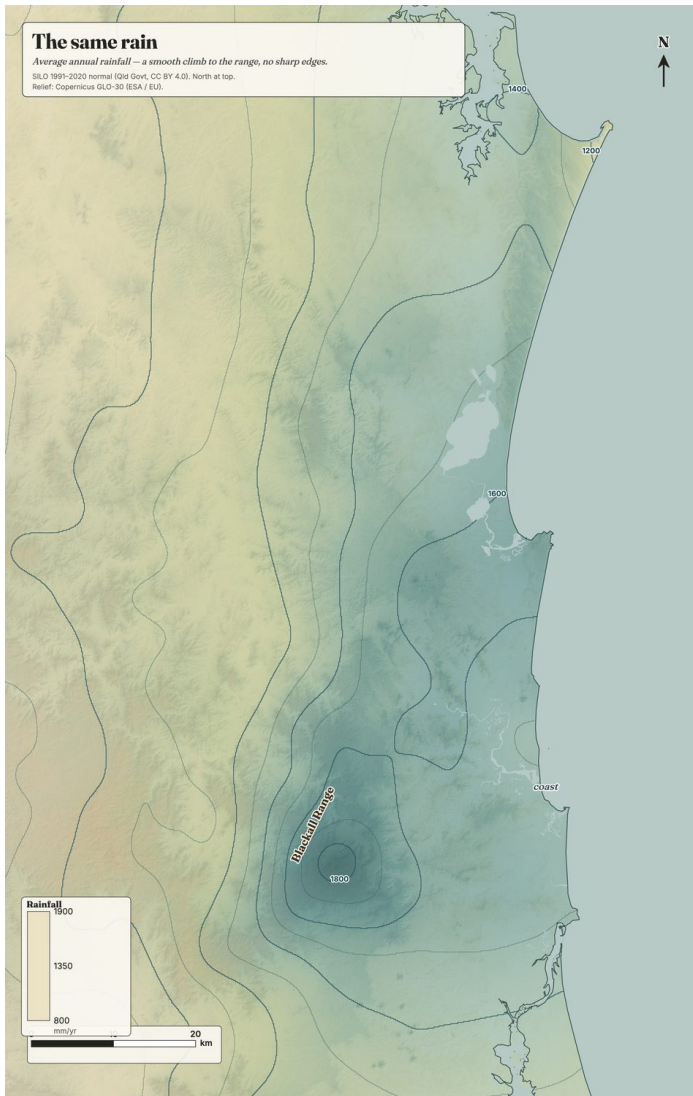


Figure 7.3 — The same rain. Average annual rainfall climbs smoothly from coast to range — a gentle gradient with none of the sharp edges the ecosystems have.

Why the poorest country is often the richest

The strangest lesson on the whole gradient is saved for the very bottom, down on the sand. It is the poorest-ground-richest-flora rule again: the wallum heath on that hungry sand, which you would expect to carry the fewest kinds of plant, instead packs in

more than almost anywhere else in the region, while the rain-forest on the richest earth makes do with a modest cast of big trees. The pauper, it turns out, keeps the crowded house; the millionaire rattles around in a near-empty one.

The mechanism behind it is one of the great stories of Australian ecology, and Chapter 4 followed it all the way to the bottom of the sand. In brief: on rich ground a few fast growers monopolise the plenty and shoulder everyone else aside, while on starved ground nobody can pull far enough ahead to dominate, so the field stays open to a throng of specialists, each scraping a living from almost nothing a different way. What the gradient adds to that story is only a matter of address: the furnace sits right at the foot of the slope, under the hungriest sand of the lot, which is why the drive ends richer in species than it began.

Sidebar — The lesson in the sand: the Cooloola dunes.

Just north of Noosa, the Cooloola sand mass rises in a series of dunes that obligingly get older the further inland you walk: the youngest down near the beach, the oldest pushed back perhaps seven or eight hundred thousand years. Nearly everything else about them barely changes: the climate, the very sand they are made of. That lines them up as a kind of natural calendar, one that has taught the world how soils age and, stranger still, how the poorest ground can grow the richest flora. That is the story Chapter 4 tells in full. The one image to carry down the hill is the punchline: Cooloola's giant podzols, bone-white columns of leached sand, run more than twenty metres deep, a column deeper than the forest standing on it is tall. And they hold that forest up anyway.

The same rule, at every scale

One last thing before we make the descent, because it turns the gradient from a single scenic drive into a tool you can use anywhere. The great slope from the range to the sea is only the grandest performance of the rule; the same rule is playing, quietly, at every scale beneath it.

Climb almost any of the region's hills and you will find the gradient repeated in miniature. On Mount Ninderry, a modest peak behind Yandina, the thin, dry, fast-draining soil of the exposed slopes grows open, grassy, fire-loving eucalypt forest. A few steps away, in the gullies where deeper soil collects and the air stays damp, the very same hill grows tall, shade-loving wet forest edging toward rainforest. Two worlds on one small mountain, sorted by nothing more than which way the ground faces and where the water gathers. Walk the Cooloola dunes and the gradient is there again, laid out this time not up a slope but back through time, the forest shrinking to low heath as the sand ages and its phosphorus drains away. Even the two banks of a single creek can carry two different worlds, if one is basalt and the other sand.

This is why the rule is worth the trouble of learning. It is not a fact about one drive; it is a grammar that works at any scale, from the whole coast down to the patch of ground under your boots. Once you have it, you never quite look at a hillside the same way again. You see instead a set of answers to a single question the land is forever being asked: what will grow here, given this rock, this soil, this water? You can very often read the answer before you have taken a step.

The whole slope at a glance

With the rule safely in hand, let us coast down it once more, from the ranges to the sea, stopping to shake hands with each world in turn. Think of what follows as the view from the aircraft window: every one of these worlds gets its own chapter further on, but here is the whole slope at a glance before we land and walk it. And when we do walk it, we will go the other way — turning round at the bottom and climbing back up, from the reef to the range, the direction the land itself was built. Coast down to see the gradient whole; climb back up to understand it.

The rainforest ranges. On the red basalt of Maleny, Montville and Mapleton, and down in the steep gullies that crease the hills, sits the region's rainforest, the "big scrub" that cloaked the range before the cedar-getters and the dairy farmers arrived to undress

it. It is fire's exact opposite: a closed, humid, self-shading world that, left to its own devices, actively keeps fire out by refusing to dry out. Hoop pines spear up through the canopy; figs throttle their hosts in slow motion; the floor is a tangle of palms and ferns. This is the richest soil and the gentlest climate on the gradient, and the forest spends every penny of that wealth on sheer mass and structure.

The eucalypt forests. Step down onto the foothills and the drier slopes and the canopy throws its windows open into eucalypt forest and woodland: blackbutt, tallowwood, grey gum, iron-bark, spotted gum, all standing over a grassy or shrubby floor. This is fire's own country: a light burn every few years keeps it open and diverse, and many of its plants flatly require fire to seed or to sprout. It is koala country too, the feed trees scattered through it. Withhold fire long enough and the rainforest will come creeping out of the gullies to shade the eucalypts into the grave, a slow, patient tug-of-war between two kinds of forest that fire alone keeps from being settled.

The floodplain and its swamps. Lower still, the rivers have rolled out fertile flats, long since cleared for cane and small crops, which is exactly why the floodplain looks like the emptiest part of the gradient and is in fact the busiest part of the restoration story. In the wettest hollows, where the water table loiters near the surface, broad-leaved paperbarks gather into swamp forest, their spongy white bark peeling off in sheets like sunburn, their roots quietly filtering and holding the water. These wetlands are flood sponges, water filters and nurseries, all at once and all on the same shift.

The wallum and the dunes. Then comes the sand, the wallum, named from what is widely reported to be the Kabi Kabi word for the banksia that crowns it. Heath and low woodland on bright, bleached, acidic sand, this is the gradient's specialist quarter, and its waters are so sour that they have bred frogs found nowhere else on Earth. Behind the beach, the dunes are built and held against the sea by a thin, scruffy green crew of pioneers: spinifex grass, pigface, goat's-foot. They are the front line, and a brave one for plants with no roots to speak of in shifting sand.

The estuary. And right at the bottom, where the Maroochy and its sister rivers meet the tide, the land gives up the argument and dissolves into mangrove and saltmarsh and seagrass, the most productive ground of the lot, and the powerhouse of the coast's fisheries. There is a neat symmetry in that: we began the drive in the richest soil of all and we end it in the richest *water*, with the poorest, hungriest ground sandwiched in between. Here the gradient ends with no tidy line at all, only a daily negotiation between fresh water and salt, mud and sea, conducted twice a day with no recess. And even the tideline is not quite the end: beyond it the transect slips underwater, running on through the seagrass meadows to the sand flats and reefs offshore — the sea country that closes Part II and carries the slope out to the reef.



Figure 7.4 — Reef to range. Extend the land relief seaward with real bathymetry and coast and shelf become one continuous surface — the drowned ground the sea flooded, the sand masses carrying their form on underwater.

Sidebar — How a frog drinks vinegar. The tea-coloured water that pools in the wallum is acidic, often somewhere around pH 3.5 to 4.5, about as sour as orange juice, and well short of vinegar. For the average frog this is a death sentence: it leaches the salts straight out of the body and burns that famously delicate skin. And yet a handful of small frogs breed in it and in nothing else: the wallum froglet, the wallum and Cooloola sedgefrogs, the wallum rocketfrog. They pull it off through quiet feats of plumbing: specialised skin and gills that grip sodium where other species would hand it over. The acid is less a hardship they put up with than a wall they have learned to hide behind, since it keeps out every competitor and predator that cannot stomach it. Which is also precisely why they are so fragile: sweeten or pollute the water, or let the water table drop, and the wall comes down, and with it the only home they have. So if you ever want to save one of these frogs, do not fuss over the frog. Protect the strange, sour water, and the whole hungry system that brews it.

Reading the country

This is the deeper reason to bother learning the gradient at all. Beyond telling you where a plant will grow or how a frog comes to live in water sour enough to kill almost anything else, it is the grammar of the landscape. Once you can read it — once a single glance at the lie of the land and the colour of the soil tells you what *should* be growing, and a glance at what *is* growing tells you what the land has lived through — every drive becomes a story, and every patch of bush a sentence in it.

The chapters that follow take each world of the gradient in turn, climbing from the tide right back up to the range — from the reef to the range, exactly as the book's title promises. But keep this one map folded in your head as you go. Whatever ecosystem you happen to be standing in, you are also standing somewhere on this one long slope from the sea to the hills, and the slope explains nearly all of it.

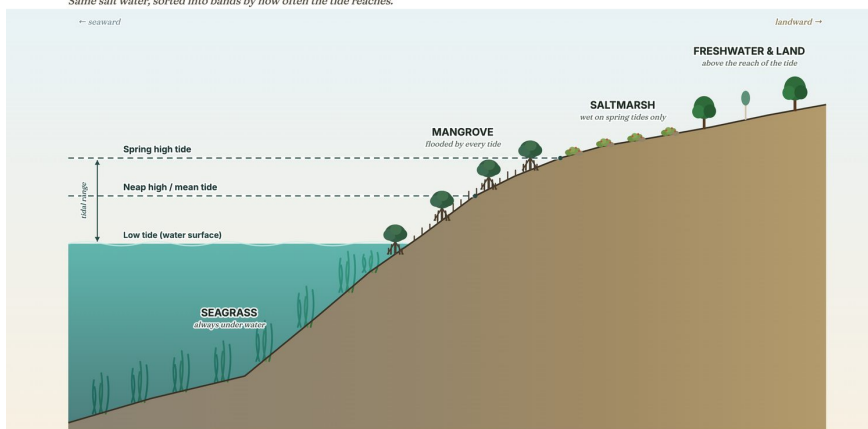
Chapter 8 • Estuaries, mangroves and saltmarsh

An estuary runs not on sunlight but on dead leaves — and that is the whole secret of how it feeds the coast.

For two centuries the standard response to a mangrove swamp was to drain it, fill it and build something tidier on top. It was one of the great misreadings of the Australian coast. The tidal flats where the rivers meet the sea — the mangroves, the saltmarsh behind them, the seagrass in the shallows — are muddy, sulphurous and hard to love, and they are also the most productive ground on the whole gradient: the nursery the region's fisheries are built on, a wall against storms and floods that repairs itself for free, and among the densest stores of carbon on Earth.

We arrive here by walking down the gradient to its very bottom, the place Chapter 5 promised and then saved for here. Where the Maroochy, the Mooloolah, the Noosa and the Pumicestone Passage meet the tide, the land stops being land and becomes something stranger and more precarious: a place that is flooded and drained twice a day, that is neither fresh nor salt but a restless mixture of both, and that has assembled a cast of plants and animals found nowhere else, precisely because almost nothing else can tolerate the conditions. To read the estuary you have to throw out the idea of solid ground and think instead in tides.

FIG 8.1

Estuary zonation*Same salt water, sorted into bands by how often the tide reaches.*

The estuary sorted by the tide: each plant lives at the exact height where it can stand the salt and the soaking — seagrass under water, mangrove in the tide, saltmarsh at its edge.

Figure 8.1 — Estuary zonation. Each plant lives at the tidal height where it can stand the salt and the soaking — seagrass under water, mangrove in the tide, saltmarsh at its edge.

Living between the tides

Begin by appreciating just how brutal a home the tidal zone is, because everything that follows is a response to its difficulties. Twice a day the salt water rushes in and then drains away. A plant rooted here is alternately drowned in seawater and left high and dry; the mud it stands in is so waterlogged that it holds almost no oxygen, going black and sulphurous a few centimetres down; and the water is salt, which for most plants is simply poison, drawing the moisture out of their tissues as fast as their roots can take it in. By every normal botanical reckoning, nothing should be able to grow here at all.

And yet a small group of extraordinary trees has cracked the problem, and they are the mangroves. The word covers not one plant but a guild of unrelated species that have independently solved the same set of impossible conditions. On this coast the dominant species is the grey mangrove.

Consider the salt problem first. The grey mangrove deals with it at both ends: its roots filter out most of the salt before it ever enters the tree, and whatever slips through is pushed back out through glands on the leaves, so that on a still day the foliage can be faintly crusted with exuded salt. The tree is literally sweating out the sea. Then the oxygen problem: because the mud is suffocatingly airless, the grey mangrove gets no air from it, and instead sends up thousands of slender, pencil-like roots that stand vertically out of the mud all around the trunk. These are snorkels. At low tide they take air directly from the atmosphere and pipe it down to the drowned roots below. Wade through a mangrove forest at low water and you are walking through a forest breathing through its ankles.

There is more, and it is even stranger. Mangroves do not trust their seeds to the tide as a gamble the way other trees do; the seed germinates while still attached to the parent. In the grey mangrove the embryo sprouts inside the fruit and waits there until the fruit falls, a habit botanists call cryptovivipary. In the stilt-rooted red mangroves it goes further: the seedling bursts clean through the fruit and dangles from the branch as a long green spear before dropping, which is true vivipary. Either way the tree sends its young into the world already growing rather than as a helpless seed, primed to root in the first patch of mud they lodge against. For a plant colonising a surface that is underwater half the time, it is a decisive head start.

A walk out onto the flats

Reading about the tidal zone is one thing; walking out into it is another, and the estuary rewards the effort, because at low tide it hides nothing. So pick a falling tide and come out onto the Maroochy, where a boardwalk carries you over the mud and lets you meet the community band by band without sinking to your knees. At low water the flats are drained and everything that lives on them is out of its burrow and working.

The tree that can blind you. Start at the landward edge, in the scrubby fringe the tide reaches only on its higher days, and give the first small tree a wide berth. The milky mangrove (*Excoecaria*

agallocha), known along this coast, with feeling, as the blind-your-eyes tree, is barely a mangrove at all in the engineering sense: it keeps to the drier landward margin, grows no snorkel roots and few salt glands, and hedges its bets by dropping its leaves in a flush of scarlet when the going turns hard. What it does have is a milky white sap that runs from any broken leaf or twig and is violently caustic: on the skin it blisters, and flicked into the eye it causes a searing pain and a temporary blindness that give the tree its name. It is the estuary's version of the rainforest's stinging tree, a plant you learn early and thereafter leave well alone.

The mangrove that flowers for the bees. A step seaward and the true mangroves begin, the first of them a modest one. The river mangrove (*Aegiceras corniculatum*) is a shrubby, many-stemmed tree of the upper estuary and the landward fringe, its smallish leaves faintly rimed with excreted salt. It smothers itself in clusters of small, sweet-scented white flowers, and the bees work them hard for their nectar. Its fruit is a small green curved horn, from which it takes its name (*corniculatum*, "little horned"), and inside it, in the mangrove fashion, the seed has already begun to grow before it drops.

The grey army and its snorkels. Now you come into the main event, the broad band of grey mangrove (*Avicennia marina*) we met a moment ago, and this time look down rather than up. The mud between the trunks is studded, as far as you can see, with the thousands of upright snorkel-roots, and the spaces between them are where the real business of the estuary goes on, because from here everything depends on the animals, and the flat at your feet is crawling with them.

The blue armies. Out on the open, drained mud beyond the trees, the ground itself appears to be moving. Look closely and it resolves into a slow tide of soldier crabs (*Mictyris longicarpus*), hundreds of them, each the size of a marble and an improbable pale blue, marching across the flat in loose battalions — the only crabs on the coast that walk forwards instead of sidling. They feed as they go, scooping up the surface mud, sieving out the film of algae and rotting matter, and leaving a trail of little rolled pellets of cleaned sand behind them. Step toward them and the whole

army, feeling the vibration, corkscrews down into the mud at once, each crab spinning itself under sideways and gone, so that a flat teeming with life a second ago is suddenly, eerily, bare.

The one-armed wavers. Nearer the mangrove edge, where the mud lies softer and wetter, the burrows belong to the fiddler crabs, and the males are unmissable: each carries one small feeding claw and one absurdly enlarged claw, often brightly coloured and as big as the rest of his body, which he waves in slow rhythmic beckoning to warn off rival males and to signal to the females. He cannot feed with the big claw, which is purely for show and for combat, so he shovels mud to his mouth with the small one, sorting out the edible film and dropping the spent sediment in neat pellets around his door. A bank of fiddler burrows at low tide is a slow forest of waving arms, every male at his own front step, semaphoring.

The crabs that feed the coast. Less showy, and far more important, are the dark crabs you catch dragging fallen mangrove leaves backwards into their burrows in the shade of the trees: the sesarmid, or leaf-eating, crabs. They are what makes the estuary fertile. A mangrove forest sheds an enormous tonnage of leaves, and these crabs harvest them, hauling them underground to shred and eat, passing out the remains as fragments that microbes break down further. That flood of shredded, rotting, microbe-rich leaf matter (detritus) is the base of the estuarine food web, the reason the mud is so productive, and the ultimate source of the fatness of the prawns and fish everyone downstream is so keen to catch. The estuary runs not on sunlight but on dead leaves, and the leaf-crabs set the process going.

The prize in the creek. Where a tidal creek cuts deeper through the mangroves and always holds a little water lives the animal most of the boats on the river are really here for: the mud crab (*Scylla serrata*), a heavy, broad, mottled green-brown swimming crab that can span a dinner plate and crush a shell — or a careless finger — in claws built for exactly that. It lies dug into a bank or a root tangle through the day and hunts the flats as the

tide covers them, and it is prized enough on the plate that the baited crab pot is as much a fixture of these creeks as the mangroves themselves.

The fish that climbs out of the water. Down where the water's edge meets the mud, something the length of your finger props itself up on its front fins, out in the open air, and skips away across the surface as you come near. This is a mudskipper, a small goby that has taken the estuary's amphibious logic to its conclusion and simply left the water. It breathes through its skin and the lining of its mouth for as long as it stays damp, hops over the mud on muscular fins, and defends a little territory around its burrow, seeing off rivals with a flash of its raised fin. A fish, out of the water, on the mud, by choice.

The reef we forgot. Finally, look at the hard surfaces. The lower trunks, an old pylon, any rock: all are crusted with oysters, the Sydney rock oyster (*Saccostrea glomerata*), each one cemented in place and straining the passing water for food, filtering litres of it a day. It is easy to walk past them without a thought, and easy to forget that they are the survivors of something far greater. The region's rivers and the wider bay once held extensive oyster reefs, dense living banks of shell that cleaned the water and sheltered fish, and that were dredged and harvested away within a few generations until almost none were left. That a few of them, on rivers like the Noosa, are now being deliberately rebuilt is a story for a later chapter; for now, note the oyster on the root as the last trace of a lost habitat.

Now stand on the boardwalk and take in what you have walked through. A few hundred metres of mud that looks, to the casual eye, like wasteland is in truth one of the busiest food factories on the coast: leaves shredded to detritus, detritus feeding the crabs and prawns and fish, fish feeding the birds and us.

The engineers of the coast

The mangrove does not merely survive the estuary: it builds it.

That thicket of breathing roots and trunks does something simple and far-reaching: it slows the water down. Every tide that washes in through a mangrove forest is forced to filter through a dense tangle, and slow water drops its load of suspended mud and silt. So the mangroves trap sediment, tide after tide, year after year, raising and extending the very ground they stand on. Left alone, a mangrove forest grows seaward, building new land out of muddy water. Ecologists call organisms that reshape their own environment “ecosystem engineers,” and few do it more literally than these.

That engineering is worth a fortune to everyone downstream of it, ourselves included. The wall of roots that traps mud also absorbs the punch of storms and the surge of floods, protecting the softer shore behind it: a sea defence that builds itself, and never sends anyone an invoice. The same roots filter pollutants and sediment out of the water before it reaches the open bay and its seagrass and reefs. And the maze of submerged roots is one of the safest nurseries in the sea.

That last point deserves its own emphasis, because it is the one with a price tag the coast understands. The great majority of the fish and prawns that the region’s anglers and trawlers pull from the sea spend the vulnerable juvenile stage of their lives in the estuaries, hiding among the mangrove roots and the seagrass, where the water is rich with food and the cover is thick enough to keep the bigger predators out. Drain an estuary and you are demolishing the maternity ward, and the losses turn up years later and kilometres away as empty nets. The mangroves and the fishery are the same system. You cannot keep one and bulldoze the other, though we spent a long time trying.

Sidebar — Blue carbon: the swamp as a vault. Waterlogged coastal soils, the muds beneath mangroves, saltmarsh and seagrass, are among the most powerful carbon stores on Earth, gram for gram far outpacing even rainforest. The reason is the airless mud. On dry land, dead plant material is attacked by oxygen-breathing decomposers that release its carbon back to the air as it rots. In the suffocating, waterlogged mud of a tidal wetland, that decay all but stops, and the carbon in every fallen leaf and root is locked away in the sediment, where it stays, accumulating, for centuries to millennia. This is “blue carbon.” The swamp we used to drain as worthless is in fact doing, quietly and for nothing, a job we would otherwise pay dearly to have done. On the Maroochy floodplain, the Blue Heart project is part of a new wave of schemes letting the tide back into drained land precisely to rebuild these wetlands, for flood storage, for habitat, and to start the carbon vault filling again, and (as the freshwater wetlands of Chapter 10 will show) to keep a buried chemical hazard, the acid-sulfate soils, safely drowned.

Behind the mangroves, and beneath the water

The mangroves get the attention, but they are only the middle of three tidal worlds, and the other two are easy to miss.

Landward of the mangroves, on the higher flats that the tide reaches only now and then, lies the **saltmarsh**, a low, open, often sun-baked carpet of salt-tolerant succulents and grasses, the samphires and glassworts whose fleshy stems store water against the salt. It looks like the most barren ground imaginable, a flat grey-green nothing, which is precisely why so much of it has been reclaimed, drained or used as dumping ground over the years. In fact saltmarsh is a crucial high-tide feeding ground: when the spring tides flood it, fish push up onto the marsh to gorge, and when it drains, the crabs and the birds take over. It is also, like the mangroves, a blue-carbon store and a flood buffer, and it has been steadily vanishing along this coast for a century. Much of what remains is now, belatedly, protected.

Seaward of the mangroves, out in the shallow subtidal water, lie the **seagrass** meadows, and these, despite the name and the look of them, are not seaweed but true flowering plants, returned to the sea, cloaking the sandy shallows with green. Seagrass is the pasture of the estuary. It feeds the things that graze it directly, most famously the dugong and the green turtle, which crop the meadows like underwater cattle, and it shelters yet another generation of juvenile fish and prawns. The seagrass beds of the broader Moreton Bay region, including the sheltered waters of the Pumicestone Passage, harbour nationally significant numbers of dugong, a large, shy, slow-breathing mammal that most residents of the coast never see and would be astonished to learn is grazing quietly offshore. Protect the seagrass and you keep the dugong. Foul the water so the seagrass is shaded out and dies, and the dugong starve.

The longest commute on Earth

If the estuary's productivity needs one final witness, it arrives every spring on wings, from the other side of the planet.

The mudflats exposed at low tide, which look to us like the very definition of empty, are dense with buried life: worms, crabs, molluscs, the rich harvest of all that trapped sediment and rotting leaf. And every year that harvest draws a crowd of travellers: the migratory shorebirds. Birds such as the bar-tailed godwit breed in the brief Arctic summer of Alaska and Siberia and then fly south to spend the rest of the year feeding on flats like these, returning north to breed again. Some of them make the journey in non-stop flights of many days and many thousands of kilometres over open ocean, without once landing to rest or feed. The estuaries and bays of this coast are a link in that chain, the East Asian–Australasian Flyway, and the wider Moreton Bay is recognised internationally, as a Ramsar wetland, for exactly this reason. The unremarkable-looking mud the birds are probing is, to them, the fuel stop that makes the impossible journey possible. Pave it over and a bird that nests in the Arctic loses a link in a chain strung halfway around the globe.

Not all of them cross the ocean in one heroic leap. The largest of these travellers, the eastern curlew, works the flats in a different register, stalking the mud on long legs and probing it with a preposterous down-curved bill, the better part of a hand-span of it, shaped precisely to reach down a crab's burrow and draw the crab out. It too breeds in the far north and spends the rest of the year on flats like these, and it has become a grim barometer of their health: as the mudflats of the flyway have been drained, walled and built over, the eastern curlew has declined so steeply that it is now listed as critically endangered.

Sidebar — Reading the tidal zones. The estuary's three bands — seagrass, mangrove, saltmarsh — are not a random patchwork but a gradient set by a single variable: how often the salt water reaches. It is the great slope of Chapter 7 all over again, compressed into a few hundred metres and driven by the tide instead of the rock, and you can read it all from a kayak. The plants are sorted by their tolerance of salt and soaking exactly as the plants of the dunes are sorted by their tolerance of poverty: each band is the set of specialists that can stand a little more of what the band seaward of it cannot.

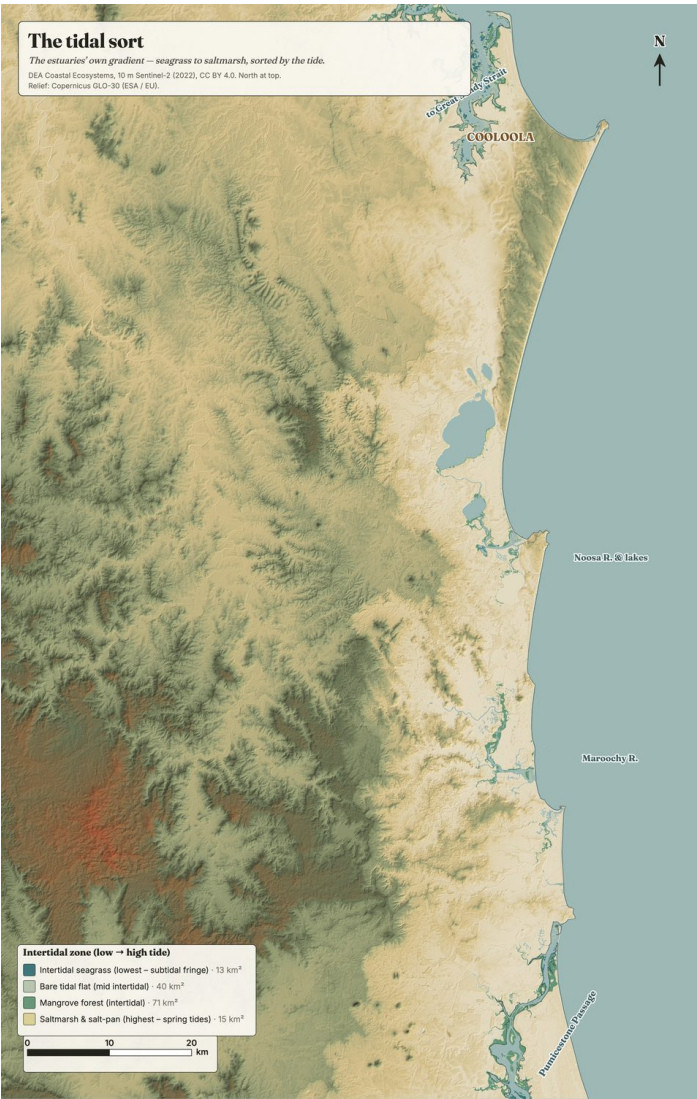


Figure 8.2 — The tidal sort. The estuary sorted by the tide, from real mapping: seagrass on the lowest banks, then mangrove, then saltmarsh at the high-tide edge — the gradient rule written in salt water.

Reading the tidal country

Walk it once at low tide and the prejudice starts to slip. The grey-green succulent flat baking above the tideline is saltmarsh, at once a high-tide dinner table and a carbon vault. The dark forest of muddy trees on its thousand snorkel-roots is mangrove, the

nursery and the sea wall, building new coast with every tide. And the green meadow in the clear shallows is seagrass, the dugong's pasture.

The three bands work as one. The saltmarsh behind and the seagrass in front run the same economy at their own heights on the tide, and all three bury carbon in the airless mud as they go. Each leans on the others, and all of them on the tide that drives the lot — a single machine, run by the moon.

None of it is pretty in the postcard sense, and all of it is doing more for the coast, for its fish, its floods, its climate and its birds, than the manicured foreshore we so often replaced it with. The engine room of the whole coast was hiding, all along, in the place we held our noses and looked away from.

Now we turn back toward the land and start to climb. The first ground we meet above the reach of the tide is the brightest and the strangest on the gradient: the bleached, flower-strewn, acid-watered sand country of the wallum, where the lesson is no longer salt but poverty — and where, against all expectation, poverty turns out to be the making of the place.

Chapter 9 • Dunes, wallum and acid waters

This is what a landscape looks like when no one is allowed to win.

Pull off almost any beach on this coast, climb the dunes behind it, and you step into a country most people write off at a glance: low grey scrub on bleached, bottomless sand, leached so hard that barely a trace of nutrient survives. It looks like wasteland, and twice it was very nearly dug up for the heavy minerals buried in its sand. But wait for spring. The grey scrub erupts into flower: peas and boronias, wattles and grevilleas, ground orchids and insect-eating sundews, hundreds of species crowded where almost nothing should grow. The water threaded through it runs as sour as orange juice and is lethal to most freshwater life; and that same acidity is the one reason a handful of frogs found nowhere else on Earth can breed in it at all. This is the wallum, one of the most remarkable plant communities in the country, and the least likely.

We reach it by climbing up off the tidal flats of the last chapter, out of the reach of the salt, onto the great coastal sand masses. The lesson of the estuary was salt; the lesson here is poverty. The soil is sand almost all the way down, leached over hundreds of thousands of years until barely a trace of usable nutrient remains, the famous Cooloola chronosequence written into the dunes. We do not need to retell that story. Here we are interested not in how the soil got so poor but in the astonishing living world that poverty has bred: the plants that crack the problem, the frogs that exploit the by-product, and the fire and water that hold it all together.

Holding the line: the dunes

Start at the front, on the bare sand behind the beach, where the system begins and where the conditions are, if anything, even harsher than the wallum behind. The foredune is a place of shifting sand, salt spray, furnace heat and zero soil, and almost nothing can grow there — except a small, tough crew of pioneers whose entire job is to hold the sand still long enough for anything else to follow.

The chief of these is spinifex, not the spiky desert spinifex of the inland, confusingly, but a sprawling coastal grass that sends out long runners across the open sand, pinning it down and catching wind-blown grains until a dune begins to build around it. Alongside it grow the pigface, with its fat, water-storing leaves and improbable magenta flowers, and the goat's-foot, a beach morning-glory that throws purple-flowered vines metres across the bare sand like rope thrown across a deck. These plants are doing the coast a real service: building and anchoring the dune that shelters everything behind it. The vegetated foredune is the coast's first and cheapest sea defence, held together by a handful of plants most beachgoers step over without a glance. Strip them off, with too many feet or too many vehicles, and the dune begins to walk inland with the next big wind.

Behind the shifting front, where the pioneers have done their work and the sand has settled, the vegetation thickens into dune scrub and then, on the older and more stable sand further back, into the wallum proper.

The wallum: a masterclass in poverty

The word *wallum* is widely reported to come from the Kabi Kabi name for the wallum banksia, the gnarled, knobbly-coned shrub-tree that crowns this country and gives the landscape its name. There is something fitting in a banksia being the emblem, because the banksias are the great champions of life on nothing.

The puzzle of the wallum is the one Chapter 4 set out and solved: the poorest soil grows the most species. This starved white sand grows a low, scrubby heath that, in spring, erupts into

flower: grevilleas and peas, wattles and boronias, wax flowers, ground orchids, lilies, and the glittering, insect-eating sundews (the banksias, despite naming the place, sit the spring out; their season is autumn and the cold months), hundreds of species packed together where you would expect almost nothing. The mechanism is the same one: poverty so complete that no plant can outgrow the rest, and the field falls open to specialists. The wallum is where you get to watch it happen.

The wallum is the best place on the coast to catch those specialists at work. Each plant is a different answer to the same brutal exam question, *how do you live on nothing?*: some strike deals with fungi, some mine the soil by chemistry with dense brushes of “cluster roots,” some trap and digest insects for their nitrogen, some rent nitrogen-fixing bacteria — the full account of those partnerships comes later. And almost every leaf in sight is hard, tough and long-lived, the “sclerophyll” leaf of plants too poor to afford a soft one. The astonishing diversity of the wallum is really the diversity of those answers.

The heath in flower

To watch the wallum turn its poverty into wealth you have to walk into it, and the time to do it is spring, when those exam answers come into flower all at once. So come up off the open dunes into the heath behind, at Cooloola or any of the sand-country reserves strung along this coast, on a sandy track through low, hard, grey-green scrub not much higher than your head. At first it looks like nothing: a monotonous, matted, waist-to-shoulder tangle on bare white sand, the kind of country you would drive straight past. Then you begin to notice the flowers, and the count starts to climb, and it does not stop.

The shrub that named the country. Start with the plant the landscape is named for. The wallum banksia (*Banksia aemula*) is a gnarled, crooked, corky-barked shrub-tree that carries its entire life story on its branches at once: fat greenish-yellow flower-brushes, older brushes gone grey and bristling, and the spent cones — woody grey knobs studded with what look like half-open eyes and gaping mouths. Come in spring and it is mostly the grey

brushes and the cones you will meet, because this banksia flowers from late summer into the cold months, out of step with the heath around it. Those are the “big bad Banksia men” that menaced generations of Australian children in May Gibbs’s gumnut books; she drew them from the spent cones of banksias, and though the trees of her own childhood were western species, the wallum banksia’s twisted grey knobs are their very image. The mouths are seed-follicles, and on the wallum banksia most of them stay clamped shut for years, holding their seed against the day fire sweeps through; the heat cracks them open and the seed drops onto cleared, ash-fertilised sand. Meanwhile the flower-brushes are among the richest nectar sources in the heath, feeding honeyeaters through the day and pygmy-possums and gliders through the night.

The bells of high summer. Push on and, especially in the year or two after a fire, you may find, standing clear of the scrub on a slender stalk, Christmas bells (*Blandfordia grandiflora*), a spray of big, waxy, pendulous trumpets glowing red-orange and tipped with gold, hung out like lanterns. They flower toward Christmas, which is how they came by the name, and their colour and shape are an advertisement aimed squarely at birds, which pollinate them as they probe for the nectar. So showy a thing, standing clear out of bottomless white sand, is the wallum’s paradox in a single plant.

The plants that eat animals. Now crouch down, because some of the wallum’s cleverest specialists are ankle-high and easy to walk past. Scattered on the damp bare sand between the shrubs are the sundews (*Drosera*), small rosettes of leaves each fringed with glistening red-tipped hairs that look, in the sun, as though they are beaded with dew. The dew is glue. A midge or an ant that settles is held fast, the leaf curls slowly around it, and the plant digests its catch — because the one thing the sand cannot offer it is nitrogen, and an insect is a parcel of nitrogen that has made the mistake of walking within reach.

Sidebar — The plants that turned carnivore. The wallum holds one of the richest gatherings of meat-eating plants in Australia, and every one of them is doing the same thing for the same reason: taking from animals the nitrogen the sand will not give. The sundews trap their prey in glue. Out in the swampy hollows, hidden in the tea-coloured water, the bladderworts (*Utricularia*) do something stranger still: they hang tiny hollow bladders along their underwater stems, each one pumped empty and cocked like a mousetrap, and when a passing water-flea brushes a trigger-hair the bladder springs open and sucks it in on a rush of water. The trapdoor fires in well under a thousandth of a second, among the fastest movements known anywhere in the plant kingdom. A plant with no stomach, no muscles and no nerves has built itself a spring-loaded trap faster than you can blink.

The birds that run the flowers. Now stand and listen, because a wallum heath in flower is loud with honeyeaters, and they are not merely passing through. They are the pollinators, the flying half of the bargain the banksias and grevilleas depend on. The eastern spinebill probes the tubular flowers with a fine down-curved bill; little wattlebirds squabble raucously in the banksias; and the flagship of these heaths, the white-cheeked honeyeater, works steadily through the brushes, ferrying pollen from plant to plant as it feeds. The birds get nectar and the flowers get their pollen carried, and on soil this poor neither would manage half so well alone.

The bird you will almost certainly not see. And somewhere in the low heath around you, quite possibly only paces away, is a bird you are very unlikely ever to set eyes on: the ground parrot (*Pezoporus wallicus*), a slim, barred, grass-green parrot that has given up the trees altogether to live its whole life on the ground in the thick of the wallum. It creeps through the heath and flushes only at the last moment in a low, jinking flight before dropping back into cover. Its presence is usually given away only by its voice, a thin series of rising notes delivered at dusk and dawn. The ground parrot is one of the truest specialists of this country and one of

the most demanding: it needs large, unbroken tracts of heath of just the right age since fire — long enough unburnt to be dense and seed-rich, not so long that it grows rank. And as that particular country has been cleared, fragmented and burnt at the wrong times, the ground parrot has retreated to a handful of strongholds like Cooloola. It is the wallum's requirements made flesh: get the fire, the water and the space exactly right and it holds on; get any one of them wrong and it is gone without a sound.

The wet ground, and the tea-coloured water. Finally, follow the track down into one of the damp swales between the sand ridges, and the heath shifts under your feet. The shrubs give way to a low sward of wiry sedges and rushes that thrive where the ground stays wet; the grass-trees here are the low, swamp-loving *Xanthorrhoea fulva* rather than the tall kind of the ridges; and the sand between them glistens with standing water the colour of strong, cold tea. This is the acid blackwater we met earlier, stained brown by the slow leaching of the peaty ground. And it is in exactly this sour, tannin-brown water that the wallum's strangest animals make their impossible living.

The frogs that drink vinegar

Now to the by-product, and one of the oddest stories on the coast. The water that gathers in the wallum, in its swamps, its perched lakes and its tea-coloured streams, is acidic, often somewhere around pH 3.5 to 4.5 — about as sour as orange juice, and a good deal short of vinegar. For most freshwater animals it is lethal all the same: the acid strips the salts out of their bodies and burns delicate tissues. And yet a small, specialised club of frogs lives here and, in some cases, *only* here.

