-James Joyce

Welcome O Life!
I go to Encounter
For the millionth time
The reality of experience
And to forge in the smithy
Of my soul the uncreated
Conscious of my race.
Old Father, old artificer,
Stand me now and
Ever in good stead.

-James Joyce

To Sewanee's professors,
for always encouraging me,
even when they knew better.

1st edition: December 2007.
This revised edition: August 2011.

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This document was the product of an independent study
at Sewanee: The University of the South.
It would have been impossible without the support of many, particularly
Dr. David Haskell, who was brave enough to advise me in this project.

ISBN 978-1-257-96581-6
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Oceania in Time-Lapse

Mapping the Story of Life Down Under

Eric M. Keen

Preface to the 1st Edition

"When I rest my feet my mind also ceases to function."
- J.G. Hamann

The experiences, misadventures, and research presented here were born out of a seven-month trip to the South Pacific in 2007. Plans for this time away from my Sewanee studies began as a mere application to the Institute For Study Abroad (IFSA – Butler), but by December 2006 they had grown into an ambitious "expedition", hurriedly outlined in an independent study proposal. Miraculously, my advisor signed off on it. The basic plan was to document Oceania's natural history through the medium of time-lapse photography. I promised to do this in not only New Zealand, but in Australia and Fiji as well.

By the following July, it was all over, and it had all happened, so much more so than originally planned. My semester in New Zealand spanned February to late June; the experience was phenomenal. Each and every weekend was a chance to go to a completely different landscape and experience for myself a notorious treasure of the country's natural history. Throughout my time in New Zealand, I was surrounded by the most outgoing and fun group of friends – my travel team – I could have hoped for. In my final month there, I was joined by B. Luke Padgett (the "Captain"), and we traveled around the entirety of the country, racking up one unforgettable experience after another.

Before New Zealand, I spent five weeks in Australia. For the first two, I traveled via coach and rail to multiple national parks in New South Wales, South Australia, and Victoria. For the remainder of my time in that country, I stayed on the Kangaroo Island farm of Bob and Lorraine Zannack, two of the kindest and compassionate people I would meet in that hemisphere. I was a worker on their farm through the WWOOF program (WorldWide Opportunities on Organic Farms). In exchange for my labor, I was given food, lodging, and the chance to care for their pet kangaroos. They welcomed me and two other guests, Leonardo and Patrick, into their family. Leo was a young man from Italy, Patrick an older man from France. Both were there to not only help on the farm but to learn English.

After we left New Zealand, Luke and I enjoyed a brief, 10-day layover in Fiji; not much time at all to offer an island nation, but we took what we could get, and we packed a lot in. Making the seconds count is what the Captain and I do well together.

So. Australia, New Zealand and Fiji. Seven months of natural history. Seven months of dreams realized. Seven months walking the land. Seven months with beautiful friends, loving people. "Love not man the less, but nature more…"

Throughout the assembly of this small book, my gratitude for those seven months and my wonder at what I saw have only deepened. I should hope so, because that is my basis thesis here: learning about a place is learning to love it. You connect with it by knowing it, by questioning it. I felt such a connection while Down Under, a devotion to place that I had only ever sense at my home university. This paper is the brainchild of that connection.

My goal is to give credit to the idea that life, simply life, is worth our admiration. I hope you enjoy.

To live in one land, is captivitie,
To runn all countries, a wild roguery.
– John Donne

-- EMK
Sewanee, TN
December 2007

Preface to the 2nd Edition

Oceania taught me many things. In only seven months, I changed much. I was shaped by the land, the people, and the experiences. I brought a bit of Oceania back with me (and I don't mean the moa femur). It is a part of me still. Those seven months set the tone for the remainder of my youth. They have prepared me for the changes to come. On a personal level, I still owe much to the mysteries and discoveries of Oceania. Sure, it was only seven months, "long ago," and they flew by. But I bet, for many years to come, whenever I find myself before a map of the world, my eyes will still drift habitually to that far right corner…

I think this book is poorly written, inadequately researched, and, in general, embarrassing. The first draft was written in less than three months in the midst of taking five courses and dealing with the stresses of senior year. It can hardly be called a book; rather, it was (still is) a book-length, report of below-average quality.

It was intended to be just a corollary to my independent study's main purpose: to give a presentation, based in science, about my time in Oceania and the time-lapses I had compiled there. These endeavors quickly ballooned out of control. The presentation ended up utilizing two screens that displayed different but coordinated PowerPoint's simultaneously. Total number of slides: 1,350. Because of its foolish and impossible scale, I delivered the presentation cold, without ever practicing it. It ran almost three hours long. I chocked the whole thing up as a great failure, a grand public exhibition of my lack of control or common sense.

By the end of the semester I had grown burnt out and bitter about the whole thing. I turned in the first draft to my advisor and tried to forget the whole thing. He was kind enough to read and make notes, cover to cover, over the Christmas holiday. I was astonished, flattered, and guilt-ridden. It must have been torture.

I didn't have the desire or the time to look at the book again for three and a half years, until I found myself in a summer job with all the time in the world: a fire tower lookout on the Grand Canyon's north rim. I decided to spend a few hours of tower-time each week going through the book, fixing typos, and making it a bit more readable. I can't say that I enjoyed the ordeal. But, on the bright side, the project did pass the time, and it also reacquainted me with memories from Oceania. For this I am truly grateful; I am happy I've done this.

The second draft ("edition") before you is the result of that second-read-through. I still can not say that I am proud of it, but it is now something I willing to accept and put out of my mind for good.

It will sit on my shelf, never opened, as a glaring reminder of how carried away I can sometimes get, how susceptible I am to my own blind ambitions, how easily I lose perspective in the throes of projects, and how my own energies, if poorly channeled, can be a danger to myself and a bore for others.

But for all this self-deprecation, there is one aspect of this project of which I remain proud. Sure, it had only been seven months. Sure, it had been facilitated by a "program". And sure, thousands of spoiled American students go abroad each year;, and you don't see *them* writing books about their travels. But *could they*? *Would they*, if they were dumb enough, like me, to try? Back during the first draft, the amount I gave of myself to this project – an amount represented by all the words in this book – was proportional to how much I got out of that semester abroad.

Place can change you, but only if you let it. The same goes for time, for books, for films, for classes, for friends, for adventure. It is all about attitude – it is a perspective -- and as such, it can not happen without *all* of you, without the *best* of you. Give all of yourself to something, and you are sure to come out different, older, smarter, and better for it. The life you take is equal to the life you make.

So yes, I maybe I did waste quite a bit of time on this piece of junk. Its place on my shelf will always signify that. But it will also signify something more, something well worth remembering about those seven months down yonder, something that this book will dare me to do again, wherever I might go next. This is what it means:

Once upon a time, Eric, you were alive. You were *alive*. You were alive and you were thrashing, you were desperate and unstoppable. You lived, man, you *lived*, you lived the hell out of that place. Eric, boy, did you ever live! You gave it all you had. And you were never the same again.

Oceania is what it's like to be alive.

You should try that again some time

.

-- EMK
Kaibab Plateau
August 3, 2011

Chapter 1

Discovery

"Everything a well-regulated continent should not be"[1]

It started, as my favorite stories do, with a blank space on the map. A beckoning, terrifying, inkless area, a sinkhole of dreams and ambitions, a fountainhead of nightmare and fantasy. It dominated the hemisphere, there, at the intersection of the Indian and Pacific Oceans.

Four hundred years ago, geographers did not know Oceania existed. There were only rumors. Victorian murmurs and furrowed Germanic brows were exchanged during the proceedings of philosophical societies; eminent naturalists shifted uncomfortably in their seats. *Something* was down there, in that grey fog of the South Pacific; they had heard rough translations from those tradesmen who bartered warily with the Polynesian islanders; and yet, to the dismay of the West, a fourth of their ornate world maps remained smeared with vexing, looming question marks – and the hollow letters of a provisional name, at once embarrassing and alluring: "Terra Incognita".

Before the first Europeans encountered the shorelines of Australia, cartographers grouped the islands of Oceania along with the unreachable continent of Antarctica under this mythical title: the

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[1] Qtd. in Evans, Howard Ensign and Mary Alice Evans. *Australia: A natural history.* USA: Smithsonian Institution, 1983.

"Unknown Land." *Something* was down there at world's end, but no one was sure what.

Then, within only a short series of wildly successful circumnavigations, the cartographers began scribbling in the details. Oceania was "discovered," and the known world was never the same again. On November 24, 1642, Dutch explorer Abel Tasman sighted the west coast of a large, mountainous landmass off the southeast Australian coast. "Van Diemen's Land," he called it (Today, in his honor, Tasmania). With seas too rough to make a landing, Tasman never did set foot on his new discovery; he delegated that task to the ship's carpenter, who was made to swim to shore, plant a Dutch flag, and if possible, swim back.

And with that anticlimactic ceremony, *Terra Incognita* became known, to the western world, as "Novae Hollandiae," the New Holland.

In the same month, Tasman stumbled upon the North Island of New Zealand as well. Again he was denied the privilege of setting foot on his discovery. War canoes full of belligerent Maoris, bodies ornamented with obscene tattoos, attacked his ship and killed four his men – a clear warning that not even the East India Trading Company was yet ready for the surprises lurking in those misty coastal ranges. His ship returned to Europe, sails trimmed full with bitterness and tall tales. And with that, Oceania was no longer a myth -- but no less a curiosity.

Over a century later, the British came for a visit. In the late 1790's, Captain James Cook charted the east coast of "Novae Hollandiae," renaming it "Terra Australis" in the process. In another circumnavigation, Cook and his naturalist Joseph Banks swung south and east, hoping for a glimpse of those looming black mountains of the Maori. Their compass' aim was true, and Cook mapped the entire coast of what is known now as New Zealand (a land the Maori referred to reverently as Aotearoa, "Land of the Long White Cloud"). Banks also managed to fulfill his imperial mandate, planting native plants of Great Britain along the coastal forests of this newly acquired English real estate. His legacy blossoms still today.

Progress quickened. At the turn of the century, Matthew Flinders circumnavigated Terra Australis and mapped the rest of the coastline, naming islands from the hip as he sailed along: Kangaroo Island, for example, was named thus after he saw how easy it was simply to walk up to, literally punch out, and grill up all a kangaroo, a freakish creature that was so abundant they were overflowing onto the beaches of the island. Flinders was the first European to eat kangaroo.

Tales of the frightful, outrageous, and sometimes silly denizens of these newly charted lands began to drift back, embellished and stretched by Patagonian trade winds, to the ears of western Europe's naturalist's and eager gentry. Whispers were racing through the scientific communities of Europe: Oceania was alive.

One exasperated naturalist, "exiled" in Botany Bay, wrote to his dear Aunt Dumfries: "This will seem to [the adventurer] to be a country of enchantments. The generality of the birds and the beasts sleeping by day, and singing or catering in the night, is such an inversion in nature as is hitherto unknown."[2] Another witness from Terra Australis, a historian, was equally aghast: "Nature may be said to have in this country indulged in whim…The whole animal creation appears to be different from that of every other region; no less the vegetable…"[3]

But as tends to happen amidst such wondrous bouts of discovery, what remained unknown, unseen, and unmapped far overshadowed the rest, and the questions became all the more glaring. Upon first laying eyes on their respective discoveries, upon stumbling out of their captain's corners and squinting to the horizon in the direction of the crow's nest eager directions, little did Tasman, Cook, Banks, or Flinders know of their truly humbling place in the long, eventful history of the *Incognita.* Little did they know how many eyes before them had looked upon those shores, nor of the generations of men for whom those huddled clouds on the horizon meant familiarity -- not discovery – and conjured bouts of homesickness -- not wanderlust. Little did they know that people had been on Terra Australis for possibly as long as 100,000 years. Little did they know that the Maori of Aotearoa had been exploring the Southern Alps for almost 1,000 years. Little did they know that only 400 years before charting those shores, monsters like 12-foot tall flightless birds roamed those hillsides, numbering in the millions.

But discovery, as always, depends on where you are coming from. And despite its ignorance, the West's enthusiasm for these finds was unabated, monumental, exuberant.

In the clarity of hindsight, we now see that these men's wildest hopes for what their "discoveries" might come to mean could not

[2] Thomas Watling, in *Letters from an Exile at Botany Bay*, to his Aunt in Dumfries. 1794
[3] James O'Hara, *History of New South Wales*, 1817

compare to the reality, to the earth-shattering environmental, intellectual, and humanitarian consequences, or to the full immensity of Oceania. For all their euphoric swagger, these natural imperialists were utterly unprepared for the wisdom and knowledge brooding in the bedrock, forests, biota and peoples of those lands. Ignorant of the pageantry of life that had paraded across Oceania throughout deep time, these explorers could see only inchoate shorelines of formless and story-less continents, devoid of a known natural history, but also rich with endless possibilities; found, yes, but still awaiting true discovery.

In a very real sense, this corner of the map remained blank.

> *I had been lying on a sunny bank, and was reflecting on the strange character of the animals of this country as compared with the rest of the world. An unbeliever in everything beyond his own reason might exclaim, 'Two distinct Creators must have been at work'.*
>
> -Charles Darwin

In a time when such discoveries were revising world maps more quickly than they could be published, the governing concepts of natural history were lagging even farther behind. In the age of Cook and Banks, and even three decades later during the H.M.S. Beagle's journey, science still looked upon living oddities, such as those teeming within Oceania, with dogmatic assumptions of constancy and immediacy. There was no story behind the platypus, no history to the kiwi, no tale to the kangaroo, no accounting for the Tasmanian tiger, no explanation for the koala, no sense to be made of the tuatara. They were merely there -- fantastic, mythical, and just there.

The term "evolution" did not yet exist, at least not used in its contemporary sense. The concept of "biogeography" was fetal; "historical biogeography", non-existent. There were never any debates over the question of "dispersal or vicariance". And, excepting the nascent field of paleontology, there was absolutely no dialogue between the fields of geology and biology – certainly no discussions about what an oceanic trench had to do with a particular monkey's whereabouts, for instance, or anything else along those lines.

Natural history was a brachiated tree of knowledge split asunder. Introverted specialties receded deep into their alcoves. Congregations were divided impermeably into denominations. The hermitages seemed indefinite, no vestige of a beginning, no prospect of an end. There was nothing, no narrative coherent or convincing enough to push any of the pews together.

Likewise, the phenomenon of life itself seemed isolated from its environment. Life was certainly no *reaction*, certainly not engaged in any *dialectic* with its environment; it was a divine, inspired proclamation. Life was an assertive product of Creation, superimposed upon landscapes and timelines, shaped not by these contextual hosts but by a supreme, heavenly sculptor.

The outlandish, nonsensical biota of Oceania complicated this perfectly comfortable, if crude, worldview. The specimens trickling in from the far side of the world somehow, vexingly, both epitomized and undermined it all, all at once. Something about them was both aggressively threatening and utterly promising; impossible, yet irresistible; horrifying, but inescapable.

The Platypus Perplex

"Just to watch a platypus, without knowing anything about its importance as a primitive mammal, is enough to convince anyone of its oddity." [4]

When the stuffed specimen was sent to the British Royal Society in 1799, it was thought to be a hoax, some lame idea of a joke from a crazed, sea-sick naturalist drifting around the South Pacific. It took years for the platypus to be accepted as something real. The advent of the platypus managed to aggravate, epitomize, caricature, and embody the world's mixed reaction to Oceania.

This is of no surprise, considering that platypus really are remarkably weird. The beak of a duck. The tail of a beaver. The body of a thick-furred rat . Its feet are webbed. And as you look closer, this animal only gets weirder. The females lack a vagina, the males seemed to lack testicles. Its shoulder joints are oddly reptilian, almost like a crocodile's. It has electro-receptors and mechanoreceptors that allow it to find prey in the complete dark. They dig 10- meter deep burrows in the banks of streams. When swimming, its heart rate drops from 140 beats per minute to 40 in less than 40 seconds, and once at the surface again, the rate

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[4] Bergaminin, David & the Editors of LIFE. *The Land and Wildlife of Australia.* Canada: Life, 1964. Pg. 60.

immediately jumps to 200 bpm.[5],[6] The males have venom-filled spur on their back legs, which can easily kill animals as large as dogs and seriously harm humans. And here's the kicker: these mammals laid eggs.