These are the acid frogs, among them the wallum froglet, the wallum and Cooloola sedgefrogs, and the wallum rocketfrog. Rather than avoiding the poisonous water, they have evolved the physiology to breed in it, through quiet feats of plumbing that let their eggs and tadpoles hold onto vital salts where other species would lose them. Detailed work on the Cooloola sedgefrog has shown just how finely tuned this acid tolerance is, and surveys across the region have mapped the narrow pH windows within

which each species can and cannot breed. It is a precise and hard-won adaptation, and it raises an obvious question. Why evolve to live somewhere so hostile in the first place?

The answer is the deep logic of the wallum, applied to animals. The acid water is hostile to almost everything, including, crucially, the predators and competitors that would otherwise eat the frogs' eggs and tadpoles or crowd them out. Most tellingly, it is largely hostile to introduced fish: the mosquitofish that have invaded so much of Australia's fresh water, and that devastate native frogs elsewhere, struggle in the most acidic wallum waters and are mostly shut out of them. So the sour water that looks like a death trap is, for the frogs, something close to a fortress. The acidity is a wall they hide behind rather than a hardship they suffer, exactly as the wallum plants use poverty to escape competition.

Which is also precisely why they are so fragile. A fortress works only as long as its walls stand. Anything that sweetens or pollutes the acid water, whether run-off from a new housing estate, fertiliser, or a drain that lets ordinary water in, lowers the drawbridge and lets the fish and the competitors march straight in. Anything that drops the water table can dry the breeding sites out altogether. To protect these frogs you do not manage the frogs at all. You protect the strange, sour, acid water, and the whole hungry system that brews it, which means protecting the wallum entire.

Sidebar — Why you cannot move a wallum. There is a temptation, whenever a patch of “scrub” stands in the way of something we want to build, to imagine the valuable bits can simply be shifted — replanted, offset, recreated somewhere more convenient. The wallum is a standing rebuke to that idea. Its richness is not a collection of plants you could dig up and move; it is the product of a particular soil that took seven or eight hundred thousand years to leach, a particular water table sitting at a particular depth, a particular chemistry of acid water, and a particular rhythm of fire, all interlocking. You cannot manufacture a seven-hundred-thousand-year-old podzol, or a perched water table, or the precise acidity that keeps the fish out, in a few seasons on a new site. A wallum destroyed is simply gone, and what replaces an “offset” is at best a rough green approximation missing most of the specialists that made the original worth saving. Some things can be rebuilt. This is not yet one of them.

Fire and water: the hidden machinery

Two forces from earlier chapters keep the wallum running, and both are easy to overlook because one is invisible and the other only shows up occasionally.

The invisible one is water, and specifically the groundwater of Chapter 5: the great freshwater sponge inside the sand, which keeps the wallum’s swamps, streams and lakes alive through the dry season and supplies the steady, acid, nutrient-poor water its whole community is tuned to. Recent mapping of these groundwater-dependent ecosystems has underlined how completely the wallum leans on a water table you cannot see, and how easily that support is stripped away by extraction or drainage without anything visibly changing at the surface until it is too late.

The occasional one is fire, and the wallum is the most fire-hungry country on the gradient. Many of its banksias and peas need the heat of a fire to release or germinate their seed; the spring wildflower spectacle is often at its most extravagant in the season after a burn; and without fire at the right interval the heath

grows rank, leggy and woody, and its diversity quietly drains away. Too much fire, too often, is just as damaging. The wallum needs neither fire excluded nor fire constantly, but the particular rhythm its plants evolved with, which is exactly the kind of knowledge the region's cultural and scientific fire practitioners are working to recover and apply.

Put those together and the wallum reveals itself as the most demanding patch of country on the coast to look after, precisely because it depends on so many things at once: an ancient soil, a hidden water table, an acid chemistry, and a particular fire rhythm, every one of them breakable. It is a wonder it survives at all, and twice in living memory it nearly didn't.

Reading the sand country

The wallum has been twice fought over by sand miners drawn not to the surface life but to the heavy minerals buried in the dunes, and the long battle to save the Cooloola sand mass, eventually protected, after a fierce public campaign, as national park in the 1970s, is one of the founding stories of Australian conservation, and one we return to in the later history chapters. That it had to be fought at all is a measure of how thoroughly this country was misread: dismissed as worthless scrub by people who could see the dollar value of the sand and not the irreplaceable value of what grew on it.

For all its apparent chaos of flowers, the wallum is as tightly ordered as anything on the coast, and every part of it runs from a single fact: the sand has nothing to give. The sprawling grass and purple vines pinning down the open dune are the pioneers, building the coast's first sea wall. The low, hard-leaved, knobbly heath that bursts into impossible flower in spring is the wallum itself, a wildflower garden growing on nothing. And the dark, still, tea-coloured water threaded through it, which reads as a polluted ditch, is in fact a fortress, sheltering frogs that have learned to breed in water sour enough to kill almost anything else. A whole living world balanced on four scarcities at once: poverty, acid, fire, and a

water table you cannot see. Pull any one thread and the rest unravel. It is the most elaborate thing Australia builds out of nothing at all.

In the wettest hollows of the sand country, and along the sluggish lowland streams, that tea-coloured water gathers and stands, and a different kind of vegetation takes over: the broad-leaved paperbarks, gathering into swamp forests that filter and store the water and flood-proof the land behind them. Those freshwater wetlands, the humblest-looking and among the hardest-working country on the coast, are where we go next.

Chapter 10 • Paperbark swamps and freshwater wetlands

A swamp is a machine for doing, slowly and for free, several of the most expensive jobs we know how to do badly.

For most of the last two centuries we read a swamp as wet, muddy, mosquito-ridden ground fit only for draining — and drained it we did, until the lowland wetlands became among the most thoroughly destroyed ecosystems on the coast. It turns out to have been one of the costliest mistakes we have made here, because a wetland does more unpaid work than almost any ground on the coast: it stores floodwater, filters what runs through it, recharges the aquifer beneath, and shelters a dense crowd of fish, frogs and birds.

We arrive here by following the water downhill. The tea-coloured, acid water of the wallum, and the run-off from the slopes above, drains into the lowest, flattest, wettest ground: the hollows in the sand, the margins of the lagoons, and above all the broad river floodplains. And there it gathers and stands, too wet to drain away quickly, too flat to run off. Where water sits like this, a particular and wonderful kind of forest takes over: the paperbark swamp.

Two kinds of wet country hide under the one word “swamp,” and almost everything about them differs, so keep them apart from the start. On the great sand masses (Cooloola, the Noosa back-country) the swamps are fed by the same poor, acid, tannin-stained water as the wallum, and they are hungry, blackwater places: sedge and paperbark on bottomless sand, slowly building peat, starved of nutrient. On the river floodplains (the Maroochy, the Mooloolah) the swamps sit instead on rich, heavy, river-laid mud, and they are fat, productive, reed-filled places. The two look much alike from the bank, a flat green sheet of wet ground, but

they run on opposite chemistry, carry different plants and animals, bank carbon or hide acid by turns, and face different fates. Keep the distinction in your pocket; we will visit both.

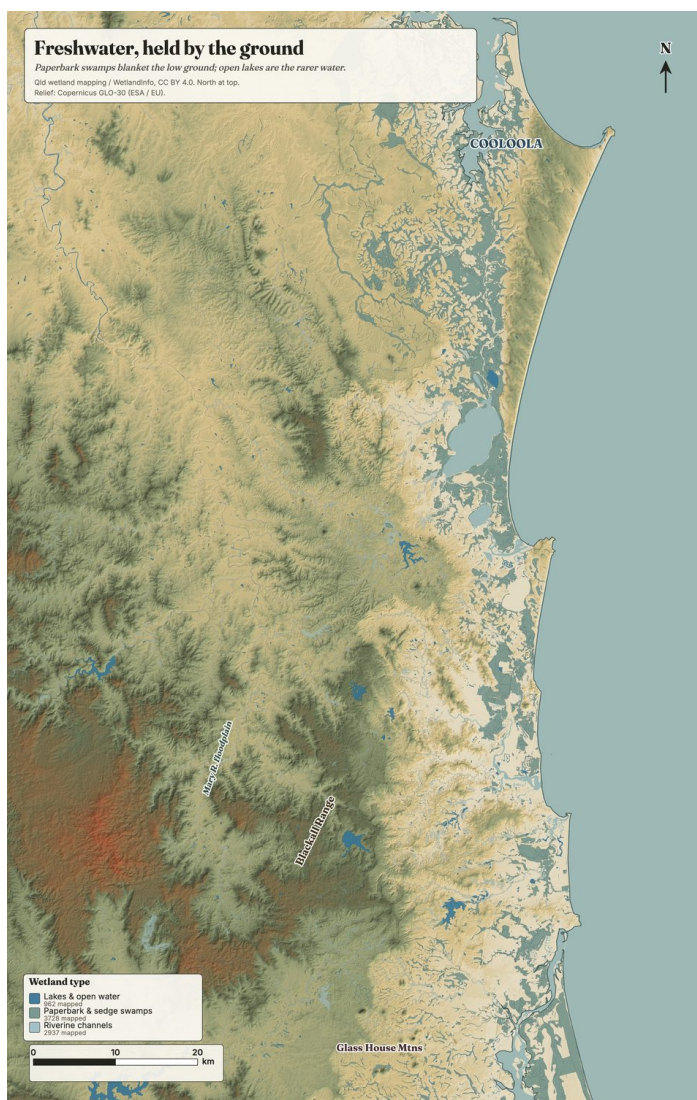


Figure 10.2 — Freshwater held by the ground. The region’s paperbark and sedge swamps blanket the low ground — 97% of them on alluvium or coastal sand — while open lakes are the rarer water.

The tree that lives with its feet wet

The paperbark is one of the most recognisable trees on the coast, and once you know it you will see it everywhere the ground goes soggy. Its trademark is the bark: thick, soft, spongy and pale, peeling away from the trunk in papery sheets you can lift off in handfuls, layer upon layer of it like the pages of a sodden old book. The great swamp-former of this region is the broad-leaved paperbark (*Melaleuca quinquenervia*), which gathers into dense, pale-trunked stands in the wettest lowland hollows, often with its boots underwater for months at a time.

Living with your feet permanently wet is, for a tree, nearly as hard a trick as living in salt, and for a related reason: waterlogged soil is airless soil, and roots need to breathe. The paperbarks cope where an ordinary tree would drown, tolerating long flooding and surviving the swing between drought and inundation that defines a floodplain. That famous spongy bark is part of the kit: it insulates the trunk against the fires that run the swamp edges in dry years, and it sheds and regrows freely. The tree is built, in short, for instability — for a world flooded one season and parched the next.

A wetland is a pulse, not a place

What rules a wetland like this is not how high the ground is, nor how rich, but water, and above all time: how many days a year each patch of it spends underwater. That one number sorts the plants into their bands and times the animals to their seasons, and the flood that fills the swamp and the dry that empties it are not interruptions to its life but the engine of it. To read a wetland, then, you have to read it in time as much as in space.

To see the pulse written into the ground, there is no better place than the Noosa Everglades. Put a canoe on the upper Noosa River, above the broad, shallow sheet of Lake Cootharaba, and paddle north into the Cooloola section of Great Sandy National Park, and the river slows almost to a standstill. On a windless morning the water turns to dark glass, holding the paperbarks and the sky so perfectly upside down that it is hard to tell bank from reflection.

Sidebar — There is no such thing as an everglade. That mirror-stillness is how the reach earned its tourist name, the River of Mirrors. You will also hear it called one of only two everglade systems in the world, the other being Florida's. Both are fine things to put on a postcard, and both are worth a moment's scepticism, because there is no scientific definition of an "everglade" at all: treat it as an evocative label rather than a fact. What is true is plainer, and no less remarkable: this is a low, sand-bound catchment where clear, tannin-dark water drifts so slowly through lake, channel and swamp that few places on Earth match it, whatever we agree to call it.

The water is the colour of strong tea, and the colour is the first thing to read: it is dissolved tannin, leached from the peaty, acidic sand of the wallum all around, the same blackwater chemistry we met in the last chapter, now gathered into a river. Lake Cootharaba, downstream, is barely a metre and a half deep across its whole broad expanse and, fed by tides from the estuary below, faintly brackish; the true freshwater everglade is up here, above it, where the sand country drains in clean and slow. And the banks, if you read them, are the pulse's signature: where each plant stands is set above all by how long its feet stay wet, so they sort themselves into bands, just as the country behind us sorted itself by soil and by salt.

Out in the open water lie the **waterlilies**, among them the native blue waterlily (*Nymphaea violacea*), rooted in the dark bottom and floating their round pads and star-shaped, pale-violet flowers on the surface. The pads are more than decoration: they are a floating pavement that a surprising crowd of wetland life lives on and under, fish and insects sheltering in the shade beneath, and at least one bird walking across the top. Open water with lilies is the wettest band of all, the part that never dries.

Where the water shallows toward the bank, the lilies give way to **sedge**, and the master sedge of this sand country is the grey twig-rush (*Lepironia articulata*). At first it does not look like much: a dense, blue-grey sward of round, leafless, rush-like stems standing a couple of metres tall. But it is doing something clever. Its

leaves are reduced almost to nothing, the work of the leaf handed instead to those smooth round green stems, which are partitioned inside like bamboo and light enough to float; and it grows not just at the edge but out into deep water, forming great floating-edged beds that are among the most important nurseries and nesting cover in the wetland. On the lean wallum sand, where richer plants cannot get a footing, the grey twig-rush takes the reeds' place, building the swamp's green walls almost single-handed. Among it grow finer twig-rushes (*Baumea*) and the saw-sedges (*Gahnia*), big arching tussocks whose leaf-edges are exactly what the name warns: fine enough to slice a careless finger.

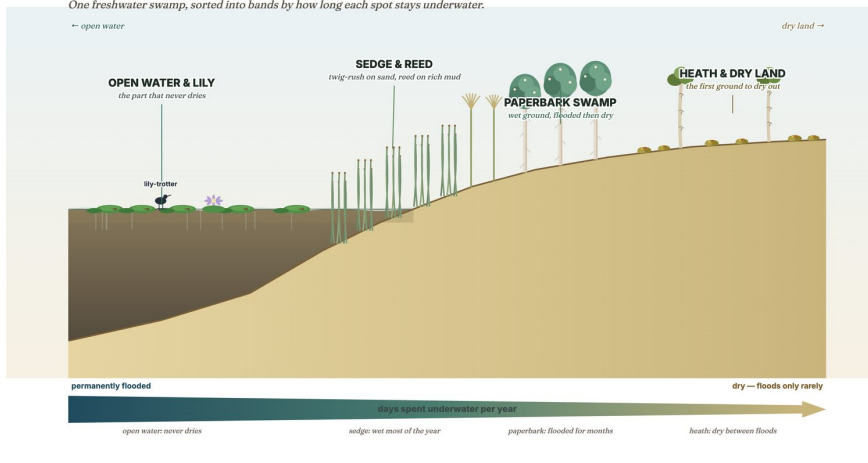
Behind the sedge, on ground that is wet but no longer permanently flooded, stands the **paperbark swamp** itself, the *Melaleuca quinquenervia* forest we have already met, pale-trunked and dim. The paperbark keeps company here. On slightly firmer ground around it grows the **swamp mahogany** (*Eucalyptus robusta*), a stout, dark-crowned gum in thick, soft, reddish bark and one of the heaviest nectar trees on the coast. When it flowers through the cooler months it feeds the honeyeaters and flying-foxes at the leanest time of the year. And where the floodplain runs down toward the estuary and the freshwater turns brackish, the paperbarks hand over to the **swamp oak** (*Casuarina glauca*), its fine, drooping branchlets the same reduced foliage as the she-oaks of the dry ridges and, like them, fed by root nodules that pull nitrogen from the air; it suckers into dense stands on the saline mud, a coastal forest now scarce enough to be listed as endangered.

Behind the paperbarks again, on the first ground that dries between floods, the wallum heath and scribbly gums (*Eucalyptus racemosa*) of the surrounding sand take over, and the wetland shades off into ordinary land. Read the shore from channel to dry land and you have read the bands in order: open water, lily, sedge, paperbark, heath, each a community tuned to a slightly shorter drink than the last.

FIG 10.1

Wetland zonation

One freshwater swamp, sorted into bands by how long each spot stays underwater.



Read the swamp the way you read the shore: open lily-water, sedge, paperbark, then heath — each band a slightly shorter drink than the last, the whole slope a tide-gauge of how many days a year the ground spends underwater.

Schematic freshwater cross-section (a wallum everglade); heights, spacing and hydroperiod not to scale.

Figure 10.1 — Wetland zonation. Paddle from open water to dry land and the swamp sorts itself into bands — lily, sedge, paperbark, then heath — each tuned to a slightly shorter drink than the last, so the shore reads like a tide-gauge of how many days a year the ground stays underwater.

One thing changes downstream. Out here on the hungry wallum sand, sedges rule the shallows, not reeds. On the richer river floodplains (the Maroochy, the Mooloolah), where the soil holds more nutrient, tall reeds take the sedges' place: the common reed (*Phragmites australis*), the same feathery-plumed reed that lines wet ditches the world over, and the cumbungi or bulrush (*Typha orientalis*), with its brown, sausage-shaped flower-spike that breaks into drifting seed-fluff in autumn. Both stand in thick beds where the twig-rush would stand on poorer ground. Same job, different plant, and the difference is once more written in the soil.

When the flood comes

For most of the year the pulse is the part you cannot see: the wetland sits, holds its level, waits. Then the rains come — and on this coast they come hard — and the whole system detonates into life. The plants flush, the paperbarks bloom, the frogs and the fish and the birds all cash in at once, and a healthy wetland in the right

season becomes one of the noisiest, most crowded places on the coast. The catch is that the moment does not last, so everything that can seize it, does.

And the paperbark itself joins the feast, for you do not fully appreciate the tree until you are standing beneath one when it blooms. A paperbark in flower is smothered in creamy, bottlebrush-like spikes dripping with nectar, and when a whole swamp comes into blossom at once it lays on one of the largest free meals in the landscape. Lorikeets pour in by the screeching, tumbling flock; honeyeaters work the spikes from first light; and after dark the flying-foxes arrive to drink, ferrying pollen from tree to tree and, as it happens, carrying the seed of the rainforest fruits they also feed on from one patch of forest to the next. Many of these nectar-feeders are nomads, ranging across the country after whatever is in flower, so a swamp coming into bloom can summon animals from tens of kilometres away. The humble paperbark also runs a roadhouse.

Start with the frogs, because you will hear them long before you see anything at all. After warm rain a lowland swamp erupts into a chorus loud enough to carry across the paddocks, and the trick is to pick the voices apart. The sharp, repeated *tok* (like a finger flicked against a taut drum, or a dripping tap) is the striped marsh frog (*Limnodynastes peronii*). The deep, hollow *bonk*, plucked like a banjo string and answered from across the swamp, is the eastern banjo frog or pobblebonk (*Limnodynastes dumerilii*), named for the very sound. A low growl from the reeds is the green tree frog (*Litoria caerulea*), a fat, placid, blue-green animal as happy in a suburban downpipe as a swamp. And the long, ringing, almost painful scream, far too big for the small frog producing it, is the bleating tree frog (*Litoria balatus*). For a frog the wetland is everything at once: the water to breed in, the cover to hide in, the insects to eat. And a swamp in full chorus is the sound of a great many small animals seizing a moment that, on a floodplain, closes fast.

Then the birds, which arrive in a procession tuned to the rising and falling water. As a swamp fills, the waders and the stalkers wade into the shallows: the great egret (*Ardea alba*), white and

statue-still, waits and then strikes. The royal spoonbill (*Platalea regia*) sweeps its absurd spatulate bill from side to side through the shallows, feeling for anything that moves. And out on the floating waterlily leaves walks the comb-crested jacana (*Irediparra gallinacea*), the “lily-trotter,” whose enormously elongated toes spread its weight so well that it strides across the pads as if walking on the water itself. Presiding over the whole affair on long legs is the black-necked stork (*Ephippiorhynchus asiaticus*), Australia’s only stork, which almost everyone here still calls the jabiru, and which stalks the shallows alone or in pairs, never in numbers — a tall, glossy, faintly improbable bird that a healthy floodplain still just manages to support.

Where the wetland runs to rank sedge and grass, magpie geese (*Anseranas semipalmata*) graze in clattering mobs, and out on the open water the ducks, grebes and cormorants dabble and dive.

Beneath the frogs and the birds lies the part you never see, and it is the part that feeds everything else. The real powerhouse of a wetland is its invertebrates: the dragonflies and damselflies, whose larvae are voracious underwater hunters for months before they haul out and unfold into the wetland’s flying jewellery; the water-beetles and the larvae of midges and mosquitoes; the drifting clouds of tiny crustaceans, and the worms and snails working the mud. They live, in the main, on detritus: the slow rain of dead leaves and sedge-stems rotting in the shallows. They turn it into the abundant, protein-rich food that the frogs, the fish and the waterbirds all draw on. Take the invertebrates away and the bright surface of the wetland would quietly starve.

The fish are part of the same works, and they tie the swamp to the river and the sea. When a flood reconnects the channel to the floodplain, the door swings open between them: fish fan out across the drowned flats to feed and, for some, to spawn, and the warm, weedy shallows become a nursery where the young grow fast on the flush of food, before the falling water draws them and their production back to the river and on toward the estuary. A few travel much further. The Australian bass (*Perca latipes*) spends its life in fresh water but runs downstream to spawn in the brackish reaches, cued by the winter floods; the

eels, longfin and shortfin, go furthest of all. The still water holds a crowd of smaller natives too, and with them the introduced eastern mosquitofish (*Gambusia holbrooki*), a pugnacious little import that nips fins and eats the eggs of frogs and native fish. And in the acid, tea-dark wallum waters live two specialists found almost nowhere else on Earth: the honey blue-eye (*Pseudomugil mellis*) and the Oxleyan pygmy perch (*Nannoperca oxleyana*), both now nationally threatened. They hold on in exactly the blackwater chemistry that keeps the weeds out and the mosquitofish largely at bay.

When the water falls

Then the dry returns, and the pulse runs the other way. As the water shrinks back, the boom collapses: the wetland contracts to its last permanent pools, and most of the cast dies back, disperses or waits. The frogs fall silent and dig in; and the waterbirds, many of them nomads built for precisely this, lift off and range vast distances across the continent in search of wherever the next rain has filled a wetland. So a coastal swamp filling after rain can draw birds from far inland within days, and empty of them again as fast when it dries.

Sidebar — The eel that spawns once. Of all the swamp's fish, the eels are the great travellers. The longfin (*Anguilla reinhardtii*) and the shortfin (*A. australis*) feed and grow in these tea-dark lowland waters for years, even decades — fattening quietly, seemingly settled — then slip away downstream, out through the estuary and off into the open sea, to spawn, once, far out in the Coral Sea, and die there. A whole patient life in a swamp, spent on a single journey it never returns from. (*Both species are catadromous and breed in the Coral Sea region; the precise oceanic spawning grounds remain imperfectly known.*)

And the reverse matters just as much. When the great inland dries out, as for most of the time it does, these reliable coastal wetlands become refuges, the places life retreats to and holds on. A floodplain wetland lives by that pulse, and its animals are timed to it;

the permanent waters — the deep everglade reaches, the dune-lakes that never dry — are the steady refuges that carry life through between the booms.

The unpaid work of a wetland

To understand why a wetland matters so far out of proportion to its looks, watch what it does with a flood.

When heavy rain comes, the wetlands on the floodplain do something no drain ever does as well: they spread out and *hold* the water. A swamp is a giant, shallow sponge. It takes the surge of a flood, stores it across a wide, flat area, and releases it slowly over the following days and weeks, shaving the dangerous peak off the flood downstream and feeding the rivers steadily long after the rain has stopped. Drain that swamp and channel it, and the same rain now arrives downstream all at once, in a sharp, destructive spike, which is why so much “flood mitigation” by drainage has, over the years, simply shunted the flooding somewhere else and made it worse. The wetland was the flood mitigation. We drained the solution and called it progress.

The same slow passage through the swamp does a second job: it cleans the water. As run-off creeps through the sedges and the paperbark roots, the plants and the mud strip out sediment, excess nutrients and pollutants, so that what finally seeps into the rivers, the aquifer and the estuary is markedly cleaner than what arrived — a wetland is a water-treatment plant that builds and runs itself.

It does a third job, too, more slowly and far more quietly: it banks carbon. In the waterlogged, airless mud of a swamp, dead leaves and roots and sedge-stems rot only sluggishly, so year after year the undecayed remains pile up as peat: dark, spongy, carbon-rich soil that can lie metres deep on the old sand swamps. The great sand masses of Cooloola and K’gari hold some of the region’s deepest freshwater peat, and every tonne of it is carbon kept out of the air. It is the freshwater cousin of the “blue carbon” locked in the tidal mangroves and saltmarsh of Chapter 8, and

just as worth leaving in the ground. Drain the swamp and let the air in, and the peat begins, slowly, to oxidise away to carbon dioxide instead.

So a wetland stores floods, filters water, recharges the aquifer and banks carbon, and runs a nursery and a refuge besides: for frogs by the thousand, for fish that run in to breed when the floods join the swamps to the rivers, for waterbirds in great numbers, and, in the dry, as a last reservoir of water and food when the surrounding country has parched.

Sidebar — How to make acid by accident. One of the meanest tricks in the region is also a powerful argument against draining a swamp on a whim. Many of the low, waterlogged soils of the coastal lowlands are rich in iron sulfides, built up over thousands of years in the airless mud. Left wet, they are perfectly harmless and sit there doing nothing. Drain them, though — dig a channel, lower the water table, let the air in — and the oxygen reacts with those sulfides to produce, of all things, sulfuric acid. The drained soil turns acid, and the next big rain flushes that acid, along with dissolved iron and aluminium, into the waterways in a slug strong enough to strip the oxygen from the water and the protective slime from a fish's skin. These are “acid sulfate soils,” the buried landmine beneath a great deal of drained coastal floodplain in eastern Australia, and the Maroochy floodplain has its share: the outbreaks of “red-spot” disease that leave bream and flathead around Bli Bli covered in ulcers tend to follow exactly these acid pulses, the acid stressing the fish until a waterborne mould can take hold. A swamp is storing water and carbon and keeping a chemical hazard safely asleep besides; wake it carelessly and the bill arrives, years later, as dead fish and corroded drains.

The wetland's future

These wetlands have always lived by change, but the change now coming at them is of a different order. The most far-reaching is the sea. As the climate warms and the ocean rises, saltwater will

push further and further up the coastal floodplains, and the freshwater swamps nearest the coast (the lowest-lying paperbark stands and sedge flats) are expected to give way to saltmarsh and mangrove as the salt arrives. In northern Australia, where the seas have already crept inland, whole stands of freshwater paperbark have died as the salt reached them, a preview of what a rising sea does to a freshwater swamp. Where a wetland has room to retreat inland it may simply migrate and persist; but where roads, canals, cane and houses block the way, as they do along much of this coast, it has nowhere to go, and is squeezed between the advancing salt and the hard edge of development until it is gone.

The rest of the climate will not so much change the wetland's rhythm as crank it up. South-East Queensland is set to grow hotter through this century, its droughts longer and harder; and though no one can yet say whether the average year will turn wetter or drier, the downpours when they come are expected to fall heavier and faster — deeper dries, that is, broken by fiercer wets. That is simply the wetland's old boom and bust wound tighter, and a healthy swamp can take a good deal of it. What it takes less well is the combination with the drained acid sulfate soils of the lowlands: a long, hot drought bakes and exposes the buried sulfides, and the rains that finally break it flush the acid out all at once, so the very swing that empties the swamp also primes it to poison its own water the day it refills. None of this is beyond reach (most of it turns on how we drain, build and farm the floodplain, and where we choose to let the water go), but it does mean the wetlands of the next century will be worked harder, by salt and drought and flood at once, than any drainage scheme ever worked them.

What we lost, and what we are learning

The freshwater wetlands have taken a heavier beating than almost any other ecosystem on the coast, and the reasons are depressingly simple. They sat on the flat, fertile floodplains that were the easiest and most valuable land to farm; they were wet, and draining them was straightforward; and nobody, until quite

recently, counted the services they were providing, because none of those services came with an invoice. So they were drained for cane and pasture, filled for housing and industry, channelled and cleared, and, on the richer floodplains, choked with weeds: para grass (*Urochloa mutica*) smothering the margins, mats of salvinia (*Salvinia molesta*) and water hyacinth (*Pontederia crassipes*) blanketing the open water. Only fragments of the original lowland wetland survived.

The turning point has come from a change in the accounting. Once you price what a wetland does, the case for keeping and rebuilding it becomes overwhelming, and a new generation of projects is doing exactly that. The clearest local proof is Yandina Creek Wetland, on the Maroochy floodplain, whose story is almost a parable. It is now part of the Blue Heart, a larger effort across the Maroochy floodplain — a partnership of Sunshine Coast Council, the Queensland Government, Unitywater and the Kabi Kabi — to let both fresh and tidal water back onto land that was drained generations ago, restoring wetland for flood storage, habitat and carbon together.

Sidebar — The accident that became a wetland. Yandina Creek Wetland, on the Maroochy floodplain, was drained and farmed for sugarcane from the 1920s, then sold off after the local mill closed. Nobody planned what happened next: its ageing tidal floodgates failed, the river crept back in, and within a few years the old cane paddocks had quietly turned themselves back into a wetland thick with birds. One man noticed. Greg Roberts, a local birdwatcher, had been documenting the extraordinary birdlife gathering on the reflooded paddocks, so when the floodgates were repaired in 2015 and the water drained away again, stranding the nesting waterbirds, it was his alarm that lit the campaign to save the place. It ended with the regional water authority, Unitywater, buying the 191-hectare site, reopening it to the tides, and managing it for conservation. More than a hundred and sixty bird species have since been recorded there.

It is restoration of an unglamorous, deeply practical kind, undoing at no small cost what an earlier and more confident era spent so much effort to do. We are, slowly, learning to read the swamp as an asset rather than an obstacle — and, as Yandina Creek showed, the wetland is often willing to rebuild itself the moment we let the water back.

Reading the wet country

So read the wet country for what it is, against the long habit of seeing it as a problem. And read it by the water. Here the whole gradient hangs not from the rock, as it has so far, but from the water: how many days a year each patch spends underwater sorts the plants into their bands as surely as salt sorted the estuary behind us. A dense stand of pale, papery-barked trees with their feet in the water is paperbark swamp, built for a world that floods and dries by turns. Reedy or sedgy open water and a lagoon behind the river are the freshwater wetlands, a sponge and a filter and a nursery at once, and the bands of plant life (from open lily-water through sedge or reed to paperbark and heath) read like a tide-gauge of how long each spot stays wet. A fresh-cut drain leading away from a low paddock is very often a wetland in the act of being lost, and, if the soil beneath is the wrong kind, a chemical hazard in the act of being armed. The swamp is no wasteland but the coast's hardest-working and least-thanked ground. Its boom-and-bust rhythm is not a fault to be engineered out but the engine the frogs and fish and waterbirds breed and feed by, so a wetland held forever at one fixed level is one with its engine switched off.

We have now followed the gradient up out of the salt, across the poor bright sand of the wallum, and through the wet hollows of the floodplain. Ahead, the ground begins to rise and dry. On the foothills and the slopes, where the soil firms up and the water drains away, the swamps give out and the most quintessentially Australian country of all comes into its own: the open eucalypt forests and woodlands, the land of the gum tree, the fire and the koala. That is where we climb next.

Chapter 11 • Eucalypt forests and woodlands

How much fire does a gum forest need? Too little and it chokes; too much and it is gutted; there is no setting that is simply right.

Picture the Australian bush. Whatever image came to mind — the tall straight trunks, the hanging grey-green leaves, the dappled light, the smell of eucalyptus on a hot afternoon, the call of a whipbird or the laugh of a kookaburra — you have just pictured a eucalypt forest, and you have pictured the stretch of the Sunshine Coast that looks Australian to the bone. It is also the country we notice least. The rainforest is dramatic, the wallum is curious, the beach is the beach; the gum forest is merely *there*, the green-grey backdrop to everything else. But the backdrop turns out to be the stage: the largest and most fiercely contested ecosystem on the gradient, and the home of the animal the whole region has chosen as its face.

We climb into it off the wet lowlands of the last chapter. As the floodplain rises into foothills and the soil firms up and drains, the swamps give out and the gum trees take over, and they keep on taking over, all the way up the slopes until, near the wet tops of the range, they finally meet their old rival the rainforest. Between the swamp and the rainforest lies a vast sweep of eucalypt country, and the first thing to learn about it is that it is not one forest but two.

Wet and dry: the two sclerophyll forests

The eucalypts and their relatives are sclerophyll plants, the hard-leaved tribe we met in the wallum, their tough, leathery, long-lived leaves the mark of a flora raised on poor soils. But eucalypts

span a huge range of conditions, and on the Sunshine Coast they sort themselves into two broad kinds of forest, divided by how much water and nourishment the ground can offer.

On the better, moister soils (the foothills, and the gullies and lower slopes with a bit of richness to them) grows **wet sclerophyll forest**: tall, even towering, open eucalypt forest whose straight trunks rise clear for many metres before they branch, standing over a soft-leaved, shrubby, almost rainforest-like understorey. This is the tall timber, and it lives a curiously double life, forever poised on the edge of becoming something else.

On the poorer, drier ground (the harder foundation rock of Chapter 3, the ridges and the free-draining slopes) grows **dry sclerophyll forest and woodland**: lower, more open, more sparse, standing over a floor of grass and scattered hardy shrubs. This is the open, sunny bush of the postcards, the country you can walk through easily and see a long way into. It is less showy than the wet forest and, in its way, even richer in species at ground level, and it is classic habitat for a wide range of the region's animals.

The difference between the two is written in the ground. Give a eucalypt forest more water and nutrient and it grows tall, dense and shrubby; starve it and it opens out into grassy woodland. Same family of trees, the richness of the soil dialled up or down, producing two different worlds. And running through both, setting the boundaries, is fire. (We will walk through both forests, tree by tree, on a single hill. But first, the force behind them.)

Sidebar — The richest few inches. Look at a dry, open eucalypt woodland and your eye goes straight to the trees, which is a pity, because most of the variety is down around your boots. The grassy, sunlit floor of this country can hold a startling number of small plants in a single patch: kangaroo grass and wiregrass between the trunks, and threaded among them flax lilies, native peas, daisies, ground orchids and the little pink trigger plants, with hairpin banksia, grass-trees (*Xanthorrhoea johnsonii*) and the stout, palm-like cycad *Macrozamia miquelii* standing up through the sward. Many are there only because regular, gentle fire keeps the canopy open and stops any one shrub from shading them out. It is the inside-out of the rainforest: the trees spaced and modest, the riches underfoot, renewed every few years by a cool burn. Walk through such a woodland in spring and the ground will be in flower. Walk the same patch after decades without fire and you will find it closing over with a few woody shrubs, the small plants gone, the diversity spent.

A forest that lives by fire

Everything Chapter 6 said about fire comes into its own here. These are the very trees that chapter described: the ones that make themselves flammable with oily leaves and wick-like bark, and then ride out the blaze they invite behind insulating bark, epicormic buds and buried lignotubers. A eucalypt forest is fire-*dependent*, built around the regular passage of flame, and much of its understorey needs fire to regenerate.

This is at its most dramatic in the tall wet sclerophyll forest, which is caught between two fates: its towering eucalypts cannot reproduce in their own shade, so without fire to open the ground and hold back the rainforest creeping up the gullies, the tall forest slowly gives way to rainforest altogether — some of the most majestic forest on the coast standing only at the sufferance of flame.

The dry forest repeats the same pattern lower down, in the understorey, and this is the change most walkers will actually see. There, fire's work is to keep the ground open. A cool burn every few years kills off the woody seedlings, clears the litter, and lets the grasses, lilies and small flowering plants of the sunny floor come away again from their roots and seed, which is why the richest dry woodlands are, counter-intuitively, the regularly burnt ones. Take the fire away, and the floor begins to close over. Woody shrubs and small trees that a burn would have knocked back grow up instead unchecked and crowd into the mid-storey: wattles, mainly *Acacia leiocalyx* and *A. disparrima*, which germinate in dense flushes; the black she-oak, *Allocasuarina littoralis*, the most persistent local offender; and, in moister or disturbed patches, rainforest pioneers and the smothering exotic weed lantana. As the shade deepens, the grassy, flowering ground layer is starved of light and thins and vanishes. Ecologists call this **woody thickening**, and it is one of the commonest ways an Australian woodland loses its diversity without losing a single tree to the chain-saw. Where it is rainforest plants doing the thickening, the loss has been measured directly in this region: the number of understorey species roughly halved, and the small plants of the open forest all but gone.

A long-running burning experiment at Peachester, just north of the Glass House Mountains and running for close on half a century, has watched precisely this unfold. Plots burnt every few years kept their open structure and their crowd of small ground plants; plots left unburnt for decades closed over. In the heath plots, the open ground vanished under a dense blanket of coral fern. The same study turned up a genuine catch: frequent burning, for all that it preserves that ground-layer diversity, also draws down the carbon stored in the topsoil. Fire here works less like a simple good than like a dial, and it runs wrong in both directions. Too little, and the woodland thickens and shades out its ground layer. Too much, or too fierce, is its own kind of harm: burn a patch hard and often and the slow growers never get the years they need to recover — the she-oaks knocked back before they

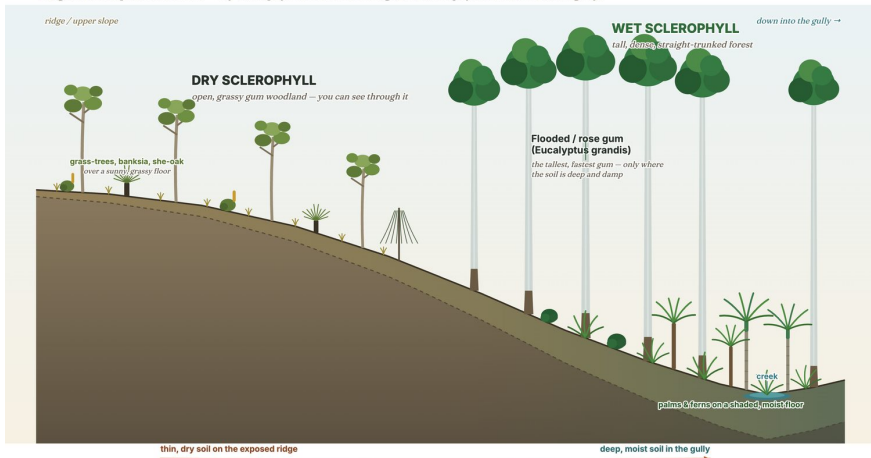
can seed again, the fire-sensitive plants of the gully and the old hollow-bearing trees killed outright. There is no correct setting, only trade-offs.

A walk up Mount Ninderry

All of this — the two forests, the fire, the plants that need it and the plants it holds back — comes together on the ground, so come up an actual hill with me. **Mount Ninderry**, the 304-metre rhyolite peak behind Yandina, is built of hard, silica-rich volcanic rock that weathers into thin, hungry soil, so its exposed slopes carry dry sclerophyll forest while deeper, moister soil collects in its gullies and grows wet. Both forests on one mountain, then. We will climb the open slope first and drop into a gully after, and I will stop at the plants worth knowing: what you are looking at, what makes each one worth a second look, and how it leans on the things around it.

Both forests on one hill

The gum forest splits itself in two — dry sclerophyll on the starved ridge, wet sclerophyll down in the moist gully.



One hillside, one family of trees, two forests: an open, grassy gum woodland on the thin dry ridge gives way, as the soil deepens and the damp collects, to the tall flooded gums of the gully.

Schematic slope-to-gully cross-section (after Mount Ninderry); heights, depths and spacing not to scale.

Figure 11.1 — Both forests on one hill. Climb Ninderry and the gum forest divides itself in two: an open, grassy woodland on the thin, dry soil of the exposed ridge, and — where the soil deepens and the damp gathers in the gully — the tall, straight flooded gums of the wet sclerophyll, rising over palms and ferns; the split is written, as ever, in the depth of the ground and the water it holds.

On the open slope. The first tree to learn is the one shedding its skin. **Grey gum** (*Eucalyptus propinqua*) is a true gum, smooth-barked from base to twig, and once a year it drops its old bark in strips and slabs to bare fresh bark beneath that is almost apricot: a soft orange you would not believe was a gum trunk. Over the following months that orange fades through fawn to grey, and because the shedding is patchy, a single trunk wears every stage at once, grey and cream and salmon marbled together. The leaves confirm it: long, narrow, slightly sickle-shaped, glossy on top and paler underneath, so the crown flickers two-toned in a breeze. Its capsules are tiny, four to six millimetres, the valves poking up above the rim like little teeth, which tells it from the spotted gum it can resemble, whose gumnuts are fat urns. And it is one of the koala's favoured feed trees on this coast, as is its constant companion the **tallowwood** (*Eucalyptus microcorys*), which wears soft, fibrous, reddish-brown bark right up the trunk over a timber so greasy when freshly cut that the old sawyers likened it to working a block of tallow. Where the two grow side by side, as they do here, you are standing in the best browse the open forest offers, and koalas live where the soil is just rich enough to grow these trees: the first hint that this slope is koala country.

If the grey gum throws its bark away, the next tree does the opposite, and for a reason. **Grey ironbark** (*Eucalyptus siderophloia*) keeps its bark — dark grey to nearly black, baked hard, ploughed into deep furrows that run the length of the trunk and out to the smallest branches — and that thick dead coat is armour. While a grass fire runs through the understorey, the living tissue beneath the ironbark's casing stays cool enough to survive, and the tree barely notices. Ironbarks earn their place in the food web by their timing: they flower into the cooler months, when little else does, and that out-of-season nectar is a windfall for honeyeaters, lorikeets, gliders and flying-foxes through the lean part of the year.

Cut the next tree and it bleeds: the **pink bloodwood** (*Corymbia intermedia*), known at a glance by bark like crocodile hide and named for the dark, blood-red gum, or kino, it weeps from any wound. In high summer it stages one of the great flowering events

of the open forest, clouds of scented cream blossom that pull in lorikeets and honeyeaters by day and flying-foxes by night. And the yellow-bellied glider scores its bark to drink the bleed, so this one tree is three things at once: a summer nectar bar, a sap well, and, as it ages, a maker of hollows.

Now look down before you look up. If the ground is scattered with little cones chewed and splintered to shreds, like cracked pistachio shells, then the slender tree above you with the fine, dark, weeping foliage is a **black she-oak** (*Allocasuarina littoralis*), and you have found the dinner table of the **glossy black-cockatoo** (*Calyptorhynchus lathami*). Look closer and the tree has more to show. Those drooping “needles” are not leaves at all but green branchlets, jointed like bamboo, with the true leaves shrunk to a ring of tiny scale-teeth at each joint. And they are why a she-oak in any breeze gives off that soft, continuous sighing, a sound like distant surf. The plants are male or female on separate trees: in autumn the males flush rusty orange with pollen, while the females carry crimson-styled flowers that harden into the cones the cockatoo wants. Underground, meanwhile, the she-oak’s roots carry nodules of a bacterium, *Frankia*, that pulls nitrogen from the air and feeds it into the poor rhyolite soil: the tree is quietly fertilising the ground it stands on.

Sidebar — The cockatoo that eats one thing. Those cones chewed and splintered beneath the she-oak are the work of the glossy black-cockatoo, which eats almost nothing else and is obsessive about it: returning to the same favoured trees year after year, ignoring perfectly good ones next door, working each woody cone slowly for a small, hard-won meal. And the she-oak has one weakness: a hot fire kills it outright, and it takes the best part of a decade to grow back to cone-bearing size, so a single bad burn switches off the cockatoo’s larder for ten years or more. A bird’s whole living, hung on one slow-growing tree and the fires that pass through it.

The shaggy mophead on a short blackened trunk nearby may be the oldest living thing on the hillside. A **grass-tree** (*Xanthorrhoea johnsonii*), neither a grass nor a tree, builds its trunk from thou-

sands of old leaf-bases cemented by its own resin and grows it at perhaps a centimetre a year, so a waist-high one has stood here the better part of a century and the tallest are older still. (To name the species, snap a leaf: in *johnsonii* the cut end is roughly square, almost as thick as it is wide.) Everything about it is built around fire. The skirt of dead leaves is flammable, and a passing fire chars the trunk black without harm. The resin-packed stem and the growing point buried in the crown are well insulated, and the smoke itself is the cue to flower. In the spring after a burn it throws up a tall spear topped by a dense spike of hundreds of small, nectar-rich cream flowers, and a whole hillside will flower at once, as if on a signal, which is exactly what it is.

Older still, as a kind, is the stiff palm-like rosette of hard fronds beside it: a cycad, **Macrozamia** (*Macrozamia miquelii*), whose lineage is older than the dinosaurs. Its stout stem is almost entirely underground, so the crown seems to sprout straight from bare earth, and when its big seed cones break open they spill large seeds in a fleshy orange-red coat that are loaded with toxins and dangerous to eat untreated. Like the she-oak, it farms its own fertiliser: among its roots are strange, knobbly “coralloid” roots that grow upward toward the surface and house nitrogen-fixing microbes.

Sidebar — The thermogenic cycad. The cycad breeds by a trick the flowering plants long ago gave up: it is pollinated by tiny, host-specific thrips that live in its male cones. A close relative just down the coast, *Macrozamia lucida*, takes the trick further still: its male cones warm themselves and give off a scent strong enough to drive the thrips out in their thousands and onto the female cones, ferrying the pollen across. A plant that runs a fever to move its own pollinators is not what you expect of a squat, dark rosette sprouting straight from the earth.

One shrub here is hoarding its seed for a fire that has not happened yet: the **hairpin banksia** (*Banksia spinulosa*), which holds up a fat golden flower-spike bristling with the long wiry styles, each hooked and dark-tipped, that give it its name. That spike is a nectar factory for honeyeaters and native bees by day

and small gliders by night. Once flowering is done it hardens into a grey woody cone that stays shut, holding its seed for years, until the heat of a fire makes it gape and drop onto fresh ash — the same fire-banking trick you met out in the wallum.

Down in the gully

Now follow the slope down into one of the gullies that drain the mountain's southern flank, and feel the forest change. As the ground hollows, soil washes in and deepens, the air cools and stays damp, and within a few paces the open, grassy, sunlit woodland closes into something taller, denser and dimmer. This is wet sclerophyll, and the plants change with it. It announces itself overhead: the tree rocketing straight up out of the gully floor — a clean, pale, blue-white column with a short rough sock of grey-brown bark around its base and smooth bark all the way up — is the **flooded gum**, or **rose gum** (*Eucalyptus grandis*). It is among the very tallest of all eucalypts, commonly fifty metres and reaching past seventy, and one of the fastest-growing trees in the country, throwing itself skyward wherever its roots find deep, moist soil. Unlike the slope trees it has no lignotuber, no buried reserve to fall back on; it is committed to height and speed. But its size is the least of it: what decides its future is growing up underneath.

The gully floor belongs to the palms. The tall, smooth, grey-ringed one growing in colonies along the wettest ground is the **piccabeen**, or **bangalow palm** (*Archontophoenix cunninghamiana*): tell it from its near-twin the Alexandra palm by the smooth green sheath (the “crownshaft”) just below the fronds, and by the sprays of lilac-mauve flowers that hang from it. Those flowers set bunches of round fruit that ripen bright red, and the fruit is the point: the wompoo fruit-dove, the topknot pigeon and the flying-foxes eat it and carry the seed off to the next gully, planting tomorrow's palms.

Crush a handful of leaves from the **red ash**, or **soap tree** (*Alphitonia excelsa*), and they lather like soap and smell startlingly of sarsaparilla. It is a fast pioneer creeping up from the deeper gullies, throwing the shade in which slower, more permanent rain-forest trees get their start. Where light still reaches the floor,

bracken (*Pteridium esculentum*) fills the gaps, the coarse, waist-high fern everyone knows, which springs straight back from a deep, far-running, effectively fireproof rhizome after any burn or clearing. That is why a thicket of it so often flags disturbed ground.

Now stand still in the gully and put it together. The flooded gums overhead cannot reproduce down here in their own shade. Their seedlings need open, sunlit, ash-cleared ground to get away. But the palms, the ferns and the rainforest saplings crowding the floor are built for shade and need no such help. So the tall gum forest is, slowly, losing. Left undisturbed, with fire kept out of the gully, that shade-loving understorey keeps rising until it closes over and shuts out the next generation of gums, and the wet sclerophyll can become rainforest for good, provided a rainforest seed-source stands close enough to colonise it and no drought or harsher fire cuts across the process first. It is a strong tendency, not a certainty. But where the conditions line up, the giants overhead are the last gum generation of a forest already on its way to becoming rainforest, and only fire, reaching up into the gully every few decades to knock the rainforest back and open the soil, resets the contest and lets the gums seed again.

How old is this?

Walk this slope and a natural question arrives: how old is all this? It is harder to answer than you would think, because a eucalypt will not tell you its age the way a pine or an oak will. In places with hard winters a tree lays down one clear growth ring a year and you can count them; but here, where growth never quite stops and is ruled more by rain than by season, eucalypts lay down rings that are faint, false or missing, and counting them is no use at all. Size is a poor guide too. Growth depends so heavily on water, soil and crowding that two trunks of the same girth can be a century apart. A lean grey gum on this starved rhyolite may be far older than a fat flooded gum that shot up in a rich, wet gully. The foresters who have measured tens of thousands of Queensland trees over decades find the average eucalypt adds only about a quarter-centimetre of diameter a year, so a trunk the thickness of a power

pole (thirty-odd centimetres through) is, on average, around a hundred and twenty years old. But the spread is huge, and once a tree passes about eighty centimetres through, its girth tells you nothing more useful than “old.”

So you read age indirectly, from the things only time can make. The surest is the hollow. A eucalypt does not grow hollows; they are excavated, slowly, by fungi, termites, fire and rot working into the heartwood of a tree that has lived long enough to have heartwood worth rotting — and that takes a very long time. In these forests a blackbutt carries no hollow a possum could use until it is about a hundred and sixty years old; a tallowwood’s small hollows come at around two centuries, its big ones at two hundred and fifty or more. So a tree riddled with holes, a glider’s apartment block, was standing well before any European saw this coast. The slow plants are clocks too: that grass-tree, growing a centimetre a year, is already a century old at waist height and the tall ones may be three or four hundred; the cycad beside it, slower still, may be older than the gum trees shading it. Even fire leaves a record: the blackened, healed scar at the base of an old trunk, a “cat-face,” is the overlaid wound of fires gone by, though here, without reliable rings, it tells you that fire has come through, not exactly when.

Was it ever cut?

Which raises the second question, the one that changes how you see the forest: is this the untouched wildwood, or did someone cut it and is this what grew back? Almost everywhere on this coast, it is the second. The South-East Queensland hardwoods (blackbutt, tallowwood, ironbark, spotted gum, flooded gum) were worked hard from the mid-1800s, and a study of nine million hectares of southern-Queensland native forest could not find a single plot that had escaped some tree removal since European settlement; genuinely untouched old-growth survives only where the ground was too steep or wet to bother with. That whole history is Chapter 17’s to tell in full. What matters on the slope is that you can read it off the trees in front of you.

What surprises people is that nobody planted it back. Cut a eucalypt and it fights back — resprouting from dormant buds beneath the bark, shooting from the woody lignotuber at its base, seeding from canopy and soil — so a logged forest grows again from its own roots, usually back to much the same mix of species. The bush on this slope is neither pristine wilderness nor plantation, but native forest knocked about, repeatedly, and grown back each time. (The real plantations, reading completely differently, are the dead-straight rows of hoop pine and the dark stands of exotic pine on cleared ground elsewhere on the coast, even-aged and single-species.)

Once you know to look, that history stands in front of you in the marks left by axe and fire. True old-growth looks the opposite of a worked forest: uneven, all ages at once, a few enormous broken-crowned trees standing over younger ones, the ground littered with great fallen logs. That structure is rare now, which is exactly why the patches that still have it, and the few old hollow-bearing trees scattered through the regrowth, are worth so much.

Sidebar — Reading the axemen’s marks. A worked forest keeps a record of its own handling, and once you know the signs a stand will date itself. Hollows are the surest clock: a eucalypt cannot excavate them, so a trunk riddled with holes has stood well over a century. An old stump with a deep horizontal notch cut a foot or two up once held a “springboard,” the plank a cutter stood on to swing his axe above the wide, hard base of the tree. A ring of same-sized trunks rising from a single point is coppice: regrowth off a cut or burnt stump, whose rootstock may be far older than the stems above it. Trees all of one size, close and straight as poles, came up together after a fire or a felling cleared the ground at a stroke. And the plain absence of giants is itself a reading: the biggest, most hollow-filled veterans were the first to be carried off.

Mount Ninderry is a fair example of all this. Its steep rhyolite slopes were never easy ground to clear or cart timber off, so much of the bush you climb through is remnant (old, self-sown native forest rather than heavily logged regrowth), part of why one small

reserve still holds some four hundred native plant species. But the mountain was not untouched: bananas were grown on its lower slopes in the 1920s, gold was prospected on it in the 1930s, and one of today's walking tracks runs through an old banana paddock now choked with exotic Bana grass. The mountain you climb is recovering country: largely its old native forest, scarred and slowly being weeded back.

Reading the forest

So look again at the backdrop, and read it. Tall, straight-trunked forest over a soft, shrubby floor is wet sclerophyll; low, open, grassy woodland of spotted gum and ironbark is dry. Read the floor as a clock: grassy and flowering means fire has come through recently and often; shrubby, dim and litter-deep, thick with wattle and black she-oak, means a long time without one. Read the trees for age in their hollows, and read the old stumps and even-aged poles for the long history of cutting and regrowth. Do that, and a stretch of bush you might once have driven past as a green blur becomes a legible record of soil, fire and time.

But the trees are only half of it. The next chapter belongs to their tenants — the koala in the high fork, the cockatoo at the she-oak cone, the glider denning in a century-old hollow — and to the exact, and dangerous, dependence that binds each of them to a particular tree, before the gradient makes its final climb into the rainforest.

Chapter 12 · Tenants of the gum forest

A forest is not only its trees. It is everything that has learned to make a living among them — and on this coast, that begins with an animal asleep in a fork.

Somewhere in the high fork of one of those grey gums, an animal the size of a small dog is asleep, as it will be for some twenty hours out of the day, eating almost nothing but the leaves around it. The koala is the face this region has chosen for itself. It is only the most famous of the gum forest's tenants, a cast of gliders, cockatoos and owls each fitted to the trees as precisely as a key is cut to a lock, and each in trouble now for exactly that reason.

The koala, the region's emblem

We have met the koala's larder, the grey gums and tallowwoods of the open slope; now meet the animal itself.

The koala (*Phascolarctos cinereus*) depends on the eucalypt almost completely. It eats almost nothing else: the leaves of a particular set of gum species, leaves so low in nourishment and so loaded with toxins and indigestible fibre that almost no other mammal will touch them. The koala gets away with it by doing as little as possible, moving slowly, and running a gut and a metabolism finely tuned to wring a meagre living from a near-worthless food that nothing else is competing for. It is the same logic as the wallum, played out in an animal: survive on what others cannot use, and you escape the competition. For all its fame, though, the koala is a bit-player in the forest's leaf economy. Far more eucalypt foliage is eaten not by koalas but by insects, in quantities no mammal comes close to, and it was largely against those insect armies that the gums first loaded their leaves with oils and toxins: the very defences the koala has merely learned to tolerate. But that dependence on the gum leaf ties the koala utterly to particu-

lar trees in particular forests, and once those forests start to go, the very thing that let it prosper is what undoes it. The koala needs the right feed trees, enough of them, connected closely enough to move between safely, and across South-East Queensland, including this coast, those forests have been cleared, fragmented and cut through with roads at cruel cost.

The result is one of the most-studied and most-troubling wild-life declines in the country, and it is on this coast's doorstep. Long-term studies across the region have tracked the toll of vehicle strikes, dog attacks, habitat loss and, above all, disease: a chlamydial infection that spreads through populations and causes blindness, infertility and death. The koala has gone, in a generation or two, from common to officially threatened across its eastern range. And yet this coast is also pushing back against that decline — and with a piece of science you would not expect.

Sidebar — A vaccine for a koala. Among the most hopeful pieces of science to come out of the Sunshine Coast is, of all things, a vaccine for koalas, against the chlamydial disease that has been hollowing out their populations. Researchers at the University of the Sunshine Coast, led by Peter Timms, spent more than a decade developing and trialling it, and in 2025 it passed a landmark: the national regulator granted a permit allowing the vaccine to be used more widely in koalas, after field trials in wild populations cut deaths from the disease substantially. Think for a moment about what that involves: identifying the strain, designing the vaccine, and then testing it on a notoriously delicate wild animal that sleeps most of the day and bites, all to buy time for a species being squeezed on every other front at once. A vaccine is no substitute for the thing the koala actually needs, which is enough connected forest to live in; you cannot inoculate an animal against bulldozers and traffic. But it is a real feat, and a homegrown one.

The koala is only the most famous tenant. The eucalypt forest is full of dependencies as tight as the koala's: gliders that need the nectar and the sap and the hollows; the glossy black-cockatoo, which feeds almost entirely on the seed of she-oaks and nests

only in large tree hollows; a great parade of birds, bats, reptiles and insects, many of them tied to one particular resource the forest holds. One of those resources deserves a special mention, because it is so easily destroyed and so slow to replace: the hollow.

Sidebar — The century-old hollow. A surprising number of the animals of the eucalypt forest — parrots, owls, gliders, possums, microbats, the glossy black-cockatoo — cannot breed without a hollow in a tree to nest in. The catch is that a eucalypt does not grow hollows. They are *excavated* by time, by decades of fungi, termites, fire and rot working away at the heartwood of an old tree, and a hollow big enough for a cockatoo or an owl may take a hundred years or more to form. This means that the most valuable real estate in the forest is also the slowest to build and the first to go: the big, old, half-dead, “useless”-looking trees that a tidy-minded manager is most tempted to clear. Cut down a two-hundred-year-old hollow-bearing tree and you have not removed one tree; you have removed two centuries of housing that nothing can replace within any human time-frame. Nest boxes help a little, but they are a stopgap. There is no fast way to make an old tree.

The night shift

By day the eucalypt forest is loud enough. A kookaburra detonates its laugh from a dead branch; rainbow lorikeets tear shrieking through the blossom; magpies carol, honeyeaters and pale-headed rosellas comb the canopy, and a lace monitor (*Varanus varius*) scratches up a trunk at your approach. And yet a daytime walk can still feel oddly underpopulated, because most of the forest’s mammals are asleep, waiting for dark. The eucalypt forest runs a night shift, and that is where the forest does much of its living.

After sunset the canopy fills with gliders, possums that have stretched a membrane between wrist and ankle into a wing and learned to launch from a high branch and steer in long, swooping glides from tree to tree without once touching the ground. The greater glider (*Petauroides volans*), a slow leaf-eater about the size

of a cat, drifts through the tall forest. The smaller sugar glider (*Petaurus breviceps*) and squirrel glider (*Petaurus norfolcensis*) work the blossom and the insects. The yellow-bellied glider (*Petaurus australis*) cuts neat grooves in the bark of certain favoured trees and laps the sap that wells out, coming back to the same trees night after night. Above them hunts the powerful owl (*Ninox strenua*), the largest owl on the continent, which takes gliders and possums out of the air and needs a wide territory of old forest to find enough of them. Add the microbats flickering between the trunks after moths, the possums, the owlet-nightjars and the frogs, and the dark forest turns out to be far busier than the daylit one.

Nearly all of these animals share one requirement: a hollow to shelter and breed in. The gliders den in hollows through the day; the owls and parrots nest in them; the microbats roost in them. So clearing the big, old, hollow-bearing veterans removes far more than timber. It evicts the whole nocturnal population at once and leaves it nowhere to go. A stretch of forest can look perfectly healthy by day, green and loud with birdsong, while quietly failing the animals that depend on it most.

The trap of a perfect fit

There is a pattern hiding in all of this: the koala fitted to its gum leaf, the glossy black-cockatoo to its she-oak seed, the yellow-bellied glider to its favoured sap trees, each with a living almost nothing else in this forest can reach. The same precise fit that secures that living can, when the forest changes, turn from a triumph into a trap. That is a principle the whole coast draws out, and one a later chapter takes up in full; here it is enough to watch it bite in one forest.

And this forest sets its own particular version of the trap. A cleared feed tree might, given enough decades, grow back within reach of a young animal's lifetime; a felled hollow-bearing veteran carries off two centuries of housing that no goodwill can conjure back in time. These animals were shaped by a forest that changed

slowly, over the unhurried span in which heartwood rots out its chambers and she-oaks mature and drop their cones. Now they are being asked to cope with a forest changing fast.

The koala asleep in its fork stands in for the rest. What threatens it threatens all of them, and a forest kept standing and joined up for the koala is kept, at the same stroke, for the tenants behind it.

Reading the forest after dark

By now the forest reads as more than trees, and as more than a collection of separate lives. Its parts are wired together: clear the she-oaks and the glossy black-cockatoo goes hungry, fell the hollow trees and the night shift has nowhere to breed, withhold fire too long or burn too hard too often and the mix of what grows begins to shift. The koala asleep in a fork is its emblem, and it will hold on only where enough of this forest is left standing and joined up. Read the old, half-dead, hollow-bearing giants as the most valuable ground of all, a century or more of housing for everything that dens or nests in a hole, and read a stand of neat, even-aged young poles as a forest that has been cut and is still too young to shelter them.

And all of it is moving in time. The forest you are standing in is not a fixed picture but a slow film, a fire-pruned, century-old-and-older community that has been cut and has healed and is healing still, with a few ancient survivors standing among the younger trees like a memory of what was here before. The trouble is that the film is speeding up. South-East Queensland is projected to grow steadily hotter through this century, with longer fire seasons, more days of dangerous fire weather, and more severe droughts. Hot, deep droughts already stress and kill canopy eucalypts across eastern Australia, pushing their internal plumbing past the point where it can lift water to the leaves. And in disturbed, lantana-thickened wet forests of this region a slower affliction is at work — bell-miner-associated dieback, in which colonies of the native bell miner farm sap-sucking insects on the foliage and drive off the smaller birds that would keep them in check, until the canopy thins and dies from within. (The lantana is

a travelling companion of the syndrome rather than its proven cause; the trigger seems to be disturbance to the canopy itself.) The risk falls hardest on the parts of the forest that take longest to build: the centuries-old hollow-bearing trees, the slow-maturing she-oaks, the fire-sensitive plants of the gully. None of them can be regrown in a human lifetime, so each one lost to a fiercer fire or a deeper drought is, in practice, gone for good. The open question of the century is whether this forest can keep rebuilding itself as fast as the new pressures take it apart.

But come back after dark and read it again: the glide of a greater glider caught in the torch beam, the fresh sap-wells cut in a favoured trunk, the low double hoot of a powerful owl all tell you the same thing, that the real business of the gum forest keeps its own hours.

Above the tall wet forest, where the basalt holds the richest soil and the range wrings the most rain out of the sky, the eucalypts finally lose their long argument with their rival. The fire cannot reach into the wettest, most sheltered gullies and the cool high tops, and there the green wall closes overhead, the light goes deep and dim, and we enter the oldest and most luxuriant forest of all. The rainforest is the subject of the next chapter, and the summit of the climb.

Chapter 13 · Rainforests

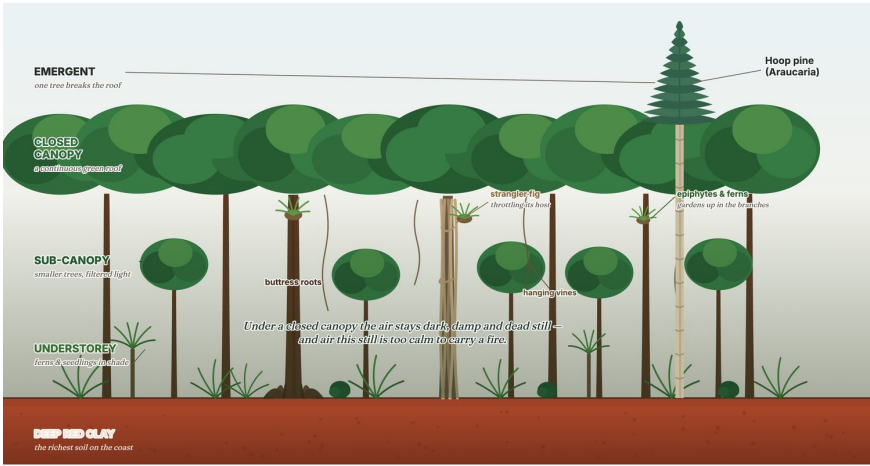
A rainforest is the one ecosystem on the coast that cannot be hurried, cannot be moved, and — once it is gone — cannot reliably be brought back. Which is exactly why so little of it is left.

At the top of the climb, on the richest soil and under the most rain, sits the forest everyone agrees is glorious: the rainforest. It is the tallest and oldest forest on the coast, and by a distance the most crowded, with more layers, more species, more sheer plant packed into a hectare than anywhere else on the gradient: buttressed trunks, strangling figs, hanging vines and dripping ferns, descended in part from the ancient forests of Gondwana that once covered this continent. It is also, and not coincidentally, the ecosystem we have destroyed most completely. The “big scrub” that once cloaked the basalt range was felled within a few decades of European arrival, and what survives today is fragments: precious, beautiful, and far harder to rebuild than they were to remove. A forest that defends itself so cleverly against fire, it turned out, had no defence at all against the axe.

We arrive here at the end of the long climb up from the sea. Through the last chapter the eucalypts rose and thickened until, near the wet tops of the range and deep in the sheltered gullies, they finally lost their ancient argument with the rainforest. In the wettest, most fire-protected places, on the deep red basalt soils, the green wall closes overhead, the light dims, and a different kind of forest takes hold — the opposite of everything the wallum taught us.

The closed green room

Subtropical rainforest builds itself in layers – and the layers are what keep the fire out.



Rainforest builds itself a room: layer on layer of closed canopy that keeps the floor dark, damp and windless – and too still to burn.

Schematic profile of subtropical rainforest structure; heights and spacing not to scale.

Figure 13.1 — Rainforest structure. The forest stacks in tiers — a single hoop pine spearing clear above a closed canopy, sub-canopy and shaded understorey rooted in deep red clay — and the very closure that keeps the floor dark and damp is what keeps it too still to burn.

The opposite of the wallum

That contrast is worth holding onto, because the rainforest and the wallum are the two poles of the whole gradient. The wallum grows on the poorest soil, in the open, demanding fire, and answers its poverty with a riot of small, hard-leaved specialists. The rainforest grows on the richest soil, in deep shelter, excluding fire, and answers its wealth with raw mass and structure: enormous trees, many layered one above another, soft broad leaves built to catch dim light, and a comparatively short list of giants rather than a long list of specialists. Where the wallum is a crowded democracy of the poor, the rainforest is a towering aristocracy of the well-fed. Both are diverse, but at opposite ends of the same gradient.

The rainforest's wealth shows in its architecture, which is unlike anything else on the coast. The trees stand in tiers, the tallest emerging above a dense closed canopy, with smaller trees, palms, ferns and seedlings filling every layer below. The big trees throw

out buttress roots, broad flanges of wood bracing the trunk against soft, shallow rooting in deep soil. Strangler figs begin life as seeds dropped high in another tree's fork, send roots creeping down to the ground, and slowly enclose and kill their host, until the fig stands as a hollow lattice where a tree used to be. Lianas loop from the canopy; epiphytes (orchids, ferns, mosses) perch on the branches, gardening the air. And among the giants stand the conifers that mark this as ancient country: the hoop pines spearing above the canopy, and, on certain ranges, the bunya, the huge dome-crowned pine whose cones, borne heavily every few years, drew large First Nations gatherings to the bunya forests of the region.

That is the theory of the place. To feel it you have to go inside.

Into the big scrub

So come into one of the survivors: the reserve at Mary Cairncross on the Blackall Range, some fifty-five hectares of the old big scrub kept whole on the deep red basalt where this book's very first drive began. Step off the mown edge into the trees and the change is instant and physical. The light drops by half; the air cools, dampens and goes still; the glare and the traffic fall away behind you; and the sounds that replace them are water dripping from leaf to leaf, the crack of a whipbird, and the sudden clatter of an unseen pigeon leaving a branch. You have walked out of the Queensland sun and into a green room. Here is what to look at while your eyes adjust.

The tree that begins as a murderer. The first thing to learn is a tree that does not start as a tree. A strangler fig (here most often the Watkins' fig, *Ficus watkinsiana*) begins life as a seed wiped from a pigeon's gut onto a high fork of some other tree, germinates up there in a pocket of trapped leaf litter, and lets down slender roots toward the soil far below. Once those roots reach the ground the fig changes gear: it thickens, branches and fuses into a lattice, sheathing its host in a living cage that tightens and shades year on year until the original tree, starved and squeezed, dies and rots away inside, leaving the fig standing as a hollow cylinder where another tree used to be. It is a patient killing that can

take a century. It is also one of the forest's most important ladders: a big fig in fruit feeds pigeons, bowerbirds, flying-foxes and half the canopy at once, and because different figs fruit at different times, a forest with its figs intact rarely has a month when nothing is bearing.

The giant with feet. The massive grey trunks nearby that flare out at the base into great thin fins of wood, like the buttresses of a cathedral, belong most often to the booyongs (*Argyrodendron* species), the towering signature trees of the subtropical big scrub. The buttresses answer a real engineering problem. A booyong is a very tall, very heavy tree that roots shallowly rather than driving a taproot deep into the ground, so it braces itself sideways instead, spreading these wide, thin flanges around its base like guy-ropes turned to timber. Follow the trunk up and it simply vanishes into the canopy; you will rarely see its leaves from the ground, which are held in a hand of leaflets, silvery on the underside, far overhead.

The pale spear above the roof. Every so often a pale, straight column punches clear above the green canopy, bare of branches for most of its height and topped with a dark, domed, faintly bristly crown. That is a hoop pine, *Araucaria cunninghamii*, named for the rings of rough bark that circle the trunk like the hoops of a barrel. It is a conifer, and its presence overhead is a badge of great antiquity, because the araucarias are survivors of the Gondwanan forests that clothed this part of the world long before the flowering trees rose to crowd them out. This same tree grown in ruler-straight, even-aged rows on cleared ground elsewhere on the coast is a timber plantation; a hoop pine standing wild and alone above a real rainforest canopy is a very different and much older thing.

The ghost of the forest. Look for a tall tree with a straight, pale bole that, in spring, breaks out in a flush of new leaves in an improbable coppery pink-red, and you may be looking at a survivor of the tree that emptied these forests. Red cedar, *Toona ciliata*, is one of the very few local rainforest trees that drops its leaves (briefly bare in winter, then flushing that startling colour), and it was, for a century, the most valuable timber tree in eastern Aus-

tralia. A standing cedar today is rare enough to pull you up short. It is also still a working part of the forest, and an unusual one: among these mostly animal-planted trees, the cedar scatters small winged seeds that spin away on the wind and colonise fast into any sunny gap, which is exactly the habit that let a felled forest waste no time regrowing — as something other than cedar.

The one you learn so you never touch it. One tree here you memorise by sight precisely so you can keep away from it. The giant stinging tree, *Dendrocnide excelsa*, carries big, soft, pale-green, heart-shaped leaves that look as innocent as a mulberry's, and every surface of them is furred with fine silica hairs loaded with a venom that causes a burning pain wildly disproportionate to the plant: a sting that can smoulder for days, and flare up again months later when the old skin is wetted or chilled. It is one of the fastest of all the rainforest pioneers, shooting up wherever a big tree has crashed and opened the canopy. And in one of the small marvels of this forest, several animals eat it without the slightest trouble: red-legged pademelons can strip a whole plant overnight, and beetles and other insects chew the leaves, dining in comfort on a plant that would put a person in hospital.

The plant that grabs you back. Something snags your sleeve, and when you turn to free it you find a slender green whip trailing out of the understorey, edged and tipped with rows of small, back-curved hooks that let go of nothing willingly. This is lawyer cane, or wait-a-while (*Calamus muelleri*), a climbing palm. It has given up standing on its own and instead hauls itself toward the canopy light on the backs of its neighbours, flinging out long grapnel-tipped tendrils to hook the branches above and reel itself upward. “Wait-a-while” is its polite name; extracting yourself from a patch of it, one hook at a time and in no particular hurry, is precisely the experience the name promises.

Gardens in the air. Now look up into the forks and along the big horizontal limbs, because the branches themselves are gardened. The nests of stiff, upright, apple-green fronds wedged into the crotches of trees are bird's-nest ferns (*Asplenium australasicum*), shaped like a giant shuttlecock for exactly one reason: to funnel falling leaves and rainwater into their own centre and

build themselves a private compost heap up in the canopy. Beside them ride the staghorns and elkhorns (*Platycerium*), their round brown backing-fronds pressed flat to the bark and their forked green fronds thrown out like antlers, and, smaller and far harder to find, the orchids. None of these is a parasite; they take nothing from the tree but a perch, high up where the light is. Together they turn a single big rainforest tree into a vertical wetland — a hanging garden of pockets of soil, water, frogs and insects held dozens of metres above the ground.

The dim floor. Down at your feet the forest is dark, and that dimness is the point of the place. So little light reaches the floor of a closed rainforest that almost nothing grows there but the shade-hardened seedlings of the canopy trees, a scatter of ferns, and the palms: young piccabeens crowding the shaded floor in colonies before they race up for the canopy, and the truly small walking-stick palm (*Linospadix monostachyos*), a single slender stem no higher than your chest, hung with dangling strings of scarlet fruit. Kneel down, though, and the floor is anything but idle: it is a deep, soft mat of leaf litter being taken apart at speed. In the warm, wet, windless air, fungi and insects rot fallen leaves and timber far faster than in the dry forest upslope, and the nutrients they release are seized back almost at once by the shallow, hungry roots of the living trees and the mycorrhizal fungi threaded through them. The basalt soil here is genuinely rich (it is why the dairy farmers wanted it), yet the forest still runs its nourishment on this tight, fast, hand-to-hand cycle overhead, barely letting it touch the ground. Which is why clearing does such lasting harm: fell the forest and the wealth does not stay behind for the paddock. Most of it walks away in the logs, and the rest washes off the bared red slope in the first summer storm.

The life of the interior

All that architecture would be a stage with no players if you only read the trees, and the rainforest's animals are the easiest thing in it to miss, because most of them are high in the canopy, quiet, or shy of the open. Stand still on the track for ten minutes, though, and the green room fills with life.

Much of that life is busy doing the forest's most important job, which is moving seed. The fruit-doves come for the figs and the laurels: the wompoo fruit-dove, one of the largest in the country and outlandishly dressed in green, purple and gold, calling a deep bubbling note from somewhere in the canopy you will never quite locate, and the smaller rose-crowned fruit-dove alongside it. Top-knot pigeons sweep through in nomadic flocks, chasing whatever is fruiting. Every one of them is part of the delivery service: they swallow the fruit whole and carry the seed away, so that a rainforest with its pigeons shot out or starved is a rainforest that can no longer move.

Then there are the show-offs. The green catbird is heard long before it is seen, its call a drawn-out wail exactly like a cat, or a crying child, unnerving the first time it reaches you out of the gloom. Its relative the regent bowerbird trades noise for spectacle: the male is a flame of gold and black, and he builds and tends a twig bower on the forest floor to court the females that pass. Strangest of all, the paradise riflebird, the southernmost bird-of-paradise in the world, throws its black wings into a stiff, shimmering display, a scrap of New Guinea performing in a Queensland gully.

Down at ground level the forest is just as alive, if harder to catch. Pademelons — small round rufous wallabies, here the red-legged pademelon (*Thylogale stigmatica*) — browse the edges at dusk and crash into the undergrowth at the first footfall, though the habituated colony at Mary Cairncross has long since stopped bothering to run. A carpet python may be looped along a branch, digesting. And under the rotting logs lives the land mullet, a glossy blue-black skink that grows to the length of your forearm and, in the Conondale Range just west of here, runs out of continent: that is about as far north as the species reaches.

A living museum

Everything about a rainforest is slow, and the deepest slowness is its history. The hoop pines spearing above the canopy, and the bunya on certain ranges, are araucarias, an ancient line of conifers that dominated the forests of the southern supercontinent

Gondwana when the continents were joined and dinosaurs browsed forests not unlike these. The flowering trees came later and largely displaced the old conifers the world over. But here, in the wet, sheltered, fire-free pockets of the eastern Australian ranges, whole lineages of that older world hung on, and hang on still. Many of the region's rainforest plants belong to families whose deepest roots reach back to Gondwana, which is why ecologists speak of these forests as the living remnant of a far older Australia, from a time before the continent dried out, before fire took hold, before the eucalypts and the grass inherited the open country.

That antiquity is not a museum curiosity. It is the reason the loss of these forests cuts so deep and mends so slowly. When you stand in a rainforest gully you are not looking at a stand of trees that will grow back within a lifetime or two. You are looking at the frayed edge of something that took the better part of a hundred million years to assemble, and that was cleared, across most of its range, in about fifty.

Sidebar — The bunya. Now and then a rainforest tree steps out of the canopy and becomes an event. The bunya pine (*Araucaria bidwillii*) is a huge, dark, dome-crowned conifer, a cousin of the hoop pine and a survivor of the same Gondwanan line, and every few years it does something spectacular: from high in its crown it drops cones the size of a football and the weight of a bowling ball, five to ten kilograms of woody cone apiece, packed with big, starchy, nutritious seeds. A good bunya season, when the trees of a district fruited heavily all at once, produced one of the great gatherings of pre-colonial Australia, drawing Aboriginal people from across a wide region to the bunya forests to harvest and share the seed, a well-documented feature of the historical record. Recent research even reads the bunya's present-day distribution as carrying the fingerprint of that harvesting, its range shaped over centuries by the people who valued it and carried its seed. The tree's great stronghold is the Bunya Mountains, west and north of the Sunshine Coast, but the Blackall Range and Maleny (this very hinterland) were one of its natural centres too, so a bunya here is a genuine local rather than a stray. And once seen it is never mistaken: a great green dome riding clear above the canopy, with — if you are standing in the wrong place in the wrong season — a woody cannonball or two waiting to fall.

A forest with no reverse gear

The defining fact about rainforest, the one that governs its whole fate, is the one introduced back in Chapter 6: it survives fire by refusing to let it start at all. The closed canopy keeps the interior dark, humid and still; the litter stays damp; a fire racing through the eucalypt forest next door arrives at the rainforest edge and gutters out for want of dry fuel. This is a brilliant defence, and where the forest is large and intact it works almost perfectly, which is why rainforest persists as islands in a sea of fire-prone eucalypt country, holding the gullies and the wet tops that flame cannot reach.

But the defence has a fatal weakness: it is all or nothing. A rainforest keeps itself wet by being whole. Clear it, fragment it, drive a road through it, or let a single bad fire breach its edge, and it loses the closed canopy that kept it humid; the edges dry out; and for the first time the forest becomes able to burn. And a rainforest that burns does not bounce back the way a eucalypt forest does. It has none of the eucalypts' fire tricks: no thick bark, no resprouting buds, no fire-triggered seed, and its species are built for stability, not for catastrophe. A burnt or cleared rainforest tends to come back, if it comes back at all, as eucalypt forest or as a tangle of weeds, rarely as rainforest. It has, in effect, no reverse gear.

The big scrub, and the men with axes

Which brings us to what happened here. The deep red basalt soils of the Blackall Range once carried extensive subtropical rainforest, the "big scrub," and it was doomed by the very thing that made it grand. It grew on the best soil in the region, a stand of rainforest that was two prizes at once: valuable timber above, and, once cleared, the richest farmland on the coast below. Both were taken, and quickly. Within a few decades of European arrival the great forest was felled (for its red cedar first, then for the dairy farms that replaced it) and reduced from an unbroken canopy to a scatter of remnants, patches saved by steep ground, luck, or deliberate foresight. The reserve at Mary Cairncross is one such survivor. Today the rainforest is among the most cleared and most legally protected vegetation on the coast, a reversal of fortune that came only just in time. How the clearing happened, and what else was taken with it, is the fuller story of Chapter 17.