If you were a turn of the (19th) century naturalist who stumbled upon this mismatched animal in a land filled with other wacky critters, a side show that ranged from wombats to kangaroos to flying foxes to thorny devils to saltwater crocodiles to koalas, you too might suspect some malicious devilry to be behind it all. Such was the reaction of the Britain's learned societies, not to mention the appalled gentry.

Nothing in their natural theology had prepared them for the arrival of a platypus in their post. Indeed, the biota of Australia, New Zealand and the rest of Oceania, referred to fondly as "Down Under," have played an ironic and pivotal role in turning Victorian conceptions of natural order completely *upside down.* Cages were rattled, and cradles were rocked. It soon became clear that as the map's blank spaces were filled in, the intellectual geography of the age would need revision as well. Mental boundaries would have to be breached, uncharted courses into the unknown risked.

It soon became clear that Oceania was opening the doors to a new kind of adventurer, a new order of naturalist.

"Billabongs and coolabahs. Barramundis and wallaroos. Bandicoots and bimbils. Here is a continent where all life, and the land itself, have evolved their own individual patterns."

– John Gunther[7]

A lot has changed since that platypus was postmarked. Now, for the post-Darwinian naturalists, for those protégés of Wallace, Simpson, Mahr, Wilson and McArthur, Dawkins and Gould, life on this planet is looked upon as something that has a story- that is, a history. Now, when we look at the wombat, the echidna, and the glossy black cockatoo of Australia, or the Takahe, royal albatross and short-tailed bat of New Zealand, we are not looking at life that is plopped upon a world that once-was-lost-but-now-is-found. We are looking at a consummate result, a shape-shifting menagerie. A

[5] A feature now recognized as common among diving mammals, termed *bradycardia.*
[6] Berra, Timm M. *A Natural History of Australia.* San Diego, CA: Academic Press, 1998. Pg. 222.
[7] *Inside Australia*, 1972.

tapestry of energy and relation. A synthesis. A long story. Manifesto of circumstance. Product of deep time.

Consider all this evidence, [Darwin] argued excitedly,
and 'the fabric falls!'[8]

The learned concept of life, these days, has become inextricably tied to the land in which it evolved. Without a history of life, and without understanding its relationship to the land, only a superficial and hollow conception of life is possible – *especially*, it seems, in the case of Oceania. Looking at an ecosystem and seeing it in terms of time adds an entirely new dimension and brings about a completely different perspective of the community of life within that environment. There is something emergent and glorious that happens to one's worldview when the dimension of time is added. Depth is gained – that is, profundity. So much is lost, we now know, with an instantaneous view of life – it's like attempting to let a still frame speak for a movie. Oceania was once merely a photograph of life in a far corner of the world; now, one can argue that it is understood as a time-lapse, a series of instances in the history of life that iterates and combines and amalgamates into a seamless and enchanting moving image.

At least, this was the conviction I was turning over in my mind as I packed my hand lens, insect pins and camera into my rucksack. The next morning I would leave for Oceania, and I wouldn't be back for seven months. It was my impression that, given the advancements in evolutionary theory and biogeography, the age of exploration may be far gone, but the age of discovery is here and now. I envisioned slipping into the mindset of the naturalist on board that *Boeing* 747 and stepping out in Sydney ready to discover it all again, anew, for myself. To appreciate fully the work of these explorers, it was compulsory for me to trace their course, but to experience the wilds of Oceania on my own terms.

Like the great explorers of the heyday of natural history, I would look at the biota of Oceania with eyes wide open and jaw-dropped, expecting upheaval and thirsty for revelation. I was in it for my own 'landscape enlightenment.' "The Darwin-Wallace tradition [was] a science of the improbable, the rare, the mysterious,

[8] David Quammen, *The Reluctant Mr. Darwin.* pg. 37.

and the miraculous,"[9] and no accumulation of decades or technology could undermine that for me. Not even in 2007. As far as I was concerned, the map was still blank.

But for all my whimsy, I understood that all would not be the same, and I don't mean the recent prevalence of hostels and air travel. Unlike Tasman, Flinders, Cook or even Darwin, I would be approaching Oceania with all the advantages of modern ideas; with an advanced understanding of life's history and its mechanisms of change. So yes, this would change things – but there was something exhilarating about that. How would Oceania unfold itself before me, and how would that differ from the exasperation of pre-Darwinian voyagers? What other lessons are down there, lurking amid eucalyptus and beech, waiting to be coaxed out? After all, the most alluring blank spaces are the ones we don't yet know of.

Having since returned from the journey, and having since reflected and recuperated, I am now closer to comprehending the bipolar paradoxes of the *Incognita*, how Oceania was – and still is -- a notorious source of both unending discovery and irrepressible confusion. It is indeed the perfect example of just how damned complicated it is to make sense of life's history. Managing to advance one's perspective from still frame to time lapse may answer a multitude of questions, but it cannot be done without spawning new ones, questions all the more grandiose, unsettling, and urgent for their elegance and subtlety. There's an odd symbiosis between discovery and mystery, a relentless alternation of generations between the two. One cannot live without the other, and they cannot commingle either. When the cartographer fills in a blank space, new and unwritten worlds suddenly surface.

Yes, it was this very oddity – this mixture, in some ways unique to Oceania, of discovery and mystery, of the instructive and the nonsensical, of the story and the moral – that I was commissioned to study, puzzle over, explore and become changed by. Away I went.

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[9] Nelson, Qtd. in Evans, Howard Ensign and Mary Alice Evans. *Australia: A natural history*. USA: Smithsonian Institution, 1983. Pg. 111

The Austral Connection

"Oceania is notably different from elsewhere. Its biological inhabitants have captured the imagination of naturalists ever since Joseph Banks and his stream of successors visited our shores." [10]

The foci of my journey were Australia, New Zealand and Fiji, and the ways in which they represent the different but related sides of this thing called Oceania. Here I will focus on the history of its landscape and the life it contains: its geology, geography, flora and fauna, old and new, Paleo-, Meso- and Ceno-. But more importantly, I will be addressing how these different aspects of the natural world – and the sciences that study them -- are inextricably interwoven by deep time into an ecological and evolutionary fabric. At this point some readers may be asking, as admittedly I was while planning the journey: "Wait. What, exactly, *is* Oceania?"

The brief answer: Oceania is a collection of island groups in the South Pacific, some of them continental in size, others mere sandbars, shaped by a combination of subduction, sedimentation, uplifted oceanic crust, and volcanism, all related by their common ancestry, at least in part, with a super-continent dismantled and laid to waste ages ago.

The most logical question that follows the "what?" is, of course, the "why?" Why is Oceania such a coveted study area for historical biogeographers? What on earth is so special about it? Although the answer to "Why Oceania?" seems all too obvious after the fact, the words that follow comprise my best attempt to convey it.

"In many ways, explanations for the Southern Hemisphere pose much greater challenges to a biogeographer…And New Zealand has much to offer when it comes to the riddles of the South." [11]

As mentioned, Oceania perfectly embodies the paradoxes inherent in the pursuit of the natural history of deep time. There is something oddly in common with the biota of Oceania, something referred to as the "Austral Connection." The wildly diverse flora and fauna of Oceania are bound by a similar story, one that unites them despite horizons of isolating seas. It is a story of overcoming

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[10] Gibbs, George. *Ghosts of Gondwana: The History of Life in New Zealand.* Nelson, NZ: Craig Patton Publishing, 2006. Pg. 7.
[11] Gibbs 185.

fantastic evolutionary and geographic obstacles in the struggle to perpetuate. The fractured tectonic movements in the region of Oceania have accumulated over deep time to bring sweeping climactic and biogeographic reforms, consequences that have resonated beyond Oceania's hermitage into ecosystems around the world.

The fact is that the biota of Australia, New Zealand, the Sub-Antarctic islands, New Caledonia, and the myriad island arcs that surround them are uniquely odd, yet uniquely common. There seems to be some camaraderie among them, solidarity even, born of the same forbearance towards sea level transgressions, glacial invasions, seismic juggernauts and volcanic plumes – a camaraderie that enables these different provinces to be grouped within this patchy term of "Oceania." This connection is evident within Oceania's current biota but equally impossible to discern if we only look that far. The fact is this: if biologists are to understand the present extent and influence of the Austral Connection, they must, however reluctantly, look far into the past. For some, however, this is an enticing mandate, particularly for those ecologists who, like me, have not grown out of their childhood dreams of being paleontologists. For those scientists who are not particularly attracted to the present or to the past, but instead to the relationship between them, Oceania is the place for them.

For that is where Oceania lay, in a world apart, an anachronism suspended in the map's southern corner, neither old-timey nor new-fangled, neither here nor there, then nor now, both clandestine and ostentatious, enticing and foreboding, revelatory and perplexing. And that is what drew me in. I wanted to be dumbfounded, and I wanted it to fall into place.

Chapter 2

Archipelagone

"There was something *about islands. Their simplicity and isolation and anomalous faunas, like premises of a thought experiment, helped clear the head."*[12]

It was in Fiji that I saw my first flying fish.

Captain Luke was at the bow of a high-speed catamaran gliding boisterously over the equatorial Pacific's exuberant blues. The vessel was carrying us and our freight, which consisted of journals, graphites, mosquito net, Speedos and two sulus (the Fijian version of a serong), along the west coast of the Yasawa Arc, exclaiming the western bracket of the island nation like a quotation mark. Our first stop in the group was to be Makatewa Levu, a half-sunken volcano whose shallows were frequented by lurking bull sharks.

True to form, the Captain's keen eye was the first to notice the flying fish, and as usual he was the first to lose composure. Over the roar of the wind, he beckoned me to the bowsprit. Grabbing my shoulders and positioning me just right, he ordered me eagerly to keep an eye on the bow of the ship. "Wait for it, wait for it, trust me man, just wait!" And I did, diligently and patiently, because I had long ago learned to trust his eye for awesome.

And then, as the catamaran plummeted down on the other side of a particularly impressive swell, a sheet of fluttering pixies broke the water's surface and radiated out over the water, streaming like rays of sunlight out of our way. They fluttered alongside us for what

[12] David Quammen, *The Reluctant Mr. Darwin.* pg. 29.

seemed like minutes before tucking in their "wings" and dropping back again into that distinctly blue Fijian water.

The next swell came, and the flying fish scattered again. I realized I was whooping and hollering. I had dreamed and pondered of these fish since childhood, puzzling at their oddities and wishing for their amphibious modes of transportation. Who needs land when you can both swim *and* fly?

And thus, with each subsequent burst of flying fish from just in front of the double-bow of the catamaran, my induction into a forgotten world of insular oddities pupated from latent, brooding dream to jubilant reality, wings unfurled and glaringly real. Tugging on my sleeve, the Captain pulled me out of my reverie and back into the Yasawa arc. My eyes followed his gesture from flying fish to the horizon unrolling itself before us. On its edge was a small island, solitary and meek against the blue backdrop of sea and sky. Cumulus clouds boiled and blossomed immediately above it, like an eager thought bubble. A remote, tropical isle in the middle of a Polynesian arc. Blue sky, bluer ocean. I was here. It was now. I was ready. Ready to feel between my toes the sands of those islands I had studied so much. Island life was about to begin.

Although Fiji happened to me at the end of my time Down There, this young, bright, volcanic archipelago is the ideal starting point for our story. Fiji's network of small islands were brought about by a confusing combination of subduction, volcanic activity, fluctuating sea level, and encroaching coral reefs. The island nation's boundaries encompass 322 islands, of which less than half (106) are inhabited by humans. It embodies the very kind of tropical scenario in which the 19th century naturalists realized the vast importance of islands in the basic study of life and its distribution on earth. It was in arcs like Fiji's that the field of biogeography erupted onto the frontiers of natural history. Looking at the communities of life on each of these islands in relation to those on neighboring ones, and how distributions overlap between islands, is what biogeography is all about.

Tropical Pacific archipelagos became the textbooks of a new and daring set of ideas, notions that would later be the key to unlocking Oceania's deeper secrets.

"…it isn't too much to say that when we have mastered the difficulties presented by the peculiarities of island life we shall find it comparatively easy to deal with the more complex and less clearly defined problems of continental distribution." [13]

This memorable statement, scribbled in passing by A.R. Wallace, a founding father of biogeography and the theory of evolution, hints at the central premise at the heart of island biogeography: understand island life, and life elsewhere will be that much clearer. Understand island life, and mainland, mainstream questions will start finding their answers.

An island is the closest thing to a controlled environment that natural scientists can hope for. Being scientists at heart, naturalists tend to suffer from what amounts to "control deprivation." There are often so many variables and unknowns in an ecosystem that a comprehensive picture of the way things work is night impossible to paint. This just doesn't jive with what experiment-based scientists were trained to appreciate. But islands offer a kind of fix. They are the closest thing to units occurring in nature at the scale of the landscape -- discrete, numerous, and often internally quantifiable. They are the closest things to closed systems we can get our hands on and our minds around. For this reason, for the attentive observer, pattern and process on islands have a tendency to leap off the page.

"Because they impose something like laboratory conditions on a natural environment, islands have always been fascinating to evolutionists, from the time of Darwin & Wallace to the present day."
– Allen Keast

After over a hundred years of close interpretation of island life, scientists have come far in their effort to grasp the ecological implications of the small size and isolated nature inherent to insular life. Textbooks have been written. Lists of rules and patterns have been fleshed out.

One such pattern is this: island life tends to be both species-poor and disharmonic, meaning a peculiar, asymmetric representation of the taxa you'd expect to see. Another pattern, seemingly contrary to that one, is that islands are also rich in

[13] Whittaker, Robert J. and José María Fernández-Palacios. *Island biogeography : ecology, evolution, and conservation.* New York: Oxford University Press, 2007. Pg. 242.

endemics – a classy scientific term for "unique." An endemic species lives in a certain place and nowhere else. So, generally speaking, islands have a lower number of total species than analogous habitats on the mainland, but a much higher proportion of those species are endemic. The basic implication, essentially, is that, compared to their mainland neighbors and any other species in the world, island life is weird.

Such patterns are so prevalent in the world's island groups that they seem integral, essential even, to the idea of the island. It amounts to a different and unforgiving set of rules, rules to which new arrivals must either adapt or perish.

Another pattern has to do with a remarkable correlation between the number of species on an island to that island's size. These correlations are called "species-area curves," plots that illustrate the link between species richness and habitat area. Islands tend to have characteristic curves, and the same goes for the mainland. And the two are surprisingly dissimilar.

Islands typically have fewer species per unit area than the mainland,
& this distinction is more marked the smaller the area of the island.[14]

It may seem odd that islands, being so notorious for being well-springs of biodiversity, are just not that, well, diverse. But consider that "diversity" can imply two different things: the number of different entities, and how stark the differences are between those entities. Islands specialize in the latter; archipelagos tend to assemble a wacky and eclectic cast of characters. Islands are truly treasure-chests of diversity and variation.

This seems to be partly because island circumstances are especially conducive to speciation events; population bottlenecks for example, are fairly common occurrences. The fewer breeding individuals, the greater the impact their differences will have on the genetic composition of subsequent generations. And it is rarely more than a few individuals that manage to colonize and island (this is known as the Founder Principle, which I say more about in the coming pages). Bottlenecks, and therefore divergence, seems to be integral parts of life on islands.

Likewise, extinction on islands happens uncommonly often, relative to the mainland. The biological history of an island is riddled with failed attempts at colonization, fleeting visits and

[14] Ibid., pg. 49.

desertions, and cataclysmic resets by volcanic and seismic disturbances. The kinds that manage to survive tend to selected for randomly, making the remaining line-up seem discontinuous, disparate, and chaotic.

Unless their habitat is split in half by a major interstate highway, continental populations tend to remain in tact until a mountain-building event or some other cataclysmic landscape splits them apart. Since geographic isolation leads to genetic isolation, this kind of speciation can take millions of years on the mainland. But when a roaming population descends upon an island group, its members become divided into subgroups according to the island(s) they tend to spend the most time on. A single population is thus diffused into several small populations, rarely and irregularly interacting. This compartmentalization leads to genetic divergence, at a much higher rate than could be possible on the mainland. Island speciation is like watching normal evolutionary processes, normally creeping and imperceptible, in fast-forward – in time-lapse.