How a rainforest comes back

Because we destroyed so much of it, the central practical question about rainforest on this coast is no longer how it lives but how, and whether, it can be brought back. And the answer hinges on something easy to miss: the rainforest cannot regenerate without animals.

Unlike the wind-blown, fire-triggered seed of the eucalypts and the wallum, a great many rainforest trees wrap their seed in fleshy fruit and rely on animals to eat it and carry it (the fruit-pigeons and other birds, the flying-foxes, and once a wider cast besides), depositing the seed, neatly fertilised, far from the parent tree. The forest and its seed-dispersers are a single system: lose the animals and the forest cannot move its seed; lose the forest and the animals starve. This is why a cleared paddock next to intact forest does not simply turn back into rainforest on its own. The grass holds, the seed does not arrive, and what little does cannot establish in the open, sun-baked, weed-choked ground.

The insight that cracked the problem works *with* this dependence rather than against it. Rather than trying to plant a whole rainforest tree by tree, restorers establish a framework of a few dozen fast-growing natives that closes a canopy, shades out the weeds, and draws the seed-carrying birds and bats back in. The animals then re-sow the rest, filling the planting out beneath into a real, diverse forest. It is a piece of ecological judo: you rebuild not the forest but the *conditions*, and let the forest's own machinery rebuild itself. It is slow, it needs intact forest nearby to seed from, and it is no substitute for never having cleared the forest in the first place. But it works, and how it is being done across the region today, paddock by paddock, project by project, is the subject of Chapter 18.

Sidebar — The butterfly and the vine. Of all the creatures tied to this lost lowland scrub, none makes the bond plainer than the Richmond birdwing, one of Australia's largest and most spectacular butterflies: a hand-span of black, gold and iridescent green that is, for all its glamour, a rainforest animal through and through. Its caterpillars can feed on the leaves of a single thing: a native rainforest climber, the birdwing vine (*Pararistolochia praevenosa*), which threads up through the lowland and hinterland scrubs the butterfly haunts. Where the vine grows, the great butterfly can breed; where the scrub was felled and the vine went with it, the butterfly's range collapsed in step, because a caterpillar that eats only one plant cannot follow the forest anywhere else. It is the chapter in miniature — a magnificent thing wholly dependent on the tangle of vines and trees around it, and undone the moment that tangle is broken. The vine still needs the forest, and the butterfly still needs the vine; how that broken chain is now being mended, garden by garden, is a story of patient repair.

Reading the rainforest

Read the rainforest from the ground up, the way we read the gum forest on Mount Ninderry. But notice that here almost every rule runs the opposite way. Deep red basalt soil, and a range that wrings the most rain out of the sky, grow the forest tall and dense, and the density is what makes everything else possible: a closed canopy keeps the floor dark, cool, damp and still, and that shelter is what excludes fire, which is what lets the forest exist at all. The architecture follows from the shelter, the animals from the architecture, and the nourishment runs not through the soil but overhead, hand to hand. Every one of those links is also a vulnerability, because each depends on the forest staying whole. It is the most magnificent ecosystem on the coast and the most delicate, and the two facts are the same fact.

The signs are worth carrying out with you. A closed, dim, multi-layered forest of buttressed trunks, figs and palms on deep red soil is subtropical rainforest, the big scrub. A pale, straight, hoop-ringed conifer or a great dark dome standing clear above the can-

opy is an araucaria (a hoop pine or a bunya) and a signature of forest far older than the eucalypts around it. A dark tongue of rainforest running up a moist gully through the gum forest is a fire refuge, holding the ground flame cannot reach. And a young, even-aged stand of mixed natives closing over an old paddock is a rebuilt forest, proof that, with enough care and enough surviving forest nearby to seed it, even this most fragile and least forgiving of ecosystems can sometimes be coaxed back.

With the rainforest we reach the top of the gradient, and the end of the long climb overland from the tide to the range. But the gradient does not stop at the shoreline. It runs on, underwater, into the sea country that rings the coast — the seagrass pastures, the boulder reefs, the winter highway of the whales — the last stretch of the transect, and the subject of the next chapter. We have climbed from the reef to the range; to finish the walk, we turn back to the reef.

Chapter 14 • Sea country

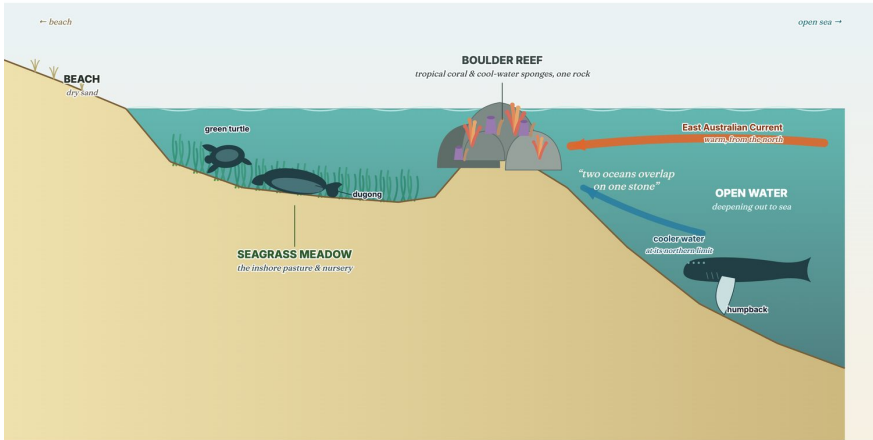
The land does not stop at the beach. It simply changes into something we cannot walk on, and so have learned to overlook.

The Sunshine Coast does not end where the sand goes under the water. The soils, the slopes, the meadows and the reefs all continue out beneath the waves, and with them an entire living world as ordered and interconnected as anything ashore. We tend to read the sea as a blank blue edge to the map, a backdrop to the beach, when it is country in its own right: grazed, hunted, migrated through and depended upon by dugong and turtle, by whales on the longest of journeys, by shorebirds from the far side of the planet, and, for many thousands of years, by people.

The very name “sea country” is the place to start, because it insists on something European maps left out: that the sea is a place with its own distinct, connected habitats. The science bears that out. The sea off this coast is a mosaic, as legible, once you know how to read it, as the gradient ashore.

Sea country: the gradient continued

The land does not stop at the beach — sand gives way to seagrass, then to reef.



The gradient does not stop at the beach: sand gives way to seagrass pasture and then to reef, where a warm current lands tropical life at the cool edge of its range.
 Schematic shore-to-sea cross-section; depths, distances and animals not to scale.

Figure 14.1 — Sea country in cross-section. The land's gradient runs on underwater — beach to seagrass pasture to a boulder reef where the warm current lays tropical coral against cool-water sponge on one stone — grazed by dugong and green turtle inshore, with the humpbacks passing further out.

The gradient goes on underwater

Think of the seabed near the shore as the land's gradient continued, only flooded. Where rivers and tides drop their fine sediment, in the sheltered waters of the bays and passages, the bottom is soft mud and sand, and there, wherever the water is shallow and clear enough for light to reach, grow the seagrass meadows we met at the edge of the estuary in Chapter 8. Further out, and around the rocky headlands and offshore reefs, the bottom is hard, and a completely different community of seaweeds, sponges, corals and reef fish claims the rock. Between and around them lie the open sandy stretches, the channels, the surf zone. Each is its own world, sorted by depth, light, exposure and the nature of the bottom, exactly as the land's ecosystems are sorted by soil and water and fire.

And as on land, one of these habitats shoulders a quiet, disproportionate amount of the work. The seagrass meadow is the pasture, the nursery and the filter of the inshore sea all at once: a

flowering plant, remember, not a weed, carpeting the shallows, feeding the things that graze it, sheltering a generation of young fish and prawns among its blades, holding the sediment steady, and, like its cousins the mangrove and the saltmarsh, locking away carbon in the mud beneath. It is the underwater equivalent of the wetland: humble, easily overlooked, easily destroyed by anything that clouds the water and shades it out. Lose the seagrass and you do not lose one plant; you pull the floor out from under the inshore food web.

Where the warm current meets the cool

Out past the seagrass and the open sand, around the rocky headlands and the scattered offshore reefs, the bottom turns hard, and a wholly different community takes hold: seaweeds, sponges, soft corals, urchins and reef fish clinging to the rock. These reefs occupy one of the more interesting addresses in Australian marine biology, because this stretch of coast is where two oceans' worth of species meet.

The reason is a current. The East Australian Current, the same warm southward flow made briefly famous by a cartoon turtle, runs down the Queensland coast carrying tropical water, and with it the drifting larvae of tropical fish, corals and invertebrates spawned far to the north on the Great Barrier Reef. Many of those larvae settle here, at or near the southern limit of where warm-water species can survive, while cooler-water species from the temperate south reach their northern limit not far away. On a local rocky reef the two overlap in a way you would find in neither the pure tropics nor the cool south — tropical species and temperate ones on the same rock, each near the very edge of where it can live.

That overlap is also what makes these reefs sensitive. A community living at the edge of its members' tolerances feels every shift in the water keenly. The warming and marine heatwaves now reaching down the current are already shifting the boundary, nudging tropical species further south and pressing the cooler-

water ones that have nowhere cooler to go. The headland reefs are a gauge of how fast the sea is changing, read in the slow reshuffling of who lives on the rock.

Down on the reef

To feel that overlap for yourself you have to get in the water, so take a mask down to one of the headland reefs: the rocky shoals off Point Cartwright and Mooloolaba, or the boulder reef ringing Mudjimba Island, the little island off Maroochydore that older maps call Old Woman Island. Duck under and the first surprise is that the reef is not one community but a collision of two. On a single boulder, hard coral, unmistakably tropical, grows within a fin's-length of the leathery brown seaweeds and sponges of the cool south. Bright tropical reef fish mingle with stouter temperate wrasses and the sober, inquisitive fish of cooler water. Butterfly-fish move in pairs, clouds of small damselfish hang over the coral, a parrotfish crunches at the rock.

Look, too, at what is not swimming. A wobbegong may be lying motionless in a gutter: a flat, frilled, superbly camouflaged carpet shark, looking for all the world like a frill of weedy rock until it resolves, unnervingly, into a shark with a fringed beard, harmless unless you are careless enough to tread on it. A turtle may be parked under a ledge, resting. Sea stars and urchins graze the stone; a moray watches from a crevice; and over all of it drifts the slow snow of plankton that feeds the coral and the sponges. This is the reef the East Australian Current built, a subtropical mongrel of two oceans, hidden a few metres under a surface most of us only ever see from the top.

Sidebar — The warship that became a reef. Off Mooolaba, on the sand in about twenty-eight metres of water, lies a 133-metre guided-missile destroyer — the former HMAS *Brisbane*, stripped, cleaned and deliberately scuttled in 2005 to make an artificial reef and a dive site. It was a striking act of faith, sinking a warship on purpose in the hope that the sea would move in, and it has paid off. Bare steel is an empty lot, and the sea does not leave it empty for long. Within months the hull was fuzzed with algae and hydroids; then came the filter-feeders, the corals and sponges and sea-tulips cementing themselves to the metal; then the fish that shelter and hunt among structure, until a ship built to cut through the water had become a place that holds life in it. It is a small, deliberate demonstration of the principle behind the shellfish-reef story later in this chapter: give the sea something solid to build on, and build it will.

The sharks nobody should fear

The word “shark” does a great deal of unfair work. Most of the sharks and rays off this coast are harmless to us; several are in far more danger from us than we are from them; and the best place on the coast to meet them lies just to the north, at a cluster of volcanic pinnacles called Wolf Rock.

Wolf Rock rises from deep water off Double Island Point, at the seaward end of the Cooloola sand mass, and it is one of the most important shark sites in eastern Australia: one of the very few places where the grey nurse shark gathers, and gathers all year round. The grey nurse looks like everyone’s nightmare of a shark: heavy-bodied, snaggle-toothed, its mouth fixed in a permanent grin of needle teeth. It is also almost absurdly placid, a slow-cruising fish that eats other fish and wants nothing to do with a diver. That fearsome face helped drive it to the brink. For decades it was speared and hunted as a “man-eater” on exactly the reputation it looks invited, until the east-coast population collapsed; today it is listed as critically endangered, among the most imperilled sharks in Australian waters. Wolf Rock, where pregnant females shelter, is now closed to fishing precisely because so few of these harmless-looking monsters are left.

It has company. Wolf Rock and the reefs near it also draw leopard sharks (slender, spotted, entirely harmless bottom-dwellers that lie on the sand through the day) and, through the warmer months, manta rays that soar in on the current to hang above the pinnacle while little fish clean their skin, wings spanning several metres, filtering plankton with a wide, slow grace.

Sidebar — The blue paddock offshore. The whales get the attention, but they are only the largest of the travellers using the water off this coast as a road. The same blue stretch carries turtles moving between feeding grounds and nesting beaches, sharks following the warm water south, rays and game fish on their own seasonal runs, and the seabirds that work the surface far out of sight of land. None of it respects a line drawn on a chart. A marine reserve or a fishing rule set off this coast is really an attempt to look after a piece of moving water that animals merely pass through, on journeys that span the whole eastern seaboard. That is what makes minding the sea so much harder than fencing a paddock, and so much more dependent on what everyone else along the coast chooses to do.

The grazing giants

Nothing makes the value of the seagrass plainer than the two great animals that live off it. The first is the dugong, a large, slow, shy marine mammal, a vegetarian relative of nothing you would guess, that grazes seagrass meadows like an underwater cow, ploughing furrows through the beds as it crops them. Most people who live here have never seen one and would be astonished to learn that the broader Moreton Bay region, on this coast's southern doorstep, supports a nationally significant dugong population: some hundreds of animals, often said to be the largest living this close to a major city, with the sheltered waters of the Pumicestone Passage among their haunts. The dugong's whole existence is staked on the seagrass. It is as much a specialist as the koala, and as fragile in the same way: foul or cloud the water so the meadows die, and the dugong has nothing to eat.

The second grazer is the green turtle, which crops the same seagrass meadows. Its cousin the loggerhead carries the dependence that reaches ashore: it is the turtle that nests on these mainland beaches, hauling out on summer nights to bury a clutch in the warm sand above the tideline, while the green turtle nests here only rarely. So between them the turtles tie the sea country to the land country directly (the green turtle needing healthy seagrass to feed, the loggerhead undisturbed dark beaches to nest), and they fall foul of threats in both worlds: boat strike, discarded netting and seagrass loss at sea; lights, vehicles, dogs and development on the nesting beaches. Together they drive home that land and sea are one country: damage the water and you starve the dugong and the green turtle; light up the beach and you confuse the turtle.

Sidebar — The living beach. Of all the coast's habitats, the open surf beach looks the most like a dead one: sand, wind and water, scoured twice a day and apparently empty. It is nothing of the sort. Dig into the wet sand at the edge of the swash and you may turn up a pipi, a small, glossy, wedge-shaped clam that lives by the million in the surf zone, riding the waves up and down the beach and filtering food from the backwash. Deeper in the sand hide the beach worms the anglers prize, long and quick, drawn out of their burrows with a scrap of fish. After dark, pale, stalk-eyed, startlingly fast ghost crabs sprint from their burrows above the tideline to comb the strandline. And the beach has its hunters overhead: the osprey that hangs and plunges for fish, the pied oystercatcher probing the wet sand, the terns diving beyond the break. Even this barest-looking strip is a working community, a narrow, mobile world of specialists tuned to ground that is rearranged by every tide and every storm. It is also a nursery: the same warm, dry sand above the tideline is where the loggerhead turtles that feed off this coast haul out on summer nights to bury their eggs — which is why a dark, quiet, undeveloped beach is worth far more than it seems.

The longest commute, revisited

The mudflats and sandflats exposed at each low tide, which we passed in Chapter 8 calling them the unglamorous fuel stops of a global journey, deserve a second visit here, because they belong as much to the sea country as to the estuary. Dense with buried worms and crabs and molluscs, they are the feeding grounds for the migratory shorebirds that arrive each year from the breeding grounds of the Arctic, having flown staggering distances down the chain of coastal wetlands known as the East Asian–Australasian Flyway. Birds such as the bar-tailed godwit make part of that journey in non-stop flights of many days over open ocean, sustained entirely by fat laid down on flats like these. The wider Moreton Bay is recognised internationally as a Ramsar wetland in large part for this reason. To a godwit, the unremarkable mud of this coast is not the edge of anything; it is a link in a chain strung halfway around the world, and a link that cannot be replaced if it is paved.

The whales came back

Twice a year the best conservation news on this coast swims past in plain sight. Every winter the humpback whales of eastern Australia migrate north along this coastline to their breeding grounds in the warm tropics, and every spring they stream back south again, often with calves, a procession of great animals so close and so reliable that watching them has become a fixture of winter here.

Worth remembering how nearly we lost them. Within living memory, humpbacks were hunted along this coast almost to oblivion. The whaling station at Tangalooma, on nearby Moreton Island, killed more than six thousand of them between 1952 and 1962, before the whales simply ran out and it closed. By then the eastern population had been driven to a few hundred animals clinging on. Then it turned around. Protected from whaling from 1963, the population climbed, decade on decade, back into the tens of thousands; recent surveys suggest something like forty

thousand. The “humpback highway” off this coast is once again one of the densest gatherings of great whales on Earth. All they needed was to be left alive.

Sidebar — The reefs we forgot we had. Most people on this coast do not know the shellfish reef ever existed. Before European settlement, the estuaries and bays of eastern Australia held extensive reefs built by native oysters and other shellfish, dense living structures that filtered enormous volumes of water, stabilised the bottom, and provided habitat for fish exactly as a coral reef does. Then, through the nineteenth and twentieth centuries, they were dredged up for lime and for food and harvested out of existence, so completely and so long ago that they vanished from the water and from memory alike. Most people now assume the muddy, oyster-less estuaries they know are the natural state. They are not; they are a ruin we inherited without realising it was a ruin. The reefs, though, are being rebuilt: in the Noosa River, restoration projects have been laying the foundations for native shellfish reefs to re-establish, betting that if you give the oysters something to grow on, they will start once again to filter the water and shelter the fish. It is an unusual kind of restoration: putting back not just a forgotten ecosystem but the memory that it was ever there.

Reading the sea country

So read the sea as country, not as scenery. The pale green shallows over sand are seagrass, the underwater pasture and nursery, feeding the dugong and the turtle and filtering the inshore sea. The furrowed meadow with a slow dark shape moving over it is the dugong, a specialist as fragile as any on land, staked entirely on a plant that clouded water can kill. The boulder reef off the headland, coral and cool-water sponges sharing one rock, is the warm current’s handiwork and a gauge of how fast the sea is changing, and the heavy, snaggle-toothed shark hanging placidly above a pinnacle up the coast is a grey nurse, critically endangered and a monster only in its looks. The bare surf beach is

alive too, a mobile community of pipis and ghost crabs that doubles as the turtles' nursery. The mudflat crawling with invisible life at low tide is a fuel stop on a journey that begins in the Arctic, while the spout and the breach offshore in winter are the humpbacks, hunted to a few hundred and back now in their tens of thousands. And the new-laid shell beds in the river are a forgotten ecosystem being coaxed back into being. The sea country is every bit as legible as the land — and every bit as easy to wreck without meaning to.

With the sea, the gradient is complete. We have read it from the reef to the range and back to the reef again: every major ecosystem in its place, each one legible from the ground, or the seabed, it stands on. But the places are only half of it; what ties them together is the deals struck across them — the plants and the partners that feed them, the animals and the things they cannot live without. That is the subject of the next part of the book, which steps back from *where* things live to ask *how* they depend on one another. We have read the stage. Now for the play.

Chapter 15 • Plants and the partnerships that feed them

A tree looks like the most self-sufficient thing alive. It is in fact a small business kept afloat by a great many partners, most of which it never sees.

Few things look more self-reliant than a plant. It stands in one spot, spins its own food from sunlight and air, and appears to ask the world for nothing but a place to root. Look underground, though, and that independence turns out to be a fiction: a plant is less a solitary individual than the hub of a web of deals, trading sugar with fungi, renting bacteria to pull nitrogen from the air, and paying animals to carry its pollen and its seed across the landscape. None of it is free, and the poorer the ground, the more partners it takes to survive, which is why the starved soils of this coast run some of the busiest underground economies anywhere.

So far we have been reading the physical ground of rock, soil, water and fire, and the ordered ecosystems they produce. This part is about the deals struck across it: the partnerships and dependencies that knit the living world together. And there is no better place to begin than with the plants, because they sit at the bottom of every food web and the centre of every partnership, and because their dependence on others is the most surprising, being the best hidden.

The underground economy

Start beneath the surface, with the most widespread partnership on Earth, and one almost nobody can see. Nearly every plant on this coast — the rainforest giant, the wallum banksia, the gum tree, the paperbark — runs its roots in alliance with fungi, in a relationship called mycorrhiza, literally “fungus-root.” The deal is elegantly simple. The fungus threads its impossibly fine filaments out through the soil, far beyond the reach of the plant’s own roots,

and harvests scarce water and nutrients that the plant could never have reached alone. In return, the plant pays the fungus in sugar, the energy it has captured from sunlight, which the fungus, living in the dark, cannot make for itself. Sugar for minerals, photosynthesis for plumbing: it is one of the oldest and most successful trade agreements in the history of life, older than forests, possibly the very thing that allowed plants to colonise the land in the first place.

The deal matters most where the soil is poorest. On the rich red basalt, a plant can afford to be a little casual about its fungal partners; on the starved white sand of the wallum, where, as Chapter 4 explained, the phosphorus has been all but leached away, those partnerships are the difference between life and death. The fungal network is how a banksia or a scribbly gum scrapes a living from sand that has, by any normal measure, nothing left to give, and different plants run their own fungal partnerships, each tuned to a particular sliver of the meagre soil. Local work comparing the wallum's scribbly gum with a pampered, fertile-country relative found that what decides how hard a tree leans on its fungi is not which tree it is but what ground it stands in: on wallum sand both depended heavily on the partnership, on rich soil neither much bothered. The wallum, in other words, is a community of plant-and-fungus partnerships, and the plants are merely the parts that show above ground.

There is a further twist to the fungal deal, and it has become one of the most debated ideas in modern forest science. Because a single fungus can be joined to the roots of many plants at once, its threads running on from tree to tree, the floor of a forest is laced with what popular writing has christened the "wood-wide web": a fungal network potentially wiring dozens of plants into a single connected system. The claims made for it have been spectacular: that great "mother trees" use the network to nurse their own seedlings, that trees pump spare sugar to sick or shaded neighbours along the fungal threads, even that a plant under attack can send chemical warnings to the others wired in beside it.

It is a captivating picture, and parts of it may well prove true. But in the last few years a hard-nosed reassessment has set in. Reviewing the actual field evidence, a number of researchers have concluded that the boldest versions of the story have run a long way ahead of anything anyone has yet demonstrated in a real forest. We simply do not know how much passes between trees through these networks, nor whether the fungus is running a charity or a business of its own. What is not in doubt is the basic partnership — plant feeds fungus, fungus feeds plant — and its outsized importance on poor ground. The rest is one of those places, refreshingly common in ecology, where the honest answer is that we are still finding out.

Mining, manufacturing, and the nitrogen renters

Not every plant solves the poverty problem the same way, and the wallum is a gallery of alternatives to the fungal deal, each another kind of partnership, or another kind of self-reliance.

Some plants go into mining. The banksias, grevilleas and hakeas of the Proteaceae largely forgo the fungal route, growing their dense brushes of “cluster roots” to prise the locked-up phosphorus loose directly. It is do-it-yourself chemistry, and it works brilliantly on the very poorest ground of all, the bleached sand of the Cooloola dunes and the wallum. Others go into manufacturing of a darker kind: the sundews, unable to wring enough nitrogen from the sand, trap and digest insects, turning animals into fertiliser. And a great many, the wattles and the native peas above all, solve the nitrogen problem by renting it. They house colonies of bacteria in nodules on their roots, bacteria that can do the one thing no plant can: pull inert nitrogen straight out of the air and fix it into a usable form. The plant feeds and shelters the bacteria; the bacteria pay rent in nitrogen. It is why wattles are so often the first plants to colonise bare or burnt ground, arriving with their own fertiliser factories pre-installed.

These underground arrangements were covered, from the soil's point of view, earlier in the book. The pattern is worth carrying forward: on poor country, no plant stands alone. It survives by partnership, by chemistry, or by predation, most often by some combination of all three.

Hiring a pollinator

Now lift your eyes above the ground, to a problem every plant faces and none can solve by itself: sex. A plant cannot go in search of a mate. Rooted to the spot, it must somehow get its pollen to another plant of its kind, often hundreds of metres away, and for this it has only two options: broadcast pollen to the wind and trust to luck, or hire a courier. A great many of this coast's plants hire couriers, and pay them in food.

This is what a flower *is*: an advertisement and a payment counter. The colour, the scent, the nectar all exist to attract an animal, reward it with a meal, and dust it with pollen to carry to the next bloom. The arrangement runs the full spectrum from casual to obsessive. The banksias and grevilleas pour out copious nectar and are worked over by a noisy crowd of honeyeaters and lorikeets, by small mammals, and by insects, a come-one-come-all approach. The paperbarks of the Noosa Everglades throw a swamp-wide feast that draws lorikeets by day and flying-foxes by night.

Not all the couriers are birds and bats. The unshowy majority of pollination on this coast is done by insects, and by a far greater range of them than most people suppose: alongside the introduced honeybee work hundreds of species of native bee, from the tiny black stingless bees (*Tetragonula*) that hoard honey in hollow trees — the nearest thing Australia has to a native hive bee — to the fast, glittering blue-banded bees that nest in clay banks. Some of the coast's plants demand a particular trick of their bee couriers. Their anthers do not shed pollen freely; they keep it sealed in tubes that let go only when shaken at just the right pitch, so the bee must clamp onto the flower and shiver its flight muscles into a hard buzz to knock the pollen loose. This is “buzz pollination,” and it is a skill the imported honeybee lacks and many native bees, the

blue-banded bee above all, perform expertly, which is why certain native plants set seed far better tended by their own bees than by the hive.

At the other extreme are the specialists, plants whose flowers are shaped to fit one kind of pollinator and no other, and nothing illustrates the far end of that scale more astonishingly than the fig.

Sidebar — The fig and the wasp: a contract sealed in the dark. A fig is a flower turned outside-in, a hollow ball with hundreds of tiny flowers lining the inside, sealed almost shut. Which raises an obvious question: if the flowers are locked inside, how on earth do they get pollinated? The answer is one of the most precise and uncompromising partnerships in all of nature. Each species of fig has its own species of tiny wasp, and only that wasp, evolved to pollinate it. A pregnant female wasp forces her way in through the fig's narrow pore — so narrow it usually tears off her wings on the way, committing her utterly — lays her eggs, pollinates the flowers, and dies inside. Her offspring hatch, mate, and the new females gather pollen and fly off to find another fig of exactly the right kind to begin again. Neither partner can reproduce without the other, at all, ever: no wasp, no fig seed; no fig, no wasp. The strangling figs of the hinterland rainforest, the ones we met throttling their hosts in the scrub at Mary Cairncross, depend for their very existence on an insect a few millimetres long, and that insect depends absolutely on them. It is a contract sealed in the dark, tens of millions of years old, and renewed in every single fig on every single tree.

Spreading the seed

Having solved sex, a plant faces the same problem all over again with its seed. A seed that falls straight down lands in its parent's shade, to compete with it and its siblings for the same scrap of ground; far better to travel. And so, once more, plants pay couriers, this time to carry their children away.

The currency, again, is food. A great many of this coast's plants, above all in the rainforest of the Blackall Range, wrap their seed in sweet, fleshy, brightly coloured fruit, offering a meal to any animal that will swallow it whole and carry the indigestible seed away to be dropped, neatly packaged in its own fertiliser, somewhere new. The fruit-pigeons that gorge in the rainforest canopy, the flying-foxes that range for tens of kilometres a night, and once a wider cast besides, are the unpaid delivery service on which the forest depends. As we saw earlier, a rainforest that loses its fruit-eaters loses its ability to move, and a cleared paddock stays a paddock because the seed never arrives.

Not every plant pays in fruit. Some bribe ants, of all things: a surprising number of the wallum and sclerophyll plants attach a small, oil-rich morsel to each seed, an irresistible snack that ants carry off to their nests, eat, and discard the seed below ground, conveniently buried, safe from fire and from seed-eating birds. Others dispense with couriers entirely and trust to the wind, or, as we saw in the fire chapter, hoard their seed in woody fruits and fling it onto the ash-bed after a burn. But the principle holds across all of them: a plant that cannot move must persuade the things that *can* move to do its travelling for it, paying its way in nectar, fruit and oil.

Sidebar — Ants: the coast's unpaid workforce. Watch the ground of a dry forest or a heath for a while and you begin to notice how much of its work the ants are doing, and how many plants have quietly gone into business with them. Two deals stand out. The first is delivery: a great many wattles, peas and other sclerophyll plants glue a small, pale, oil-rich food-body — an elaiosome, or in the wattles an aril — onto each hard seed, a bribe finely calibrated to an ant's tastes. The ants haul the seeds home, eat the morsel, and dump the seed itself, intact, in their underground rubbish chambers, out of the reach of seed-eating birds and buried deep enough to ride out the next fire, until its moment comes. Australia's heaths and dry forests are, for this reason, one of the great world centres of ant-planted flora. The second deal is protection. Many wattles carry tiny nectar glands not on their flowers but out on the leaf-stalks. These extrafloral nectaries do nothing for pollination and appear to buy defence instead: they draw ants to patrol the foliage, and a well-attended plant may be one that caterpillars and other leaf-eaters tend to leave alone. It is a looser, more part-time arrangement than the standing ant-armies that some Central American acacias keep, but the currency is the same: nectar for muscle. Between carrying the seed and guarding the leaf, the ants of this coast are among its busiest and least-thanked employees.

The freeloaders and the cheats

So far the partnerships have all been more or less honest: both sides pay, both sides profit. But a web of trades this rich is bound to attract operators who have worked out how to take without giving, and the coast has its share of them.

The most conspicuous is the mistletoe. Look up into almost any stand of eucalypts and you will sooner or later spot a denser, darker, slightly wrong-looking clump of foliage slung in the canopy, its leaves not quite matching the tree that carries them. That is a mistletoe, a parasite that has driven a specialised root through its host's bark and into its plumbing, and taps the tree's water and dissolved nutrients for itself. It is stealing, plainly enough.

And yet — here is the lovely complication — the thief is itself the hub of one of the tightest partnerships on the coast. The mistletoe's sticky, sugary fruit is very nearly the entire diet of a small, brilliant bird, the mistletoebird, which ranges the country in search of it. The bird gets a year-round meal; the mistletoe gets a devoted courier, and a fastidious one. The seed passes through the bird in a matter of minutes, and the bird, perched along a branch rather than across it, wipes the still-sticky seed off onto the bark with a little sideways shuffle, planting it exactly where it must land to grow: on a branch, of another tree, primed to sink its root. A parasite on the tree; a perfect partner to the bird. And for all that it robs the individual trees it rides on, the mistletoe earns a certain keep in the wider forest: its dense clumps are prized nesting cover, and its nectar and fruit feed a long list of birds and insects, so that, against all intuition, a woodland with mistletoe in it is usually a richer one.

Then there are the freeloaders of the underground economy, the plants that have found a way to plug into the fungal network and steal from it. Here and there on the floor of the gum forest, without fanfare, a leafless flower spike pushes up out of the litter: no green leaves anywhere on it, sometimes no green at all, just a naked stem of spotted, purplish bloom. These are the hyacinth orchids and their kind, plants that have given up photosynthesis altogether. Lacking chlorophyll, they make no sugar of their own; instead they tap into the very mycorrhizal fungi that the surrounding trees feed, and draw their whole living, second-hand, from the sugar those trees pumped into the network. They pay the fungus nothing and the trees nothing; they are cheats, quietly tapping the pipeline. And the con grew out of the most respectable partnership of all — because every orchid on the coast begins life as a kind of cheat. Orchid seeds are little more than dust, far too small to pack a food store, and in the wild cannot germinate at all until the right fungus finds them and feeds the infant plant. Most orchids repay the loan later, unfurling green leaves and trading sugar back to the fungus like honest citizens. A few, like the hyacinth orchid, never get around to going straight.

Plants worth knowing by name

All of this can stay abstract until you meet the plants doing it, so here are four of the coast's own, each a partnership made visible.

Start with the great confidence trick of the local flora: the tongue orchids. Where the fig and its wasp keep a straight contract, paying in food and lodging, the orchid is a swindler. Its flower mimics a female wasp closely enough, in shape and above all in scent, that male wasps arrive and try to mate with it, and in their fumbling carry its pollen away to the next fraud. The plant offers no reward at all; it counterfeits a partner. A single species of wasp is fooled by all the Australian tongue orchids, so the whole arrangement hangs, precariously, on one gullible insect.

The cycads play the oldest game of all. The zamias of the heath and open forest, the *Macrozamia* cycads, are survivors from an older world, gymnosperms from a lineage older than the flowering plants, squat and palm-like, their fat cones packed with vivid, poisonous seeds. They are not wind-pollinated, as you might expect of so ancient a plant, but courted by tiny specialist insects, thrips or weevils depending on the cycad, that breed inside the warm pollen cones and carry pollen from the male plant to the female. It is a partnership tens of millions of years older than the bees.

The sundews run the darkest trade. These small, jewel-like plants of the wet wallum spread leaves studded with glistening droplets that look like dew and are in fact glue, and digest whatever lands on them for the nitrogen the sand will not provide. In the swamps their cousins the bladderworts do the same underwater, with minuscule suction traps that snap open and swallow a mosquito larva in a few thousandths of a second. On the poorest ground, a plant that cannot find nitrogen has learned to eat it.

And presiding over the heath stands the grass-tree, the slow heart of this country. A big one, its charred trunk topped with a fountain of wiry leaves and, at the right season, a tall flower spike, may be centuries old, for it adds only a centimetre or so of trunk a year. It leans, like nearly everything here, on fungal partners at its

roots, and it answers fire not with death but with flowering: a burn that blackens the trunk triggers the great spike, so that a recently burnt heath fairly bristles with them. (Its old colonial name is one we now leave behind; “grass-tree” will do.) Patient, fire-summoned and partnered underground, it is the whole lesson of the wallum standing up in a single plant.

Reading the country

The plants of this coast have never been the solitary, self-sufficient things they appear, and to know a plant is to know its partners: the fungus at its roots, the bacteria in its nodules, the bird at its flowers, the wasp in its figs, the ant carrying its seed.

So read the green world as a web of trades rather than a collection of individuals. The banksia is at once a partnership with a fungus and a deal with a honeyeater, while the wattle is a landlord renting rooms to nitrogen-fixing bacteria. The fig is one half of an unbreakable contract with a wasp, and even the rainforest itself cannot reproduce without its pigeons and flying-foxes. Pull on any plant and you find it tied, by invisible threads of sugar and nectar and fruit, to a dozen other lives. Some of those threads, we have seen, are robberies rather than deals: the mistletoe tapping the branch it sits on, the leafless orchid siphoning sugar from the network underground. But even the cheats exist only because there is a web of honest trade for them to cheat. Nothing here grows alone — which is exactly what makes it a living web, and not just a lot of living things standing side by side.

Every one of those threads has another end, and the other end is almost always an animal. We have just seen how completely the plants depend on them: for pollination, for dispersal, for the very continuation of the forest. The next chapter turns the relationship around and reads it from the animal’s side, at the creatures of this coast and the things they, in turn, cannot live without.

Chapter 16 • Animals and their dependencies

The animals we love the most are very often the ones that have gambled everything on a single thing — which is exactly why they are in trouble.

The koala asleep in its gum tree, the black-cockatoo cracking a she-oak cone, the frog that can only breed in sour water: the animals of the Sunshine Coast that people most want to see nearly all share one unsettling thing. Each has staked its whole existence on a single food, tree or chemistry, and each is in trouble for exactly that reason. Specialisation is a brilliant strategy: it hands you a way of life almost nothing else can compete for. But it comes with a bill attached, and the bill falls due the moment the one thing you depend on is taken away.

We met several of these animals in passing as we walked the gradient; here we give them their due, and watch what a narrow specialism costs when the world changes faster than evolution can keep up.



Figure 16.1 — Creatures of the country. Four signature animals, each plotted from real records over the land-zone substrate: koala on the eucalypt foothills, glossy black-cockatoo on the she-oak sands, wallum sedge frog on the acid coastal wetlands, Richmond birdwing on the rainforest. The animal follows the plant; the plant follows the ground.

The specialist's bargain

We have met this bargain before, the trap of a perfect fit, and watched it run through the wallum's plants; here it crosses from plants to animals and organises a whole coast. In any rich, crowded environment the generalists, the animals that can eat anything and live anywhere, tend to win by being flexible, but flexibility is competitive, and everyone ends up fighting over the same broad resources. The specialist takes the opposite bet. By evolving to exploit something difficult — a food too toxic for others, a habitat too harsh, a resource too awkward to bother with — it escapes the competition entirely and claims a niche all to itself. The koala's poisonous leaves, the acid frog's sour water, the cockatoo's awkward seed: each is a door that the specialist alone has the key to, locked behind it where no competitor can follow.

The catch is that a key fits only one lock. A generalist whose favourite food disappears simply eats something else; a specialist whose one resource disappears has nowhere to go. And almost everything that has happened to this coast in the last two centuries — the clearing, the fragmenting, the draining, the introduced animals, the changing climate — has been a story of particular resources disappearing. Which is why the animals that made the most specialised bargains are, again and again, the ones now teetering closest to the edge. Keep that in mind through the portraits that follow, though, because it is only half the tale: run the same logic backwards and you meet the animals that struck no such bargain, the hardy generalists, thriving in exactly the broken world that is undoing the specialists. Not every animal in these pages is on its way out.

The koala: a life staked on a leaf

No animal is more narrowly committed, or more beloved for it, than the koala asleep in its fork. Its whole existence is built on the eucalyptus leaf, a food so poor and so laced with poison that almost nothing else on the continent will touch it, survivable only through a slow, low-energy life and a gut full of microbes that break the leaves down and disarm them. It is a beautifully disciplined way of life, and for as long as the trees stand it works.

But that diet ties the koala absolutely to its trees: not to eucalypts in general but, in practice, to its preferred species, growing densely enough and close enough together that an animal can move between them without coming to ground. And that is precisely the thing the modern landscape has taken away. Across South-East Queensland, including this coast, the koala's forests have been cleared for farms and suburbs, carved into fragments by roads, and isolated into patches too small or too far apart to sustain a population — the setting for the grinding, well-documented decline, and the reason that in the space of a few human generations the koala has gone from abundant to officially threatened across its eastern range.

And yet this is also a place fighting back: there is a vaccine now against the chlamydial disease — but a vaccine treats only one of the threats in the koala's path. It cannot manufacture forest, and the koala's deepest problem stays brutally simple: it needs enough connected trees to live in. Save the forest and you might save the koala; save the koala without the forest and you have saved very little.

The cockatoo and the she-oak

Watch a glossy black-cockatoo feed and you are watching one of the most laborious meals in the forest: bill-first into the woody she-oak cones, tree by obsessive tree, for a return so meagre that almost nothing else bothers to try. That spectacular inefficiency is exactly why the cockatoo has the she-oaks nearly to itself, and exactly why it depends so completely on having enough of the right ones (the casuarinas) in the right places. It is the narrowest wager here, and a double one.

That is only half the bargain. Like so many of the eucalypt forest's animals, the glossy black-cockatoo cannot breed without a large hollow in an old tree, one of those century-in-the-making hollows, and it is fussy about those too, needing big ones in big old trees. So the bird is squeezed between two slow-to-replace resources at once: the feed trees and the nest hollows. Clear the she-oaks and it starves; remove the old hollow-bearing trees and it cannot raise young; do both, as land-clearing tends to, and you

lose the bird. That makes the glossy black-cockatoo a living audit of how intact a stretch of woodland really is: it hangs on only where both its dependencies still survive together, and is among the first birds to drop out of a woodland that is being pulled apart.

The gliders' double bind

The koala is not the only leaf-eater in the gum forest living with no margin, and the glossy black-cockatoo is not the only animal caught between a special food and a scarce hollow. Come back to the forest after dark, to the animals of the night shift, and you meet the gliders, sailing tree to tree on their stretched flaps of skin. The largest of them, the greater glider, was once common the length of the eastern forests and is now, since a 2022 uplisting, formally Endangered — a collapse that has gone almost unnoticed beside the koala's, though it springs from almost exactly the koala's predicament. This slow, cat-sized, wide-eyed folivore eats little but eucalypt leaves, browses only a favoured handful of species, and pays for that thrifty diet by living slowly and denning, through the day, in the hollow of an old tree. It needs, in other words, the two slowest things the forest makes: the right feed trees and a century-old hollow. And it needs them side by side, because a glider that cannot cross open ground cannot shop around.

What pushed it over was the familiar list, with one addition. Land-clearing thinned its forests and took the old hollow-bearing trees; but the greater glider is also peculiarly undone by heat, its thick fur and meagre diet leaving it badly equipped for a hotter, drier climate. On nights that stay warm it struggles to shed enough body heat, and a severe heatwave, or a hot fire running through the canopy it cannot flee, can empty a whole forest of them. The koala's plight is famous; the greater glider's, every bit as steep, is barely known.

Its cousins have made their own narrow commitments. The yellow-bellied glider, a loud, acrobatic night-flier, taps a few favoured trees for sap (the V-grooves), so that its whole territory is organised around a handful of irreplaceable trees. The feathertail glider, no bigger than a mouse, steers on a stiff, two-edged tail like a tiny quill and works the blossom for nectar and pollen. Each

works the same forest differently, and each depends on it keeping its old trees, its hollows and its spread of species intact — the very things a bulldozer takes first and a century cannot quickly give back.

The frogs that need bad water

Down in the wallum, the strangest specialists of all stake their survival not on a food or a tree but on a chemistry — and a hostile one at that. The acid frogs breed in tea-coloured water too acidic for almost anything else to endure, and that hostility is the whole point of the arrangement: the sourness is not a hardship they put up with but a wall they hide behind, shutting out the predators, competitors and introduced fish that would otherwise eat them out of existence. We met them in the sour heath: the wallum froglet, the wallum and Cooloola sedgefrogs and the wallum rocket-frog, evolved to live where nothing much can follow.

That is a brilliant defence and a perilous one, because it commits them to the single thing they cannot do without and cannot replace: the acid water itself. They cannot retreat to sweeter water, because sweeter water is exactly what lets their enemies in. So anything that sweetens or pollutes the wallum's water, or lowers the table that holds it there, removes the one condition under which they can exist at all — and there is nowhere sweeter and safer for them to go.

Sidebar — When a link breaks: the butterfly and its vine.

We met the Richmond birdwing back in the rainforest (Chapter 13): one of Australia's largest and most dazzling butterflies, whose caterpillars can eat the leaves of one native vine and almost nothing else, so that as the lowland scrub was cleared the great insect's range collapsed with it. Read as a broken link, its story carries a second, crueller turn. A pretty South American climber, the exotic Dutchman's pipe (*Aristolochia*), widely planted in gardens, looks and smells enough like the real birdwing vine to fool egg-laying females into laying on it — and then poisons the caterpillars that hatch, turning a garden ornament into a death trap that empties the butterfly's future one clutch at a time. So the specialist is undone twice over: first by the loss of the one plant it needs, then by a lookalike that lures it to breed where its young cannot survive. The response has been one of the most heartening grassroots efforts on the coast: a long campaign through schools, gardens, parks and bush-regen groups to tear out the killer vine and replant the native one, stitching the butterfly's food back across the gaps so the insect can move and breed again. Break the one link a specialist depends on and it falls; mend the link, patiently, and sometimes it climbs back.

The keystone everyone has been taught to hate

Not every dependence runs one way, and the most important animal in this chapter may be the one most people would happily be rid of: the flying-fox. These big fruit- and nectar-eating bats are noisy, they smell, they roost in great, obvious camps near towns, and they carry a couple of serious viruses (at very low risk, and only to those who handle them or are bitten or scratched), all of which has earned them a thoroughly bad press. It is one of the great misjudgements of the coast, in the same family as our old contempt for the mangrove and the swamp.

Because the flying-fox is a keystone. Ranging tens of kilometres in a single night, flying-foxes are among the most prolific long-distance pollinators and seed-dispersers in eastern Australia. They carry pollen between eucalypts and paperbarks and ferry

the seed of rainforest trees from one fragment of forest to the next: exactly the long-range delivery service the rainforest of Chapter 13 cannot regenerate without. In a landscape chopped into isolated patches, the flying-fox is often the only thing still physically connecting them, gene by gene and seed by seed. Remove it and the forests it services begin, slowly, to wink out. And the flying-foxes are themselves under growing pressure, from the loss of their feeding habitat, from conflict where their camps meet expanding towns, and, increasingly, from extreme heat events that can kill them in their thousands in a single afternoon. We would miss them far more than we imagine, and mostly in ways we would never connect back to the maligned bats we drove away.

The gardeners underground

Some of the coast's most important dependencies are also its least visible, buried in the soil and worked by animals almost nobody sees. Recall, from the last chapter, that nearly every tree and shrub on this coast feeds a fungus at its roots and is fed in return — the mycorrhizal partnership without which these poor soils would grow very little. Many of those fungi fruit not as toadstools above the ground but as truffle-like bodies below it, sealed in the soil, and a fungus underground has exactly the problem of a plant rooted to the spot: it cannot move its own spores. So it strikes the same kind of deal the plants do, and pays in food.

The couriers are a guild of small, snuffling, night-digging marsupials: here the bandicoots and the potoroos, and out in the drier country beyond them the bettongs that are the arch-diggers of the tribe. They sniff out these buried fungi, dig them up and eat them, and carry the spores off in their gut to be dropped, still alive, across the forest floor. In eating the fungus they plant it. A long-nosed potoroo or a bandicoot working the ground at night, turning and aerating the soil with thousands of little conical diggings, is not merely feeding itself; it is sowing the underground partner on which the forest's nutrition depends. Take the digger away,

and over time you thin the fungal network, and weaken the trees that lean on it, in a slow unravelling almost no one would ever trace back to a missing marsupial.

Which is more or less what has happened. The digging marsupials sit squarely in the size range the fox and the feral cat find easiest to kill, and across much of Australia they have been hunted down to scattered remnants or lost altogether. The Sunshine Coast's larger and better-protected bushlands still keep some of theirs, for now, but their thinning is one more thread drawn softly out of the web — and one whose loss would be felt not up at the surface, where we might notice, but down in the roots, where hardly anyone thinks to look.

The platypus, and the reptiles we flinch from

Not every notable animal here is a doomed specialist or a misjudged bat. Some are merely overlooked, and a few are feared.

Up in the clear, cool streams of the hinterland lives the strangest mammal on the coast and one of the strangest anywhere: the platypus. A duck-billed, web-footed, egg-laying mammal that hunts with its eyes shut, finding prey by the faint electric fields of their muscles, it looks assembled from spare parts, and yet it is exquisitely tuned to one thing: clean, flowing freshwater with soft earthen banks to burrow into. Obi Obi Creek at Maleny is one of the more reliable places on this coast to watch one work the dawn water. That precision is also its weakness. Silt the stream, dam it, foul it, or strip the bank of the roots that hold the burrow, and the platypus quietly vanishes, which is why naturalists read its presence as a certificate of a healthy creek.

The reptiles ask for something different again: not pity, just a second's pause before the flinch. The lace monitor, a goanna up to two metres long, lumbers through the forest and the picnic ground raiding nests and carrion, then bolts up the nearest trunk when startled. The carpet python loops itself along a rafter or a branch and does the unpaid work of keeping the rats down. And the snakes the region most fears, the eastern brown and the red-bellied black, want nothing to do with people and strike only

when cornered. Each is a predator doing a predator's job in the web, and each is worth far more alive than the old reflex to kill it ever allowed.

The opposite of a specialist

Run the chapter's logic backwards and you can see why some animals are not in trouble at all. The specialist is fragile because it commits everything to one resource; the animals thriving in the modern, disrupted landscape committed to nothing in particular. They are the generalists and the invaders.

The cane toad, spreading west and south across the continent since it was loosed on the north Queensland cane fields in the 1930s, eats almost anything and poisons almost anything that eats it. The red fox and the feral cat hunt across every habitat from the beach to the range, and between them have done more damage to Australia's small mammals than any amount of clearing. The mosquitofish slips into any water not too acidic to stop it, the wallum's one defence from Chapter 9, and strips out the tadpoles. None of these animals depends on a particular tree, hollow or chemistry, and that is exactly why they prosper while the specialists fade. A simplified, broken landscape is a generalist's paradise, and every fragment we make and every wetland we sweeten tilts the board a little further their way.

Sidebar — The bird that built a thermostat. Not every generalist is an invader, and not every native animal is in retreat. One of the coast's quiet success stories is a big, dark, red-headed bird you will meet scratching up the mulch in gardens and picnic grounds from the range to the sea: the Australian brush-turkey. It belongs to an ancient group, the megapodes or "mound-builders," that have given up the warm parental body most birds incubate with and let rot do the work instead. The male rakes together a huge mound of leaf litter and soil — a compost heap a metre or more high and several across, the patient labour of weeks — and the eggs are laid deep inside it, to be incubated by the heat of decay. The real marvel is what comes next: he manages the temperature, testing the mound with his bill and adding or scraping away litter to hold it near the mid-thirties the eggs need, a living thermostat in feathers. The chicks hatch far down in the mound and must dig their own way up through it, a slog of many hours; they surface already on their own, never having met a parent, and can flutter up into a tree within hours of reaching the light. Once hunted hard and pushed back, the brush-turkey has returned in force and moved cheerfully into suburbia, to the mixed feelings of gardeners whose flowerbeds it rediscovers. It is a cheering counter-melody, proof that an odd, robust, all-purpose way of life can not only survive the human landscape but settle happily into it.

The one native check on them sits mostly just to the north. The dingo, the wongari, survives in a genetically significant population on K'gari, the giant sand island that is Butchulla Country beyond Cooloola; along the settled mainland coast it has been largely shot, baited and bred out. Its near-absence is felt right through the web, in foxes and cats left without a rival: pull out one thread and you change the weave of all the others.

Reading the country

So read the animals of this coast for the bargains they have struck, and for the fragility those bargains carry. The koala asleep in its fork has staked its whole life on a poisonous leaf, and the forest that grows it is disappearing. The dark cockatoo working a she-oak cone is squeezed between two slow-grown resources at once, and shows up only where the woodland is still whole. The frog calling from the acid swamp hides behind a chemical wall that we can dismantle without meaning to, while the great butterfly waits on a single broken link and its slow mending. Even the despised bats streaming out at dusk turn out to be the keystone holding the fragmented forests together, hated for all the wrong reasons. Behind these five moves a wider cast: gliders and night-diggers, the platypus that reads a creek's health, the goanna and the python, and the cane toads and foxes and cats that thrive on the very disruption that undoes the rest. Every native one of them is tied, by a thread it cannot do without, to something else in this living web, and every one is a measure of whether that something else still survives.

We have followed the living web from the plants and their partners to the animals that cannot live without them. With that, the natural picture is complete: the physical ground, the ecosystems ranged along it from reef to range, and the web of dependence strung across the whole. One force is still missing from it — the one that has lately changed everything. How this country came to be as it is today, what two centuries of settlement did to it, and how it might yet be cared for, is the subject of the final part of the book. That is where we go next.

Chapter 17 • An environmental history

You cannot read the country we have without reading what was done to it. Every view is also a record.

The Sunshine Coast you can drive across today is not a natural landscape with people added on top. It is a landscape people have made, unmade and partly remade, and almost every view you admire is, if you know how to read it, also a record of what was done to get it. The cedar was carried off, the range was cleared, the swamps were drained, the whales were hunted off Moreton Island and the dunes were dug open for their sand; and then, late and still unfinished, came the slow work of putting some of it back. Read in order, that is the story this chapter tells.

It runs as a sequence, because it broadly happened as one: a vast era of careful custodianship, then a short, violent century of extraction, then a turn toward repair, still underway, still uncertain. The country we will spend the final chapters trying to care for is the product of all three.

The long custodianship

The first and longest chapter of this history is also the one we can say least about, and deliberately keep briefest. The Kabi Kabi (Gubbi Gubbi) people have lived on, used and managed this Country for many thousands of years. Set against the day we used, back in Chapter 2, to measure deep time, the entire European period is the camera-click. In 2024 the Federal Court formally recognised their native title over a large part of the region.

What the earlier chapters have shown, from the ecological side, is that this was never a passive occupation. The open, park-like forests the first Europeans so admired were in significant part the product of careful, frequent, patchy burning (Chapter 6); the mosaic of heath, woodland and grassland, and the abundance of

game, were shaped by that management. The country the colonists called “wilderness” was, in truth, a long-tended one. That is why the single biggest ecological consequence of colonisation was not any one clearing or drainage but the abrupt removal of that custodianship: the breaking, within a generation, of a land-management system tens of thousands of years deep.

The century of extraction

What replaced it was extraction, and it advanced through the landscape in an orderly sequence, taking the most valuable things first.

The rainforest went almost immediately, for one tree above all. Red cedar was tall, soft, richly coloured and easily worked, the “red gold” of the colonial timber trade, and so prized that the cedar-getters pushed into the scrubs ahead of nearly all other settlement. They were a rough, itinerant advance guard who lived hard in the rainforest, felled the giants with axe and cross-cut saw, and used the rivers as their only road. They floated the logs downstream on the floods to the mills and the ships waiting at the coast. Cedar does not grow in stands but scattered singly through the scrub, so the getters had to range widely to find it, and in a few decades of that ranging they had cut out nearly every mature tree in the district. A large red cedar is a rare sight on this coast today, a century and more after the trade that hunted it moved on. They were followed into the rainforest by the hoop-pine loggers, and then by the clearing proper: because, as Chapter 13 explained, the rainforest grew on the richest soil, and once the timber was gone that deep red basalt earth was the most coveted farmland in the region. The felling and burning that followed was astonishingly fast and thorough. Within the span of a single working life the great scrub of the Blackall Range went from a closed forest that had stood for many thousands of years to a scatter of steep-gully remnants, its red soil handed over to dairy farms, small crops and townships.

The lowlands went next, and differently. The fertile river floodplains were cleared and, crucially, drained: the wetlands of Chapter 10 dug through with channels and converted to sugar

cane and pasture, on the confident assumption that a drained swamp was an improved one. The open eucalypt forests were cleared, thinned, grazed and cut for timber. The sea, too, was mined. The humpback whales were hunted along this coast almost to extinction, with a whaling station operating on nearby Moreton Island into the early 1960s (Chapter 14). The shellfish reefs of the estuaries were dredged and harvested out of existence so completely that we forgot they had ever been there.

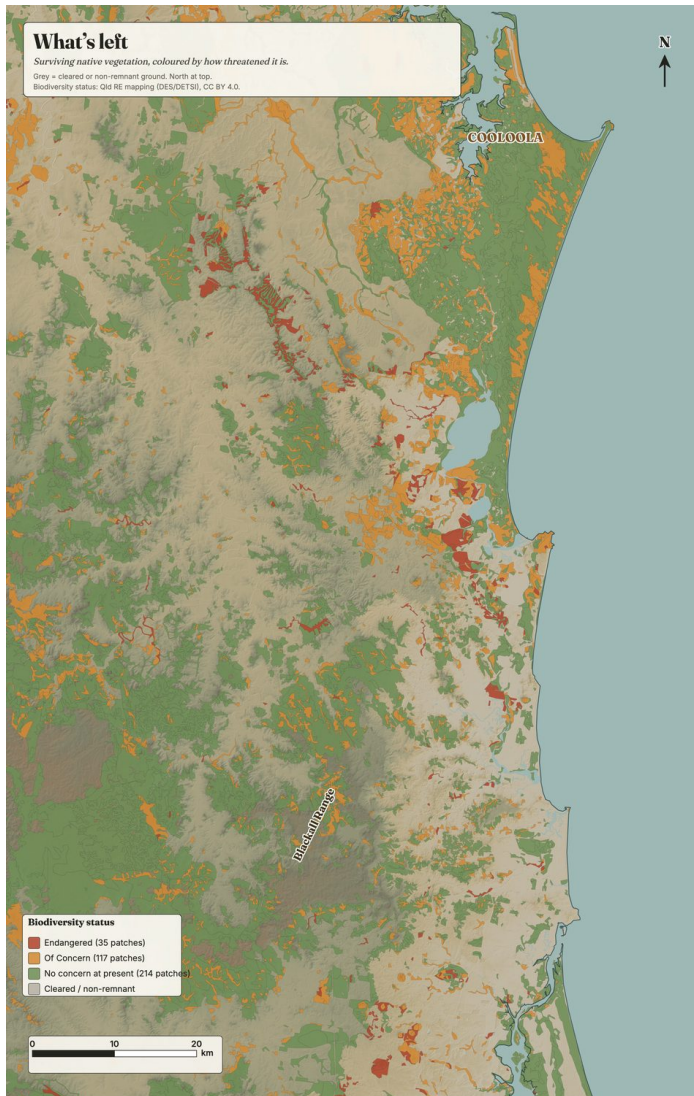


Figure 17.1 — What's left. Surviving native vegetation, coloured by how threatened it is: the fertile lowlands were cleared first and are now the most endangered, while the great unbroken green is the infertile sand and ranges the plough passed over.

The living animals of the land were mined as well, and none more brutally than the koala. In the early twentieth century the koala was not the protected emblem it is now but a commodity, killed in vast numbers for its dense fur, which was sold under other names to buyers who would not knowingly wear a koala. Queensland

was the last stronghold of that trade, and it ended in one notorious spasm. In 1927 the state government, under pressure from trappers in a hard season, declared a brief open season lasting a single month. In it some six hundred thousand koala skins were sold. Once the unsold, the spoiled and the orphaned young are counted, perhaps eight hundred thousand animals were killed in the episode still remembered as “Black August.” That works out to a koala killed somewhere in the state roughly every three seconds, around the clock, for thirty-one days. The public outrage that followed helped finish the fur trade for good and pushed the koala toward protection. But the animal never regained its former abundance, and the brush-tailed possums went the same way, in their millions, for the same trade. It was extraction of the living, as surely as the felling of the cedar: the forests emptied of their animals even as the axe emptied them of their trees.

The animals and plants we let loose

Extraction was only half of the ecological upheaval. The other half was addition: the deliberate and accidental importing of a whole new cast of living things, and it has proved every bit as far-reaching. The colonists arrived with the busy, well-meaning habit of “acclimatisation”: the project of stocking the new country with the familiar species of home, and with anything thought useful or pleasant. Its results are still reshaping the coast today.

Some of the worst arrivals were imports that escaped their purpose. The most infamous is the cane toad, brought to Queensland in 1935 to control the beetles that plagued the sugar cane, the crop that then ruled this very coast. It was released with high hopes and no caution at all. It did little for the beetles and a great deal to everything else, breeding in prodigious numbers, poisoning the native predators that tried to eat it, and spreading outward in a slow toxic tide still advancing across the continent today. The European fox and the domestic cat, gone wild in the bush, became between them the most destructive predators the Australian fauna had ever met. As Chapter 16 described, they fell hardest on exactly the small and medium mammals the country could least

afford to lose. Rabbits, deer, feral pigs, the mosquitofish slipped into the creeks — the list runs long, and every name on it is a species now living wild in country that had no defences ready for it.

The plants came too, and some have made over whole landscapes. Lantana, a garden ornamental gone feral, now smothers cleared and disturbed ground across the region in dense, thorny thickets that shade out all beneath them. Camphor laurel, planted as a handsome shade and street tree, seeds itself into old pasture and gully and grows into weed-forests standing where rainforest should be. Both are so common now that a newcomer might take them for native bush, which is precisely the trouble: the green is not always the country's own. Between the imported predators, grazers and weeds, the settlers did not only subtract from the region's ecology; they overwrote large parts of it with a blander, borrowed set of players. Much of the next chapter is the patient work of undoing that.

Extraction itself, meanwhile, was not finished. Its last great act fell on the one kind of country that had so far been spared for its very poverty: the mineral sands of the great dune fields drew the miners. By the middle of the twentieth century the bright, "useless" sand of Cooloola was wanted for the heavy minerals locked in its dunes. This was the very country whose poverty, as Chapters 4 and 9 showed, had bred such extraordinary richness, and now the sand-mining leases loomed.

What saved it began, of all things, with wildflowers. Kathleen McArthur, the Caloundra wildflower painter, and the poet Judith Wright were two of the founders, in 1962, of the Wildlife Preservation Society of Queensland, and they took up Cooloola as their cause. McArthur was central to the long public campaign that followed, the kind of patient, unglamorous work that wins slowly or not at all. They won: in 1975 Cooloola was gazetted a national park. It became one of the founding campaigns of the Australian conservation movement, and the fight that marks the turning point in this story.

Sidebar — What was nearly lost. Weigh what the leases would have taken. Locked in those dunes were the heavy minerals the miners were after — but running through the same sand was the irreplaceable, seven-hundred-thousand-year soil chronosequence that has taught the world how soils and ecosystems age. One of the most scientifically precious landscapes on Earth was very nearly dug up for the titanium in its sand, and was saved only because enough people had learned to read its value against the grain of the times. The lesson keeps recurring: the country worth least to a developer or a miner is very often worth most to everyone else.

The turn toward repair

The Cooloola campaign was a sign of something larger: a slow, contested change in how the wider community read the landscape, from a stock of resources to be converted into a heritage to be kept. From the 1960s and 1970s onward, national parks and reserves were declared, the worst clearing was reined in, whaling was banned and the whales began their long recovery, and a conservation ethic took hold that would, in time, grow into the restoration projects of the next chapter.

Two threads of that turn run straight into the present. The first is the rise of restoration as a serious discipline. It grew from the realisation that protecting what remained was not enough, that the cleared and drained and degraded country could, with skill and patience, be actively mended. With it came the methods (bush regeneration, rainforest framework-species planting, wetland re-wetting) that make that mending possible. The second is the long-overdue movement to bring First Nations knowledge and authority back to the centre of how Country is managed: cultural fire, ranger programs, and the kind of formal recognition that the 2024 native title determination represents. Both threads are the subject of Chapter 18. The history did not end with the extraction. It turned.

The turn was not all in the distant past. As recently as 2009, after a sustained community campaign, the federal government refused to dam the Mary River, the same north-flowing river of Chapter 3, at Traveston Crossing. It did so on a telling ground: not cost, not engineering, but a handful of creatures that live in the Mary and, essentially, nowhere else. It was Cooloola's lesson, repeated a generation on.

Sidebar — The dam that wasn't built. The Mary is an old, quiet, unglamorous river, and to a water planner in 2006, casting about for somewhere to supply a fast-growing South-East Queensland, its broad flat valley looked like an ideal place to park a very large dam. What the plan weighed too lightly was the river's tenants. The Mary is one of the last strongholds of three animals found in it and almost nowhere else on Earth. The first is the Australian lungfish, a heavy, big-scaled survivor of a lineage so ancient it was gulping air in rivers like this one long before the first dinosaurs. The second is the Mary River turtle, a distinctive local endemic once sold, in ignorance, as a hatchling “penny turtle” in pet shops, and able to stay down for hours by taking in oxygen through its hind end. The third is the Mary River cod, among the rarest freshwater fish in the country. All three breed in the shallow, flowing, gravel-bottomed reaches that a dam would have stilled and drowned. A long, dogged campaign by Mary Valley landholders, scientists and conservationists made exactly that case. In 2009 the federal environment minister refused the dam under national environment law, on the ground that it posed an unacceptable risk to those species. The river runs free today because enough people could read what a spreadsheet could not: that the least conspicuous residents of an ordinary-looking valley can be the most irreplaceable thing in it.

The coast fills up

It would be dishonest, though, to tell this as a tidy story of damage and then repair. While the conservation movement was gathering, a different and ultimately larger transformation was getting under way, one that has since become the dominant force shaping the region's ecology. The Sunshine Coast was filling up with people.

For most of its colonial history this had been a quiet, rural, working coast: timber, cane, dairy and fishing, with a scatter of small towns and a long, mostly empty shore. Then, through the second half of the twentieth century, it discovered its real modern vocation, which was the beach. Better roads brought Brisbane within an easy drive; the holiday shacks multiplied into suburbs; the suburbs spread and merged into a nearly continuous coastal strip; and what had been a farming district with beaches attached became one of the fastest-growing urban regions in the country, its population climbing decade on decade with no sign of levelling off. The change was in kind as much as in numbers. The land was no longer being cleared to grow something on; it was being cleared to live on, which is a more or less permanent conversion.

That shift rewrote the threat to the country's ecology from top to bottom. The dominant pressure today is the subdivision: the steady conversion of bushland, wetland and koala forest into housing; the slicing of habitat into ever-smaller islands by roads and fences; the squeeze on the very mangroves, dunes and wetlands the earlier chapters defended; and, over all of it, the lengthening shadow of a changing climate. The pressure never really stopped. It just changed costume, traded the cross-cut saw for the surveyor's peg, and kept going.

Sidebar — The estate built on a drowned swamp. If you want a single emblem of the development era's habit of mind, look at a canal estate. The recipe, popular through the mid-to-late twentieth century, was simple and, at the time, considered clever: take a stretch of "useless" coastal wetland or low river-flat, dredge a network of canals through it, pile the spoil to raise the ground between, and sell the result as prime waterfront housing, every block with a boat mooring at the bottom of the garden. What it actually did, in the terms of Chapters 8 and 10, was destroy some of the most productive country on the coast twice over. It bulldozed the wetland and mangrove nursery that fed the fisheries and buffered the floods, and, where the dredging disturbed the wrong soils, sometimes woke the sleeping acid-sulfate hazard as well. The canals look benign, even attractive, lined with houses and tidy lawns. They are, ecologically, among the most thoroughly converted ground on the coast: a wetland drowned and built upon rather than merely drained, and almost impossible to recover.

Reading the country

This is where the reading skill pays its richest dividend, because once you know the history, the landscape narrates it to you everywhere you look. A green range with a few deep gullies of rain-forest and everything else in pasture is the big scrub, felled for its timber and its soil, with the survivors hiding where the ground was too steep to clear. A dead-straight drain leading off a flat paddock is a wetland in the act of having been killed, generations ago. A lonely, massive old gum standing in a field of younger trees is a survivor of the original forest, left for shade, now an island of habitat. A dense thicket of lantana or camphor laurel is the green scar tissue of disturbance, exotic weeds colonising ground that was cleared. And a stretch of bright heath behind the beach that was never built on is very possibly land that someone, once, fought to save. The whole coast is legible as history, and most of that history is recent enough to still be reversible.

We have spent this chapter on the keeping and the taking. The next is about the giving back: the people, projects and principles now working to care for this Country, and what this book suggests about how to do it well.

Chapter 18 • Caring for Country today

It turns out you cannot put a landscape back the way a watch-maker fixes a watch. You can only give the country the conditions it needs, and let it do the rest.

Caring for Country well asks for exactly the skill these pages have been trying to teach. Read the landscape: the rock and soil and water and fire beneath it, the web of partnership strung across it, the history written into it. Then act with the grain of all that rather than against it. Across the Sunshine Coast a great many people are already doing precisely that, and the recovering whales, the rebuilt rainforests and the returning wetlands show it can work. This is a chapter about repair, and about practical hope.

It opens, as the history did, with the people who have been caring for this Country the longest.

Caring for Country, led from the front

The phrase “caring for Country” names an idea older than conservation: that people and land exist in a relationship of mutual responsibility, in which looking after the land and its living things is an obligation rather than a hobby. On this coast, as across Australia, one of the most important developments in land management has been the movement to bring Traditional Owner knowledge and authority back toward the centre of it. You can see it in the 2024 recognition of Kabi Kabi native title (Chapter 17), and in the revival of cultural fire. The cool, frequent, patchy burning of Chapter 6 is being reapplied. Practitioners and networks (the work gathered in Victor Steffensen’s *Fire Country*, the Firesticks Alliance and others) are bringing traditional burning back onto Country, often in partnership with the agencies that once suppressed it.

This leads to a conclusion drawn straight from the ecology: you cannot care for this country simply by leaving it alone, because leaving it alone is not what made it. The “natural” landscape was a managed one (Chapters 6 and 17), and it has to be actively, knowledgeably tended. That recognition runs through every method and project in the rest of this chapter.

The art of getting out of the way

Alongside that older knowledge, over the last half-century, a practical discipline of ecological restoration has grown up, and this region has been a serious contributor to it. What it has mostly learned is how little of the work is really ours to do. Given half a chance, the land is far better at rebuilding itself than we are at rebuilding it, and the restorer’s true skill lies in setting up the conditions and then, as much as possible, standing back.

Take the framework-species method of rainforest restoration (Chapter 13). You cannot plant a rainforest tree by tree: it is too intricate, too interdependent, and nobody has the centuries to spare. So restorers do not try. They plant instead a modest scaffold of fast-growing natives, just enough to shade out the weeds and, more to the point, to fruit; and the fruit draws back the seed-dispersing birds and flying-foxes (Chapter 15). It is those couriers, not the planters, who carry in the seed of hundreds of other species and re-sow the forest themselves. Tired paddocks across the region have been coaxed back into young, diversifying rainforest exactly this way — by people who planted a beginning and let the birds finish it.

Bush regeneration works to the same grain, and asks for the same patience. The influential Bradley method starts not with the worst of the weeds but with the best of the surviving bush, working slowly outward from the healthiest, least-disturbed ground and letting the natives recolonise the cleared edges on their own, rather than scalping everything at once and leaving a bare, weed-prone vacuum. It is slow and undramatic. It works because a living system heals best from its own intact edges.

And sometimes what needs mending is neither a plant nor an animal but the link between them. The recovery of the Richmond birdwing (Chapters 13 and 16) never set out to breed and release butterflies. It replanted, up and down the coast, the single native vine the caterpillars cannot live without, stitching a broken thread back across the landscape and letting the butterfly find it, and move, and breed, on its own.

Sidebar — Why you mend the conditions, not the thing.

The lesson of restoration on this coast, repeated across project after project, is counter-intuitive: the way to bring something back is usually to restore the conditions it needs and then get out of the way, rather than to install the thing itself. You do not glue a rainforest back together tree by tree; you plant a framework and let the birds re-sow it. Nobody manufactures acid frogs; you protect the strange acid water (Chapter 9) and the hidden water table that brews it, and the frogs follow. An oyster reef is not assembled shellfish by shellfish either. You lay down something hard for the oysters to settle on (Chapter 14) and let them rebuild it. And you cannot vaccinate a koala back to abundance without giving it the connected forest to live in (Chapters 12, 16). Again and again, the living world proves better at rebuilding itself than we are at rebuilding it, provided we restore the soil, the water, the fire, the connections and the partners it depends on.

Where it is already working

Three projects, each glimpsed in earlier chapters, show all of this working at something close to landscape scale, and between them they run most of the way down the gradient.

Begin on the Maroochy floodplain, on low ground that a century ago was cut off from its own river, drained and levee-banked and turned over to cane and grazing, and that is now, deliberately, being handed back to the water. This is the Blue Heart (Chapters 8 and 10), a shared undertaking of the council, the state government, the local water utility and the Kabi Kabi people, reaching across more than five thousand hectares, a substantial share of

the whole floodplain. Its method is mostly subtraction: cut a gap in an old levee, and let the tide do the rest. The water feels its way back along a drain it had been shut out of for generations, spreads across an old cane paddock, and settles. And the country begins to remember what it was: saltmarsh and mangrove on the tidal ground, freshwater wetland on the higher slope where the salt does not reach, a flat long written off as farmland putting itself back together, more or less unaided. It is a slow, costly, deliberate undoing of a nineteenth-century certainty, that a drained swamp was an improved one; and a belated crediting of everything an intact wetland does for nothing — soaking up the floods that would otherwise reach houses, cleaning the water on its way to the bay, nursing the fisheries, and locking carbon away in its waterlogged mud.

In the Noosa estuary, a similar patience is at work below the water. The native oyster reefs that once floored the river were dredged out of existence and forgotten; the shellfish-reef restoration (Chapter 14) is laying down hard ground for the oysters to settle on and rebuild, so they can resume their old, unpaid work of filtering the water and sheltering the fish. What is being restored is less the oyster than the reef itself, a whole working part of the estuary that had slipped out of living memory.

And across the forests and the suburbs runs the longest campaign of all: the effort to keep the koala (Chapters 12 and 16). It is waged on every front at once: protecting the habitat that remains, replanting corridors between the fragments, softening roads and managing dogs, and, at the University of the Sunshine Coast, developing a vaccine against the chlamydial disease. All of it helps. But the science keeps returning the same verdict: the one thing the koala cannot do without is enough connected forest to live in, and no vaccine will stand in for that.

Keeping what's left

Restoration mends what was damaged; but the cheapest and surest form of care is simply to keep the intact country intact. A great deal of the best of this coast survives at all because it was, at some point, formally protected: reserved as national park or con-

servation reserve, and so taken off the table of development. The Cooloola sand mass saved in the 1970s (Chapter 17), the Glass House Mountains, the headland and hinterland reserves, the marine parks offshore: these are the anchor points of the region's ecology, the large, secured cores from which recovery can spread. Every one of them represents a decision, usually contested at the time, to value the country as country rather than as real estate.

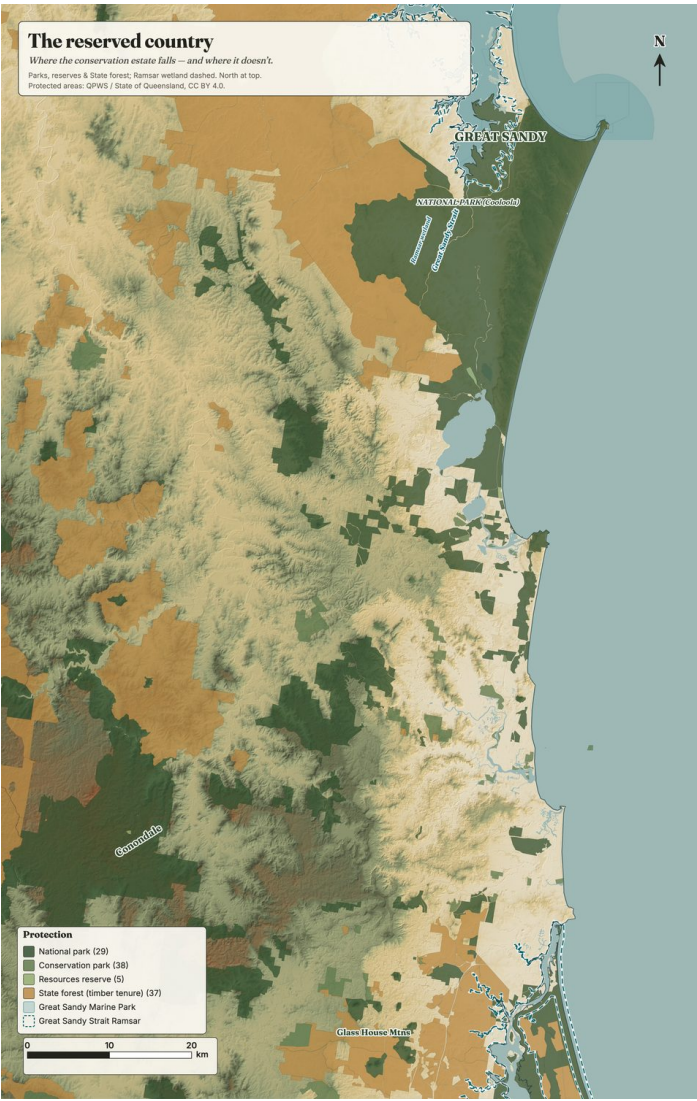


Figure 18.1 — The reserved country. The conservation estate clusters on the infertile ground nobody wanted to farm: 72% of the coastal sand is reserved, but only 9% of the basalt tableland.

But the reserve system, however vital, can only ever protect a fraction of the ground. On a coast being rapidly subdivided, a great deal of what matters, from koala forest to wetland to wild-life corridor, lies on private land, outside any park. This is where two humbler mechanisms do work out of all proportion to their

fame. The first is private-land conservation: voluntary programs through which landholders agree to protect and manage the bush on their own property. These run from the widespread Land for Wildlife scheme to permanent conservation covenants that bind the protection to the land title for good. A farm or a bush block managed for its wildlife is, in effect, a small reserve that cost the public purse almost nothing. The second is local funding aimed squarely at the problem. Through a dedicated council environment levy, the Sunshine Coast has for three decades been buying up and caring for high-value conservation land: more than four thousand hectares of it, some forty square kilometres of bush, wetland and koala forest bought back from the market block by block. It has helped private landholders do the same, a community taxing itself, modestly and deliberately, to hold on to its own natural capital before it is gone. Between the big public reserves and the scatter of protected private blocks, the region is slowly assembling the one thing a fragmenting landscape most needs: a network of secured habitat that development cannot casually undo.



Figure 18.2 — The Mending Ground. The active repair, from real council data: 117 reserves totalling 4,454 ha, bought back for \$69.3 million by the environment levy since 1994, marching down the gradient onto the fertile lowlands that were cleared first; with 223 revegetation sites and 999 fauna structures (nest boxes, glider poles, road crossings) stitching the rest back together. Read against the wound the clearing map shows — this is the healing.

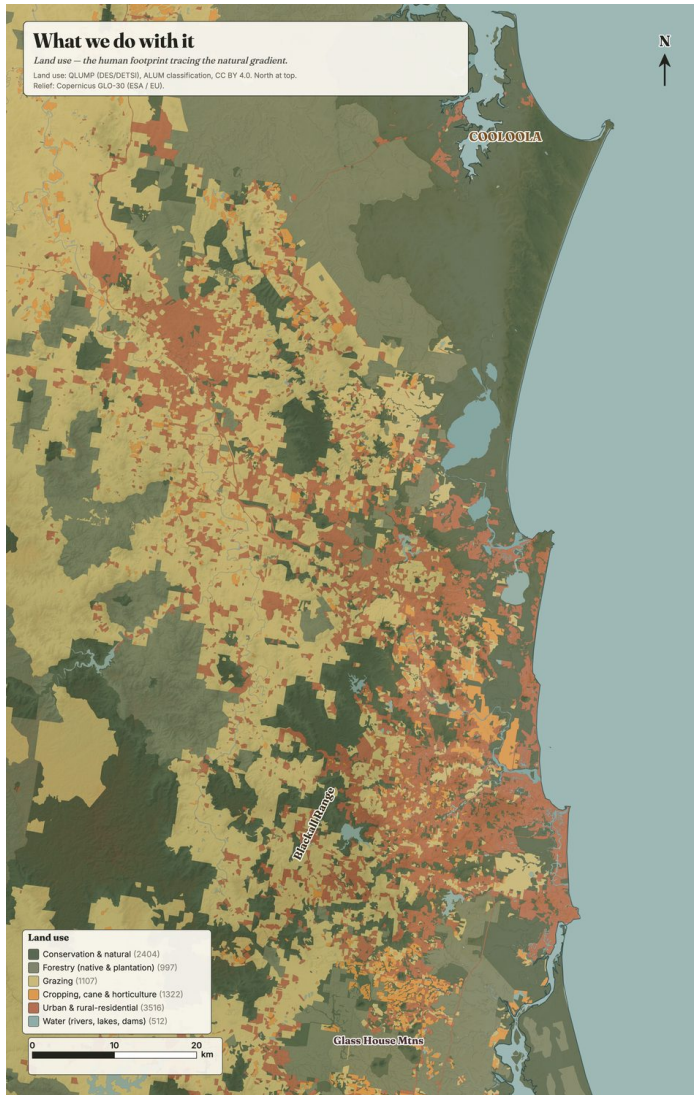


Figure 18.3 — What we do with the ground. The human footprint mirrors the natural gradient: cane on the alluvial flats, grazing on the cleared foothills, conservation on the sand and ranges, towns on the coast.