Throes of an Island's Arc

Scientists have come up with several possible explanations for why islands, being small and dynamic as they are, accelerate speciation and evolution as they do. Most of these reasons stem from the circumstances inherent to the feat of arriving on an island; this is what the "Founder Principle" is all about. The principle states that typically a group immigrating to a remote island will consist of only a few individuals.[15] This may seem obvious, but its implications are grave. In a large population, natural selection tends to mediate the successful passing of unusual characteristics. What I mean is, life is inherently conservative. The status quo is generally the status quo for a reason, and whatever variation there is in a population generally gets lost in all the numbers. Even when a new mutation is harmless – or even slightly helpful – it still has to survive dozens of generations of dilution from interbreeding with prevailing genes in order to establish itself. This is highly improbable. Compare this to the democratic process: one person's ideas, regardless of how good they are, tend to be lost within a crow of millions. Variation can usually muscle its way into a large gene pool only when it is highly accommodating, increasing survivability and reproductive fitness.

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[15] Ibid., 167.

What's more, in a large population, the minute differences among individuals tend to lose their significance. Noteworthy variation becomes proportionally less significant, self-minimizing. The larger the population gets, the more similar its constituents seem to be. But of course, every individual is slightly different genetically, some more deviant than others. But – and this is the key to the Founder Principle - if you take a small selection of individuals and plop them on an island, you will have transplanted only a small percentage of the total genetic diversity of that population. Some of the variation will be lost, but the differences that remain become a lot more relevant. Suddenly, the national caucus becomes a New England town meeting. Your voice and your vote seem a lot more influential now. Each variant has a drastically higher chance of becoming popularized into the new status quo.

The implications of this are far-reaching. The establishment of a new population by only a few individuals is essentially a bottleneck event. This new population's gene pool is markedly shallower than the mainland population, and it has found itself in a new habitat, a new arena, with different resources and a different array of neighboring biota. It is no surprise, then, that changes come quickly, and in ways that had been impossible or impractical on the mainland. An entirely new context is calling the shots now, and criteria of natural selection change in turn, and the features of the population must follow suit, or else.

The very enterprise of dispersal, as well as the violently dynamic circumstances of island life, have a tendency to "wear" on a population. Islands, in all their weirdness, shape their biota in curious ways. Evolutionary fates are twisted by and by, and symptoms start to manifest themselves. Some refer to this distinctly disruptive aspect of insular settings as "The Island Syndrome."[16]

The malady comes in different forms, for different reasons. When a creature arrives on an island, the ecological role it had carved for itself on the mainland is almost never available in its new habitat; the niche is either non-existent or already occupied. Islands are just too different and too small for a species to find a familiar spot waiting. New arrivals can see this as an obstacle or an opportunity – those who choose the latter tend to be the ones that make it. It is a ruthless hegemony: step out of your ecological comfort zone and try something new, or perish. So species do, and sometimes their adaptations are lucrative enough to enable survival.

[16] A term coined by Levins in 1994.

This phenomenon is called nice-shifting, and it tends to turn species on their heads. Islands are for the evolutionary entrepreneurs, the risk-takers, the visionaries; others need not apply. And the result is palpable: there is something creative, daring about island species.

The usual scenario is that a new species arrives only to find its niche already taken, and it changes trades. When ecologically similar species confront each other, their specialties tend to diverge, reducing competition. It's non-confrontational, but it works, and its byproduct is diversity, the wacky kind. Birds become flightless ground scavengers. Some become the avian equivalent of monster kangaroos. Kangaroos take to the trees. Lizards take to the skies. Parrots act like woodpeckers. This brand of niche shifting is termed 'character displacement'. Either because they can or because they must, species start living in unprecedented ways.

An opposite phenomenon can also occur: sometimes newcomers come ashore only to find no threat at all of resource competition or predation. It's like stumbling upon a promised land – a landscape utterly conducive to their survival, entirely unprepared for their kind. What follows is known as "ecological release": the species lets its hair down, slips into something more comfortable, and kicks back. Some of the traits with which the species arrived are no longer necessary, e.g. certain defenses, coloration patterns, or, in the case of many New Zealand birds, wings. Why invest in traits that no longer harbor any potential pay off? Other traits, on the other hand, are enhanced or even developed from scratch. In such serendipitous founding events, like a Cat Stevens song, the possibilities seem endless. If you want to sing out, find an under-utilized island and sing out.

Other interesting things are happening on islands other than these elaborate role playing games. For example, and this is one of my favorite things about islands, there exists a phenomenon called "density compensation." Islands are literally packed with life - teeming, overflowing, bursting at the seams. The ecological gap carved out by less diversity is filled in with larger populations; there may be fewer species running amok, but more numbers are representing each kind.

And then there's size-shifting. There is a tendency for species to change in average size when establishing on islands, but this change is hardly unidirectional; some species get bigger, others shrink. Both gigantism (think the giant tortoises of the Galapagos, or the moas of New Zealand, or the dragon of the Komodo Islands, or foot-long stick insects in Fiji) and nanism (seen in several island subspecies of ducks) are common in the same island arcs.[17] What is even more incongruous the directionality of size-shifting in some clades is predictable, and in others not so much. Reptiles tend to get bigger on islands; birds, heavier. But in plants and insects, it is a toss up. They may balloon out of control, or they may wane into obscurity. In mammals and other vertebrates, it is more complex: when they colonize an island, smaller mainland species to get bigger and for larger mainland species to get smaller[18]. This amalgam of reverse tendencies is referred to broadly as the Island Rule.[19] Of course, there are exceptions, but the fundamental pattern remains: Islands change your life.

Islands in Time

If you ever go to Fiji, you will probably hear all about this thing called "Fiji Time," a phenomenon that explains why boats leave and arrive to islands late, why business hour signs in shop windows are almost sarcastic, and why meal times at island resorts are gross estimates. In fact, "Fiji Time" has now become the motto of the nation's tourism industry. Fiji is a place where you go to relax and slow down. Perhaps this time warp is induced by the exhausting equatorial sun, or the life of plenty and nonchalance typical of fertile paradises. Whatever the reason, their notorious national pace is epitomized and exacerbated by the prolonged ceremonies surrounding their famed national drank: kava.

Fijians drink kava morning, noon and night, with some more goes in between. The kava ceremony involves a circle of friends, a central basin in which the kava powder is mixed with rainwater, and a bunch of clapping and shouting the Fijian greeting, "Bula!" in unison. Kava itself is a powder that is made of the ground-up root of a native pepper tree that is aged for years before being pulled down from the shelf. When mixed with water, the concoction serves as a fast-acting, highly potent sedative. It also numbs your mouth. The first time the Captain and I tried it, in a shop in Nadi,

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[17] Ibid., 186.
[18] Ibid., 186.
[19] van Valen. 1973. A New Evolutionary Law. *Evolutionary Theory*; Lomolino, M.V. 1985. Body Size of Mammals on Island: The Island Rule re-examined. *American Naturalist*, Vol. 125, pp. 310-316.; Lomolino, M.V. 2005. Body size evolution in insular vertebrates: generality of the island rule. *Journal of Biogeography*. Volume 32 Is. 10, pg. 1683-1699.

we asked the shopkeeper what kava does to you. He responded with a cackle and a broad grin, "My brothas, kava make you Fiji Time!"

With all the Fiji Time on my hands in the coming weeks, I had plenty of chances to reflect on the role islands such as these played in the development of evolutionary theory.

Ecological phenomena have characteristic spatial & temporal signatures, to which different principles often apply. [20]

The intricacies of island biogeography were first elucidated, convincingly and thoroughly at least, by an odd couple of naturalists: Charles Darwin, who wrote at length about islands long before the publication of his *Origin of Species*, and, more eloquently but less notoriously, by his contemporary Alfred Russel Wallace. In fact, these naturalists, in observing island life's unmistakable link to place in their studies of the world's most legendary archipelagoes, separately found the same muse for the revelation of evolution by natural selection. Darwin learned in the Galapagos and Oceania, as Wallace had in the Malay Archipelago, that basic fact whose significance had so long eluded the scientific community: Place Matters. Place matters, more than we've ever imagined. Life is responding to it continuously, changing according to its dictates constantly. Place: geography, topography, climate, available resources, and all the rest, are the true authorities over this wondrous creation called "life." Scientists, with Wallace and Darwin at the helm, were finally delving into that terrifying realization of the Importance of Context.

Islands in Islands

In 1967, E.O. Wilson and Macarthur published a wildly influential paper entitled, "The theory of island biogeography"[21]. While this paper established some of the founding principles of biogeography discussed above, it also asked an important question: How, exactly, does one define the idea of an 'island'? Does it have to be surrounded by water? What if it were a habitat surrounded by, say, pavement?

[20] Whittaker and Fernández-Palacios.

[21] Wilson, E.O. and Robert MacArthur. 1967. The Theory of Island Biogeography. Princeton: Princeton University Press.

What is an island, anyhow? [22]

Over the years, more and more conservation biologists have looked to this idea, that dispersal and survival patterns in an archipelago can be applied to those in broken habitats surrounded by seas of civilization. Just look at a map; the analog is immediately compelling. All the classic archipelagos, from the Solomon Islands, to Malaysia, to the Galapagos, to the Channel Islands, to archetypal Fiji, have analogs in the middle of continents, amid urban sprawl. Constellations of forest patches interrupted by roads and golf courses; wilderness areas subdivided by subdivisions; mountain ranges dissected into discrete units by winding roads. In our age of voracious development, what happens on remote Pacific islands has become hugely relevant to life everywhere. Islands, defined in this way, become ominously ubiquitous. Even in the middle of continents, the strangeness of islands prevails. Perhaps the better question is, What *isn't* an island?

Places like Australia and New Zealand raise the stakes even further: even islands have islands. They are of interest not only because they are themselves islands, but the fragmented habitats of their continental interiors are also insular in nature. There is a second-order biogeography – something "meta" -- going on down there. These islands, composed themselves of collided and congealed pieces of more ancient island arcs, may have grown so continental in size that they transcended the symptoms and syndromes of island life, those local oddities so pervasive in the Fijis of our world, but, due to human activity, even the subcontinents have suffered an ever-accelerating fragmentation of natural habitat – a violent return to its archipelagic roots. Once an island, always...

Ecological systems have emergent statistical properties, detectable for example in regularities of form of the abundance and number of species, and which point to the existence of some fundamental governing ecological rules or processes.[23]

E.O. Wilson and Macarthur revolutionized the scientific approach to island life in a number of ways, but one particularly helpful development was that island trends tended to hold to

[22] Whittaker and Fernández-Palacios, 9
[23] Ibid., 106.

statistically significant patterns. As many aspects of ecology were departing from the merely "descriptive" to the numerically illustrative, so too was the study of islands. And most of these ecological studies based their analyses on a few basic, harmless presumptions; namely that species were to be dealt with as unchanging, fixed units.[24] They were static concepts in the logarithms of population ecology, constants – not variables. The statistics of biogeography developed with a preoccupation on processes and patterns unfolding on strictly ecological timescales. Being fueled by its innovative application to conservation biology – the future of species – modern biogeography had little motive, at least at first, to preoccupy itself with the past, let alone the ancient.

> *Much of the research on island assembly has been based around 'snapshot' data, capturing distributions at a particular point in time. However, the dynamics of island biotas have also been the focus of study and debate.* [25]

While the biogeographers of Wilson and Macarthur's era were rifling through the "snapshots", the emerging faces of "historical biogeography" began asking some unconventional and ambitious questions, the central one being: what happens when to an island's biogeography when viewed through the lens of time?

It is important to note that a comprehensible view of natural history at any time scale requires literacy in both evolutionary biology *and* ecology. They may be asking different questions, but the work of ecologists and evolutionists are nonetheless inextricable. This is because evolution is simply ecology-writ-large, and conversely, ecology is the mechanism of evolution. Their respective proceedings are perpetually, dialectically enforcing each other. Each field would be incomplete and myopic without the other. "Evolution cannot work without ecology to drive it; ecological communities operate within the constraints of evolution."[26]

This creates an interesting and at times confounding dynamic. To look around and see the interaction of these two machinations synthetically and comprehensively is a tall order indeed. But those revelatory moments in which their dance becomes apparent and beautiful are truly extraordinary and sublime, if rare and challenging.

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[24] Ibid., 5.
[25] Ibid., 6
[26] Ibid., 5.

It must be earned. It is the naturalist's nirvana. But to achieve this deep perception of life, just as much as we must immerse ourselves in the diversity of the present, we must also call upon the wisdom of the past – of deep time. We must consider biogeographic patterns in the world's biota both spatially *and* temporally. Indeed, a serious comprehension of the consequences of the interplay between deep time, speciation and ecological processes truly requires a comprehensive approach.

> *The islands move horizontally and vertically and thereby grossly modify the environment on and around them. Life forms too must evolve, migrate, or become extinct as the land changes under them.*[27]

The vast promises of this kind of synthesis have only recently been pursued with collective earnest, and the coincidences of the field's birth are remarkable. The other ingredients for this new pursuit were actually coming together while Wilson and Macarthur were refining and undergoing peer reviews for their theory of island biogeography in the 60's, but it was occurring in an entirely different academic department, a field presumed to be only anecdotally and quaintly related: geology.

The study of the earth was undergoing its own revolutions in that unpredictable decade. The seeds of this revolution had been germinating for almost a half century, brooding and boiling ever since Alfred Wegener first muttered the words, "continental drift" to chilled reception of his peers at the turn of the century.

Following the eventual acceptance of the theory of plate tectonics, geology was in prime position to offer its insights into Wilson and Macarthur's nascent field. And, as it turns out, geology came to have the same intoxicating, sublime effect on the fringes of modern island theory that kava has on the visitors to Fiji. Geology, with its dark corridors of deep time, invite the ecologist to take another round of kava, broaden the temporal dimensions by which they assess the world, and with a hearty shout of "Bula!, celebrate the new, ancient profundity of the nature. True to its island roots, biogeography got a dose of "Fiji time" in its partnership with the revolutionary theory of tectonics.

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[27] Menard (1986) qtd. in Whittaker, Robert J. and José María Fernández-Palacios. 2007. *Island biogeography : ecology, evolution, and conservation.* New York: Oxford University Press. pg. 196.

Chapter 3

(R)evolution

Quic Quid Subterra Est
"Whatever is Under the Earth"

It was that very partnership, between where life is and what is lives atop, that brought me to London four months after my return from Oceania. The Captain and I had parted ways on a blustery day in late July, on a corner of the Cumberland Plateau, with an indefinite goodbye. He was off to a year of round-the-globe research, in search of notorious fossil localities. I had a year left of school, during which I'd be applying for similar kinds of post-matriculation adventures, and there was no telling when we would see each other again.

Then, out of the blue, the Captain contacted me in late October with an urgent message: through contacts with a museum in Eichstadt, Germany, he had secured two tickets to the 200th annual conference of the Geological Society of London. The theme of the conference: "In the Footsteps of Our Founding Fathers," a framework for reflecting on the long process of integrating geology into the other natural sciences. It was to be a historic event, remarkable even for this, one of the oldest learned societies in the world. If I could raise the funds for a flight, I'd be able to reunite with the Captain in ground zero of the naturalist revolutions of the 19th century, the epicenter of those seismic trains of thought that demolished and rebuilt the worldviews of entire civilizations. We would walk the same streets that Owen, Banks, Darwin and Wallace had walked as they were mulling over the nascent puzzles that would lead to their explosive theories. We would explore the far corners of the natural history museum, reverie in the multi-floored, mahogany adorned shelves of the Geological Society's archives. In our own meager worlds, it would be an outrageous landmark. I had to meet him there.

Somehow, I found the funding. My professors and advisors exhibited amazing faith and support for this idea, and suddenly, serendipitously, I made it onto a Delta flight with a stand-by ticket that would disperse me high over the Atlantic to the next island of my wide-eyed attention: England.