The work of many hands

It would be easy, reading about native title, university vaccines and council-scale wetland projects, to imagine that caring for Country is the business of governments, scientists and large organisations. A great deal of it is. But a surprising share of the

actual work, the hours on the ground year after year, is done by ordinary people in small, persistent, unglamorous acts. Any fair account of looking after this coast has to put them at the centre.

The backbone of this is the community land-care movement, in its various guises: the Landcare and bushcare groups, the catchment and “rivercare” volunteers, the dune-care teams, the friends-of-this-reserve associations that have adopted patches of bush, creek and foreshore all across the region. Their work is the Bradley method written into thousands of weekends: pulling lantana and camphor laurel, replanting natives, fencing stock out of creek lines, nursing local seedlings in community nurseries, and slowly, patch by patch, healing ground that no single agency could ever tend at that resolution. It is drudgery and it is indispensable, because an ecosystem is mended at the scale of the weed and the seedling, and that scale can only be reached by many hands.

Sidebar — The emergency room for wildlife. Not all care is slow. Alongside the patient work of weeding and replanting runs a faster, harder kind, the rescue and rehabilitation of individual animals hurt by the very pressures this book keeps describing: the koala hit on a road or torn by a dog, the flying-fox pulled from a heat-struck camp, the seabird tangled in line. A network of volunteer wildlife carers across the region takes these animals in. Near its centre sits one of the busiest wildlife hospitals in the world, the Australia Zoo Wildlife Hospital at Beerwah, in the shadow of the Glass House Mountains, which treats close to ten thousand native animals a year: better than twenty-five through its doors on an average day, koalas among the largest single share of them. Be honest about what this work is and is not. A wildlife hospital does not fix the underlying problem; you cannot treat your way out of habitat loss any more than you can vaccinate your way out of it. But it saves lives one at a time, returns healed animals to the bush, and serves as a kind of casualty ward and early-warning station for the coast, its intake books a running tally of what the landscape is doing to the animals that live in it. It is care at the scale of the single creature, and a great many people give their weekends to it.

Alongside the hands have come the eyes. Ordinary residents now feed the science itself, through citizen monitoring of the kind that has tracked koala numbers across South-East Queensland, through frog-call and bird surveys, through the recording of sightings that lets researchers see patterns no single team could piece together. The Richmond birdwing recovery of Chapters 13 and 16 ran in large part through schools, gardeners and community groups replanting the butterfly's vine in their own backyards and parks: restoration distributed across an entire community, one vine at a time. When enough people are watching and tending a landscape, the landscape gains something no reserve fence can give it: a population that would actually notice if the frogs went quiet.

That distributed care matters most for the problem the development era left behind: fragmentation. The most useful thing many landholders and communities can do is to *reconnect* what survives: replanting corridors along creeks and between remnants, retaining the big old hollow-bearing trees (Chapter 12), and knitting the islands of bush back into something an animal can move through. A koala, a glossy black-cockatoo or a flying-fox does not need any one block to be perfect; it needs to be able to get from one patch to the next. On a coast being steadily subdivided, this reconnection may be the most important restoration of all.

The hard part, and the hope

It would be a poor history that ended in easy optimism, because the pressures are real and growing. The Sunshine Coast is one of the fastest-growing regions in the country, and every year more bushland, wetland and koala forest is converted to housing for a population that keeps arriving. Habitat is fragmented by roads; introduced plants and animals keep spreading; and over all of it hangs a changing climate that is already showing up as fiercer fire weather, hotter heat events lethal to flying-foxes, and rising seas pressing on the coastal wetlands. Set against all of that, caring for this Country means working steadily against the grain of a coast that keeps filling up. None of those pressures is easing, and several are getting worse.

And yet the grounds for hope are equally real. The humpbacks, hunted to a few hundred, now pass the coast in their tens of thousands, proof that a population given the one thing it needs can come back from near-extinction. Cleared paddocks have become young rainforest; drained flats are becoming wetland again; a butterfly has been coaxed back along its replanted vine; a forgotten reef is being relaid in the river. None of these is a fantasy of returning the coast to some untouched past, a country that never existed, having been tended by people for tens of thousands of years. They are something better and more practical: evidence

that a wrecked landscape, read right and given back the conditions it needs, will do most of the rebuilding itself, often faster than anyone dared predict.

Reading the country

By now you can see what good care looks like on the ground. A creek line fenced from stock and replanted with a framework of natives is a rainforest being handed back the conditions to rebuild itself. A patch of bush weeded patiently from its healthy heart outward is the Bradley method at work, healing from strength. A low paddock with its drains blocked and the water creeping back is a wetland being allowed to resume its unpaid work. And a cool, patchy burn moving slowly through open forest in the right season is fire being used as a tool rather than feared as a disaster, increasingly by the people who always used it. Each is a piece of country being read correctly and tended accordingly.

That is what good care amounts to, and much of it is within reach of an ordinary person with a weekend and a patch to tend. Which leaves just one thing still to do: get out there and read the country with your own eyes. The last chapter is a companion for exactly that.

Chapter 19 • A field companion

A book about a landscape is only ever a set of instructions. The landscape itself is waiting outside, and it is far better company.

Everything in this book has been building toward one simple act: going outside and reading the country for yourself. The reading skill we have assembled chapter by chapter was never meant to stay on the page; it only works with your boots on the ground. This last chapter is the companion for that: a quick method for reading any patch of this coast at a glance, a tour of where to go and what each place will teach you, and a few notes on doing it well and lightly.

The Reader's Year

Four seasons of watching on the Sunshine Coast, from the heath to the horizon.

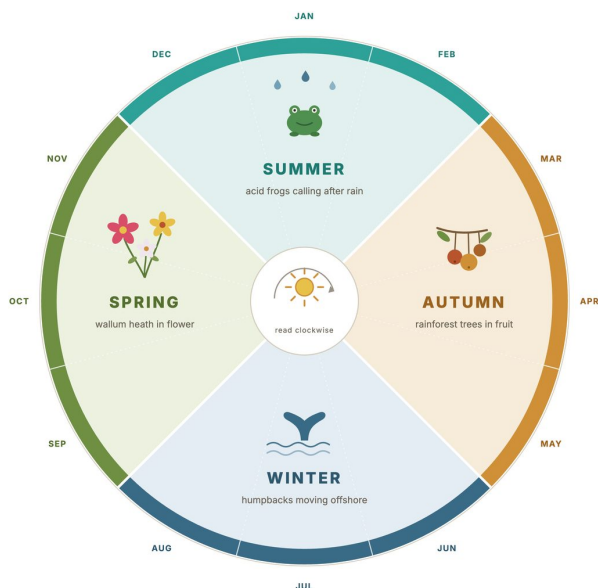


Figure 19.1 — The naturalist's year. Spring wildflowers, a summer of frog-song, autumn fruit, and whales off the winter beaches.

One word before you go. The country in these pages is alive and forever rearranging itself, and so is your way into it. Tracks wash out and gates close; seasons open one place and shut another; tides, fire and flood can rewrite a day's plan without asking your leave. So check the current access, tides, conditions and park rules before you set out, and treat what you find on the ground as the last word over anything printed here. Respect private land, closures and protected areas as you meet them. Tread lightly, and take out what you carry in. And take full responsibility for your own safety, because the bush will not look after you. A little planning is the whole price of a good day out.

How to read any landscape in five minutes

Here, gathered into one place, is the whole method, in the order you can run it in the field. Stand somewhere — anywhere — on the Sunshine Coast, and ask these questions in turn.

First, read the shape (Chapters 2–3). What is the lie of the land? A lone, steep, sharp peak is a volcanic plug, the hard core of a vanished volcano. A flat-topped range with a steep rim is a basalt cap. Low rolling hills are the soft foundation rock. Dead-flat coastal ground is young sand or river flat. The shape tells you the rock, and the rock starts everything.

Second, read the soil (Chapter 4). What colour is the ground? Deep chocolate-red means basalt clay, the richest soil there is. Thin, pale, mixed soil means the softer foundation rock. Dark, fertile flats mean river alluvium. And bright, bleached, bottomless white sand means the oldest, poorest country of all, the wallum.

Third, read the water (Chapter 5). What colour is any water you can see? Clear and cool off a green range is basalt water. Brown and turbid is sediment-laden floodplain water. Clear-but-tea-stained, dark and still, is the acid blackwater of the sand country.

Fourth, read the vegetation (Chapters 7–13). Closed, dim, multi-layered forest on red soil is rainforest. Tall or open gum forest over grass is eucalypt country. Pale, papery-trunked trees

with wet feet are paperbark swamp. Low, hard-leaved heath that flowers in spring is wallum. Trees breathing through snorkel roots in tidal mud are mangroves.

Fifth, read the fire and the history (Chapters 6, 17). Blackened trunks resprouting in green fuzz, or grass-trees in flower, mean a recent burn. Rainforest creeping into the gully means country long unburnt. A straight drain, a lonely giant old tree in a paddock, a thicket of lantana: these are the scars of clearing and disturbance.

Run those five readings and you will know, within a few minutes and before consulting any sign, roughly what you are standing in, why it is there, and what it has been through. That is the entire book, folded down to something you can do from a lookout. (The single-page **field guide** and the **ecological zones map** are designed to ride in a pocket or a glovebox for this.)

The art of looking

The five-minute method tells you what to read; here is a word on *how* to look.

The most useful skill in the field is also the simplest: slow down, and stop. Most of what lives here will not show itself to a walking human, but a great deal of it resumes its business within a few minutes of your going still. Pick a log or a rock, sit, and let the bush forget you are there: the pademelon edges back out, the small birds return to the low scrub, the skink slides back onto its sunlit stone. Ten quiet minutes in one place will nearly always show you more than a brisk hour covering ground.

Go at the edges of the day. Dawn and dusk are when the country is busiest — the daytime animals feeding hardest, the night ones beginning to stir — and, not by coincidence, when the light is kindest and the heat least. On a summer walk a dawn start is at once the most rewarding and the safest.

Learn to read with your ears as much as your eyes, because much of this country announces itself in sound long before you see it. Listen for the explosive crack of a whipbird and the answering note from its mate; the carolling song of a magpie; the soft

sigh of wind through a she-oak, heard before you find the tree; the shriek of lorikeets tearing through blossom; and, on a warm wet night, the layered chorus of frogs, each species calling its own line.

Two small tools open it all up, and neither costs much. A pair of binoculars pulls the honeyeaters, the fruit-doves and the far-off whale-spout into reach; a simple hand lens turns the ground at your feet into a whole other landscape: the sundew's glistening traps, the works of a wildflower, the lichen crusting a rock. Between them they take in the far and the very near, the places the naked eye can't.

And do not always turn for home at dusk. Much of the coast's cast comes out only after dark: the gliders, the owls, the possums, the frogs, the whole night shift of Chapter 12. A still night in the bush is a different country from the same place by day. A quiet wait near a flowering tree, or a slow walk with a dim, red-filtered torch, may show you gliders working the blossom or an owl on a branch; a warm, wet night beside a wallum swamp is the frogs' great hour. Keep it gentle: a soft or red light, a low voice, no beam held on an animal more than a moment, and nothing touched.

The one-day gradient

If you do only one thing with this book, make the drive that opened Chapter 7: from Maleny down to the coast at Mooloolaba, reading the gradient as you descend. It runs the opposite way to the book's climb from reef to range: in the field it is far easier to start in the cool of the range and coast down with gravity. It is the best classroom on the coast, crossing nearly every ecosystem in one short traverse, in order.

Start high, in the rainforest of the Blackall Range. **Mary Cairncross Scenic Reserve** is the classic stop, a surviving fragment of the big scrub, cool and dim and dripping, on deep red basalt soil. Then point downhill and watch the reading change beneath you: the rainforest thinning into tall eucalypt forest; the forest opening into drier grassy woodland; the slopes flattening into the old floodplain, with its cane, its drains, and the occasional

forest red gum left standing. Lower still, the ground turns to sand, with paperbark in the hollows and heath on the rises, and finally the mangroves and open water of the Maroochy mouth, where the tide runs in and out. Six worlds, one drive. Do it slowly, stop often, and run the five-minute reading at each change of country.

A reader's tour

Beyond the one-day gradient, here is where to go to meet each ecosystem properly: a checklist of country, roughly from the range to the sea. The signature species to watch for at each, with their scientific names, are gathered in the field checklist in the back of the book.

- **A volcanic plug, up close.** The **Glass House Mountains** are the grand set piece, with lookouts at their feet and walking tracks on several of the peaks, but **Mount Coolum**, **Mount Tinbeerwah** and **Mount Ninderry** all offer the same lesson on a gentler scale: hard rhyolite or trachyte standing where softer country has worn away. (A worked example of one such peak is set out in the **Mount Ninderry deep-dive**.)
- **Rainforest.** Mary Cairncross and the reserves of the **Blackall Range** (Maleny–Montville–Mapleton), and the gully and waterfall walks of the hinterland at Kondalilla and Mapleton, where streams saw down through the basalt cap.
- **Eucalypt forest and woodland.** The foothill and range reserves throughout the hinterland; almost any patch of open, straight-trunked gum forest over grass. Look for hollow-bearing old trees, and listen for the glossy black-cockatoo where she-oaks grow.
- **Wallum and dunes.** **Noosa National Park** and, above all, the **Cooloola** section of the **Great Sandy National Park**, the heart of the book's science: bleached sand, spring wildflowers, perched lakes such as **Lake Poona**, and the tea-coloured **Noosa Everglades** of the upper Noosa River, the blackwater of Chapter 5 made visible.

- **Paperbark swamp and freshwater wetland.** The **Marroochy** floodplain wetlands and reserves; melaleuca stands in any low, wet hollow. (The community restoration story of one such reach is set out in the **South Marroochy RiverCare deep-dive**.)
- **Estuary, mangrove and saltmarsh.** Mangrove boardwalks on the **Marroochy River**, and the long sheltered **Pumicestone Passage** behind Bribie Island — best read at low tide, when the zones from seagrass to mangrove to saltmarsh lie open.
- **Sea country.** The headlands of Noosa and Point Cartwright for the offshore view, the **Pumicestone Passage** for seagrass, dugong and turtle country, and, in season, the whales offshore.

A reader’s calendar

This country reads differently through the year, and timing a visit well can mean the difference between an empty heath and a blazing one. The country runs on weather rather than the calendar, so treat the table below as cues, not a timetable.

Season	What to look for
Spring (Sep–Nov)	Wallum and heath at their flowering peak: the best time to see why the poorest soil grows the richest flora. Migratory shorebirds arriving on the flats from the Arctic. Humpbacks heading south, often with calves.
Summer (Dec–Feb)	The wet season: frog choruses erupting after warm rain, storms recharging the swamps and the sand-mass aquifer, shorebirds feeding on the flats. Hot, humid and storm-prone — see the safety notes below.
Autumn (Mar–May)	The wet easing; the rainforest lush and dripping; fruiting that draws the fruit-doves and flying-foxes.

Season	What to look for
Winter (Jun–Aug)	The dry season: humpbacks heading north to breed (the peak of the “humpback highway”); the driest, safest walking; the main season for planned and cultural burning in the fire-country.

Three fixed highlights are worth planning a trip around: the **spring wildflower** flush in the wallum, the **whale migration** (north through winter, south through spring), and the **frog chor-us** on the first warm, wet nights of summer.

Before you go: stay safe, and tread lightly

This is beautiful country, and some of it is hazardous to the unprepared. A few plain cautions first, then a few manners.

Staying safe. - Heat, sun and water. The summer here is hot and humid. Carry more water than you think you need, cover up, and stay off exposed walks in the middle of the day; most tracks have no drinking water. - **The peaks are real climbs.** Several of the Glass House Mountains are steep, exposed scrambles that have cost lives — not gentle strolls. Some routes are closed or restricted. Check the current status, respect the grading, and turn back in the wet, when the rock grows slick. - **Snakes and ticks.** This is snake country — the eastern brown and red-bellied black among them. Watch where you put your feet, leave any snake alone, and learn the pressure-immobilisation first aid. Paralysis ticks are common in the moist forest, so check yourself afterwards. - **Water and tides.** Surf beaches have rips; the estuaries, sandflats and Pumicestone Passage run on the tide; and the Cooloola and Noosa North Shore sand tracks are four-wheel-drive only and strand the unwary on a rising tide. Read the tide before you set out onto a flat or a sand track. - **Tell someone, and don’t count on a phone.** Much of the hinterland and the sand country has no mobile signal. Leave word of where you are going and when you expect to be back. - **Check before you go.** Park access, track closures, fire and flood conditions and seasonal re-

strictions all change; confirm them with Queensland Parks and Wildlife or the local council before you leave, rather than trusting any printed guide, this one included.

Treading lightly. A landscape you have learned to read is one you will want to leave intact: - Keep to the tracks and stay off bare dunes; the foredune pioneers of Chapter 9 hold the coast together and are easily killed by trampling and wheels. - Do not foul the water. The acid wallum and its frogs (Chapters 9, 16) are undone by anything that sweetens or pollutes them, so clean your boots and gear between wetlands to avoid spreading weeds and disease. - Leave plants, animals and rocks where they are; a wildflower left standing makes next year's seed. - Keep dogs out of wildlife habitat, drive carefully through bush at night, give nests, roosts and hauled-out animals a wide berth, and never handle bats. - Respect cultural sites: much of this landscape holds places of deep significance to the Kabi Kabi people; treat all sites and any access restrictions with respect.

Getting involved

Reading the country is the first act of caring for it, but it need not be the last. As Chapter 18 described, much of the work of looking after this coast is done by ordinary people in small, persistent acts, and they are always glad of another pair of hands. Local **Landcare, bushcare, dune-care and "rivercare" groups**, catchment and "friends of" associations, and community nurseries work on patches of bush, creek, dune and wetland all across the region. **Citizen-science** programs welcome your frog calls, bird lists, koala sightings and wildflower records. And replanting efforts, from rainforest framework plantings to the backyard bird-wing vine, turn private gardens into part of the repair.

Reading the country

And so we end outside, with the skill in your hands and the country open in front of you. Where the Sunshine Coast once looked like a random scatter of pretty places, you now see a structured, connected landscape with a history you can read on sight.

This is not wilderness but a living system, one that people have shaped and can still help mend. The country is waiting outside, and it is far better company than the book. So go.

Acknowledgements

This book stands on the work of many others. The science it draws together is the achievement of the researchers, ecologists, geologists and field naturalists named throughout the text and gathered in the references; a book like this one is really a retelling of what they discovered, and the errors that survive in the retelling are mine alone.

Special thanks to my wife, who has encouraged (endured?) all my ideas over the years, and kept supporting me as I find my path.

The Sunshine Coast is Kabi Kabi (Gubbi Gubbi) Country. The debt this book owes to the people who have read and tended it for many thousands of years is acknowledged more fully in the opening pages.

A field checklist of signature species

A selected, not exhaustive, list of the plants and animals named in this book — the species that most clearly mark each kind of country. Common name first, then scientific name; tick them off as you meet them. Conservation status and detail are discussed in the relevant chapters.

Plants

Rainforest and wet forest (Ch 11–13)

- ☐ Red cedar — *Toona ciliata*
- ☐ Hoop pine — *Araucaria cunninghamii*
- ☐ Bunya pine — *Araucaria bidwillii*
- ☐ Strangler fig — *Ficus watkinsiana*
- ☐ Piccabeen palm — *Archontophoenix cunninghamiana*
- ☐ King / rock orchid — *Dendrobium speciosum* (*Thelychiton speciosus*)

Eucalypt forest and woodland (Ch 11, 15)

- ☐ Blackbutt — *Eucalyptus pilularis*
- ☐ Tallowwood — *Eucalyptus microcorys*
- ☐ Flooded / rose gum — *Eucalyptus grandis*
- ☐ Forest red gum — *Eucalyptus tereticornis*
- ☐ Spotted gum — *Corymbia citriodora* subsp. *variegata*
- ☐ Grey gum — *Eucalyptus propinqua*
- ☐ Ironbark — *Eucalyptus* spp. (e.g. *E. crebra*, *E. siderophloia*)
- ☐ She-oaks — *Allocasuarina* spp. (*glossy black-cockatoo food*)
- ☐ Mistletoes — *Amyema* spp. (*hemiparasites; the mistletoebird's food*)
- ☐ Forest grass-tree — *Xanthorrhoea johnsonii*

Wallum heath and dunes (Ch 9)

- ☐ Wallum banksia — *Banksia aemula* (*the plant the landscape is named for*)

- ☐ Coast banksia — *Banksia integrifolia*
- ☐ Scribbly gum — *Eucalyptus racemosa*
- ☐ Swamp / wallum grass-tree — *Xanthorrhoea fulva*
- ☐ Wattles — *Acacia* spp. (*nitrogen-fixers*)
- ☐ Grevilleas and hakeas — Proteaceae (*cluster roots*)
- ☐ Sundews — *Drosera* spp. (*carnivorous*)
- ☐ Bladderworts — *Utricularia* spp. (*carnivorous*)
- ☐ Tongue orchids — *Cryptostylis* spp. (*sexual-deception pollination*)
- ☐ Zamia / cycad — *Macrozamia miquelii*
- ☐ Coastal spinifex — *Spinifex sericeus* (*dune-builder*)
- ☐ Goat's-foot / beach morning-glory — *Ipomoea pes-caprae*
- ☐ Pigface — *Carpobrotus glaucescens*

Wetlands, estuary and coast (Ch 8, 10, 14)

- ☐ Broad-leaved paperbark — *Melaleuca quinquenervia*
- ☐ Grey mangrove — *Avicennia marina*
- ☐ Red / stilt mangrove — *Rhizophora stylosa*
- ☐ Saltmarsh samphire / glasswort — *Salicornia*, *Tecticornia* spp.
- ☐ Seagrasses — *Zostera*, *Halophila*, *Halodule* spp.
- ☐ Richmond birdwing vine — *Pararistolochia praevenosa*

Animals

Mammals (Ch 9, 12, 14, 16)

- ☐ Koala — *Phascolarctos cinereus*
- ☐ Greater glider — *Petauroides volans*
- ☐ Yellow-bellied glider — *Petaurus australis*
- ☐ Sugar glider — *Petaurus breviceps* (sens. lat.)
- ☐ Feathertail glider — *Acrobates pygmaeus* (*smallest gliding mammal*)
- ☐ Grey-headed flying-fox — *Pteropus poliocephalus*
- ☐ Red-legged pademelon — *Thylogale stigmatica*
- ☐ Swamp wallaby — *Wallabia bicolor*

- ☐ Northern brown bandicoot — *Isoodon macrourus* (a gardener underground; spreads fungal spores)
- ☐ Long-nosed potoroo — *Potorous tridactylus* (a gardener underground; spreads fungal spores)
- ☐ Short-beaked echidna — *Tachyglossus aculeatus*
- ☐ Platypus — *Ornithorhynchus anatinus*
- ☐ Dugong — *Dugong dugon*
- ☐ Humpback whale — *Megaptera novaeangliae*
- ☐ Dingo / wongari — *Canis dingo* (on K'gari, Butchulla Country, just north)

Birds (Ch 8, 9, 10, 11, 13, 14, 15, 16)

- ☐ Australian brush-turkey — *Alectura lathami* (megapode; mound-builder)
- ☐ Eastern ground parrot — *Pezoporus wallicus wallicus* (wallum heath specialist; Vulnerable in Queensland)
- ☐ Glossy black-cockatoo — *Calyptorhynchus lathami lathami*
- ☐ Powerful owl — *Ninox strenua*
- ☐ Laughing kookaburra — *Dacelo novaeguineae*
- ☐ Rainbow lorikeet — *Trichoglossus moluccanus*
- ☐ Wompoo fruit-dove — *Ptilinopus magnificus*
- ☐ Rose-crowned fruit-dove — *Ptilinopus regina*
- ☐ Topknot pigeon — *Lopholaimus antarcticus*
- ☐ Green catbird — *Ailuroedus crassirostris*
- ☐ Regent bowerbird — *Sericulus chrysocephalus*
- ☐ Paradise riflebird — *Ptiloris paradiseus*
- ☐ Mistletoebird — *Dicaeum hirundinaceum*
- ☐ Bar-tailed godwit — *Limosa lapponica* (Arctic migrant)
- ☐ Black-necked stork (jabiru) — *Ephippiorhynchus asiaticus*
- ☐ Magpie goose — *Anseranas semipalmata*

Reptiles and frogs (Ch 9, 11, 13, 14, 16)

- ☐ Lace monitor — *Varanus varius*
- ☐ Coastal carpet python — *Morelia spilota mcdowelli*
- ☐ Eastern brown snake — *Pseudonaja textilis*
- ☐ Red-bellied black snake — *Pseudechis porphyriacus*

- ☐ Land mullet — *Bellatorias major* (northern range limit, Conondale Range)
- ☐ Loggerhead turtle — *Caretta caretta* (the turtle that nests on these mainland beaches)
- ☐ Green turtle — *Chelonia mydas* (the seagrass grazer; nests here only rarely)
- ☐ Wallum froglet — *Crinia tinnula*
- ☐ Wallum sedgefrog — *Litoria olongburensis*
- ☐ Cooloola sedgefrog — *Litoria cooloolensis*
- ☐ Wallum rocketfrog — *Litoria freycineti*
- ☐ Eastern banjo frog / pobblebonk — *Limnodynastes dumerilii*
- ☐ Striped marsh frog — *Limnodynastes peronii*
- ☐ Green tree frog — *Litoria caerulea*

Invertebrates (Ch 13–15)

- ☐ Richmond birdwing — *Ornithoptera richmondia*
- ☐ Orchid dupe wasp — *Lissopimpla excelsa* (pollinates the tongue orchids)
- ☐ Fig wasps — Agaonidae (e.g. *Pleistodontes* spp.) (each fig its own wasp)

Introduced — the watch-list (Ch 16, 17–18)

- ☐ Cane toad — *Rhinella marina*
- ☐ Red fox — *Vulpes vulpes*
- ☐ Feral cat — *Felis catus*
- ☐ Mosquitofish — *Gambusia holbrooki*
- ☐ Lantana — *Lantana camara*
- ☐ Camphor laurel — *Cinnamomum camphora*
- ☐ Dutchman's pipe (the birdwing trap) — *Aristolochia littoralis* (*A. elegans*)

Glossary

Plain-language definitions of the technical terms used in this book. The chapter where each is introduced is given in brackets.

Acid sulfate soil — Coastal soil rich in buried iron pyrite, harmless while waterlogged; drain it and the pyrite oxidises to sulfuric acid, which the next rain flushes into waterways, killing fish. (Ch 10)

Alluvium — Sediment (silt, sand and clay) laid down by flowing water; the fertile, easily worked soils of river floodplains. (Ch 4)

Basalt — A dark, fine-grained volcanic rock formed from fluid, silica-poor lava; under high rainfall it weathers into deep, fertile red clay. (Ch 2–3)

Blackwater — Freshwater stained brown by dissolved tannins leached from leaf litter; clear but tea-coloured, and typically acidic and nutrient-poor. Characteristic of the wallum. (Ch 5)

Blue carbon — Carbon locked in the waterlogged soils of coastal wetlands (mangrove, saltmarsh, seagrass), where airless mud halts decay; among the densest carbon stores on Earth. (Ch 8)

Buzz pollination (sonication) — The release of pollen from a flower's sealed anthers by a bee gripping the flower and vibrating its flight muscles at the right pitch; performed by many native bees but not the introduced honeybee. (Ch 15)

Chronosequence — A set of sites that differ in age but are otherwise similar, so that change over time can be read across space. The Cooloola dunes are a classic example. (Ch 4)

Cluster roots (proteoid roots) — Dense brushes of fine roots, grown by many Proteaceae, that flood a patch of soil with acids and enzymes to prise loose scarce phosphorus. (Ch 4, 15)

Corestone — A rounded kernel of sound rock left when weathering rots a jointed rock inward from its cracks; heaps of exposed corestones make the tumbled boulder tors seen on hillcrests. (Ch 3)

Country — In Aboriginal Australian usage, the lands, waters and all they hold to which a people belong and for which they carry responsibility; written with a capital C. (Ch 1)

Cryptovivipary / vivipary — The germination of a seed while it is still attached to the parent. In *true vivipary* (e.g. the stilt mangroves, *Rhizophora*) the seedling bursts through the fruit and dangles before dropping; in *cryptovivipary* (e.g. the grey mangrove) it sprouts but stays hidden inside the fruit. (Ch 8)

Detritus — Dead organic matter — fallen leaves, litter, rotting wood — broken down by microbes and animals; the base of the estuary's food web, which runs on dead leaves rather than living green pasture. (Ch 8)

Ecosystem engineer — An organism that physically reshapes its surroundings and so creates habitat for others; mangroves, which trap sediment and build coastline, are a clear example. (Ch 8)

Elaiosome — An oil-rich food body attached to a seed to bribe ants into carrying it off and burying it (see *myrmecochory*). (Ch 15)

Endemic — Occurring naturally in one region only and nowhere else. (Ch 9, 13)

Epicormic buds — Dormant buds beneath the bark and deep in the wood of eucalypts that burst into new shoots after fire, regreening a scorched trunk. (Ch 6)

Epiphyte — A plant that grows perched on another plant for support only, taking nothing from it — e.g. the staghorn ferns and orchids on rainforest trees. Not a parasite. (Ch 13–15)

Estuary — The tidal mouth of a river, where fresh and salt water mix twice a day; among the most productive of all habitats. (Ch 5, 8)

Ferrosol — A deep, well-structured red clay soil, rich in iron oxides, formed on basalt; the most fertile soil in the region. (Older name: krasnozem.) (Ch 4)

Fire-behaviour triangle — The three things that decide how a landscape fire burns: fuel, weather and topography (slope). Distinct from the chemistry “fire triangle” of heat, fuel and oxygen. (Ch 6)

Flood pulse — The periodic overbank flooding of a lowland river onto its floodplain, which delivers nutrient and sediment, connects off-channel wetlands, and cues fish and waterbirds to breed; a renewal, not merely a hazard. (Ch 5)

Folivore — A leaf-eater; an animal living mostly on leaves, like the koala and the greater glider. (Ch 12, 16)

Framework-species method — A rainforest-restoration technique: plant a few dozen fast-growing native species to close a canopy and draw back seed-dispersing animals, which then carry in the seed of everything else. (Ch 13, 18)

Frugivore / frugivory — A fruit-eating animal / the eating of fruit; frugivores such as fruit-doves and flying-foxes disperse the seed of fleshy-fruited rainforest plants. (Ch 13, 16)

Groundwater-dependent ecosystem (GDE) — A wetland, lake or stream that lives off the water table beneath it. The wallum’s swamps, streams and lakes are GDEs fed by the freshwater stored in the sand. (Ch 5, 9)

Hemiparasite — A parasitic plant that draws water and dissolved minerals from a host but keeps green leaves and makes its own sugar; the mistletoes are hemiparasites. (Ch 15)

Hotspot — A fixed plume of hot mantle that melts the crust drifting over it, leaving an age-progressive trail of volcanoes. The Glass House Mountains belong to such a system. (Ch 2)

Keystone species — A species whose role in an ecosystem is far larger than its numbers suggest, so that its loss unravels much else; for example, the flying-fox as a long-distance pollinator and seed-disperser. (Ch 16)

Lignotuber — A woody, bud-packed swelling at the base of many shrubs and small trees that lets them resprout after fire. (Ch 6)

Mangrove — A salt-tolerant tree of the intertidal zone, equipped to handle salt, airless mud and the tides through salt glands, breathing roots and germinating seed. (Ch 8)

Mycoheterotroph — A plant that has given up photosynthesis and instead draws its sugar from mycorrhizal fungi shared with nearby trees — in effect stealing from the underground economy; e.g. the leafless hyacinth orchid. (Ch 15)

Mycorrhiza — A partnership between plant roots and fungi that trades plant sugar for the fungus's reach to water and scarce nutrients; near-universal, and most vital on the poorest soils. (Ch 4, 15)

Myrmecochory — Seed dispersal by ants, which carry off seeds for their oil-rich *elaiosomes* and dump the seed itself underground, safe from fire and seed-eaters. (Ch 15)

Nitrogen fixation — The conversion of inert atmospheric nitrogen into a usable form by certain bacteria, often housed in the root nodules of wattles and peas. (Ch 4, 15)

Pedogenesis — The formation and slow development of soil over time. (Ch 4)

Perched lake — A dune lake held *above* the regional water table on a watertight organic hardpan and fed only by rainwater (e.g. Lake Poona). Contrast a **window lake**, a basin that cuts down to *intersect* the water table. (Ch 5)

Pneumatophore — A vertical “breathing root” that mangroves send up out of the waterlogged mud to take air at low tide. (Ch 8)

Podzol — A soil with a bleached, leached layer of pale sand over a dark, cemented layer where the leached material has come to rest. Cooloola's are among the deepest in the world. (Ch 4)

Podzolisation — The process that forms a podzol: organic acids strip iron, aluminium and humus from the surface sand and redeposit them below as the dark “coffee rock.” (Ch 4)

Retrogression — The decline in productivity of an ecosystem on very old, phosphorus-exhausted soils. (Ch 4)

Rhyolite — A pale, silica-rich volcanic rock from stiff, slow-moving lava; hard and erosion-resistant, it forms several of the region's peaks. (Ch 2–3)

Saltmarsh — Low, salt-tolerant herbland on the higher tidal flats behind the mangroves; a high-tide feeding ground, carbon store and flood buffer. (Ch 8)

Sclerophyll — “Hard-leaved”: the tough, leathery, long-lived foliage typical of plants grown on poor Australian soils, and the vegetation (sclerophyll forest, heath) built from them. (Ch 4, 9, 11)

Seagrass — A flowering plant, not a seaweed, that grows in shallow marine sand; the pasture of dugong and green turtle and a nursery for fish and prawns. (Ch 8, 14)

Serotiny — The holding of seed in woody fruits on the plant, released only by the heat of fire; seen in banksias, hakeas and grevilleas. (Ch 6)

Trachyte — A silica-rich volcanic rock, like rhyolite stiff and hard, that forms domes and plugs such as several of the Glass House peaks. (Ch 2–3)

Volcanic plug (neck) — The solidified rock that filled the throat of an old volcano, left standing as a peak after the softer cone has eroded away. (Ch 2–3)

Wallum — The heath and low woodland of the coastal sand masses, growing on bleached, acidic, nutrient-poor sand; named from what is widely reported to be the Kabi Kabi word for the wallum banksia, and famous for its diversity. (Ch 9)

Window lake — See **Perched lake**.

Woody thickening — The loss of an open, grassy woodland's diversity when fire is withheld too long and woody shrubs and small trees crowd into the mid-storey and shade out the ground layer. (Ch 6, 11)

Further reading

A short, personal, and deliberately selective shelf for anyone who wants to go further — starting points, not a complete list. Full academic sources for every claim in this book are gathered in the Notes & sources appendix a few pages on, and online at sunshinecoastecology.com.au/bibliography. Titles are grouped by the part of the book they most belong to; several could sit under three headings at once.

This coast, close up

- **W. Willmott, *Rocks and Landscapes of the Sunshine Coast*** (Geological Society of Australia). The indispensable local companion to the rock: the plugs, the basalt, the sand masses, region by region. If you read only one book alongside this one, read this.
- **G. Leiper et al., *Mangroves to Mountains*** (Native Plants Queensland). The standard field guide to the region's flora, from the tidal zone to the range — the book to carry when you want to put a name to what you are looking at.
- **S. Haslam, *Noosa's Native Plants*** (Noosa Integrated Catchment Association). A generous, locally focused plant guide, especially good on the wallum and the sand country.
- **P. Davie, *Wild Guide to Moreton Bay and Adjacent Coasts*** (Queensland Museum). Two volumes covering the animals and plants of the wider bay and coast — the best single reference to the region's fauna.

Reading Australian landscapes & deep time

- **Bill Bryson, *A Short History of Nearly Everything*.** Not about this coast at all, but the spirit this book is written in: rigorous science told as an adventure. Included here because it is the standard the whole enterprise is trying to meet.
- **Tim Flannery, *The Future Eaters*.** A sweeping, argumentative ecological history of Australasia and its people — the big-picture backdrop to why Australian nature is the way it is.
- **Mary E. White, *The Greening of Gondwana*.** The deep-time story of the Australian flora, from the Gondwanan forests the rainforest chapters keep pointing back to.

Plants, animals & the living web

- **Tim Low, *Where Song Began*.** A superb, award-winning account of how Australia's nectar-rich, bird-driven ecology shaped the world's songbirds — the perfect companion to the honeyeaters, lorikeets and flowering trees of these chapters.
- **Tim Low, *The New Nature*.** On how thoroughly wild nature and the human landscape are now entangled — directly relevant to the “coast fills up” and “caring for Country” chapters.

Fire & Caring for Country

- **Victor Steffensen, *Fire Country*.** Cultural fire from the inside, by a leading practitioner; the living continuation of the story told in the fire chapter.
- **Bill Gammage, *The Biggest Estate on Earth*.** The influential (and vigorously debated) case that the open, park-like country the first colonists met was a landscape deliberately made with fire.

- **R. Bradstock, J. Williams & M. Gill (eds), *Flammable Australia*.** More technical, but the standard reference on Australian fire regimes and biodiversity for readers who want the science in full.

Sea country & the bay

- **D. McPhee, *Environmental History and Ecology of Moreton Bay*** (CSIRO Publishing). The scholarly companion to the sea-country chapters: seagrass, dugong, fisheries, and the long human history of the bay.

Tools for reading it yourself (online)

- **Atlas of Living Australia** (ala.org.au) — the national biodiversity database; look up any species and see where it has been recorded.
- **Queensland Government WetlandInfo** (wetland-info.des.qld.gov.au) — detailed, readable pages on the region's wetlands, regional ecosystems and their plants.
- **Citizen-science apps** — *iNaturalist* (record and identify anything), *eBird* (birds), and *FrogID* (frog calls, run by the Australian Museum) turn a walk into a contribution to the science, exactly as Chapter 18 describes.

Maps & Data — Sources and Credits

Every map and diagram in this book was made *for* it — drawn from open, published, properly-licensed data rather than lifted from another publication. Where a figure rests on a public dataset, that source and its licence are credited here, as those licences require. The maps share one visual language — a single shaded-relief base, one palette, one set of type — so that they read as a set, reef to range.

The shared base

- **Shaded relief** — Copernicus GLO-30 Digital Elevation Model. Contains modified Copernicus data; © ESA / European Union.
- **Sea floor** (the reef-to-range surface) — GEBCO 2020 Grid, GEBCO Compilation Group (2020), doi:10.5285/a29c5465-b138-234d-e053-6c86abc040b9.
- **Coastline & rivers** — © OpenStreetMap contributors, used under the Open Database License (ODbL); the derived coastline and river lines are © OpenStreetMap contributors.

The thematic maps

All Queensland Government datasets below are © State of Queensland and used under a Creative Commons Attribution licence (CC BY 4.0, or CC BY 3.0 AU where noted).

- **Regional ecosystems, land zones, biodiversity status & clearing** — Regional Ecosystem mapping, Queensland Herbarium & Biodiversity Science (DES / DETSI).
- **Geology** — Detailed surface geology (1:100,000), Geological Survey of Queensland.
- **Rainfall** — SILO gridded climate data, Queensland Government (via Longpaddock).

- **Substrate radiometrics** — Radiometric (gamma-ray) Grid of Australia, Radmap v4 2019, Geoscience Australia.
- **Soils** — Soil and Landscape Grid of Australia, TERN / CSIRO.
- **Fire history** — Queensland fire-scar mapping (DES / DETSI).
- **Intertidal ecosystems** — DEA Coastal Ecosystems (Sentinel-2), Digital Earth Australia / Geoscience Australia.
- **Wetlands** — Queensland wetland mapping / Wetland-Info (DES / DETSI).
- **Land use** — Queensland Land Use Mapping Program (QLUMP), Australian Land Use and Management classification (DES / DETSI).
- **Protected areas, marine park & Ramsar** — Protected Areas of Queensland and Great Sandy Marine Park (Queensland Parks & Wildlife Service / DETSI); Ramsar wetland boundary, Australian Government (DCCEEW).

Species & conservation-effort data

- **Species occurrences** — Atlas of Living Australia (ALA), aggregating Queensland WildNet, iNaturalist and museum/herbarium records; individual records carry their own licences (predominantly CC BY / CC0). Records are shown as evidence of presence, not as authoritative ranges, and sensitive-species locations appear only as generalised by their custodians.
- **Conservation effort** (“the mending ground”) — Sunshine Coast Council open data (environment-levy reserves, revegetation, fauna infrastructure, conservation estate, biosphere zones), © Sunshine Coast Regional Council, CC BY 3.0 AU; Noosa Shire Council open data, © Noosa Shire Council; recent sightings from iNaturalist (© the individual observers, under their chosen licences).

Type

The maps and this book are set in **Fraunces** and **Inter**, both under the SIL Open Font License.

A note on Country

These data describe the land; they do not speak for its people. The Kabi Kabi (Gubbi Gubbi) are the Traditional Owners and continuing custodians of this Country (see the Acknowledgement of Country at the front of the book). No cultural, sacred or ranger site is mapped or plotted anywhere in this book: where such knowledge would be needed, it has been left out rather than shown without the custodians' authority.

List of sidebars

The sidebars are the book's tangents and set-pieces — the delicious detours where a single object, animal or idea gets a closer look. They are gathered here so you can find your way back to a favourite. (Chapter numbers in brackets.)

Foundations - The longest scar on Earth (2) - Why "Glass House"? (2) - The young giant (2) - Why the Glass House Mountains are mountains at all (3) - The cracks that come built in (3) - Two soils, two worlds, one rainfall (3) - What white sand is trying to tell you (4) - A clock made of sand (4) - The most valuable worthless real estate in ecology (4) - Why the wallum doesn't die in a drought (5) - Reading water by its colour (5) - The forest that puts itself out (6) - The fire that reached the rainforest (6)

The gradient - The lesson in the sand: the Cooloola dunes (7) - How a frog drinks vinegar (7) - Blue carbon: the swamp as a vault (8) - Reading the tidal zones (8) - The plants that turned carnivore (9) - Why you cannot move a wallum (9) - How to make acid by accident (10) - The accident that became a wetland (10) - The eel that spawns once (10) - There is no such thing as an everglade (10) - The richest few inches (11) - Reading the axemen's marks (11) - The cockatoo that eats one thing (11) - The thermogenic cycad (11) - A vaccine for a koala (12) - The century-old hollow (12) - The bunya (13) - The butterfly and the vine (13) - The warship that became a reef (14) - The blue paddock offshore (14) - The living beach (14) - The reefs we forgot we had (14)

The living web - The fig and the wasp: a contract sealed in the dark (15) - Ants: the coast's unpaid workforce (15) - When a link breaks: the butterfly and its vine (16) - The bird that built a thermostat (16)

People and change - What was nearly lost (17) - The dam that wasn't built (17) - The estate built on a drowned swamp (17) - Why you mend the conditions, not the thing (18) - The emergency room for wildlife (18)

Notes & Sources

Sources and further reading, chapter by chapter.

Chapter 1 • Country

- Regional extent and geography (ABS/QGSO; Sunshine Coast Council; BoM catchment brochures): brackets Glass House Mountains (south) to the Cooloolah sand mass (north); Maroochy, Mooloolah, Noosa draining seaward; Mary River rising at Booroobin (behind the range) and flowing north (see Chapter 3, Chapter 5); Sunshine Coast ~100 km north of Brisbane. The Blackall Range is only ~**20–30 km straight-line inland** from the beaches (Maroochydore–Maleny ≈ 26 km; Montville/Mapleton ~20–25 km).
- “Fastest-growing” framing: the Sunshine Coast is consistently among Australia’s fastest-growing regions (~2.4–2.8%/yr; ERP ~366,000 at 2023) though not literally #1, so “among the fastest-growing” is a fair hedge (ABS *Regional Population*; QGSO). Figure 1.1 (locality map) rendered from the Copernicus 30 m DEM.
- *Douglas on behalf of the Kabi Kabi First Nation Traditional Owners Native Title Claim Group v State of Queensland (No 5)* [2024] FCA 645 — Federal Court consent determination of 17 June 2024, Collier ACJ; non-exclusive native title over ~365,000 ha (3,450 km² land + 202 km² waters) of the Sunshine Coast.
- Aboriginal land management with fire and the “made” character of the pre-colonial landscape — see Chapter 6; published sources incl. Gammage, B. (2011), *The Biggest Estate on Earth* (and its scholarly critique, May 2023); Bowman, D.M.J.S. (1998), *New Phytologist* 140.
- The book’s organising rule (geology → soils → life → people) is developed in Chapter 7.
- Cultural-content note: this book touches on Kabi Kabi custodianship using published, public-record sources only, and does not present cultural stories or restricted knowledge; see the Acknowledgement of Country in the front matter.

Chapter 2 • The making of the rock

- Willmott, W. (2007). *Rocks and Landscapes of the Sunshine Coast* (2nd ed.). Geological Society of Australia, Queensland Division. (*Primary regional source: hotspot volcanism, the Glass House Mountains plugs, basalt, and the coastal sand masses.*)
- Eastern Australian hotspot volcanism / age-progressive volcanic track as the continent drifted north; Tweed Volcano (Wollumbin / Mount Warning) as a younger central shield volcano to the south (~23 Ma; sacred to the Bundjalung). (*Glass House intrusions ~26–27 Ma (Cohen et al. 2007); the “longest continental hotspot track on Earth” superlative belongs to the inland Cosgrove track (~2,000 km, Davies et al. 2015) — and the Glass House plugs sit on the separate, more easterly coastal lineament, not the Cosgrove track.*)
- Mount Ninderry is **not** one of the ~26 Ma plugs: its rock is the North Arm Volcanics (Late Triassic, Yandina/Mt Ninderry; K-Ar 217 ± 2 Ma), some 190 million years older. It stands proud for the same reason — hard, unjointed rhyolite. See Ch 3.
- Rhyolite/trachyte (viscous, silica-rich) vs basalt (fluid, silica-poor) and their contrasting landforms/soils — standard igneous petrology; regional application in Willmott (2007).
- “The floor beneath the fire” — the pre-volcanic rocks (Land for Wildlife SEQ, after Willmott; Geoscience Australia — Nambour Basin):
 - (a) Folded/faulted Palaeozoic **basement** metasediments (>300 Ma, Devonian–Carboniferous; local units **Amamoor beds**, **Booloumba beds** of the upper-Mary/hinterland; the **Neranleigh–Fernvale Group** is the correlative unit of the Beenleigh Block to the south — a regional equivalent, not the on-Coast unit). The “foundation rock” of the eucalypt-hill chapters.
 - (b) Mesozoic **Nambour Basin** sedimentary rocks (Late Triassic–Early Jurassic, ~237–174 Ma): **Landsborough Sandstone** (up to ~450 m; sandstone + siltstone/shale + minor coal) — “the bedrock for most of the coastal plain from Brisbane’s northern suburbs to Coolumb”; northern **Duckinwilla Group** (Myrtle Creek Sandstone, Tiara Coal Measures). “Age of the dinosaurs, well over 100 Myr before the ~26 Ma volcanoes” (~175 Myr gap).

- Four-layer stacking (basement → Mesozoic sediments → ~26 Ma volcanics → Quaternary sand). (*Some Palaeozoic marine sediments/lavas — Cambroonian beds, Cedarton Volcanics — also sit between the oldest metasediments and the Mesozoic.*)
- Glass House Mountains naming: **James Cook, 17 May 1770** (*Endeavour*); his journal records the hills “very much resembles glass houses,” hence the name. The specific **Yorkshire glass-works** provenance is the standard secondary interpretation, not Cook’s own words.
- Coastal sand masses: northward longshore drift, Quaternary dune-building, Cooloola and K’gari (Fraser Island, world’s largest sand island). (*Net northward longshore transport along the east-Australian coast built the Quaternary sand masses, with K’gari at the downdrift terminus; oldest Cooloola dunes ~700–800 ka (Ellerton et al. 2020). See Chapter 4 (Cooloola chronosequence).*)
- Deep-time framing / “compress 25 Myr into a day” is an explanatory device, not a source claim.

Chapter 3 • Reading the rock

- Willmott, W. (2007). *Rocks and Landscapes of the Sunshine Coast* (2nd ed.). Geological Society of Australia, Queensland Division. (*Primary regional source for landforms, plug/basalt/basement geology and the Glass House Mountains.*)
- Volcanic-neck / differential-erosion interpretation of the Glass House Mountains and coastal peaks — standard regional geology; see Willmott (2007).
- “Why hard is hard” (standard geomorphology): jointing/fracture density controls weathering (water attacks along joints; dense unfractured rock resists); **spheroidal weathering** rounds jointed blocks from corners/edges inward into **core-stones** (rounded fresh kernels in a saprolite matrix), left as tumbled boulder/tor outcrops when the matrix is stripped (the boulders begin angular and are rounded by weathering, not by their original form); deep chemical weathering is favoured in the warm/wet subtropics.

- Columnar jointing sidebar: polygonal cooling-contraction joints in lava (classic in basalt; also documented in rhyolite/trachyte), later serving as weathering pathways. **Local example:** the tall trachyte columns on the north face of **Mount Beerwah**, the “Organ Pipes” (also columns at Mt Ngungun; columnar jointing is additionally described in the Mapleton–Maleny hinterland basalt/tuff – a single geotechnical study). (Willmott 2007; NPS; GSQ.)
- Local basement and cover units: Amamoor & Booloumba Beds (Late Devonian–Carboniferous metasediments, Conondale Range); North Arm Volcanics (Late Triassic, Yandina/Mt Ninderry – K-Ar 217 ± 2 Ma at Mt Ninderry, some 190 million years older than the ~26 Ma hotspot plugs); Landsborough Sandstone (Early Jurassic, coastal-plain bedrock).

Chapter 4 • Soil

- Walker, T.W. & Syers, J.K. (1976). The fate of phosphorus during pedogenesis. *Geoderma* 15: 1–19. (*The nitrogen-then-phosphorus nutrient arc. Soil chemistry only – it does not treat leaves.*)
- Beadle, N.C.W. (1966). Soil phosphate and its role in molding segments of the Australian flora and vegetation, with special reference to xeromorphy and sclerophylly. *Ecology* 47(6): 992–1007. DOI 10.2307/1935647. (*The classic statement that low soil phosphate, not aridity alone, underlies sclerophylly – the leaf half of the argument above.*)
- Thompson, C.H. (1981). Podzol chronosequences on coastal dunes of eastern Australia. *Nature* 291: 59–61. (*Giant Cooloola podzols >20 m.*)
- Zemunik, G., Turner, B.L., Lambers, H. & Laliberté, E. (2015). Diversity of plant nutrient-acquisition strategies increases during long-term ecosystem development. *Nature Plants* 1: 15050. (*Strategy diversity rises as P declines – demonstrated on the Jurien Bay chronosequence, WA. The principle, NOT a Cooloola-specific finding.*)
- Chen, C.R. et al. (2015). Soil phosphorus fractionation and nutrient dynamics along the Cooloola coastal dune chronosequence. *Geoderma* 257–258: 4–13. (*Total P (upper 30 cm) falls ~88–90% – from ~229–237 to ~24–28 kg ha⁻¹ – along the sequence.*)

- Ellerton, D. et al. (2020). An 800-kyr record of dune emplacement, Cooloola Sand Mass. *Geomorphology* 354: 106999. (*Oldest dunes ~700–800 ka, single-grain OSL dating.*)
- “A walk through half a million years” (Walker, Thompson et al. 1981, the seminal Cooloola soil–vegetation study; Peltzer et al. 2010, *Ecol. Monogr.*; Wardle et al. 2004, *Science*): forest stature/biomass rises to a maximum on **intermediate** dunes — tall blackbutt (*Eucalyptus pilularis*)/bloodwood/turpentine forest — then declines through **retrogression** to low, shrubby **wallum heath** (wallum banksia) on the oldest, most P-depleted dunes (soil total P ~35–39 → ~9–10 mg/kg). **The age of that biomass peak is ~140 ka**, from the OSL chronology, not from the 1981 succession study: Walker, Lees, Olley & Thompson 2018, *Marine Geology* 398: 73–85 — “The largest dunes at some 320 m high were dated at around 140 ka and these dunes carry the maximum vegetation biomass of this dunefield.” So ~140 kyr of progression, then ~560–660 kyr of retrogression out to the ~700–800 ka oldest dunes. The *species-richness* peak on the oldest poor soils is the general chronosequence pattern (Zemunik/Laliberté, best-evidenced at Jurien Bay, WA) — consistent with, not a direct measurement at, Cooloola.
- OSL-dating sidebar (“A clock made of sand”) (Rhodes 2011, *Annu. Rev. Earth Planet. Sci.*; standard geochronology): buried quartz accumulates trapped charge from ambient U/Th/K + cosmic radiation; sunlight bleaches it to zero at burial; lab optical stimulation yields luminescence $\propto$ equivalent dose; age = equivalent dose $\div$ dose rate = time since last daylight. Cooloola dated by **single-grain OSL** (Ellerton et al. 2020, 31 samples/21 sites; Walker et al. 2018, *Marine Geology* 398: 73–85).
- Schmidt, S., Handley, L.L. & Sangtjean, T. (2006). Ectomycorrhizal N use, *Eucalyptus racemosa* vs *E. grandis*. *Functional Plant Biology*.
- Willmott, W. (2007). *Rocks and Landscapes of the Sunshine Coast* (2nd ed.). (*Regional soils/landforms.*)

Chapter 5 • Water

- Dyring, M. et al. (2025). Groundwater-dependent ecosystems of the Cooloola sand mass. *Science of the Total Environment*. (GDE mapping; wetland/lake/stream dependence on the water table — the spine of the aquifer section.)
- Coastal sand-mass hydrology — freshwater lens/mound, residence times, perched vs window (barrage) dune lakes. (*A fresh-water mound sits on denser saline groundwater with long residence times — Minjerribah/North Stradbroke tritium MRTs 37 to >150 yr, ¹⁴C up to ~5,000 yr (Hofmann et al. 2020, HESS 24:1293). Perched = above the water table on an organic/“coffee-rock” hardpan; window = intersects the regional water table.*)
- Perched-lake examples: Lake Poona (Cooloola); Lake Boomanjin / Lake McKenzie–Boorangoora (K’gari). (*Lake Poona is a perched lake within the Cooloola sand mass; Lakes McKenzie and Boomanjin on K’gari are perched — Boomanjin the world’s largest perched dune lake, though its centre also reaches the water table.*)
- Wallum/blackwater chemistry — tannin staining, low pH (acid waters). Wallum/acid-frog water pH: Shuker, Simpkins & Hero (2016), *Ecosphere* 7(6): e01384, report occurrence and breeding limits of pH 3.53–4.61 for the wallum sedgefrog *Litoria olongburensis*.
- “When the water comes all at once” (flood section) — flashy short/steep SE Qld coastal catchments (Maroochy floods 1893...2011, 2022; Mary R.); for the Sunshine Coast the dominant flood drivers are summer-monsoon troughs and ex-cyclone / tropical-low rain (e.g. Jan 2022 Mary flood = ex-TC Seth), with East Coast Lows secondary (more a NSW/southern-Qld, cooler-season phenomenon). The flood-pulse concept (Junk, Bayley & Sparks 1989) — overbank flooding delivers nutrient/sediment, connects off-channel wetlands, cues floodplain fish/waterbird breeding; leveeing/drainage/disconnection degrades floodplain wetlands.
- Noosa Everglades — the name is informal, not gazetted; the “one of two in the world” rarity is a tourism slogan, not science. Full treatment in Chapter 10.
- Mary River drainage history (north-flowing). (*The Mary rises in the Sunshine Coast hinterland near Maleny/Boorobin and flows north ~255 km through Gympie and Maryborough to the Great Sandy Strait — see Chapter 3.*)

- Willmott, W. (2007). *Rocks and Landscapes of the Sunshine Coast* (2nd ed.). (Regional drainage, sand masses, landform context.)

Chapter 6 • Fire

- Bowman, D.M.J.S. (1998). The impact of Aboriginal landscape burning on the Australian biota. *New Phytologist* 140: 385–410. (Central framework for fire’s role in shaping Australian vegetation.)
- Bradstock, R.A., Williams, J.E. & Gill, A.M. (eds). *Flammable Australia: The Fire Regimes and Biodiversity of a Continent*. (General fire-ecology framework; rainforest–eucalypt boundary, fire regimes.)
- Dooley, M., Lewis, T. & Schmidt, S. (2023). Fire frequency has a contrasting effect on vegetation and topsoil in subcoastal heathland, woodland and forest ecosystems, SEQ (the long-term Peachester burning experiment). *Austral Ecology* 48(8). (Regular fire maintains understorey diversity, at a topsoil-carbon cost.)
- Gammage, B. (2011). *The Biggest Estate on Earth: How Aborigines Made Australia*. Allen & Unwin. (Aboriginal fire-management thesis; the chapter draws on it but flags the scholarly debate — see May, below.)
- May, D. (2023). Rethinking *The Biggest Estate on Earth*: a critique of grand unified theories. *History Australia* 20(1): 154–172. (The scholarly critique of the “grand unified” Aboriginal-fire thesis — cautions against binaries that over- or under-state pre-European Indigenous impact.)
- Steffensen, V. (2020). *Fire Country: How Indigenous Fire Management Could Help Save Australia*. Hardie Grant Explore. (Contemporary cultural-fire practice.)
- Firesticks Alliance Indigenous Corporation — contemporary cultural-burning network.
- Plant fire-adaptations (epicormic buds, lignotubers, serotiny, smoke-cued germination, *Xanthorrhoea* post-fire flowering) — standard Australian fire ecology (Bradstock, Williams & Gill, *Flammable Australia*, above); regional flora in Leiper, G. et al. (2022). *Mangroves to Mountains* (3rd ed.). Native Plants Queensland (Logan River branch).

- “How a fire moves” (NPS/GRID-Arendal fire-behaviour references; CSIRO): the **fire-behaviour triangle** (fuel, weather, topography) governs fire spread/intensity. Fuel load ↔ intensity (fuel/hazard rises then **falls**: overall fuel hazard is *higher* in forest and woodland burnt 6–12 yr previously than in stands unburnt ≥96 yr, because frequent fire holds the understorey in an early-successional shrubby state while long absence lets the shrub layer senesce — Dixon et al. 2018, *IJWF* 27(9):609–622, article WF18037. the study covers eucalypt forest and woodland in SE Australia, not wallum heath); wind = the dominant weather variable (spread + spotting/embers); spread roughly doubles per ~10° of upslope; cool-burn vs catastrophic-fire intensity distinction standard.
- “The fires to come”: SE Qld projected hotter with longer fire seasons / more dangerous fire weather + drought (Climate Change in Australia — Qld; CSIRO; BoM/CSIRO *State of the Climate 2024*). **2019–20 “Black Summer”** burned World Heritage **Gondwana Rainforests** (~196,000 ha, ~53% fire-affected — IUCN World Heritage Outlook / DCCEEW *Gondwana Rainforests State of Conservation* update, 2020) — subtropical/temperate rainforest not fire-adapted, some with no recorded prior fire since management records began (Godfree et al. 2021, *Nat. Commun.* 12:1023). **K’gari fire**: ignited mid-Oct 2020, contained mid-Dec 2020; ~85,000 ha, **more than half** the ~184,000-ha island (K’gari Bushfire Review, QFES 2020–21). **Cooloola**: 2019–20 fires burned >14,000 ha (ground-parrot recovery program). See Chapter 12.

Chapter 7 • The Great Gradient

- Walker, T.W. & Syers, J.K. (1976). The fate of phosphorus during pedogenesis. *Geoderma* 15: 1–19.
- Thompson, C.H. (1981). Podzol chronosequences on coastal dunes of eastern Australia. *Nature* 291: 59–61.
- Zemunik, G., Turner, B.L., Lambers, H. & Laliberté, E. (2015). Diversity of plant nutrient-acquisition strategies increases during long-term ecosystem development. *Nature Plants* 1: 15050. (*Jurien Bay chronosequence, WA — the principle, not a Cooloola study.*)
- Cooloola phosphorus fractionation study, *Geoderma* (2015).

- Meyer, E.A., Franklin, C.E. & Cramp, R.L. (2021). Physiological and morphological correlates of extreme acid tolerance in larvae of the acidophilic amphibian *Litoria cooloolensis*. *J. Comp. Physiol. B* 191(1): 159–171. DOI 10.1007/s00360-020-01316-y.
- Willmott, W. (2007). *Rocks and Landscapes of the Sunshine Coast* (2nd ed.). Geological Society of Australia.

Chapter 8 • Estuaries, mangroves and saltmarsh

- Blue Heart partners and scope (Sunshine Coast Council “Blue Heart” project page; Healthy Land & Water; DCCEEW *Wetlands Australia* 33, 2021): a collaboration of **Sunshine Coast Council, the Kabi Kabi Peoples Aboriginal Corporation, the Queensland Government’s Department of Environment, and Unitywater**, covering **over 5,000 ha** of the Maroochy River floodplain for flood storage, wetland restoration and water quality. (The Kabi Kabi Peoples Aboriginal Corporation joined as an official partner in May 2025.)
- Davie, P. (1998). *Wild Guide to Moreton Bay*. Queensland Museum. (*Regional estuarine/mangrove/saltmarsh natural history*.)
- McPhee, D. (2017). *Environmental History and Ecology of Moreton Bay*. CSIRO Publishing. (*Bay ecology, fisheries, seagrass, dugong, threats*.)
- Leiper, G. et al. (2022). *Mangroves to Mountains* (3rd ed.). Native Plants Queensland. (*Regional flora incl. mangroves, saltmarsh, seagrass*.)
- Grey mangrove (*Avicennia marina*) salt-exclusion/excretion, pneumatophores, vivipary/cryptovivipary — standard mangrove biology. (***Avicennia marina* is the most widespread/dominant Australian mangrove and is *cryptoviviparous* — the embryo germinates within the fruit but does not pierce it; the stilt-rooted *Rhizophora* are *truly viviparous* — the seedling bursts through the fruit and dangles as an elongated propagule before dropping. *Avicennia* = grey mangrove; *Rhizophora* = red/spotted mangrove. Sources: *Avicennia marina* — Wikipedia; ALA MangroveWatch profile; AIMS mangrove field guide.**)

- Worked example / walk: **the Maroochy River estuary** — the **Maroochy Wetlands Sanctuary** boardwalk at Bli Bli (~900 m elevated boardwalk through eucalypt/melaleuca/casuarina/saltmarsh/mangrove down to the river; Sunshine Coast Council reserve with an environmental visitor centre). (*Sunshine Coast Council reserve page*.)
- Mangrove species in the walk (AIMS *Field Guide to the Mangroves of Queensland*; Moreton Bay Foundation; Qld Govt species profiles). Moreton Bay holds **seven** mangrove species, grey mangrove dominant:
- Milky mangrove / blind-your-eyes *Excoecaria agallocha*: landward-fringe mangrove associate; caustic milky latex (phorbol-ester toxins → skin blistering, temporary blindness on eye contact); semi-deciduous, orange-red leaf-flush; non-secretor, lacks pneumatophores/prop-roots.
- River mangrove *Aegiceras corniculatum*: shrubby upper-estuary/landward species; salt-excreting leaves; scented white nectar-rich flowers, strongly bee-visited; curved horn-shaped cryptoviviparous fruit.
- (Grey mangrove *Avicennia marina* — dominant, dual salt-exclusion/excretion, pneumatophores, cryptoviviparous; red/spotted mangrove *Rhizophora stylosa* — truly viviparous, stilt roots.)
- Estuarine fauna in the walk (Queensland Museum; ALA; peer-reviewed sources; full sea-country/fishery treatment in Chapter 14):
- Soldier crab *Mictyris longicarpus*: pale blue, walks forwards, feeds by sifting surface deposit into rolled sand pellets, aggregates in “armies,” corkscrews under when disturbed.
- Fiddler crabs: males with one enlarged waving/combat claw + one small feeding claw sifting mud biofilm.
- Sesarmid (grapsid) leaf-eating crabs: collect/bury/shred fallen mangrove leaves, driving the detritus-based estuarine food web — the accepted Indo-Pacific/Australian paradigm (crabs retain >50% of leaf production in-forest; variable, and sesarmids largely absent from Neotropical mangroves). (Robertson & Daniel 1989, *Oecologia* 78:191–198 — sesarmid crabs removed 71–79% of litter fall, tropical NE Qld; DOI 10.1007/BF00377155).

- Mud crab *Scylla serrata*: large **mottled green-to-brown** portunid (“swimming crab”) of tidal creeks; crab-pot target; to ~24–28 cm carapace, ~2–3 kg.
- Mudskipper: amphibious goby, cutaneous + buccopharyngeal air-breathing while damp, territorial on the mud. Local species likely *Periophthalmus argentilineatus* (barred/silverlined mudskipper); *Scartelaos histophorus* (blue mudskipper) also in Moreton Bay.
- Sydney rock oyster *Saccostrea glomerata*: encrusts roots/hard surfaces, filter-feeder (>100 L/day). Historical estuarine oyster-reef loss (>90% nationally; Gillies et al. 2018) and Noosa River oyster-reef restoration (USC/TNC “Bring Back the Fish”; see Chapter 18).
- Estuarine detritus food web (mangrove leaf litter → shredding sesarmid crabs + microbes → prawns/fish; a detritus- rather than grazing-based system) — accepted mangrove ecology (see sesarmid refs above).
- Eastern curlew *Numenius madagascariensis*: **world’s largest shorebird** (~60–66 cm; bill to ~19 cm), probes burrows for crabs (its main Australian prey); EAAF migrant; listed **Critically Endangered under the EPBC Act (2015)** (DCCEEW; EPBC Conservation Advice 2015; BirdLife Australia).
- Mangroves/saltmarsh/seagrass as fish/prawn nurseries and as coastal/flood protection — standard estuarine ecology; regional confirmation via McPhee (2017).
- Blue carbon in tidal-wetland soils; Blue Heart Sunshine Coast (Maroochy floodplain, >5,000 ha) — partners Sunshine Coast Council, Qld Dept of Environment, Unitywater and the Kabi Kabi Peoples Aboriginal Corporation; DCCEEW *Wetlands Australia* 33 (2021).
- Moreton Bay Ramsar listing (22 Oct 1993, Site 631); East Asian–Australasian Flyway; migratory shorebirds (bar-tailed godwit non-stop migration, 2022 record 13,560 km Alaska→Tasmania).
- Dugong & seagrass, Moreton Bay / Pumicestone Passage. Nationally significant, strongly seasonal population — Lanyon’s 1995 aerial surveys, ~503–1,019.

- Noosa River shellfish/oyster-reef restoration — The Nature Conservancy with Noosa Shire Council, the Thomas Foundation and the Australian Government; reefs from 2022 (Gillies et al. 2018, PLOS ONE, on historical loss).

Chapter 9 • Dunes, wallum and acid waters

- Meyer, E.A., Franklin, C.E. & Cramp, R.L. (2021). Physiological and morphological correlates of extreme acid tolerance in larvae of the acidophilic amphibian *Litoria cooloolensis*. *J. Comp. Physiol. B* 191(1): 159–171. DOI 10.1007/s00360-020-01316-y. (*Larvae hold their salt balance down to ~pH 3.5.*)
- Shuker, J.D., Simpkins, C.A. & Hero, J.-M. (2016). Determining environmental limits of threatened species: the example of the wallum sedgefrog *Litoria olongburensis*. *Ecosphere* 7(6): e01384. (*Occurrence and breeding pH limits, pH 3.53–4.61, for that one species.*)
- Filer, A. et al. (2021). Acoustic competition in the wallum sedgefrog. *Ecology and Evolution*.
- Acid water as a *partial* refuge from introduced fish (*Gambusia*) and predators — standard wallum-frog ecology.
- Dyring, M. et al. (2025). Groundwater-dependent ecosystems of the Cooloola sand mass. *Science of the Total Environment*. (*Wallum's groundwater dependence.*)
- Walker & Syers (1976); Thompson (1981) — the Cooloola chronosequence and the poverty→diversity story (full treatment in Ch 4). Strategy-diversity principle: Zemunik et al. (2015), *Nature Plants* (Jurien Bay, WA), not Cooloola.
- Leiper, G. et al. (2022). *Mangroves to Mountains* (3rd ed.). Native Plants Queensland; Haslam, S. *Noosa's Native Plants* (4th ed.), NICA. (*Wallum/dune flora, banksias, pioneers.*)
- Worked example / walk: **the wallum heath at Cooloola** (Great Sandy NP) and comparable coastal sand-country reserves.
- Wallum-heath flora in the walk (ALA; ANPSA/ANBG; peer-reviewed sources):

- Wallum banksia *Banksia aemula*: gnarled corky heath banksia (Bundaberg–Sydney); resprouter with a serotinous (fire-cued) seed bank; heavy nectar source for honeyeaters (day) and nocturnal mammals — pygmy-possums, gliders, small ground mammals (night). “Wallum” is widely reported to be the Kabi/Gubbi Gubbi word for *B. aemula*. May Gibbs’s “big bad Banksia men” (*Snugglypot and Cuddlepie*, 1918) are a documented banksia-cone inspiration, but from her Western Australian childhood banksias.
- Christmas bells *Blandfordia grandiflora*: red-gold tubular bird-pollinated wildflower of coastal heath/wet sedgeland; flowering is fire-boosted but lagged, peaking in the **second post-fire flowering season**. Griffith & Rutherford 2020, *Aust. J. Bot.* 68(6):449–457, for *B. grandiflora*.
- Sundews *Drosera* spp. (sticky-trichome carnivory for N/P on poor sand); multiple spp. in Cooloola/SE-Qld wallum.
- Bladderworts *Utricularia* spp. (aquatic bladder traps in acid wallum water): the **trapdoor firing/suction is sub-millisecond (~0.3–0.7 ms)**, one of the fastest movements in the plant kingdom (Vincent et al. 2011, *Proc. R. Soc. B*); the full capture cycle is longer (~1–9 ms).
- Wallum grass-tree *Xanthorrhoea fulva*: low, essentially trunkless wet-heath grass-tree (vs the taller ridge *X. johnsonii* of Ch 11). Wiry wet-heath sedges/rushes (restios, sword-sedges).
- Wallum fauna in the walk (BirdLife Australia; Qld Govt; Australian Museum; full fauna treatment Ch 16):
- Heath honeyeater pollinators: eastern spinebill *Acanthorhynchus tenuirostris* (fine decurved bill), little wattlebird *Anthochaera chrysoptera*, and — the SE-Qld heath flagship — white-cheeked honeyeater *Phylidonyris niger* (strong banksia association).
- Nocturnal nectar-feeders/pollinators: eastern pygmy-possum *Cercartetus nanus* (well-documented banksia pollinator; SE Qld near its northern limit) and, secondarily, gliders (e.g. feathertail glider).

- Ground parrot *Pezoporus wallicus wallicus* (eastern subspecies): ground-dwelling heath specialist; cryptic barred grass-green; flushes low, detected by its thin ascending dusk/dawn call; needs large connected heath of intermediate post-fire age; fire-regime/fragmentation-sensitive; Cooloola/Great Sandy NP a stronghold. Listed **Vulnerable** in Queensland (*Nature Conservation Act 1992*); **not** listed under the EPBC Act — the EPBC-listed ground parrot is the western *Pezoporus flaviventris*.
- Cooloola sand-mining campaign and national-park gazettal (1975) — Kathleen McArthur, Judith Wright (Wildlife Preservation Society of Queensland); see Ch 17.
- *Wallum* as a widely reported Kabi/Gubbi Gubbi name for *Banksia aemula* / the wallum banksia — a language attribution carried in the regional literature, given as reported rather than established.

Chapter 10 • Paperbark swamps and freshwater wetlands

- Broad-leaved paperbark (*Melaleuca quinquenervia*) as the dominant lowland coastal swamp-former; waterlogging/flood/fire tolerance; papery bark; mass nectar flows for lorikeets, honeyeaters and flying-foxes. Swamp associates: swamp mahogany *Eucalyptus robusta* (heavy cool-season nectar tree), swamp box *Lophostemon suaveolens*, swamp oak *Casuarina glauca* (brackish fringe; actinorhizal N-fixer; forms the EPBC-listed Endangered Coastal Swamp Oak Forest). (Qld species profiles; Mangroves to Mountains. Weeping tea-tree *Melaleuca irbyana* forms a Critically Endangered swamp-forest community, but on inland Moreton Basin clay (Ipswich/Beau-desert), not the sandy Sunshine Coast.)
- Noosa Everglades: upper Noosa River above Lake Cootharaba, Cooloola section of Great Sandy NP; blackwater (tannin from wallum peat); “River of Mirrors”. (“One of two everglades in the world” is a tourism label, not a scientific designation. Lake Cootharaba is large, shallow (~1.5 m mean) and brackish/tidal, not freshwater; the freshwater everglade is upstream. Qld Parks; Friends of Kinaba.)

- Wetland zonation by hydroperiod: open water + waterlily (blue waterlily *Nymphaea violacea*, native) → sedgeland (grey twig-rush *Lepironia articulata*, *Baumea/Machaerina*, saw-sedge *Gahnia*) on nutrient-poor wallum, OR reedbed (common reed *Phragmites australis*, cumbungi *Typha orientalis*) on richer floodplains → paperbark swamp → wet heath/scribbly gum (*Eucalyptus racemosa*). (Wallum swamps are sedge-dominated, not reed-dominated; *Phragmites/Typha* belong on richer sites like the Maroochy. *Lepironia* is the characteristic deep-water emergent sedge of the region's wallum dune lakes/swamps. QLD WetlandInfo, Wallum freshwater biogeographic province.)
- Wetland ecosystem services (flood attenuation, filtration/nutrient & sediment removal, aquifer recharge) — standard, kept qualitative. Freshwater peat/carbon: SEQ sand-mass swamps (Cooloola, K'gari) accumulate peat Histosols and store significant carbon, distinct from tidal “blue carbon” (Ch 8). (K'gari sub-tropical peatland Histosol carbon study, ScienceDirect 2024; “forgotten peatlands of eastern Australia”).
- Acid sulfate soils: sulfide oxidation on drainage → sulfuric acid + dissolved Fe/Al flushed on first rains → deoxygenation and fish stress/kills. Local example: Maroochy floodplain ASS linked to “red-spot disease” (epizootic ulcerative syndrome) outbreaks in bream/flathead around Bli Bli after rain. (Red-spot is a fungal pathogen, *Aphanomyces invadans*, that acid stress lets take hold. Maroochy–Caloundra ASS mapped ~8,000 ha, Qld Govt. Sunshine Coast News 2024.)
- Floodplain chorus frogs (distinct from the wallum acid frogs of Ch 9): striped marsh frog *Limnodynastes peronii*, eastern banjo frog/pobblebonk *L. dumerilii*, green tree frog *Litoria caerulea* (a generalist), bleating tree frog *Litoria balatus*. (SEQ “bleating tree frog” is *L. balatus* (slender bleating tree frog), split from *L. dentata* in 2021 — *L. dentata* now sits south of the QLD border.)

- Waterbirds: black-necked stork *Ephippiorhynchus asiaticus* (jabiru; sparse, singly/pairs), magpie goose *Anseranas semipalmata*, great egret *Ardea alba*, little egret *Egretta garzetta*, white-faced heron *Egretta novaehollandiae*, Australian white ibis *Threskiornis molucca*, straw-necked ibis *T. spinicollis*, royal spoonbill *Platalea regia*, comb-crested jacana *Irediparra gallinacea*, Pacific black duck *Anas superciliosa*, grey teal *Anas gracilis*, hardhead *Aythya australis*, Australasian grebe, cormorants, Australasian swamphen *Porphyrio melanotus*. (“Australasian swamphen” preferred post-split over “purple swamphen”; see Chapter 16.)
- Boom-bust / nomadic waterbirds / coastal wetlands as drought refugia — well established (Wen et al. 2016, *Ecology & Evolution*; Kingsford long-term aerial surveys).
- Invertebrate food-web base: Odonata (dragonfly/damselfly) larvae as major aquatic predators; aquatic insect larvae, crustaceans/zooplankton and a **detritus-based** (not “peat-based”) food web underpinning frogs, fish and waterbirds. (MDBA wetland food-web resource; Odonata predation review.)
- Fish & floodplain connectivity (flood-pulse / lateral connectivity — Junk et al. 1989): fish move onto inundated floodplain to feed and (for some) spawn; vegetated shallows as nursery; production exported to channel/estuary on the falling water. (Strongest Australian evidence is inland (Murray–Darling), not a quantified SEQ measurement.) Local fish: Australian bass *Perca latipes* (formerly *Macquaria*; catadromous, flow-cued estuary spawning), longfin eel *Anguilla reinhardtii* & shortfin eel *A. australis* (catadromous, breed in the Coral Sea region), empire gudgeon *Hypseleotris compressa*, Pacific blue-eye *Pseudomugil signifer*, crimson-spotted rainbowfish *Melanotaenia duboulayi*; invasive eastern mosquitofish *Gambusia holbrooki* (restricted invasive, Qld Biosecurity Act — not attributed to any local extinction). Wallum acid-water specialists (tie to Ch 9): honey blue-eye *Pseudomugil mellis* and Oxleyan pygmy perch *Nannoperca oxleyana*, both nationally threatened. (Qld species profiles, Australian Museum, EPBC/SPRAT.)

- Wetland weeds (favour eutrophic floodplains, not the nutrient-poor wallum): para grass *Urochloa mutica* (syn. *Brachiaria mutica*; major Qld environmental weed — status per Qld Govt/Weeds Australia), salvinia *Salvinia molesta*, water hyacinth *Pontederia (Eichhornia) crassipes*, cabomba *Cabomba caroliniana* (Sunshine Coast Council priority invasive plants); alligator weed *Alternanthera philoxeroides* a high-threat watch-list/prevention target, not yet established locally.
- The wetland's future — climate: sea-level rise + saltwater intrusion expected to convert low coastal freshwater/paperbark swamps to saltmarsh/mangrove; “coastal squeeze” where landward retreat is blocked (*Melaleuca*-dieback evidence attributed to northern Australia). SEQ projected hotter, more severe droughts, heavier extreme rainfall; annual rainfall direction uncertain; drainage + ASS interaction worsens acid flushes after drought-breaking rain. Qld Govt (LongPaddock/Qld Future Climate); CSIRO/BoM; Springer “Climate Change Impacts on Coastal Wetlands of Australia”.
- Yandina Creek Wetland (Maroochy floodplain): ex-sugarcane (from 1920s); tidal floodgates failed → wetland; gates repaired July 2015 (drained, stranding nesting birds) → campaign (Greg Roberts); Unitywater bought ~191 ha (~\$4M, 2016), opened to public 2017, tides reopened 2018; 168 bird species recorded; now part of Blue Heart. (sunshinecoastbirds; Unitywater; DCCEEW.)
- Blue Heart Sunshine Coast (Maroochy floodplain, >5,000 ha) — partners Sunshine Coast Council, Qld Dept of Environment, Unitywater, Kabi Kabi Peoples Aboriginal Corporation; DCCEEW *Wetlands Australia* 33 (2021); the Kabi Kabi Peoples Aboriginal Corporation joined as an official partner in May 2025, after that source. (See also Chapter 8 and Chapter 18.)
- Wetland loss to drainage/agriculture/development on the coastal lowlands — regional environmental history (see Ch 17).