Five months to the day after Captain Luke and I had left Dunedin for our final bewildered weeks within New Zealand, I was waiting on the weathered benches of the fountain of Buckingham Palace, St. James Park, 9:30am, Greenwich Time. From around the corner, weaving between two shuffling mobs of Japanese tourists, here came the Captain. It was a drizzly, dreary, perfect London day. Needless to say, the reunion was glorious. Picking up right where we left off, we made straight for London's cathedral of natural history, the Museum. Two days mornings later, in mid-November fog, we stepped across the threshold of the Burlington House, the venue for the bicentenary conference's venue. This massive, marbled façade held within its bosom the headquarters for all the learned societies of London. Each wall of the expansive stone courtyard had at its center a heavy, ornately-hinged wood door with gold letters displayed above: the Geological Society. The Chemistry Society. The Astronomical Society. The Antiquities Society. The Center for the Arts. And, across the arched gateway from the entrance to the Geological Society, the Linnaean Society. The Captain and I were barely hanging on.

Carl Linnaeus, the famed taxonomist, botanist, and epitomic naturalist, was born in 1707, exactly 300 years Before Present. The Linnaean Society was one of the world's first natural history societies and is still the eminent flagstaff for the natural sciences worldwide. A hundred years after Linnaeus' birth the Geological Society of London, the first official geological society in the world, was born. And, slightly more than 150 years after the Linnaeus' birth and 50 years after the Geological Society's chartering, Darwin published his book, changing everything. In another 100 years, 150 after the Society's birth, island biogeography became Theory, and the geological sciences were in the throes of their own fundamental revolution: the notion of plate tectonics.

The situation for mid-20th century geologists was analogous in many ways to that for Darwin's peers once *The Origin of Species* came to press. For years, evidence had been mounting. Just as Wallace was nipping at Darwin's heels with his own, independently conjured theory of natural selection, a subversive clan of geologists were concocting their own versions of the tectonic theory, some cooperatively, others fiercely protective of their work. It was a race to publish first. But ultimately, against all odds, the earnesty of the competition culminated in widespread collaboration -- just as had the first published article about natural selection, team-written, more or less, by both Darwin and Wallace. And, just as those two had been searching for a mechanism to a long-standing truth, recognized albeit reluctantly by the majority of the mid-19th century naturalists, that life somehow changes over time, so too were the geologists of the 1960's looking for the mechanism to their own begrudgingly accepted mystery, the phenomenon of "continental drift."

Alfred Wegener was the first to coin the above phrase, in his 1915 book *The Origin of Continents and Oceans*. He wrote at length about the coasts of South America and Africa, and the curious fact that they would fit together surprisingly well, if only there weren't an ocean between them. It was almost as if, at some point in the recesses of deep time, they had indeed been all of a piece. The coastlines' inversed shapes, the ages of rock, the patterns of sedimentation and fossilization on each landmass – it all added up too well not to mean something.

Wegener was not the first to document these curiosities; he was preceded by Francis Bacon, Benjamin Franklin, and Frank Bursley Taylor, among others. But no one had ever proposed an explanation as bold as the hair-brained idea of floating continents. Not surprisingly, the scientific community responded with skepticism, unanimous and at times severe. If Darwin's experience with his release of his own cockamamie idea serves as any testament, it seems the more grand the ideas in the natural sciences, the more they are met with vehement, conservative skepticism. Geologists balked with equally dogmatic fervor at Wagener's hypothesis. By the 1950's, his ideas had been all but dismissed.

But then, in a sudden and remarkable burst of cascading discoveries, four major developments resuscitated Wegener's ideas.[28] The first was technological advancements in bathymetry, fueled by the Second World War; suddenly, oceanographers could look at high-definition maps of the sea floor's mystifying features, including

[28] Watson, J.M. "Plate Tectonics: Developing the Theory" USGS. 05 May 1999. http://pubs.usgs.gov/gip/dynamic/developing.html#anchor10936483

inexplicable ridges and shockingly young plains of basaltic flows. The second was the revelation that the global magnetic field had suffered sudden reversals throughout the earth's history. This became evident after scrutiny of basaltic ocean basins, whose metallic elements oriented themselves with undeniable patterns of polarity. The third, born of the previous two, was a new hypothesis on the block known as "sea-floor spreading". And fourth, the eyebrow-raising realization that global seismic and volcanic activity tends to be concentrated along those oceanic trenches and submarine mountain ranges. The evidence, as I said, was mounting.[29]

By the end of that formative decade, the idea of tectonics was released in a series of papers – most notably "The tectonic approach to continental drift" by Tasmanian geologist Samuel Warren Carey in 1958, and the 1962 paper "History of Ocean Basins" by Harry Hammond Hess of Princeton.[30] Hess' essay was particularly influential, the geologic analog to Darwin's *Origin*, not only in subsequent influence but also in initial apprehension and dismissal. As happened to Wegener's ideas, many scoffed at Hess and dismissed the notion of plate tectonics as downright absurd. Nevertheless, just as in Darwin's case, the more scientists that challenged the tectonic theory, the more the anti-tectonic side managed to undermine them, and the fewer reasons the opposition could cite for their stance. Slowly, the theory began to hold its own, to the extent that Hess was able to receive some vindication and honor for his work before his untimely death in 1969. And in the 70's, his theory of sea-floor spreading and subduction had reached the cusp of general consensus.[31] Despite the ideological inertia inherent to these sciences, tectonics, just like evolution, eventually achieved a heroic coup. Each has become the foundational principle – the cornerstone -- of its respective field, forever changing the trajectory of its development as a result.

A unique dimension of geology has always been that it is highly interdisciplinary. It draws on observation and experimentation from several other fields, including geography, paleontology, oceanography, chemistry, physics, climatology and even biology. This is well-illustrated by the array of specialties represented in the eleven founding members of the Geological Society of London.

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[29] Ibid.

[30] Watson, J.M. "Harry Hammond Hess: Spreading the SeaFloor" USGS. 05 May 1999. http://pubs.usgs.gov/gip/dynamic/HHH.html

[31] Ibid.

Richard Knight (1768-1844), was a chemist.[32] Parkinson, Babington, Lairel and Franck were all medical doctors.[33] Henry De La Beche was a land surveyor.[34] Most of them were Quakers.[35] Paleontology, mining, and other forms of "practical geology" certainly helped legitimize and popularize geology in Great Britain and France,[36] but even without such social utilities the field of geology first gained its footing and accreditation through its interdisciplinary basis. Since its birth, the Geological Society was notorious for its interdepartmental, synergetic, and versatile tendencies amid the partitioned walls of the Burlington House. It was a confluence. Ever since, this legacy has spread beyond the Society's varnished halls and permeated throughout the field of geology. Today, despite its increasing number of specializations, the science is a proud monument to these inclusive beginnings.

In light of science's stigma as a sanctuary of narrow-minded reductionism, it is interesting that the most historic and influential figures in modern science have been those that specialize in integration and synthesis. Charles Darwin, as an example, was not only a comparative biologist and evolutionary theorist, but also an accomplished geologist. He was a former medical student, a former seminarian, and first and foremost, a geologist, self-proclaimed. He was a long-serving member of the Geological Society of London and the Russian Geological Society.[37] Only by gathering his interdisciplinary knowledge and applying innovation and imagination to it all did he change the course of Western civilization. John

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[32] Knight, David. "Chemists Get Down to Earth." In the Footsteps of Founding Fathers Bicentennary Conference, Geological Society of London. Burlington House, London, 12 November 2007.

[33] Lewis, Cherry. "Doctoring Geology: the Society's medical men." In the Footsteps of Founding Fathers Bicentennary Conference, Geological Society of London. Burlington House, London, 12 November 2007.

[34] Clary, Renee and James H. Wandersee. "All are worthy to know the Earth: Henry De la Beche and the origin of geological literacy." In the Footsteps of Founding Fathers Bicentennary Conference, Geological Society of London. Burlington House, London, 12 November 2007.

[35] Torrens, Hugh S. "Dissenting Science: the Quakers among the founding fathers." In the Footsteps of Founding Fathers Bicentennary Conference, Geological Society of London. Burlington House, London, 12 November 2007.

[36] Knell, Simon. "A Society in a Nation of Geological Societies: the Geological Society in its early nineteenth century context." In the Footsteps of Founding Fathers Bicentennary Conference, Geological Society of London. Burlington House, London, 12 November 2007.

[37] Taquet, Phillipe. "Geology beyond the Channel: the beginnings of geohistory in France in the early nineteenth century." In the Footsteps of Founding Fathers Bicentennary Conference, Geological Society of London. Burlington House, London, 12 November 2007.

Baptiste Lamarcke, Lyell, and Cuvier – all of whom were geologists first and foremost – studied fossils too, and had each developed their own nascent notions of evolution long before Darwin climbed aboard the *H.M.S. Beagle*. It turns out that evolution, the defining idea of modern biology, came first from the minds of geologists.

It was only a matter of time before the revolution incurred by ideas of Wegener, Hess and Carey -- that the maps we have been using to illustrate the positions of land and life are too darn still, that the only illustrations that are helpful in understanding the past are animations – would grow to influence that other burgeoning brainchild of the 60's, island biogeography. Indeed, since its very inception, biogeography seemed at its best when interacting with conventional branches of natural history, an extroverted, team-building idea. Its basic theses had already been pushed well beyond the classical notion of the island, that prototypical Fijian ideal, into the realm of conservation biology. Now scientists were pushing biogeography even further, out to the brim of a much more terrific and terrifying frontier, out of biology altogether: the lost worlds of deep, tectonic time. How successful would such a radical collaboration be? Would there be space in biogeography's conceptual plane for a third dimension?

The Pangaea Paradigm

As it turned out deep time, although incomprehensibly long, allowed many to understand more completely the relationship between life and place. What happens to the biogeography of an island arc when the islands get shuffled around? This question was purely hypothetical before the tectonic revolution. But as a result of its coup, biogeographers suddenly had to reconcile their theories with shifting landscapes. Tectonics showed that landmasses change in shape and location. What does this do to the life on them? What if, for example, a once-continuous habitat becomes fragmented?

Perhaps the most obvious case study with which to begin is the breakup of Pangaea. It was once a cohesive landmass throughout which terrestrial organisms could migrate, disperse, expand distributions and explore freely. Then, in the Jurassic, as it began to rent apart along a multitude of hidden seams, Pangaea itself began evolving, literally diverging, into a collection of giant islands. The sequence of these enormous schisms, it turns out, contains the key to the otherwise senseless modern distributions of mammals worldwide. North America and Europe are largely depleted of both monotremes and marsupials (let us ignore, for the moment, the opossum), yet teeming with placentals, while South America is rich in marsupials and deplete of monotremes, and Australia is teeming with monotremes and marsupials and nearly completely depauperate of placentals? What a confusing mess! Before tectonics, these troubling facts were explained away by land bridges, which mammals used to disperse to distant lands via ephemeral corridors of land during periodic drops in global sea level. A far fetch in many ways, but now, with tectonics moving in to fill certain gaps, we have a much more cohesive and plausible working theory:

A hundred twenty million years ago, Pangaea's southern half, later named Gondwana, had already begun to split away;[38] India and Madagascar, almost immediately, split from the splitting fragment and began retreating north, back to what remained of Pangaea (known as Laurasia). Antarctica, South America and Australia were still connected in the form of Gondwana, but their divergence had also already begun, such that there were wide corridors between landmasses.

Around this time, the ancestral platypus, that wacky basal mammal known representing the crotchety subclass of the monotreme, found its way onto the corner of Gondwana that would one day be Australia. At one point the platypus' range stretched from proto-South America to larval Australia; we know because of a 63-million year old fossil tooth of a platypus found in Patagonia.[39] From South America, this group of early mammals dispersed even further, onto the North American continent, which had briefly collided and connected to its southern counterpart. When Panama's isthmus was disconnected in one of its myriad submersions by rising sea levels, these two isolated mammalian populations diverged.[40] The North American monotremes evolved into placentals. In South America, some monotremes evolved into marsupials, while others remained egg-layers, true to their heritage. When the isthmus again connected the North and South American continents, these distant-but-now-unrecognizable relatives – the placentals of the north and the marsupials of the south -- crossed into the each other and met up again, unawares of their ancient kinship. But neither could

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[38] Johnson, David. *The Geology of Australia.* School of Earth Sciences James Cook University: Cambridge University Press, 2004. Pg. 135.

[39] Ibid., 135.

[40] Berra, Timm M. *A Natural History of Australia.* San Diego, CA: Academic Press, 1998. Pg. 225.

successfully usurp the niches of the other; by the time the isthmus once more submerged, North America still belonged to placentals, and South America belonged -- albeit to a lesser degree -- to the marsupials.

While the placentals were subsequently isolated on their North American island, the South American biota were free disperse across Antarctica and into Australia, and that's precisely what they did, extensively, until a fountain of divergent plate boundaries succeeded in pushing up an ocean between Patagonia, Antarctica and Australia apart 35 million years ago.[41] For some time after their separation, when the ocean between them was young, shallow, and not yet wide, land bridges played their part in prolonging the cross-continental dispersion for some millions of years to come. Before the seas had receded for the last time, South America's marsupials had managed to hop from Antarctica all the way to Australia. Alone on their island continents, the marsupials of South America and Australia evolved their separate ways, adapting to very different landmasses with unique resources and climates. With fewer mammalian species and no placentals with which to compete, Australian marsupials radiated to fill all sorts of vacant niches. As a result, Australian marsupials look nothing like South American marsupials today.[42,43] Tectonics: the Great Sculptor.

Although it may at times be confusing and complicated, it is interesting that *story* is the best format with which to explain why these animals the way they are.

Passive Transport

Pangaea may be the most obvious go-to example of "deep biogeography," or historical biogeography, as it is commonly known. But to grasp the extent to which tectonics has affected life's distributions, we should look what was surrounding the supercontinent: a vast ocean, full of constantly shifting ocean currents, always responding to the aggregations and upheavals of

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[41] Johnson, David. *The Geology of Australia.* 135.
[42] Berra, Timm M. *A Natural History of Australia.* 225.
[43] Another crucial result of Australia's isolation was the evolution of song birds, the Passeriformes. Insular habitat allowed this lineage to evolve uniquely until another continent drifted within flight range. Jønsson, Knud, A. & Fjeldså, Jon (2006): Determining biogeographical patterns of dispersal and diversification in oscine passerine birds in Australia, Southeast Asia and Africa. *J. Biogeogr.* **33**(7): 1155–1165.

tectonics. As tectonic plates performed their amorphous waltz to the march of deep time, ocean currents responded accordingly. Sometimes, such as during the final separation of Australia and Antarctica 35 million years ago, and later the separation of Antarctica and South America, these changes have been monumental, triggering cascading changes in the biosphere and global climate. The isolation of Antarctica allowed for the formation of a circumpolar current that which completely re-routed global currents in all oceans around the world. It created a frigid barrier between marine flora and fauna within itself and those just outside of its boundaries.

The historic digressions and precessions of ocean currents have also allowed certain fauna to distribute to latitudes they would otherwise never reach. As plates continued rearranging, currents occasionally swept the Antarctic's waters up along the shorelines of austral continents, pushing polar species onto austral shores of Patagonia, Australia, New Zealand, and Africa. In the Eocene and Oligocene, rearranged ocean currents pushed a jet stream of cold water from the Antarctic circle up along the western coast of South America and past the Galapagos Islands. This enabled a population of penguins (O. Sphenisciformes) to disperse from their Antarctic feeding grounds and establish on the Galapagos.[44] These penguins are now called, predictably, the Galapagos penguin (*Spheniscus mendiculus*). This unassuming, tropical, flightless torpedo demonstrates the explanatory pattern of global landscape change in outlandish biogeographic puzzles.

In re-directing oceanic currents, plate tectonics has the first and final world on marine biography. Consider krill: these planktonic critters act as convenient tracers for watching the broad movements of ocean currents. These passively-floating microscopic fauna are swept along with the changing course of currents, and have done so deep into the ocean's past. As the krill trains change their global tour, so too does the entire marine food web; if the planktonic foundation of the trophic chain shifts course, the rest must follow suit, or perish. Even species as seemingly unmovable as the whales go to great lengths to keep up with the krill they filter feed. Tectonics, therefore, indirectly control the migratory patterns of the ocean's grandest denizens. In fact, the tectonic separation of South

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[44] Fordyce, R.E. and Jones, C.M. 1990. "The history of penguins." Pages 419-446 in Davis, L.S. and Darby, J.D. (editors). Penguin biology. Academic Press, San Diego. 467 p.

America from Antarctica is said to have been responsible for the infamous cetacean radiation during the Oligocene.[45]

Out of Many, One

So Pangaea and the changing ocean currents are iconic examples of the biogeographic repercussions of a landscape's dissolution into several chunks. Perhaps the flip side is even more interesting: what if a landscape that is now continuous were once fragmented? This could happen by mountain building or changing sea levels or continental collisions and separations? This just happened to be the case in Mesozoic Australia: about 117 million years ago, the landmass, newly disjointed from its Gondwana brethren, a massive rise in sea level divided it into a multitude of massive islands separated by shallow straits. The "Australian Arc" remained in this differentially submerged state for over 18 million years. During that time, a linear series of volcanoes erupted off the eastern coast of the continent, barraging the island-continent with volcanic effluent. As this volcanic debris accumulated on the continent it shallowed the infringing seas. By 99 million years ago, the inland sea had been pushed back to close to its original shoreline. But that 18-million-year stint as an archipelago had a profound and permanent effect on Australia's biota. Both vulcanology and biogeography is essential to comprehending the life history of a landmass that today is uniform and vast.

Geologists have found a similar situation in Oligocene New Zealand, 25 million years ago. Oddly enough at this time, New Zealand looked quite a lot like a giant Fiji. Imagine a golf course halfway submerged – with the tops of its rolling hills, tee boxes and greens dotting the otherwise submerged landscape, and that was pretty much the layout of this New Zealand Archipelago. And, of course, understanding the modern distribution of New Zealand's biota is impossible without understanding the influence of this Oligocene arc. The obvious question in this case is a specific example of the basic question of "deep" or historical biogeography. That is, to what extent does the contemporary biota of a place reflect those insular periods of its deep, obscure, and shadow past?

[45] Fordyce, R.E. 1989. Origins and Evolution of Antarctic marine mammals. –Special publication of the Geological Society of London, 47: 269-281; Whitmore, F.C. 1994. Neogene climatic change and the emergence of the modern whale fauna of the North Atlantic Ocean. –Proceedings of the San Diego Society of Natural Historuy, 29:223-227.

Answering this requires a great collaboration, a synthesis of various specialties. These partnerships – between geologists and ecologists, between deep time and our current snapshot of life - link the greatest theory in the natural sciences of the 19^{th} century (evolution by means of natural selection) to its greatest theory of the 20^{th} (plate tectonics). The resulting scientific worldview, embodied by the new field of historical biogeography, would have filled the Geological Society's founding fathers with pride.

Chapter 4

Why Not?

It is time at last to discuss directly the term on which this entire book hinges: historical biogeography, that hybridization of Island- and Tectonic-Theory, which has inherited geology's historic penchant for its integration of different field sciences and biology's growing toolbox of analytical methods. Its goal: not only to recount more completely the Story of Life, but to go the next step: to map it. To extend the principles of biogeography back into deep time, by incorporating principles and consequences of tectonic plate movement into the residential and evolutionary histories of species. To repeat, the field's primary question is this: what has happened spatially over the course of deep time to create life as we know it today? What role have tectonically changing contexts played in changing us?[46] This fairly new science (it became legitimate and influential only 20 years ago[47]) coalesced as more and more scientists were looking at the influence of plate tectonics on environments that have been subject, throughout their history, to the patterns of island biogeography. Environments like that of Australia and New Zealand. Environments like Oceania.

[Historical biogeography] is currently in the throws of an "extraordinary revolution concerning its foundations, basic concepts, methods, & relationship to other disciplines of comparative biology. [48]

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[46] Bergaminin 1964.
[47] Morrone, J.J., J.V. Crisci. 1995. Historical Biogeography: Introduction to Methods. Annual Review of Ecology and Systematics, Vol. 26, pp. 373-401.
[48] Ibid., 374.

Historical Biogeography

Simply put, historical biogeography involves 3 disciplines of the natural sciences – biology, geography, and geology. More specifically, it incorporates methodologies from five scientific niches: Dispersalism, phylogenetic biogeography, panbiogeography, cladistic biogeography, and parsimony analysis of endemicity.[49] Since the movement's beginning, taking its cue from the highly mathematical concepts of Wilson and Macarthur's theory of island biogeography, there has been an attentive emphasis on finding methods to evaluate relatedness and phylogenetic associations quantitatively.[50] This statistical penchant legitimized the new science from the start, with early papers preoccupied with improving methodology; an example of such a statistically resourceful paper.[51]

A chief difference between ecological and historical biogeography is that in the latter, the critical question of how species arrived on a landmass is much more difficult to answer. While Fiji, being so geologically young, was surely colonized by dispersal events – flying in on their own accord, floating in on a coconut, being blown in by the sea breeze, etc. -- there is compelling evidence that such events are outliers in the biota of Australia or New Zealand. Those landmasses, as we already know, were once part of an ancient supercontinent, Gondwana. So the question arises: which life arrived by dispersal and which was carried from Gondwana on the drifting tectonic plates that compose Oceania today? Which drifted in on a coconut, and which hitched its ride on a tectonic coconut? This is the basic question underpinning the heated controversy of "Dispersal vs. Vicariance", a classic and still-active area of debate within historical biogeography. Much more on this later.

As we have seen, historical biogeography is the study of what lives where and why.[52]

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[49] Ibid., 373.

[50] Ronquist, Fredrik. 1997. "Dispersal-Vicariance Analysis: A New Approcah to the Quantification of Historical Biogeography." Systematic Biology, Vol. 46, No. 1, March. Pp. 195-203.

[51] See Brooks 1990, which proposed a sounder methodology for co-speciation analysis, in which one measures the degree to which the phylogenetic evolutionary divergence of geographically and ecologically associated biota have coincided.

[52] Gibbs, *Ghosts of Gondwana.* 34.

Endemism

Thinking in terms of the unimaginable breadth of deep time compels the naturalist to look at old concepts in a new way. Let's take endemism as an example. This applies especially to the biota of Oceania, for compared to the rest of the world, and even relative to islands within the region, it is notoriously and singularly unique.

The scientific term for unique is "endemic." An endemic species is one that is found in one place and nowhere else. Geographically, temporally, physiologically unique. The proportions, numbers and natures of endemic populations in a place can often tell you a lot about the story of its life. Take New Zealand as an example. At the taxonomic organizational level of Order, three of its vertebrates are endemic; there are three orders of vertebrates in the world that can only be found in New Zealand. At the family level, nine vertebrates and five invertebrates. At the species level, 2,000+ vascular plants are endemic, 200+vertebrates, and 20,000+ invertebrates.[53]

While the latter, species-level stats seem most impressive, one gets a better feeling of a community's utter uniqueness by examining the endemism present at higher taxonomic levels. This is a basic biogeographic principle: the higher-order the endemism, the more isolated the habitat has been, geographically and temporally, throughout recent deep time.[54] New Zealand is host to an endemic family of frogs, the Leiopelmatidae, which consists of four fascinating species. It is also home to the genus *Mystacina*, short-tailed bat- the only survivor of the bat family Mystacinidae. There are three endemic insect families in New Zealand: The batflies – Mnesarchaeidae; the Chathamiidae, containing fourteen primitive moth species; and a family of marine caddisflies. There are also two spider families endemic to New Zealand.[55]

Such totals, however, do not provide the information that is most informative. Percentages are what matter most in this matter. Before humans came to New Zealand -- that is, before 1,000 years ago -- 86% of grass species were endemic. 84% of flowering plants. 71% of all its breeding birds. Of all New Zealand's land birds, 88%. All species of stoneflies, mayflies and phasmids were 100% endemic; 100% of its lizard and frog species were unique to itself. 86% of

[53] Ibid., 18.
[54] Ibid., 121.
[55] Ibid., 18.

freshwater fishes, 100% of stream insects, and 95% of all insects were endemic. These ratios are insanely high compared to normal mainland numbers.

This rampant endemism is characteristic of most island arcs. In Hawaii, 81% of bird species, 91% of angiosperm plant species, 99% of mollusks and 99% of insects are endemic. Weirdness is simply part of island life.

There is also evidence to suggest that the bigger the island, the "weirder" its life is. Huge islands, like Madagascar, New Zealand, and Australia, have both continental habitats in its interior and simulated insular habitats along their coasts; their compounded habitat diversity is reflected in the diversity and uniqueness of the biota of these macro-islands. It's the "most of both worlds." [56]

It is important to remember, however, that not all islands nowadays are host to such impressive endemics, especially not since the invention in forestry of the clear-cut. Great Britain is an unfortunate example of this. As a huge island, with continental habitats at its center, in the middle of the Atlantic Ocean, it is geographically comparable to Madagascar or New Zealand; you'd expect high endemism and dense biota there. Yet the numbers reflect no such similarity; there are only two endemic vertebrate species in Great Britain. Total. This serves as a reminder of the rarity and value of the islands within Oceania, especially in this era of receding imperialism – they are other-worldly, or at least, they might as well be. An average Australian backyard has higher reptile diversity than all of the United Kingdom. No wonder those explorers sailing under the Union Jack could not believe their eyes.

Let's skip over to Australia. 80% of Australia flora and fauna are endemic. To be honest, however, its vast, troublesome size (too big to be considered an island, to small to be a continent) makes it is difficult to gauge whether or not this statistic is actually meaningful. But do not forget that Australia is host to an endemic subclass of mammals, the monotremes. This has got to count for something.

The impressive statistics regarding Oceania's life beg a question: what is it about the history of New Zealand and Australia that leads to all this insurmountable endemism? Why is Oceania so far off the charts here?

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[56] Statistics compiled from throughout Whittaker, Robert J. and José María Fernández-Palacios. *Island biogeography : ecology, evolution, and conservation.* New York: Oxford University Press, 2007.

Let's approach this by asking the same thing on a smaller scale, within Oceania itself. New Zealand and Australia both house notoriously weird animals, but interestingly, they are weird in completely different ways. Both are in Oceania, and both are extremely close to each other, so why are they so odd even amongst themselves? Perhaps answering this question of smaller scale can assist us in the larger mysteries.

"As practiced by thoughtful scientists, biogeography does more than ask which species? Where? It also asks, why? And what is sometimes even more crucial, why not?"[57]

The central question of ecological biogeography is often, "Why?" Why is a species' distribution just so? Why is this population on that island different from this population on that island? Such questions tend to have obvious, almost tautological answers. Endemics usually live in only a certain area because that area is particularly optimal for them, or particularly not attractive to any other species. It only makes sense that a rare animal with special needs would be confined to the one habitat that suits it perfectly.

Historical biogeography, however, takes it one step further, still asking, "why?" but also asking, more persistently, "why not?" Presences tend to be much easier to explain than absences. It is especially confounding when the fossil record tells us that something was once here and now is other places instead. What *happened* to isolate a population for so long, and why is an endemic *not* successful welcome in other, seemingly identical habitats? This is a question of absence, which is marred by its own inherent mystery and speculation.

Like its opposite, the question, "Why not?" is inextricably linked to place. The question of absence must be asked in relation to nearby *presence*. For example, in New Zealand, several taxa throughout its history have been either completely absent or conspicuously rare- monotremes, snakes, crocodiles, land turtles, dinosaurs, lung-fishes, scorpions, ants, butterflies (only two of world's eight families are present), cycads, horsetails, etc. However, *all* of these taxa are both present and prominent in New Zealand's closest neighbor, Australia. Why not in New Zealand!?! If it weren't for the jagged juxtaposition, the question of "Why not?" may have never occurred to us, and it would certainly not be so

[57] Quammen, David. *Song of the Dodo*. Pg. 17.

vexing as it is. How can two such intimate landmasses be so different biologically?

The answer, of course, is in its history.

The Tuatara Disparity

The natural history of the tuatara, a hermitic, crotchety reptile of New Zealand, is an iconic example of how a tromp through deep time can both enrich our understanding of a place and its history – and pose larger questions in the process.

Though my premise here is that historical biogeography enriches and fills in the holes of the story of life, makes it even more compelling than our immediate senses can on their own, it is important to establish from the get-go that mystery still runs rampant throughout this field – and rightly so! Pushing aside the more trivial and less challenging questions to make room for the more profound, engaging, and terrifying ones is part of what science is all about. Deep time and the fossil record answer questions but simultaneously raise deeper, more compelling ones.

Once referred to as that "cold-adapted reptile for whom time seems to have stood still",[58] fossils of ancestral tuataras show that this old codger has not changed body shape or size significantly for over 100 million years. Given its name from the Maori phrase for "peaks on the back," it was originally classified as a lizard upon its discovery in 1831. But their superficial resemblance to iguanas (although serving as an excellent example of convergent evolution) shamefully hides the tuatara's true and shocking weirdness from any untrained eye.

Tuataras can live to over 100 years in age. They have no separate teeth, only sharp serrations on their jawbones, which happens to be extremely powerful. They are drastically sexually dimorphic, with males often weighing more than twice as much as females. The male tuatara is also, unofficially, the laziest fighter in the animal kingdom. Territorial disputes between them are a long, tedious, strikingly anticlimactic ordeal: the males face each other grimly, with calculated step, and slowly shift their weight from side to side, like a couple of sauntering cowboys in slow motion, in what they perceive to be menacing gestures. Eventually, after minutes of suspense, they lunge at each other's necks, feigning dangerous

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[58] Gibbs, *Ghosts of Gondwana.* 157.

strikes. Then, they rest for 20 minutes or so before resuming their battle, from the beginning, with that side-to-side sway. This can go on for hours. Surely, for tuataras, it is about as much excitement as they can handle. The rest of the animal kingdom remains nonplussed. In their defense, they *are* 100 million years old.

The tuatara's physiology is much more remarkable than their fighting style. They have a third eye, located directly on top of the skull, right above the brain. While this eye is visible on its skull when young, this primitive-light detection organ is covered by the growth of opaque scales as an adult. That eye is used to detect changes in daylight in order to maintain a circadian and seasonal rhythm; plus, it saves them the trouble of cocking their head to look up.

Their reproductive behavior is equally out there. Tuataras have a very slow breeding rate: only one or two eggs once every 4 or 5 years. This is thought to be the best they can do, being both nocturnal and cold-climate exotherms. The gestation period for this egg is 12-15 months, and the sex of their young, like crocodilians, are determined by the temperature at which it is incubated. Juveniles don't reach sexual maturity until they are 15 years of age. It is almost as if they would rather not reproduce.

Bu once upon a time, believe it or not, New Zealand was teeming with tuataras. According to the fossil record, nearly every landscape in New Zealand was host to a tuatara at some point. Despite this local ubiquity, scientists assumed, until the 1950's, that the tuatara had always lived strictly in New Zealand and nowhere else. But, much to their dismay and eventual excitement, fossil digs all around the world began digging them up; it turns out that the tuatara's order, Sphenodontia, was nearly cosmopolitan, meaning it was found on nearly every continent in the world, except understandably, Antarctica or, oddly enough, Australia. Given the difficult climactic conditions in Antarctica, its absence there is understandable; but why not Australia? It's right there! Even more perplexing is that those two landmasses were the closest platforms for any species wishing to make it to New Zealand; how did the sluggish old tuatara arrive to New Zealand if not via Oz or Antarctica? Have we just not looked hard enough on these neighboring landmasses? Possibly…but we are also compelled, impatient to work with what we have. Let's assume, in this case, absence of evidence *is* evidence of absence…

If it weren't for the fossil record, the scientists could rest easy, conclude that the tuatara evolved on Gondwana and dispersed throughout it before it broke up, then floated down into the southeastern hemisphere on the tectonic raft of New Zealand, where it survived but the Sphenodontids on all other landmasses didn't stand the test of deep time. And that would be that. Whether the tuatara truly is Gondwana-born or just an Eocene invasive, we know with certainty, from certain fossils, that it was living on New Zealand's shore before the landmass sunk in the Oligocene 25 million years ago – a period of time in which nearly all of New Zealand was submerged by advancing seas. Somehow, the tuatara survived the dunk. Perhaps the landmass wasn't completely submerged. Maybe it only got its toes wet. But for the last 25 million years, there has been no fossil evidence of tuataras on any other landmass. This fact earns the tuatara the impressive title of being a "paleoendemic,"[59] a term for species that were once greatly distributed but whose other populations elsewhere were extirpated over time. The New Zealand tuatara was left stranded, alone, in the middle of the South Pacific.[60]

Paleoendemics raise the burning question: What happened? *Why not* anywhere else anymore? Why doesn't the tuatara or its relatives still thrive in those areas of previously vast abundance? What is the deal? Is it because of the presence of mammals, their tendency to out-compete or eat anything that gets in their way? A changing climate? Rising sea levels? A world-wide tuatara-targeting virus that somehow missed lower Oceania?