Chapter 11 • Eucalypt forests and woodlands

- Wet sclerophyll canopy (SEQ ranges/foothills): blackbutt *Eucalyptus pilularis*, tallowwood *E. microcorys*, flooded/rose gum *E. grandis*, Sydney blue gum *E. saligna*, turpentine *Syncarpia glomulifera*, brush box *Lophostemon confertus* (non-eucalypt). Gully understorey: piccabeen/bangalow palm *Archontophoenix cunninghamiana*, rough tree fern *Cyathea australis*, bracken *Pteridium esculentum*, native ginger *Alpinia caerulea*, mat-rush *Lomandra*, saw-sedge *Gahnia*, and rainforest pioneers (red ash *Alphitonia excelsa*, poison peach *Trema tomentosa*, celerywood *Polyscias elegans*, *Pittosporum*).
- Dry sclerophyll/woodland (spotted gum–ironbark, REDD RE 12.11.5 / Ninderry RE 12.12.15): spotted gum *Corymbia citriodora* subsp. *variegata*, grey ironbark *E. siderophloia*, narrow-leaved ironbark *E. crebra*, grey gum *E. propinqua*, pink bloodwood *Corymbia intermedia*, forest red gum *E. tereticornis*, smooth-barked apple *Angophora leiocarpa*; she-oaks *Allocasuarina littoralis* & *A. torulosa* (glossy black-cockatoo food). Ground/shrub layer: kangaroo grass *Themeda triandra*, wiregrass *Entolasia stricta*, hairpin banksia *Banksia spinulosa*, grass-tree *Xanthorrhoea johnsonii*, cycad *Macrozamia miquelii*, wattles *Acacia leiocalyx/disparrima*, geebung *Persoonia*, flax lilies *Dianella*, trigger plants *Stylidium*, ground orchids.
- Worked example: **Mount Ninderry** (304 m rhyolite peak near Yandina; Sunshine Coast Council environmental reserve; four mapped regional ecosystems incl. dry-sclerophyll slopes RE 12.12.15 and wet-sclerophyll gully RE 12.3.2; ~400+ native plant species). Land-use history: banana growing on lower slopes (1920s), gold prospecting (1930s), now weed control / recovery; steep slopes largely remnant native forest. (Sources: Sunshine Coast Council reserve & draft Landscape Plan; Bushland Conservation Management; QLD REDD/WildNet.)

- Key species hooks: she-oak nitrogen fixation via *Frankia* (actinorhizal) and photosynthetic cladodes with reduced scale-leaves; glossy black-cockatoo feeding “orts” and tree fidelity, ~decade to cone-bearing maturity. Cycad *Macrozamia* coralloid roots with N-fixing cyanobacteria, toxic seeds (cycasin/macrozamin), host-specific thrips pollination; thermogenic “push-pull” documented specifically in *M. lucida* (Terry et al. 2007, *Science*). Grass-tree ~1 cm/yr growth, centuries old, smoke-cued mass flowering. Red ash saponin lather + sarsaparilla-scented foliage. Pink bloodwood red kino; bloodwood group named for the kino, not the timber colour.
- Tree ageing: eucalypts do not lay down reliable annual rings in this climate, so ring-counting and diameter are poor age guides (mean increment ~0.25 cm diameter/yr; ~30 cm DBH ≈ ~120 yr on average; >80 cm DBH unreliable). Hollows as age proxy (Wormington & Lamb 1999, *Australian Forestry*; via Land for Wildlife SEQ): blackbutt usable hollows ~165 yr; tallowwood small ~170–200 yr, large ~250+ yr. Grass-tree age from height ÷ growth rate. Fire scars (“cat-faces”) read as evidence of past fire, NOT datable in eucalypts. (*Source: lfwseq.org.au/how-to-age-trees; CSIRO.*)
- Logging & land-use history: SEQ coastal/hinterland hardwoods (blackbutt, tallowwood, ironbark, spotted gum, flooded gum, bloodwood) extensively *selectively* logged from the mid-1800s; a study of ~9 M ha of southern-Qld native forest found no plot free of tree removal since settlement (Frontiers in Forests & Global Change, 2021). Native forest regrew **naturally** (seed + lignotuber + epicormic resprouting), not replanted; old-growth now a scarce remnant. Plantations (hoop pine *Araucaria cunninghamii* from ~1917; exotic slash/Caribbean pine; some flooded-gum) are a separate, planted land use. Reading past disturbance: springboard-notched stumps, coppice/multi-stem regrowth, even-aged “pole” stands, scarcity of large hollow-bearing veterans; old-growth = uneven-aged with senescent giants, abundant hollows and large fallen logs.

- Eucalypt fire-adaptation and the wet-sclerophyll → rainforest succession in the absence of fire — see Ch 6; Bowman (1998); *Flammable Australia*. Succession to rainforest is contingent on a nearby seed source and the absence of other disturbance (hedged in text); intermediate fire regimes maintain wet sclerophyll, and both fire suppression *and* too-frequent severe fire are degradation pathways (Krishnan et al. 2019, *Ecol. Evol.*, K'gari; Furlaud et al. 2021).
- Woody thickening when fire is withheld (dry sclerophyll): woody shrubs/small trees (esp. black she-oak *Allocasuarina littoralis*, wattles, rainforest pioneers, exotic lantana *Lantana camara*) recruit into the mid-storey and shade out the grassy floor. Baker, A. et al. (2020), *Austral Ecology* 45: 557 (rainforest encroachment → understorey richness ~halved, open-forest specialists down ~90%).
- Peachester long-term burning experiment: Dooley, M., Lewis, T. & Schmidt, S. (2023), “Fire frequency has a contrasting effect on vegetation and topsoil in subcoastal heathland, woodland and forest ecosystems, SEQ,” *Austral Ecology* 48(8). (*Regular fire maintains an open, herbaceous-rich understorey; long-unburnt **heathland** → dominance of the coral fern *Gleichenia dicarpa** (the paper’s stated fire-exclusion result, in its heathland site; the black she-oak thickening described in the text traces to other work). frequent fire reduces topsoil organic carbon.)**

Chapter 12 • Tenants of the gum forest

- Koala decline in SEQ: Gonzalez-Astudillo, V. et al. (2017). 17-year koala mortality, SEQ. *Scientific Reports*; Robbins, A. et al. (2018). Chlamydial treatment outcomes. *PLoS One*; Dis-sanayake, R.B. et al. (2019). Citizen-science koala monitoring, SEQ. *Scientific Reports*. (*QLD/NSW/ACT koala listed Endangered under the EPBC Act, 12 February 2022.*)
- Koala *Chlamydia* vaccine: P. Timms et al., UniSC (Phillips et al., *npj Vaccines* 2024); APVMA minor-use permit (PER94984) granted June 2025, valid to June 2027 — a permit, not full registration. (*Published trial reports a 64% reduction in chlamydial mortality in vaccinated wild koalas.*)

- Glossy black-cockatoo dependence on *Allocasuarina* seed and large hollows. (*South-eastern subspecies* *Calyptrorhynchus lathamii lathamii** listed Vulnerable under the EPBC Act, effective 10 August 2022.)*
- Nocturnal arboreal fauna — greater glider, sugar/squirrel/yellow-bellied gliders, powerful owl, microbats — and their hollow-dependence. See Chapter 16 for the full fauna treatment.
- Hollow formation timelines (age proxy): hollow formation begins ~100 yr, fauna-usable hollows in blackbutt only >165 yr, the largest only at ~250+ yr (Gibbons & Lindenmayer 2002; Wormington & Lamb 1999, *Australian Forestry*, via Land for Wildlife SEQ) — see also Ch 11 (tree ageing).
- The forest's future — climate, drought & dieback: SEQ projected hotter this century with longer fire seasons, more dangerous fire weather and more severe drought — CSIRO/BoM *State of the Climate*; Climate Change in Australia (Qld). Drought-driven canopy dieback via hydraulic failure across eastern Australia, incl. Qld (Nolan et al. 2021, *New Phytologist*; Fensham, Qld dieback; *Sci. Reports* 2022 recovery study). **Bell-miner-associated dieback (BMAD)**: bell miner *Manorina melanophrys* farms psyllids and excludes insectivorous birds → canopy dieback; documented in wet/moist eucalypt forest of NE NSW & SEQ; listed a Key Threatening Process (NSW, 2008). *Lantana* is an associated/facilitating condition, NOT the proven cause — canopy disturbance is the accepted trigger (Silver & Carnegie 2017).

Chapter 13 • Rainforests

- Subtropical (“big scrub”) rainforest on basalt; gully/riparian and littoral rainforest types; Gondwanan lineages; hoop pine (*Araucaria cunninghamii*) and bunya (*Araucaria bidwillii*) — standard regional rainforest ecology.
- Worked example: **Mary Cairncross Scenic Reserve** (Maleny, Blackall Range) — a ~55-ha remnant of subtropical rainforest on deep red basalt-derived soil (krasnozem / now classed a red Ferrosol), **managed by Sunshine Coast Council**; referenced from Ch 7's opening drive. Documented flora incl. strangler figs, piccabeen/bangalow palm, white & black booyong, and red cedar (reserve plant species list); the signature/emblematic animal is the **red-legged pademelon** (*Thylogale stigmatica*), with a well-known habituated colony.

- Rainforest structure and characteristic flora:
- Strangler figs — Watkins' fig *Ficus watkinsiana* (hemi-epiphytic strangler; southern range ~Bundaberg–Lismore, favours basaltic uplands = the Blackall Range setting; Male & Roberts 2005, *Austral Ecology*), plus small-leaved fig *F. obliqua* and Moreton Bay fig *F. macrophylla* (both stranglers occurring in SE Qld). Figs = a keystone fruit resource with asynchronous fruiting.
- Booyong *Argyrodendron* spp. — white *A. trifoliolatum* & black *A. actinophyllum*, both large, strongly buttressed canopy-dominant trees of SE Qld / NE NSW subtropical rainforest; both recorded at Mary Cairncross. **Buttress = mechanical bracing for shallow rooting.**
- Hoop pine *Araucaria cunninghamii* — native emergent conifer (50–60 m), hoop-ringed bark, co-occurs with bunya in Blackall Range rainforest; also grown in plantation (see Chapter 11). Bunya *Araucaria bidwillii*: see sidebar note below.
- Red cedar *Toona ciliata* — deciduous (winter-bare, then crimson→bronze new flush); winged, **wind-dispersed** seed (unusual among the animal-dispersed canopy trees around it); “red gold,” colonial Australia’s most-prized cabinet timber. Clearing history in Chapter 17. (Sources: ANBG; Wikipedia.)
- Giant stinging tree *Dendrocnide excelsa* — large, soft, pale, heart-shaped leaves; silica-tipped hairs injecting “gympietide” neurotoxins (Gilding et al. 2020, *Science Advances*); fast canopy-gap pioneer; ranges south-NSW to ~Imbil (reaches the Conondale/Blackall area). Browsed despite the sting: red-legged pademelons can strip whole plants, and a nocturnal leaf-beetle plus other insects eat the foliage.
- Wait-a-while / lawyer cane *Calamus muelleri* — clustering climbing rattan (to ~20 m) with recurved-hooked flagella (~1.2 m); the SE Qld “wait-a-while” (Gympie south into NE NSW).
- Epiphytes — bird’s-nest fern *Asplenium australasicum* (litter-funnelling rosette), staghorn *Platyserium superbum* & elkhorn *P. bifurcatum*, orchids: non-parasitic (perch only); all SE Qld/NSW rainforest epiphytes.

- Understorey palms — piccabeen/bangalow *Archontophoenix cunninghamiana* (see Chapter 11): forms shaded floor colonies as juveniles but matures to a ~25 m canopy palm. Walking-stick palm *Linospadix monostachyos*: small single-stemmed understorey palm (<2 m) with pendulous red-fruit strings (Taree–Gympie). Deep leaf litter, rapid decomposition, tight nutrient cycling.
- Fauna of “The life of the interior” (full treatment in Chapter 16): land mullet *Bellatorias major* (formerly *Egernia major*) — large glossy blue-black rainforest skink (~40 cm+) whose **northern range limit is the Conondale Range near Maleny**. Wompoo & rose-crowned fruit-doves, topknot pigeon, green catbird, regent bowerbird, paradise riflebird — the southernmost of the birds-of-paradise, though the Sunshine Coast sits toward the *northern* end of its own range (ALA occurrence data put its stronghold in the border ranges around 28–29°S), carpet python, red-legged pademelon — standard SE Qld rainforest fauna. (See Chapter 16.)
- Rainforest as a Gondwanan relict / “living museum”: Araucariaceae is an ancient conifer family (firm fossils from the Early Jurassic, ~190 Ma; Gondwanan-dominant in the Mesozoic), largely displaced by angiosperms from the Late Cretaceous and contracted to mesic refugia — the classic Gondwanan-relict pattern. (Kershaw & Wagstaff; Kunzmann 2007; *conifers.org*.)
- Rainforest fire-sensitivity and the lack of fire-recovery traits — see Chapter 6; *Flammable Australia*.
- Red-cedar (*Toona ciliata*) logging and big-scrub clearing for dairy/agriculture — regional environmental history (full treatment in Chapter 17).
- Animal seed-dispersal dependence (fruit-pigeons, flying-foxes) and rainforest regeneration — standard rainforest ecology.
- Goosem, S. & Tucker, N.I.J. (1995/2013). *Repairing the Rainforest*. Wet Tropics Management Authority. (*Framework-species method*.) Bradley, J. (1988). *Bringing Back the Bush: The Bradley Method*. (*Bush regeneration / weed sequence*.)
- Richmond birdwing (Sands 2008; *Pararistolochia praevenosa* host, exotic *Aristolochia* trap); see Chapter 16.

- Bunya *Araucaria bidwillii* (sidebar): dome-crowned conifer; cones ~35 cm and **5–10 kg** with 30–100 large edible seeds; heavy (mast) crop roughly every 3 years; stronghold the Bunya Mts, but **the Blackall Range/Maleny is one of its natural centres** (a local bunya is genuinely native, not a stray). Gatherings: in mast years Aboriginal groups travelled long distances (radius commonly cited ~450 km) to harvest and share the seed — well-documented public-record ethnohistory (e.g. Leichhardt, 1840s). Cooke, P. et al. (2024), *Journal of Ethnobiology* 44(2): 129–140, DOI 10.1177/02780771241246853 (continued Aboriginal cultural use & dispersal, southern Qld) and Fahey, M. et al. (2024), *People and Nature* 6:286–300 (genomics: SE-Qld distribution reflects Indigenous seed movement; translocation broadened after colonisation).

Chapter 14 • Sea country

- Inshore marine habitats (seagrass meadows, rocky/offshore reefs, soft-sediment) and seagrass ecology (nursery, grazing, sediment stabilisation, blue carbon) — standard.
- Rocky-reef communities; the East Australian Current transporting tropical larvae south; tropical–temperate species overlap at/near range limits; range shifts under warming and marine heatwaves — standard east-coast marine biogeography.
- Reef immersion (“Down on the reef”): local dive/snorkel sites Point Cartwright/Mooloolaba rocky reefs and Mudjimba Island (Old Woman Island) off Maroochydore. Tropical–temperate overlap driven by the EAC (Booth et al.; Flinders Reef at the southern coral limit): tropical hard coral + reef fish (butterflyfish/damselfish/parrotfish) with temperate sponges/algae + wrasses. Wobbegong: the SE-Qld species are spotted *Orectolobus maculatus* / ornate-banded *O. ornatus*.
- HMAS *Brisbane* artificial reef: Perth-class guided-missile destroyer (133 m), scuttled 31 July 2005 off Mooloolaba / east of Mudjimba Island; rests in ~28 m (superstructure to ~15 m); Ex-HMAS Brisbane Conservation Park (marine reserve); rapid colonisation (algae/hydroids → sessile filter-feeders/corals/sponges → fish, turtles, rays). (Qld Parks.)

- Sharks & rays (“The sharks nobody should fear”): Wolf Rock, four volcanic pinnacles ~2 km off Double Island Point (seaward end of Cooloolo): year-round grey nurse shark *Carcharias taurus* aggregation — the only known east-coast gestation site for pregnant females (~half the population’s mature females recorded there) — the site-specific grey-nurse work is Bansemer, C.S. & Bennett, M.B. (2009), *Marine Ecology Progress Series* 374: 215–227, DOI 10.3354/meps07741, with east-coast movements by sex and maturity in Bansemer & Bennett (2011), *Marine and Freshwater Research* 62(6): 596, DOI 10.1071/MF10152; east-coast population Critically Endangered (EPBC); docile, historically overhunted as a wrongly-feared “man-eater”; protected as a marine-national-park (green) no-take zone in Great Sandy Marine Park. Also leopard shark *Stegostoma tigrinum* (harmless) and seasonal reef manta *Mobula alfredi* (plankton feeder; cleaning stations). (DCCEEW; Qld Parks/ Govt.)
- Living beach sidebar: pipi *Plebidonax deltooides* (surf-zone filter-feeding wedge clam; swash migration), beach worms (*Australonuphis*), ghost crabs *Ocypode* (*O. cordimana* local); predators osprey (Australian sp. *Pandion cristatus*), pied oystercatcher *Haematopus longirostris* (a documented pipi predator), terns. Loggerhead *Caretta caretta* is the predominant sea turtle nesting on SE Qld mainland beaches (small-scale — TurtleCare Sunshine Coast / Cooloolo & North Shore Coast Care; major rookery Mon Repos, Bundaberg); green turtle *Chelonia mydas* is the local seagrass grazer and nests here only rarely, far outnumbered by loggerheads (main green rookeries = offshore cays / southern GBR).
- Offshore transient/migratory fauna (turtles, sharks, rays, pelagic fish, seabirds) and the cross-jurisdiction difficulty of marine management.
- McPhee, D. (2017). *Environmental History and Ecology of Moreton Bay*. CSIRO Publishing; Davie, P. (1998). *Wild Guide to Moreton Bay*. Queensland Museum. (*Regional marine ecology, dugong, seagrass, fisheries, history.*)
- Dugong: Moreton Bay supports a nationally significant, strongly seasonal population (Lanyon’s 1995 aerial surveys, *Wildlife Research*, ~503 in July to ~1,019 in January); year-round presence in the Pumicestone Passage on *Halophila/ Halodule* seagrass (Sunshine Coast Council).

- Green turtle (*Chelonia mydas*) seagrass grazing and beach-nesting; threats (boat strike, netting, light, seagrass loss) — recognised regional threats (Qld Govt).
- Migratory shorebirds, East Asian–Australasian Flyway, Moreton Bay Ramsar listing (22 Oct 1993, Site 631), bar-tailed godwit non-stop migration (2022 record 13,560 km Alaska→Tasmania) — see Ch 8.
- Humpback whale eastern-Australian migration and recovery; Tangalooma whaling station (Moreton Island, 1952–1962).
- Shellfish/oyster reefs: historical extent and loss in eastern Australia (>90% lost by dredging/harvest, mid-1800s–early 1900s; Gillies et al. 2018, PLOS ONE); Noosa River shellfish-reef restoration — The Nature Conservancy with Noosa Shire Council, the Thomas Foundation and the Australian Government, reefs laid from 2022.

Chapter 15 • Plants and the partnerships that feed them

- Mycorrhizal symbiosis (near-universal; sugar-for-nutrients trade; greater importance on nutrient-poor soils) — standard plant ecology.
- “Wood-wide web” / common mycorrhizal networks — the popular claims (mother trees, inter-tree carbon transfer, defence signalling) and the recent scientific pushback. Karst, J., Jones, M.D. & Hoeksema, J.D. (2023), “Positive citation bias and over-interpreted results lead to misinformation on common mycorrhizal networks in forests,” *Nature Ecology & Evolution* 7(4): 501–511 — the three headline CMN claims (networks widespread in forests; network transfer benefits seedlings; mother trees preferentially provision kin / send defence signals) are not supported by field evidence, plus a documented positive-citation bias.
- Native bees & buzz pollination — stingless bees *Tetragonula carbonaria* (SE Qld; eusocial; “sugarbag” honey stored in hollow-tree nests). Buzz pollination (sonication of poricidal anthers) by native bees — esp. blue-banded bee *Amegilla* (which also head-taps the anther, ~350 Hz) — but NOT by the European honeybee *Apis mellifera*; some plants set seed/fruit better with buzz-pollinators. Poricidal-anther examples: *Solanum*/Solanaceae, many (not all) *Hibbertia*, *Dianella*; blueberry/tomato in crops.

- Schmidt, S., Handley, L.L. & Sangtiew, T. (2006). Ectomycorrhizal N use, *Eucalyptus racemosa* (wallum scribbly gum) vs *E. grandis*. *Functional Plant Biology*.
- Zemunik, G., Turner, B.L., Lambers, H. & Laliberté, E. (2015). Diversity of plant nutrient-acquisition strategies increases during long-term ecosystem development. *Nature Plants* 1: 15050. (*Jurien Bay chronosequence, WA — the principle, not a Cooloola study.*)
- Cluster roots (Proteaceae), carnivory (sundews), and rhizobial N-fixation (wattles/peas) — see Ch 4, Ch 9; standard.
- Pollination ecology (flowers as advertisement/reward; bird-, mammal- and insect-pollination; banksia/honeyeater, paperbark/lorikeet/flying-fox) — standard.
- Fig-fig-wasp obligate mutualism (species-specific; tens of millions of years) — standard; e.g. *Ficus watkinsiana* / *Pleistodontes nigriventris* in SEQ rainforest.
- Sexually deceptive pollination: tongue orchids (*Cryptostylis* spp.) pollinated by pseudocopulating male orchid dupe wasps (*Lissopimpla excelsa*); one wasp pollinates all Australian *Cryptostylis*.
- Cycads (*Macrozamia miquelii*, SEQ): ancient gymnosperms, toxic seeds; specialist insect pollination by thrips (*Cycadothrips*) or weevils (*Tranes*) depending on host.
- Carnivorous plants: sundews (*Drosera* spp., sticky-leaf traps) and bladderworts (*Utricularia* spp., suction-bladder traps) of the wallum.
- Grass-trees (*Xanthorrhoea johnsonii*, *X. fulva*, *X. macronema*): very slow-growing/long-lived, fire-stimulated flowering, mycorrhizal.
- Seed dispersal: frugivory (fruit-pigeons, flying-foxes) and rainforest regeneration (see Ch 13); ant dispersal / myrmecochory (elaiosomes) in sclerophyll flora — standard.

- Ants sidebar — (a) Myrmecochory — lipid-rich food-body (an aril in *Acacia*, functionally an elaiosome) on *Acacia*/pea seeds; Australian sclerophyll is a world hotspot (~1,500 myrmecochorous spp.). Ant burial gives solid protection from seed predators; the fire benefit is real but depth-/ant-species-dependent (and many *Acacia* seeds need fire heat to break dormancy). (b) EFNs on *Acacia* phyllodes attract ants, but ant *defence* of Australian acacias is **facultative / context-dependent** (mixed evidence — e.g. *Acacia myrtifolia* ant-exclusion showed no reproductive benefit); the obligate “bodyguard” ant-acacia system is Central American (*Vachellia*–*Pseudomyrmex*), not Australian. (Beaumont et al. 2011/2018, *Austral Ecology*.)
- Free-loaders & cheats:
- Mistletoe: aerial **hemiparasite** (keeps green leaves / makes its own carbon; takes host water + dissolved minerals via a haustorium into the xylem). Common SE Qld eucalypt-woodland genera *Amyema* and *Dendrophthoe* (Loranthaceae). **Mistletoebird** *Dicaeum hirundinaceum*: near-obligate mistletoe frugivore (~85% of diet), nomadic; rapid gut transit (defecates ~4–12 min after ingestion); voids the viable sticky seed and wipes it onto the branch it perches on. Keystone resource: Watson & Herring (2012, *Proc. R. Soc. B* 279:3853) removal experiment — sites lost ~21% of total and ~27% of woodland-dependent bird species three years after mistletoe removal, so “a woodland with mistletoe is usually a richer one” is evidence-based.
- Mycoheterotrophy: the *leafless* hyacinth orchids (*Dipodium variegatum*, *D. punctatum* — two distinct species) are achlorophyllous and fully mycoheterotrophic, drawing carbon from ectomycorrhizal *Russula* fungi shared with nearby trees (effectively epiparasites on the trees); both occur in SE Qld open eucalypt forest. (The genus also has green photosynthetic species.) Orchid dust-seeds have no endosperm and cannot germinate **in the wild** without a compatible fungus (asymbiotic lab germination is the only exception).

Chapter 16 • Animals and their dependencies

- Koala threatened-listing status/date: listed **Endangered under the EPBC Act, 12 February 2022** for the combined Queensland/NSW/ACT population (previously Vulnerable from 2 May 2012) (DCCEEW, “Koala listing under national environmental law”). Vaccine status: see Chapter 12.

- Koala ecology (eucalypt specialisation; low-energy physiology; foregut/caecum microbial fermentation and toxin handling) — standard.
- Koala decline in SEQ: Gonzalez-Astudillo, V. et al. (2017). 17-year koala mortality, SEQ. *Scientific Reports*; Robbins, A. et al. (2018). Chlamydial treatment outcomes. *PLoS One*; Dis-sanayake, R.B. et al. (2019). Citizen-science koala monitoring, SEQ. *Scientific Reports*.
- Koala *Chlamydia* vaccine: P. Timms et al., UniSC (Phillips et al., *npj Vaccines* 2024; 64% reduction in chlamydial mortality in a wild trial); APVMA minor-use permit (PER94984), June 2025 — a permit, not full registration. (See Chapter 12.)
- Glossy black-cockatoo dependence on *Allocasuarina* seed and large tree-hollows; selective feeding; slow breeding — standard. (Subspecies *C. lathami lathami*, *Vulnerable under the EPBC Act*, 10 August 2022.)
- Acid frogs: Meyer, E.A., Franklin, C.E. & Cramp, R.L. (2021). Physiological and morphological correlates of extreme acid tolerance in larvae of the acidophilic amphibian *Litoria cooloolensis*. *J. Comp. Physiol. B* 191(1): 159–171. DOI 10.1007/s00360-020-01316-y; Shuker, J.D., Simpkins, C.A. & Hero, J.-M. (2016). Wallum-frog pH envelopes. *Ecosphere*; Filer, A. et al. (2021). Acoustic competition, wallum sedgefrog. *Ecology and Evolution*. (*Gambusia is limited by low pH but not absolutely excluded*.)
- Gliders (double-dependence / decline story; see Chapter 12):
- Greater glider: the SE Qld animal is the **southern greater glider *Petauroides volans*** (2020 split into *P. volans/armillatus/minor*, McGregor et al., *Sci. Rep.*); cat-sized eucalypt-leaf folivore, hollow-denning; heat-sensitive (hyperthermic above its thermoneutral zone; evaporative cooling only) and high-severity-fire-sensitive. **Uplisted to Endangered under the EPBC Act, 5 July 2022** (listing unit “greater glider (southern and central)”); EPBC Conservation Advice 2022).
- Yellow-bellied glider *Petaurus australis*: cuts V-grooves in favoured sap trees and returns repeatedly (see Chapter 12). Feathertail glider *Acrobates pygmaeus*: smallest gliding mammal; stiff two-edged feather-tail rudder; nectar/pollen/insects.

- The diggers & the fungi (mycophagy / spore dispersal; see Chapter 15): potoroids (potoroos/bettongs) are largely mycophagous (~50–90% hypogeous fungi), bandicoots facultatively so; they void viable spores in scats, dispersing the ectomycorrhizal fungi tree roots depend on, and their diggings turn over/aerate soil (bioturbation). These critical-weight-range diggers have declined steeply to fox/cat predation. **Local occurrence:** northern brown bandicoot *Isoodon macrourus* (common) and long-nosed bandicoot *Perameles nasuta* on the Sunshine Coast; long-nosed potoroo *Potorous tridactylus* present but localised/threatened. (Claridge 1994; Johnson 1996; Woinarski et al. 2015; Fleming et al. 2014.)
- Brush-turkey sidebar: Australian brush-turkey *Alectura lathami* (megapode); male-built mound (~4 m across, ~1 m high) incubated by decomposition heat, temperature regulated (~33–38 °C) by adding/removing litter and bill-testing; super-precocial chicks dig out unaided (many hours) and can fly within hours of surfacing, no parental care; strong range expansion / suburban recolonisation (Brisbane 28→289 suburbs, 1994→2019; CSIRO *Wildlife Research* 2023). (Australian Museum; NSW Env & Heritage.)
- Platypus (*Ornithorhynchus anatinus*): clean-stream/earthen-bank dependence; Obi Obi Creek (Maleny) / upper Mary catchment a noted local site.
- Reptiles: lace monitor (*Varanus varius*); coastal carpet python (*Morelia spilota mcdowelli*); eastern brown (*Pseudonaja textilis*) and red-bellied black (*Pseudechis porphyriacus*) snakes; land mullet (*Bellatorias major*, near northern range limit at the Conondale Range) — standard SEQ herpetofauna.
- Invasive animals (Sunshine Coast Council priority pests): cane toad (*Rhinella marina*, intro. 1935), red fox (*Vulpes vulpes*), feral cat (*Felis catus*), mosquitofish (*Gambusia holbrooki*).
- Dingo / wongari (*Canis dingo*): genetically significant population on K'gari (Butchulla Country, just north).

- Sands, D. (2008). Conserving the Richmond birdwing butterfly over two decades: where to next? *Ecological Management & Restoration* 9(1): 4–16. (Larval host ***Pararistolochia praevenosa***; the introduced South American Dutchman's pipe *Aristolochia littoralis** (syn. *A. elegans*) is a lethal oviposition trap; long-running replanting program by the Richmond Birdwing Conservation Network.)*
- Flying-foxes: grey-headed *Pteropus poliocephalus*, black *P. alecto* (resident) and nomadic little red *P. scapulatus* on the Sunshine Coast (spectacled flying-fox far-N Qld only); key-stone pollinators / long-distance dispersers (forage up to ~50 km/night; 100+ tree spp.); heat-stress mass mortality (≥45,500 died in a single day, Jan 2014; risk rises sharply above ~42 °C). Disease risk LOW: ABLV only via bite/scratch; Hendra only via a horse intermediate (no casual-proximity/overflight risk). (Wildlife Qld; Welbergen et al.; NSW Env & Heritage.)
- Co-extinction / dependence-driven decline — standard ecological concept.

Chapter 17 • An environmental history

- *Douglas on behalf of the Kabi Kabi First Nation Traditional Owners Native Title Claim Group v State of Queensland (No 5)* [2024] FCA 645 — Federal Court consent determination of 17 June 2024, Collier ACJ. (*Non-exclusive native title over ~365,000 ha — 3,450 km² land + 202 km² waters — of the Sunshine Coast.*)
- Kerkhove, R. — published Sunshine Coast Indigenous histories. (*Source for the pre-colonial land-management / custodianship references.*)
- Fire-managed pre-colonial landscape — see Ch 6; Gammage, B. (2011). *The Biggest Estate on Earth* (and its scholarly critique — May, D. 2023, *History Australia* 20(1): 154–172); Bowman (1998).
- Red-cedar (*Toona ciliata*) and hoop-pine logging — timbergetters worked the Maroochy, Mooloolah and Noosa from the 1860s — then clearing of the scrubs for dairy and agriculture (from the 1880s–90s; a dairying district by the early 1900s, cream carted by tramway to the coastal railheads). Sunshine Coast Council, *Thematic History of the Sunshine Coast* (Sunshine Coast Heritage Study); *Queensland Historical Atlas*.
- Wetland drainage for cane/pasture (Ch 10); eucalypt-forest clearing and grazing — regional land-use history.

- **Fur trade / fauna extraction** (Hrdina & Gordon 2004, *Aust. Zoologist*; Australian Koala Foundation): koala & brushtail-possum killed in vast numbers for pelts (early C20; koala fur sold under other names, e.g. “wombat” in the US); **Queensland 1927 open season (“Black August,” ~month) — ~600,000 skins SOLD / likely ~800,000 killed**; ~10,000 licensed hunters; the last open season — public backlash (Australia’s first mass conservation movement) ended the trade, Commonwealth stopped export permits 10 Nov 1927; koala never regained former abundance. Possum trade in the **millions** (London-market sales >3 M/yr in the 1890s–1900s). Ties to Ch 12/16 koala.
- **Acclimatisation / biological invasion** — Queensland Acclimatisation Society (1862); **cane toad *Rhinella marina* introduced to Qld June 1935** (BSES, Gordonvale, from Hawaii; ~2,400 released Aug 1935) for cane beetles — ineffective, poisons naïve native predators (EPBC Key Threatening Process), now hundreds of millions spreading to WA. European fox, feral cat, rabbit, deer, feral pig, mosquitofish *Gambusia*. Weeds: **lantana *Lantana camara*** (ornamental ~1841; ~4 M ha E of the Divide) and **camphor laurel *Cinnamomum camphora*** (ornamental ~1822; invades CLEARED/disturbed rainforest land, not intact interior). Ecological detail in Ch 16.
- Whaling: Tangalooma whaling station, Moreton Island (1952–1962, 6,277 humpbacks taken); near-extirpation and subsequent recovery of eastern humpbacks (Ch 14).
- Shellfish-reef loss in eastern Australian estuaries (Ch 14). (*>90% lost by dredging/harvest, mid-1800s–early 1900s; Gillies et al. 2018, PLOS ONE.*)
- Cooloolo sand-mining campaign and national-park gazettal (1975) — Kathleen McArthur, Judith Wright (Wildlife Preservation Society of Queensland, founded 1962).
- Post-war tourism/population boom and the shift from a rural to an urban coast; growth/urbanisation as the dominant contemporary pressure; habitat fragmentation; climate change — regional planning/conservation/history sources.
- Canal-estate development (dredge-and-fill of coastal wetlands for waterfront housing), mid-to-late 20th century — regional development history. (*A widespread SE-Qld pattern; documented Sunshine Coast examples include Minyama/Mooloolaba/Parrearra/Kawana Island on the Mooloolah River and Pelican Waters at Caloundra. Ties to Ch 8, Ch 10 acid-sulfate soils.*)

- Traveston Crossing Dam (Mary River) — (Traveston Crossing Dam — Wikipedia; International Water Power “Garrett says no to Traveston Dam”; EDO): proposed by the Queensland Government 2006; **refused by federal Environment Minister Peter Garrett under the EPBC Act in late 2009 (the proposed refusal was announced on 11 November and finalised on 2 December 2009)**, on the ground that it posed unacceptable, serious and irreversible impacts to the nationally protected **Australian lungfish, Mary River turtle and Mary River cod**.

Chapter 18 • Caring for Country today

- “Caring for Country” as a land-management framework; the movement to centre Traditional Owner knowledge and authority; Kabi Kabi native title (2024) in practice — see Ch 17.
- Cultural fire revival: Steffensen, V. (2020). *Fire Country*. Hardie Grant Explore; Firesticks Alliance Indigenous Corporation; see Ch 6.
- Goosem, S. & Tucker, N.I.J. (1995/2013). *Repairing the Rainforest*. Wet Tropics Management Authority. (*Framework-species method*.)
- Bradley, J. (1988). *Bringing Back the Bush: The Bradley Method*. Lansdowne. (*Bush regeneration / weeding from strength*.)
- Sands, D. (2008). Conserving the Richmond birdwing butterfly over two decades: where to next? *Ecological Management & Restoration* 9(1): 4–16. (*Process/relationship restoration via vine replanting; see Ch 13, 16*.)
- Blue Heart Sunshine Coast — Maroochy floodplain (>5,000 ha); partners Sunshine Coast Council, Qld Dept of Environment, Unitywater and the Kabi Kabi Peoples Aboriginal Corporation; DCCEW *Wetlands Australia* 33 (2021); the Kabi Kabi Peoples Aboriginal Corporation joined as an official partner in May 2025, after that source. (*See Ch 8, 10*.)
- Noosa River shellfish/oyster-reef restoration — The Nature Conservancy with Noosa Shire Council, the Thomas Foundation and the Australian Government; reefs from 2022. (*See Ch 14*.)
- Koala recovery: habitat protection/corridors + UniSC *Chlamydia* vaccine (Phillips et al., npj Vaccines 2024, 64% trial efficacy; APVMA minor-use permit PER94984, June 2025). (*See Ch 12, 16*.)

- Humpback recovery as a conservation success (Ch 14). (*Recovered to ~40,000, now at/above pre-whaling levels.*)
- Community land care: regional Landcare, bushcare, catchment, dune-care and “friends of” groups and community nurseries — e.g. Barung Landcare (Blackall Range/Maleny), Noosa & District Landcare, the Mary River Catchment Coordinating Committee, and Sunshine Coast Council’s bushcare and community-nursery programs — their role in weed control and revegetation at fine scale.
- “Keeping what’s left” (protection layer) — Qld Parks; Land for Wildlife SEQ; Sunshine Coast Council: reserve/NP system as secured cores — Cooloola (first gazetted 1975, now Great Sandy NP), Glass House Mountains NP (est. 1994; peaks *mostly* but not wholly within the park), headland/hinterland reserves, Great Sandy & Moreton Bay marine parks. **Private-land conservation: Land for Wildlife** (voluntary/free/non-binding; Sunshine Coast has one of the national program’s largest memberships) and permanent **nature refuges** (perpetual covenant on title, NCA 1992). **Sunshine Coast Council Environment Levy** (~\$80/property): Land Acquisition Program — **>4,200 ha secured since the early 1990s** + management + landholder grants.
- Wildlife rescue/rehabilitation sidebar — volunteer wildlife carers; **Australia Zoo Wildlife Hospital, Beerwah** (Wildlife Warriors) — “one of the world’s largest and busiest,” **~9,000–10,000 animals/yr** (136,000+ since 2004); **koalas ~11.4% of admissions** — the largest single-species share, not a majority (Taylor-Brown et al. 2019). Rescue treats symptoms, not habitat loss. See Ch 12, 16.
- Citizen science: community koala monitoring (Dissanayake et al. 2019, SEQ) and volunteer surveys via platforms such as FroglID (Australian Museum), BirdLife Australia surveys, and iNaturalist / the Atlas of Living Australia; community-led bird-wing-vine replanting (schools/gardens). (See Ch 13, 16.)
- Habitat connectivity / wildlife corridors and retention of hollow-bearing trees as restoration priorities on a fragmenting coast — Lindenmayer, D.B. & Fischer, J. (2006). *Habitat Fragmentation and Landscape Change: An Ecological and Conservation Synthesis*. CSIRO Publishing. (See Ch 12.)

- Contemporary pressures: regional population growth/urbanisation, habitat fragmentation, invasive species, climate change (fire weather, heat events, sea-level rise) — Queensland Government, *ShapingSEQ* (South East Queensland Regional Plan); BoM & CSIRO, *State of the Climate 2024*.

Chapter 19 • A field companion

- Companion materials — the single-page **Sunshine Coast Ecology Field Guide**, the **Ecological Zones Map**, and the **Mount Ninderry** and **South Maroochy RiverCare** deep-dives — are on the companion website, sunshinecoastecology.com.au.
- Field species checklist: see the species checklist in the back of the book (the signature species, with scientific names, grouped by habitat).
- “The art of looking” (fieldcraft) — BirdLife Australia; ecotourism / light-pollution guidance: whipbird whip-crack + answering-mate antiphonal duet; magpie carol; she-oak “sigh” through its branchlets (see Chapter 11); lorikeet shriek; night frog chorus; binoculars + hand lens; nocturnal watching. Responsible spotlighting: dim/red-filtered light, brief exposure, no touching, low voice (red-light sensitivity varies by species).
- Safety content (Glass House summit difficulty/closures, snakes & ticks, rips, tides, 4WD sand tracks, mobile dead-spots) — this is general guidance, not a substitute for current official safety information.
- Seasonal cues (wallum flowering; shorebird arrival; humpback north/south migration timing; wet-season frog breeding) — standard regional natural history.
- Field ethics (track discipline, dune protection, weed/pathogen hygiene, no collecting, wildlife and dog rules, no bat handling) — standard reserve/park guidance.
- Getting involved: regional Landcare/bushcare/catchment networks, council conservation programs, citizen-science platforms; see Chapter 18.

A field checklist of signature species

- This is a *selected* list of the species named or discussed in the book, intended as an accessible field checklist rather than a regional inventory. A full species list belongs to the regional guides.

Glossary

- Definitions are written for the general reader and kept deliberately brief; the fuller treatment of each term is in the chapter indicated.

Further reading

- This is a general reader's starting list, not the book's evidence base; every factual claim is sourced in the online bibliography.