The answer to these questions, to the question of historical biogeography -- "Why not?" -- compels the relentless questioner to look again into the natural history of the landscape, to diffuse one's attention away from the tuatara alone and out into other kinds of evidence from the land – paleoclimatology, paleopathology, paleoecology, paleo-anything-and-everything. It is a wonderful thing that such an inquisitive approach to the presents and pasts of species like the tuatara inspires a second and broader look at the story of life, a closer look around.

Today the tuatara survives only on thirty two tiny, rat-free islands, including the Cook Strait Islands (between New Zealand's north and south islands) and a few remote islands off the northeast coast of the North Island, closely watched by the nation's

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[59] Pico FX, M Moller, NJ Ouborg, QCB Cronk. Single Nucleotide Polymorphisms in the Coding Region of the Developmental Gene Ccyc in Natural Populations of the Relict *Ramonda myconi* (Gesneriacaeae). *Plant Biology* 2002; 4:625-629.

[60] A "neoendemic", on the other hand, is a species whose ancestors dispersed from a population to an isolated landscape and speciated into the endemic it has become.

Department of Conservation. It is hanging on by a thread. Many have rallied behind the momentous efforts to give the tuatara hope. The Southland Museum and Art Gallery in Invercargill, at the bottom of the country, has a tuatara enclosure that recently achieved the first successful captive tuatara breeding program. Naturally, I made my pilgrimage to the gallery. It was in this way that I came to meet Henry, the world's oldest and fattest tuatara on record.

I edged up to the glass and peaked into the small, heat lamp-lit room, designed to look like an island outcrop with sand dunes punctuated by clumps of tussock grass. There Henry sat, motionless. I spent my first twenty minutes in his presence trying to determine if he were, in fact, alive. Or was this a statue of Henry, and the real tuatara was hidden in his burrow? I finally concluded that yes, this was the real Henry, and yes, he was living, if that's what you call it.

For the entire hour I spent looking at Henry, he did not move – he never even blinked. Henry was born at the end of the 19^{th} century, and weighs a whopping 1.2 kg. Perhaps it is due to his old-age cantankerousness, or perhaps he had his little heart broken by a tuatara Sheila decades ago, but for some reason Henry refuses to mate with *anyone*. He certainly had no part in making this breeding program successful; the younger, more ambitious males at the museum were used for that. In fact, he seems to hate females so much that he attacks them. Thus, his own private enclosure. I can say that my time with Henry made the tuatara's survival over these last 100 million years of tectonic roller coasters and rodent-invasions even more miraculous, and their future prospects all the more bleak.

So, as we explore the current and ancient biota of Oceania, let us remember the tuatara, and how it demonstrates the relevance of the basic question of historical biogeographers: "Why Not?" Surely it will need to be asked again. And, like with the problem of the tuatara, similar tools will be brought to task:

1) geology, especially tectonic theory;

2) the fossil record, not in the area of study only, but also in the global fossil record. Knowing where related species once were and are no longer is of vital importance, as the tuatara's past has showed us;

3) Molecular analysis, making sure to calibrate speciation rates as closely as possible with fossil evidence; and

4) the ecology of closely related extant species, because these are the best examples we have of the way animals in the past

probably lived (this tool of extrapolating ecology backwards into deep time is known formally as "taxonomic uniformitarianism").

Of course, in endeavoring to compile a cohesive, fluid narrative of Oceania's natural history, it is not enough to focus only on its endemics, although they are often the most iconic. There is a plethora of other flora and fauna one confronts on tramps through these islands' natural areas that contribute much to that impression, endemic to Oceania, that you are truly in another world.

However, before we can talk about the current biota, endemic or otherwise, we must turn Oceania's bedrock, its geologic history, and its modern geography.

Chapter 5

The Great Schism

If we could have time-lapse movies on a million year time scale we would see the ancestral continent vibrate with earthquakes, then fractures appear where the land mass was buckling upward. We would see the west open at the northern end, then India fleeing northwards, right off the map… [61]

Even the geologic story of Oceania gives listeners a lurking sensation of waywardness, as if you are on a different planet with its own special physical laws and pageantry of alien creatures. And, in reality, it might as well be on a different planet; after all, it's on a different tectonic plate – several different plates, actually. The geologic drama unfolded of these plates is long and involved, of course, but what follows is a brief synopsis, a series of highlights, a time-lapse of general events. It is far too brief, so please pardon its simplicity.

Setting: Pangaea. 400 million years ago. Australia is an icehouse, in the northeastern part of the Gondwanaland landmass. It is violently volcanic. In its southern regions, marine sediments and debris from its volcanic phalanxes are deposited in large ash fields and lava flows, adding new "terranes" to the frigid, windswept terrain, in a corner of Gondwana known retrospectively as Zealandia. These marginal terranes, with their diverse lithology, will one day be referred to collectively as New Zealand.

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[61] Gibbs, *Ghosts of Gondwana.* 141.

By the Mesozoic, the earth has warmed up, and the great ice sheets of Australia melt to uncover great inland plains, and drain into large inland seas.

Jump to 170 million years ago- the two subdivisions of the Pangaea supercontinent, Gondwana and Laurasia, split apart roughly along the equator. From here on we leave the northern continent be and focus only on Gondwana. It will stay largely intact for another 40 million years.

After this long, lonely hiatus, Gondwana finally begins to dissolve starting 130 million years ago. Chunks break off, and chunks break off those chunks; India and Madagascar tear themselves away from Gondwana's Australian corner. They won't be completely broken off for many tens of millions of years; remember that tectonics works in inches per annum.

Around this time, angiosperms evolve and take Gondwana by storm, covering the supercontinent.[62] By 99 million years ago, India and Madagascar are completely detached and moving north, quickly and in slightly diverging paths.[63] Their last view of Australia was of a temperate and moist country, dawdling in the high southern latitudes, almost at the south pole; imagine a New Zealand-like landscape, nearly the size of the United States: Cretaceous Oz.[64] Over the next hundred million years, Australia plows equator-ward, slowly heating and eroding away to become the flat, arid, tropical landmass it is today.

The next to fly the Gondwanan coop is Antarctica, as a divergent boundary begins to unzip between it and Australia. Within a few million years New Zealand and New Caledonia do the same.[65] Thus begins New Zealand's nearly 80 million years of solitary history adrift in the South Pacific.

60 million years ago, Antarctica and South America were still connected. For some time they serve as a vast land-bridge, the one that provided monotremes and proto-marsupials migration routes to and from Oceania.

35 million years ago, Australia finally breaks fully from Antarctica; between them is born the Tasman Sea, which will in time grow to make room for the Antarctic Ocean and its current.

Only 5 million years later, 30 million years ago, South America and Antarctica finally split, and the Antarctic circumpolar current is

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[62] Johnson, David . *The Geology of Australia.* 133
[63] Ibid., 139.
[64] Ibid., 132.
[65] Ibid., 140.

born; with it, ocean currents worldwide settle into something resembling their modern swirling tapestry. All the Gondwanan pieces are apart and on their own now, the legacy of the supercontinent upheld now only by the terranes' rapidly transforming biosphere.

By 15 million years ago, Antarctica is completely frozen, straddling the south pole, and Australia has dried out, having nearly reached the equator. The two are 2,000 km apart.

As of 5 million years ago, they were 3,000km apart, and the global position and shapes of Oceania resemble closely those of today.[66]

Mapping Oz

Australia is one of the oldest, flattest and lowest land areas on earth. Continental crust in Western Australia has been found to be older than 3.5 billion years, while the zircon within the island continent's metamorphic rock has been dated to 4.4 billion. This is the oldest material known on earth, only 200 million years younger than the earth itself.[67] Currently, Australia has no active mountain building areas, no fault systems. No chains of volcanoes. One third of the continent is desert. Sometimes, some parts of it can reach over 50 degrees centigrade. These impressive climate statistics are all the more jaw-dropping when one considers that at one point almost the entire continent was buried under glaciers.[68]

Australia's ancient volcanic ranges eroded away, evened out into the flat, dusty plains that dominate its map today. Its geologic past has resulted in a highly differentiated regional geography that, to understand, must be at least vaguely familiar. There are three major structural divisions of the Australian continent: the western shield (one vast crustal block, at an average elevation of 300m, covering half the continent), the central basin (a great lowland belt), and the eastern uplands (910m in average elevation, also known as the Great Dividing Range).[69] The eastern upland's southern region, near the Victoria coast, is covered in lush coastal rainforest that houses most of the country's diversity. We will return to Australian geography and its relation to its life in a few chapters.

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[66] Ibid., 152.
[67] Ibid., 3.
[68] Ibid., 10.
[69] Berra, Timm M. *A Natural History of Australia.* Pg. 4.

Continental Castaway

For the geography of New Zealand to be meaningful to readers, a little more geologic detail is required. For 70 million years, New Zealand floated aimlessly, lonely, its biota stir-crazy and growing wackier by the eon.

Zealandia, the mass of crust that separated from Gondwana, was much larger than today's New Zealand lets on. Only 10% now remains above sea level, and it is responsible for far off New Caledonia, all the sub-Antarctic islands, the Lord Howe and Norfolk Ridges, and the Chatham Rise, which compose the wide continental shelf bordering New Zealand today; this shelf is the outer limit of Zealandia.

80 million years ago, this terrane was a very different place. There were no mountains. That's right, no Southern Alps. There were hardly even any hills. As mentioned before, its winters were dark and frosty. Fern and podocarp dominated the landscape. 60 million years ago, the Tasman Sea, which separated New Zealand from Australia, stopped spreading, but both Australia and New Zealand kept moving north out of that zone of winter darkness. This meant an Eocene marked by significant climate change for Zealandia. By the end of that era, the climate cooled, and the beech forest had come to dominate its forests.

As the beech were enveloping the terrane, New Caledonia and New Zealand finally severed their last spit of connected land; this was the last contact New Zealand would ever, to this day, have with another piece of land. This means that NC is the closest land relative to NZ, and it shows in its biota – but more on that later. As the millions of years passed, New Zealand's isolation became more extreme, eventually too far out for even the strong westerlies to fling Australian flora and fauna out to it on the wind.

The Eocene-Oligocene boundary, 34 million years ago, offers a convenient "half-time" in this history. Up to now, things have been conventionally Gondwanan for New Zealand – unremarkable, by the book. Similar geologic events could have been found on Australia and Antarctica. But, with the onset of the Oligocene, things got serious.

For the first 9 million years of the Oligocene, 33-24 million years ago, New Zealand was dunked underwater. At its most submerged point it peeked out of the sea here and there in the form of an archipelago of low-lying islands, remarkably Fijian in aspect.[70] What caused Zealandia to sink? Was rising sea level to blame, or drooping tectonic plate, or a combination of both? We don't know. By the onset of the Miocene, it emerged, its baptism complete. How much had New Zealand change? How thorough was the terrane "born again"? Again, no one really knows. It's up in the air just how much of landmasses' biota survived that submersion.

And then, approximately 15 million years ago, New Zealand became a piece of tectonic Play-Doh. Relative to it, the Pacific plate started moving north faster and faster, colliding with Australia's plate along what is now called the New Zealand Alpine Fault. With this huge tectonic collision came huge changes in the landscape. Five million years ago, the Southern Alps were born and raised along their namesake's fault. Vigorous mountain building added more and more alpine zones to the landscape. Rock was lifted up into elevations where trees could not grow. This newly available upland habitat inspired a wave of speciation among New Zealand's plants, which experienced character displacement and ecological release upon being liberated from the crowded beech forests below. These new forms eventually crept back into the lowland forests, threatening to outcompete the veterans of the New Zealand bush.

Less than two million years ago, during the Pleistocene, the climate is going haywire. Cold snaps batter the global climate, allowing the beech to win back their hard-won forests. But the cold snaps were followed by stochastic heat waves. Oscillations grew more intense and more frequent. Glaciers advanced and receded like shore pound on a beach. Worldwide, the eustatic sea levels dropped 135 meters during periods of glaciation. During such icy eras, New Zealand's north and south islands were joined by a corridor of scrubland in what is now Cook Strait.

18,000 years ago was the last glacial maximum, so severe that it cause a severe bottleneck in the normally cold-tolerant beech forests. Only 2,0000 years ago do the beech forests return to what they once were before glaciation.

With all that violent deep-sea dunking and unpredictable mountain acne, it is safe to say that New Zealand's geologic history is as extraordinary as the geography and biota it buttresses from below. Perhaps this is not a coincidence. To see as much of the nation's remarkable land- and life-forms, I systematically surveyed

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[70] A minority of geologists argue that it was completely submerged (more on this heated controversy later).

the geographic provinces of New Zealand according to a rigorous weekend travel itinerary, squeezing in as much time "out there" as I could between weekday classes.

Chapter 6

Land of Clouds

While every weekend of the semester in New Zealand was spent elsewhere than my base camp of Dunedin, one weekend in particular stood out among them all. To be fully honest, I declined attendance to a few classes in order to make it an extended weekend, of sorts: Tuesday night to Sunday. OK, it was a very extended weekend. It was a whirlwind several days, and it began with a whale.

On Tuesday morning, I was restless. The previous weekend was spent on a geology field trip with Dr. Fordyce and my paleoecology class to some quarries in the Canterbury plains in search of Oligocene marine fossils. It was only an overnight trip, and it broke up my weekend such that I was unable to go on an additional outing before classes started up on Monday. While the field trip with Fordyce was enjoyable and enlightening, I sat in my room the Sunday after, restless and unsatisfied. My thirst for weekend adventure had, on this occasion, not been quenched. I knew that the coming Wednesday night, a group of friends were going to head for Fjordland to walk the famous Milford Track, but even Wednesday seemed too far away.

On that Monday, having nothing else to do, I focused my restless energy on my schoolwork and completed all my readings and essays for the week. By Tuesday, I was bouncing off the walls. In a normal week I had classes through Thursday, but as I looked at my wall maps of New Zealand, class became increasingly irrelevant compared to the possibilities before me. Conditions seemed perfect for an extended weekend. I made up my mind. It was time to go whale-watching. I packed my bag.

I do not wish to imply that Dunedin offered nothing compelling to occupy my time. Quite the contrary. I chose this particular university as my base for a semester in New Zealand for an ecology of reasons; of all institutions in the country it shared the most qualities with my U.S. alma mater that I deemed important; the class sizes were smaller, the campus was more centralized, and it was in a fantastic natural location. There was a large peninsula, by the name of Otago, next to the city that was notorious for its rare wildlife.

But the IFSA-Butler pamphlet had not mentioned that the land on which the city was sitting was once a highly active volcano. They didn't write that it was home to a permanent roost of Yellow-eyed Penguins, the second-rarest penguin in the world, and a quiet treasure of the peninsula that I would visit frequently. They didn't say it was home to the most accessible colony of Royal Albatrosses in the world. They didn't say that, if cycling out to the tip of the peninsula to see the albatrosses, you were in serious danger of hitting a jaywalking fur seal. They didn't mention anywhere that it was host to the most geologically curious and picturesque beach on the south coast: Tunnel Beach, an unfathomably beautiful picnic and swimming destination. Had they written these things in the informational packet about Dunedin, I definitely would have had a clearer sense of purpose when I arrived, could have hit the ground running.

Dunedin, with its geology department, museum of natural history, and Otago Peninsula, is a unique and amazing place for natural historians. Plus, there's a giant chocolate factory in the city center that makes the entire place smell like hazelnut. But this is where I went to school for 5 months, and though it may sound spoiled to say so, I could go see sea lions, penguins, and tunnels any day of the week (as I often did). The albatrosses could wait. The whales, on the other hand, would not.

I ran over to Leith Street, where Will, Santiago and Lena all were living. I was hoping for some companionship on my quest, but it turned out they were planning their own extended weekend, up to the rolling hills of the Nelson region in the northern reaches of the South Island. Nelson is famous for its tidal flats, white sand beaches and coastal tracks, and they were planning on cramming all those things into a single long weekend. They were already packing their car. Luckily for me, their route was going by my very destination: Kaikoura.

The Big-Headed Blower

While the forests may have been depauperate of mammalian activity, New Zealand's surrounding seas have been teeming with secondarily-aquatic mammalian life for dozens of millions of years. Why is Kaikoura one of the world's preeminent whale watching destinations? The answer, of course, is geological.

Remember that the circumpolar current opened about 30 mya; this drastically changed ocean currents, and as a result drastically changed the flow patterns of billions of tons of plankton and krill, the faunal foundations of the oceanic trophic systems. Their place at the base of the marine food web is most obvious to the human eye in places where ocean current is funneled close to shore and pushed to the surface, boiling with nutrients and ecology. Such is the case at Kaikoura, on the central east coast of the South Island, an 8-hour drive from Dunedin. It just so happens that Zealandia's eastern continental shelf has a gargantuan canyon running north to south, dead-ending precisely four miles off-shore of Kaikoura. The southern currents get re-directed at this canyon's offshore mouth, channeled up into the channel and lifted up the walls of Kaikoura canyon till it reaches the surface, an eruption of foreign water and concentrated nutrients. As the krill and plankton move towards the surface, so do their predators, and so do their predators' predators. These include several notorious mega-predators of the deep, including the largest alive today - the sperm whale.

We arrived in Kaikoura at 2 am, all tuckered out. We found the only motel still open and shared a nice room together. By 5:30 am I was walking toward the Ocean, into the sunrise. Will, Lena and Santiago remained in bed, resting up for the remainder of their northward trek. I watched the sun pop out of the ocean's horizon, maybe from launch pad on Antarctica. A consortium of tern species were feeding in the calm bay that morning. As the sky brightened, illuminating Kaikoura's rooftops with glittering orange light, I breathed in the scene. A mountain belt, snowcapped and jagged, flanked the town's rear and charges right into the ocean just to the north, a series of peaks born of the geologically infantile Kaikoura Orogeny. From shore to dune, the beach consisted of a beautiful gradient of increasingly larger pebbles, all Technicolor and shimmering. It seemed to me like a good day to be a whale.

By 7:30 in the morning, I was 3 miles off shore, with dozens of other early risers and whale enthusiasts, floating right above the rim of the abyssal Kaikoura canyon.

Before I go on, this monster deserves a proper introduction. This leviathan is one monstrous superlative. It holds records for holding records. The sperm whale (*Physeter macrocephalus*), the mythic whale of *Moby Dick,* is the largest of the Odontocetes, the largest, we think, to have ever lived. There are currently somewhere around two million of them worldwide, which is a significant rebound after the decades upon decades of their industrial slaughter. Their brain is the largest of any animal, ever. It is the largest living carnivore on earth. It is also the world's loudest animal; its sonar blasts, used in the pursuit of prey, reach 230 decibels. These leviathans feed by diving down to the depths at which schools of squid are most often found (usually between 1 and 2 miles deep, making the sperm whale the world's deepest diver). All these hyperbolic features of the sperm whale give the impression, combined with its rather prehistoric, wrinkled, inchoate, blunt-headed visage, that it is as ancient as the very sea. It is abominable, terrible, and terrifically cool. Turning all these facts and figures over in my head as we scanned the horizon that fateful morning, I just could not stop smiling.

-- Then --

"Thar she blows!" the captain cried, pointing to the east horizon. I ran to the starboard side of the ship, wide-eyed, heart racing. Holding our breaths in anticipation, we scanned the waters excitedly, not sure exactly where we should be looking. This was the moment I had been waiting for since childhood. Then we heard it: the hollow, trailing but remarkably loud "pfssshhh" of vaporous air escaping a whale's blowhole. There, 50 yards away, floating on the Pacific Ocean's surface -- after a 1.5 hour dive to depths of over 8,000 feet -- was a monstrous 60-foot sperm whale (Physeter macrocephalus). With that magical break in the silence, the mysterious, glassy New Zealand waters we had been sailing that morning gained meaningful depth. My first sperm whale.

We ended up seeing a total of three sperm whales that morning (which is 2 more than the company's reported daily average). I was on top of the world. To see these animals in real life was a dream come true.

When I got back onto dry land, I was faced with the challenge of somehow returning to Dunedin. Before I had left Dunedin the day before, I had contacted Pat, organizer of that evening's

Fjordland expedition, and told him I was still planning on going with, but if I were not at his house by 7:30pm, to leave without me. It was already 9:45 am, Wednesday morning. Even if I were driving my own car down there, I would be cutting it close. But Will, Santiago and Lena were halfway to Nelson by now, and I was alone, reliant upon good fortune and good weather – the two necessities if one is to be a successful hitch-hiker.

The Canterbury Crank

Although hitch-hiking culture is still alive in New Zealand, it is on its last legs. Which is a shame, because it is decidedly the most beautiful thing one can do while traveling abroad. It can also the scariest, or, spun more positively, the most thrilling. I stuck out my thumb for the first time in New Zealand on the first weekend of my semester there. My plan was to take a bus up to the Christchurch airport with a light backpack, pick up my road bike (which had been shipped over from the States), assemble it in an airline hanger and go on a four day bike tour of Arthur's Pass, Mt. Cook and Central Otago. The plan seemed feasible enough to me. All too soon I learned that I had overestimated several aspects of my plan: my level of fitness, my ability to ride 100 miles a day – without any recent training to speak of, and with a 30-pound backpack on my back -- and the structural integrity of my bike.

Arthur's Pass is a town nestled high in the Southern Alps. This mountain range stretches the length of the south island, beginning in the ornately carved topography of Fjordland and dissipating into the rolling hills of the Nelson region. This gorgeous mountain chain is the result of that orogeny, less than five million years old, that occurred when the Pacific and Indo-Australian plates collided to form a wicked triple fault. Five million years of extremely rapid mountain-building did not afford this region's biota much opportunity to keep up. But those that did manage it have become truly impressive, biotic wonders of the world. This mountain range is host to the world's only alpine species of parrot, gecko, and cicada. Many of the plants and animals who have survived in this alpine landscape now have narrowly restricted ranges; three genii of plants are endemic to the peaks of the Southern Alps, and seven species of weta (an endemic New Zealand insect that resembles a grasshopper) are similarly found only in their foothills.

One simply must wonder, how did these biota overcome the "alpine challenge"? To successfully respond to such a rapidly changing landscape is a true feat for any flora or fauna. The fossil record, along with molecular analysis of related species, suggests what we could have assumed: that several of these species already had physiological and behavioral features that preemptively prepared them to deal with a geologically instant uplift in their habitat. The ancestral cicada from which these nine species evolved was a riverbed species that was already accustomed to high winds, rocky habitat, and a diet of small plants. These cicadas also had to respond to several periods of glaciation in New Zealand's history, which may have suited them for life in the Alps. For their part, the alpine weta's ancestor had the amazing pre-adaptation of being able to be frozen solid, then, after thawing out, being able to walk around again almost immediately.[71]

Unlike these presaging specialists, I was not as nearly prepared for what the Alpine Orogeny had in store for me. But, to my credit, I did make it to Arthur's Pass, the highest township in New Zealand. I was able to spend an afternoon there climbing my first New Zealand mountain, encountering my first kea (a saucy alpine parrot), and drying out my tent and sleeping bag, which were still wet from the previous night's rainstorm.

Soon after this brief, triumphant layover in Arthur's Pass, however, my bike began to malfunction, my legs became stubborn, my butt became immeasurably sore with the weight of my pack, and the trip went downhill from there (not literally – quite the opposite, actually). After two nights in the Canterbury Plains and Southern Alps, I had run out of food, lost all feeling in my glutes, gained bruises on my shoulders from the backpack, exhausted myself beyond precedent, broken my bike shoe's cleat, and lost all hope.

After another 2 days of harrowing hitching rides with vehicles large enough to load my bike, I was back in Dunedin, completely defeated, absolutely stunned – and a little amused -- by my failure, and clueless about how to restore my bike's integrity.

Immediately after its conclusion, I would have insisted on calling this first trip a disaster, and a poor way to begin a semester of even more ambitious trips. But now I have enough nostalgic humor for it that I can brush it off as a learning experience, at worst, and at best, a misadventure (which is just a subspecies of Adventure).

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[71] Gibbs. *Ghosts of Gondwana.* 130.

Life at Its Core

Before arriving back in Dunedin from this bicycle fiasco with my tail between my legs, I managed a stop at one of the main natural history attractions of the east coast, other than Kaikoura's whales: the Moeraki Boulders. Dotting the beach, about 100km north of Dunedin, these boulders give the coastline a uniquely eerie, alien appearance, arranged on the beach and in the surf like some sort of modern art installation. The boulders were actually built from the inside outward, grown from a crystallizing process in mudstone that began 60 million years ago. Today each boulder weighs an average of two tons.

Here's how the process works: lime-rich minerals began to accumulate around a bone or fossil, depositing in such a way that subsequent layers grew evenly and equally outwards in concentric circles. Any organic remnant would do for the centerpieces of this process, but the Moeraki boulders typical fare include pieces of mosasaur, plesiosaur, and the shells of ammonites and bolemnites. As the lime minerals continue to aggregate, muddy marine sediments cover these fossils as well. Eventually these fossil-lime concretions are suspended in a mix of mudstone and limestone far beneath the ocean floor, deep enough to lithify under sustained pressure and heat. Tectonic activity and local sea level fluctuation eventually rearrange the earth so that the limestone bedrock housing these concretions was uplifted above sea level. Wave action and weathering began to erode away at this rock, exposing these concretions and…voila! The Moeraki Boulders. At the heart of each of them is a fossil. It's an interesting, microcosmal inversion of the normal order of things: life as the trelliswork for rock.

The Hitching Post

The first kind soul to pick me up that morning after whale-watching was a quiet, thick-skinned old woman with hair down to her knees. She took me about fifteen kilometers out of town before she had to turn off the main road. Sitting on my bag alongside a deserted South Island road for a while, I had time to think. I thought about the seven hours of charity rides I would need to accept before I could be back in Dunedin. I thought about the unlikeliness of making it back in time to go with Pat *et al.* to Fjordland. Usually, I've learned, hitch hiking instills an attitude of calm acceptance in the hopeful traveler. It is a sensation that is both serene and anxious. You know, standing there with your thumb out, that eventually you will be picked up, you just don't have much of a choice as to when. But you *will* get picked up. Eventually. The time frame of hitch hiking is at once certain and ambiguous, as ironically calculated and aimless as the act itself. You are at the complete mercy of the passerby, a prostration entirely too uncommon in our day-to-day life. There is something right about being so. There is something righteous and vindicating about this cheap-skate crapshoot. I usually love it, the whole game, the sense of adventure that comes along with it. But today, I am committing the cardinal sin of the Thumb: hitching to a schedule. I have a date with Fjordland.

So I make a bouquet of wild roadside flowers and hold them out beseechingly to the next car I see. It slows down and the driver pushes open the passenger door for me.

My usual gimmick when hitching that semester was to hold out a sign that reads "I HAVE CHOCOLATE," a tactic justified by its huge success rate. It was what got me my ride to Mt. Aspiring National Park, just weeks before. Within minutes of unveiling the sign, a young man pulled over for us. But before he let my friend Will and I in, he said, "Whoa, hold on. Is it dark or milk chocolate?"

"Both," I smiled. He unlocked the doors.

To our great fortune, this guy was driving to our exact destination, the town of Wanaka on the park's border. Mt. Aspiring is a park that borders Fjordland, and is much smaller in comparison. The latter contains 3 million gorgeous acres of untouched landscape. Only a handful of roads, utility buildings and tramping huts can be found within its borders, although many of the most-walked tracks in the nation can be found there.

While its Milford Track is undoubtedly the most famous, the others, such as the Kepler and Dusky Tracks, are not without their own merits. The Kepler Track, accessed from the town of Te Anau on the other side of Fjordland, was my first tramp of the semester. As a result it claims a special place in my sentiments for the country. It was a glorious, overwhelming induction into the forests and mountain ridges that the rugged New Zealand landscape has to offer. It was beautiful, in part because it was chock-full of geologic marvels. The first half of the track runs along glacial moraine deposited 10,000 years ago, and just below the bush-line, as you begin to climb up, you could see where bare limestone comes into direct contact with Fjordland's vast plutonic bedrock, relics of those ancient marginal terranes flowed out from Gondwana's volcanoes, the oldest visible rock in New Zealand. My two days and sixty seven kilometers on the Kepler Track certainly set a high standard for the remainder of my semester's Weekends in Natural History.

In retrospect I can attest that the walking tracks of Mt. Aspiring National Park match the Kepler in scale, beauty, and physical challenge. Another favorite track, deserving equal footing alongside Milford and the Kepler, was the Routeburn. This track crosses the range of peaks that divide Te Anau and the Fjordland region from Wanaka, Mt. Aspiring, and the rest of the Southern Alps. I frolicked on this track on two separate occasions, once during New Zealand's early fall and again during the early winter. Although it is only half the length of the Kepler, the same degree of extreme landscapes, cascading waterfalls, and tear-jerking vastness was there, more steeper and more rugged, on the Routeburn. "This can't be real," was the most common utterance in response to the towering fjord walls, magnificent displays of cloudwork, and glacial valleys.

Rodent Revival

While some of my most beautiful times in New Zealand were spent on the Routeburn and the Kepler, these tracks also served to demonstrate the thoroughly destructive influence of invasive fauna, especially the mammals, especially the rodents. Their impact has been disproportionately dire in New Zealand, because of the country's disproportionate numbers of flightless and ground-dwelling birds, as well as other rare and fragile terrestrial wildlife (tuataras, large forest beetles, and ground-dwelling bats, to name a few). The colonialist rodents and marsupials that find their way to New Zealand's shores have found the naïve, sheltered, native fauna quite literally laid at their feet, as if awaiting and welcoming invasion. Easy-pickin's.

But foreign invasion has been the work of much more than rodents, and their influence has reached far beyond the forest floor; they've even found their way up New Zealand's streams. Decades ago, the British released trout in the freshwater systems of New Zealand, and now New Zealand is both world-famous for trout-fishing and world-infamous for an otherwise stark lack of freshwater fish diversity.

As soon as rats first appeared on New Zealand, they started raiding nests, mainly of seabirds and tuataras. For 80 million years, New Zealand had been a natural experiment in large-island-evolution without the influence of mammals, whose oft-overbearing presence fundamentally stifled the evolutionary creativity of other clades.[72] The tragedy is that just naturalists were realizing how precious the New Zealand Experiment was, stotes, dogs, possums and rats were already at work irreversibly destroying the results.

Rats can swim. In other words, they can disperse. A rat was once recorded swimming over 1 mile between islands. If rats have taught biogeographers anything, it is this: given enough time, dispersal happens, one way or another. It's like hitch hiking. Life finds a way. A great example of this truism can be found at Ulva island, nestled in Half-Moon Bay on Stewart Island, which is a large block of moss just southwest of the South Island. In Maori lore, Steward Island is the anchor that keeps the canoe-like South Island steady, while the North Island is a fish, caught on a line, trying to pull the South Island away into Polynesia.

85% of the island is a national park world-famous for nesting seabirds, including wandering albatrosses and muttonbirds – thousands and thousands of muttonbirds. Although Steward Island itself is a birding Mecca in New Zealand, it is nothing compared to its own anchor, Ulva Island. About half the size of a Georgia barrier island, Ulva Island hasn't had a breeding rat population on it for about 50 years. Combine this with a highly intensive re-population program managed by the Department of Conservation, and you get the closest thing you can to pre-human and pre-rat New Zealand, minus the moa. The community of avian life on this island is utterly staggering. I spent a morning on this island, from the dawn chorus to the afternoon lull, and I was never the same again. Just go there, find a sunny opening in the forest canopy, take a seat, and wait. The spectacle is an ornithologist's fantasy, Audubon and Peterson's pre-lapsian Aviary of Eden.

But Ulva's anachronistic diversity does not come easily. As sure and steady as the winter storms, there are persistent waves of rat invasions pouring in from Stewart Island. An average of one rat a year is found hitching a ride to Ulva island, via floating debris, the lower compartment of a tourist's backpack, or in the bilge of a boat's stern. We owe the still-pristine condition of Ulva Island to the pest-control crews of the Department of Conservation.

In addition to the rat, the English brought along plenty of other unwelcome guests to the New Zealand forests: the dog, the rabbit,

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[72] However, recent fossil evidence may suggest that mammals may in fact have been present in New Zealand all along. More on this soon.

the stote, and the worst invasive of all, the brushtail possum (*Trichosurus vulpecula*). This Australian species of possum even rivals *Homo sapiens* (cultural subspecies, *occidentalis*) in its tendencies to exploit and undermine its new habitat. For before the rat or the possum had arrived, humans had already done their share of the destruction. Whether it be by war canoe or an Airbus 320, we humans have mastered the art of dispersal, and the effects -- worldwide - have been drastic. It seems to be part of our nature, to move in, take over, alter, change, destroy. Can there any hope for us? Darwin may have said it best: "If a monkey has become a man – what may not a man become?"[73]

Perhaps, Charles, but we are off to a poor start. No less than a thousand years ago, the largest flightless bird species ever, the moa, numbered between four and ten million in abundance. Once humans arrived, they had been hunted to extinction within 200 years. In the thousand years since human appeared on the Zealandia islands, over forty endemic bird species have gone extinct.

But the brushtail possum is quickly catching up to us. Having been introduced at a North Island port early in the 20th century, this pest has now spread over 95% of both main islands. There are over seventy million possums currently eking out a living somewhere in New Zealand. Compare this to the nation's four million people, and twenty five million sheep. That's about twenty possums per New Zealand resident. Collectively, in a singly night, they eat the equivalent of a field of 40cm-high grass in a field the size of Dunedin (8300 acres). That's 22,000 tons of vegetation per night, eight million tons a year.[74] Whenever Luke was behind the wheel of our trusty steel-blue Toyota Starlet Carat, it was clear he was taking it upon himself to personally run over his share of the nation's possum problem, all twenty of them, and a few of mine as well. It was absurd: go on a 3-hour drive within the foothills of the Southern Alps at night, and you will dodge at least fifteen and hit at least five – and that's if you're not trying to do so.

The invasive destruction in New Zealand is so tragic, and its native victims so hapless, that it is easy to forget that Australia has had more than its fair share of invasives. The European rabbit (*Oryctolagus cuniculus*) has been brought over on multiple occasions ever since its notorious arrival from England in 1788. It was presumed that they would be fun to hunt, the Australian version of

[73] Qtd. in David Quammen's *The Reluctant Mr. Darwin*, pg. 175.
[74] Otago Museum of Natural History, Dunedin, permanent exhibit.

the fox. The rabbits, predictably, began reproducing cancerously. What proceeded was a farce, an absurdity, a puerile mistake that governments all over the world keep making: foxes and feral cats were brought in to control the rabbit population. Now Australia has a rabbit, fox *and* cat problem. Since the arrival of human invasives from Europe, there have also introduced horses, buffalo, camels, donkeys, goats, pigs, and cane toads running wild all over the flat, dry continent.

Singing in My Soul

So without my usual gimmick of chocolate, I had to resort to a hand-picked bouquet of flowers to give drivers that extra motivation to stop. And to my delight, it worked. The first car to pass me on that quiet, middle-of-nowhere road came to a quick halt. Careful not to spoil the bouquet, I grabbed my bag and ran to catch-up. The driver reached over and opened the passenger door for me. By the look of him, the driver was the last person I would be wooed by a bouquet of flowers. Mike was an amateur rap artist and professional drug dealer, and he was passionate about both trades. This was not the first time I was offered marijuana while hitch-hiking in New Zealand, and it certainly wasn't the last. He was very understanding upon my polite decline. At least I think he was; I could not understand a word that Mike said through his extraordinarily thick Kiwi accent. He was quite easy to get along with; he freestyled for me for all of a hundred kilometers. Although his accounts of his latest adventures in prison sounded really exciting and his freestyles really were "off the chain," I opted to try my luck with another ride once he lit up his third marijuana cigarette. It was nearly noon, and still nowhere near Christchurch, let alone Dunedin.

The next driver to be enticed by my flower bouquet was just as surprising: Jack was a massive rugby player from Christchurch, and he was hurrying back from a match in Nelson to make his graduation ceremony that night. After a pleasant conversation about the rules of rugby that lasted all the way back to Christchurch, I was dropped off at a gas-station on the road that would take me south to Dunedin. It was already 3pm; making good time, but not good enough. I began to accept the reality that I would not make it back in time to join the Fjordland crew. Less urgently and with less enthusiasm, I stuck out my thumb on the busy road out of the city. This was not a good place to hitchhike. Too many cars, not a wide enough shoulder. Unlikely that any of these commuters were southbound for any helpful distance. I found a peace of cardboard and scribbled, "DUNEDIN," in big letters. I raised it half-heartedly, not thinking it would be of much help.

But almost immediately, much to my surprise and delight, a car did stop. And it just so happened to be driven by an angel.

Emily was the most beautiful New Zealander I had ever met or would ever meet. She was a "Pilates" instructor and dental hygienist. She lived in Christchurch but often made the drive down to Dunedin to visit her family. Emily was kind enough to give me a ride all the way from Christchurch to Dunedin, a grand leap of faith for a young woman to risk for a vagrant young man, a five-hour drive,. Well, for the law-abiding driver, it is five hours. But with Emily the Canterbury Angel behind the wheel, we made it down there in four.

These were undoubtedly the best four hours of hitchhiking I have ever done. We had an unforgettable conversation; it began with the cordial niceties, of course, but by the end of our time we were explaining our religious stance on this and that, even asking each other for romantic advice. She invited me to tell her everywhere I had been in New Zealand so far. I told her about the highlights: the Kepler and Routeburn Tracks, the infamous bike ride to Arthur's Pass, the Moeraki boulders, and the geology field trips. But she also wanted to know about the other weekends, those days full of so much adventure but shadowed by the more well-known destinations in New Zealand. So I told her about the days spent on the Otago Peninsula being chased by sea lions, and my weekend on Stewart Island looking for kiwis. I told her about the hike through the lush forest of Paradise, a small, aptly-named village northwest of Glenorchy in the Southern Alps. During that visit, Pat and I stumbled upon a production set for the *Chronicles of Narnia* film. Unable to resist, we snuck onto the set, explored the costume rooms and even helped ourselves to some oranges in the catering tent. I told her about the week-long trip we took up the North Island to check out the volcanoes and hot springs of Tongariro National Park and the Rotorua region. I told her about my recent overnight stay on Doubtful Sound. She was delighted to hear how quiet the fiords had been at night, a silence broken only by the occasional whinnying call of a distant kiwi.

As I recounted these adventures for her, it occurred to me that I was only halfway through my semester months in New Zealand, already with so much memory to cherish. By the end of my expedition in Aotearoa, I will have lived twice that adventure, and then some; I will have seen twice the landscape in New Zealand. I will have spent three nights under the shadow of Mt. Cook with the most beautiful friends I could ask for. I will have danced along the marginal moraines of the Franz Josef and Tasman Glaciers. I will have showed some dear friends visiting from the States, Captain Luke among them, many of these beautiful places. I will have countless more nights with Will, Santiago, Lena, Pat and other dear travel buddies in front of various jaw-dropping mountain vistas. I will have had more picnics at Tunnel Beach, and more nights at the hot springs scattered throughout the country's most remote valleys. There was so much more to adventure to live.

After hitching with five different drivers, including one drug dealer and the prettiest Kiwi around, I arrived back in Dunedin by 7:35pm. Emily dropped me off right at Pat's door, as the Fjordland crew was packing their Volvo. She gave me two CD's of her favorite music, right out of her CD changer, for us to enjoy on the way to the island's southwest corner. Thus ended the most ambitious day of hitch hiking of my life thus far.

Milford

I say goodbye to Emily and hop out of the car. The Fjordland crew say they need 15 more minutes before they are ready. Perfect. I run into my flat and change my socks. Downstairs, my flat mate calls out that supper is ready. Perfect! I down a delicious bowl of pumpkin soup in about three minutes, stick water crackers into the chest pocket of my Swann-Dri, and run out the door. At 7:45pm, I knock on Pat's door. I made it; somehow I had made it.

Within minutes my usual travel team and I were making haste for fjords, dodging possums along the way. At 7 am the following morning, we board a dinghy on Lake Te Anau that will take us to the trailhead of the Milford Track.

Crossing the waters of the fjord, the untrained eye may not gather that these waters are home to some of the most interesting and rare aquatic ecosystems in the world. Fjords are perhaps the greatest and most beautiful topographic anomalies ever. Their sheer size is utterly astounding; they are kilometers and kilometers across, and tens of kilometers long. In some places they are up to 300 meters deep; some fjords of the world are a mile in depth. These phenomena are glacial valleys that have been inundated by advancing sea levels. These submerged valleys were once home to rivers of glacial ice hundreds of meters in depth. Being connected to the ocean, fjords have all the daily dynamics of a coastline, such as a tidal flux and the constant recycling of nutrients in the upper portions of the water.

Believe it or not, the aquatic ecology of a New Zealand fjord can be as astounding as its vistas. Their walls are layered with a film of stunted beech trees, like photosynthetic wallpaper. Although the near-vertical sheer faces of these bare-rock walls may not seem like the nicest place to settle down, the extremely high precipitation characteristic of fjord valleys – it happens for more than 200 days a year, and another 100 days feature thick, dripping fog -- makes this habitat irresistible for beech trees. These representatives of the *Nothofagus* support themselves on those walls by weaving their roots in among the roots of neighboring trees. At times, the weight of this tree-film may become too much for gravity to tolerate any longer, and a cataclysmic collapse of entire strips of beech trees will peel back and plummet into the beckoning, black waters of the fjord below.

Furthermore, these beeches are tannin rich, so with each rain tannins are leached out of the trees and sloughed down into the fiord. The rain water and the tannins, being less dense, rest on top of the saltwater. This makes for fascinating interactions between freshwater and marine invertebrates, a phenomenon of precious rarity. This opaque freshwater caps also acts as a dark veil over the oceanic habitat below, depleting the amount of light that enters the fjord waters, makes it appear to certain life forms, for all they know, that they are much deeper that they actually are. Ten meters down into a fjord, you can find a species of black coral that only appears at a depth of seventy meters or more anywhere else in the ocean. In a fiord, the band of life, which is determined by light availability, is only the top forty meters of depth. These forty meters are critical breeding and feeding grounds for the southern-most population of bottlenose dolphin (*Tursiops truncatus*), one of the largest dolphin species in the world.

It is this aquatic habitat that frames the landscape through which the Milford Track runs. This walk is truly stunning. It is usually overrun with tourists, booked solid from October to mid-April. Luckily, my travel team and I did the track on the first weekend of its official "off-season", and for three days, we and a pair of two German college students were the only two people on this, the most beautiful part of the most beautiful island on earth. Kilometer-high glacial valley walls, world-record water- and cloud-falls that would pour over the saddles of hanging valleys into the dripping, moss-draped valleys below.

The landscape and biota of the Milford Track make no sense unless we associate the violently carved landscape with the period of global glaciation that concluded as recently as 18,000 years ago. New Zealand's biota have survived in a landscape that was torn apart, divided and emaciated by glaciers. In Fjordland and the Mt. Cook region of the Southern Alps, icy remnants of this glaciation linger still. New Zealand's insular isolation closed off all escape routes from the glaciers of the Pleistocene's multiple ice ages, and the only survivors among the island's biota were truly the toughest of the tough.

Glaciation is most likely responsible for the country's marked lack of ant and termite diversity or abundance, which, given New Zealand's proximity to Australia, an island with over 5,000 species of ants, is otherwise inexplicable. The paucity of ants has had extreme ecological effects: without anthills scattered along its forest floor, New Zealand soils have grown to have extremely high micro-invertebrate diversity – more so even than a tropical rainforest.

Most of the plant species that New Zealand had once shared with New Caledonia (the closest land relative to New Zealand, the last landmass to separate from Zealandia), disappeared under the glaciers. In this way, New Caledonian flora serves as a snapshot of what New Zealand forests were like before the ice ages, and as an interesting foil to what they have become since.

Glaciation was certainly a surprise for New Zealand's biota, and this is still evident in the distributions of many flora and fauna. But glaciers are also thought to be responsible for many novel physiological and behavioral adaptations common among many species there today. Adaptations like viviparity in reptiles, the lack of diapause (winter dormancy or "hibernation") in invertebrates, the large body size of ratite birds like the moa, and deciduousness in several plant species are thought to be responses to New Zealand's recently-glacial landscape.[75]

Indeed, adaptive responses to glaciation explain many mysteries regarding New Zealand life. North island plants are predominantly

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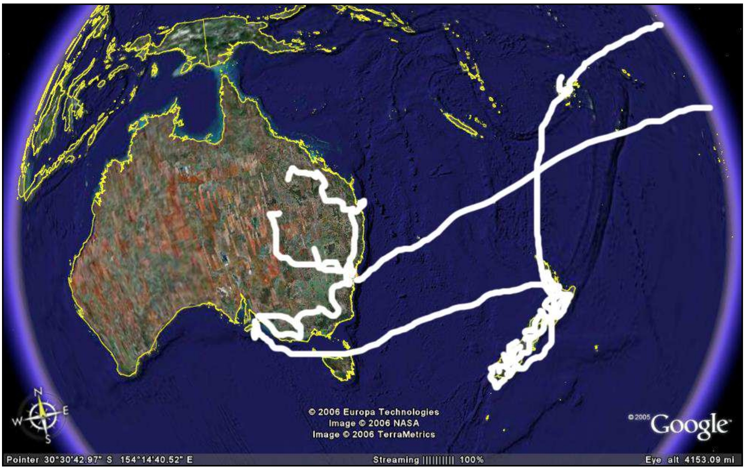
[75] Gibbs, George. *Ghosts of Gondwana: The History of Life in New Zealand.* Nelson, NZ: Craig Patton Publishing, 2006

woody, but south island plants are not. Could this be related to New Zealand's glacial past? The extreme glacial environment most likely pushed South Island plants towards the low herbaceous forms. There is a similar north-south pattern in cicadas as well, those symphonious insects. On the north island, all 20 species occur in forests. In the South Island, only 2 of 39 species dwell in the forest, the others dwell in rugged or alpine regions.

Indeed, the Milford Experience was beautiful. With each step, the landscape impressed upon me that essential lesson in historical biogeography, one that as a Floridian I was not quick to pick up: keep the power of glaciation in mind when contemplating life on earth today.

After our time on the beautiful Milford Track was up, we drove back to Dunedin and arrived in our beds at 3 am on Sunday morning. But the weekend was not over yet. At 7 am, after a groggy pancake breakfast, Pat and I were on a bus to Central Otago with the IFSA-Butler group. After a day of mountain biking, historic museums, penguin- and seal-watching at Nugget Point, *and* ice cream, I made it back to Dunedin in time for leftover pumpkin soup.

Sperm whales, hitch-hiking, the Milford Track, and mountain biking. I reflected warmly on the adventure, exhausted and satisfied, at least until the next weekend.



~ *Author's route* ~

~ *A morning in the Yasawa Islands, Fiji* ~

~ *Investigating the tidal flats in a lagoon of Makatewa Levu Island* ~

~ *A morning in the Republic of Fiji* ~

~ *The Twelve Apostles before sunset, on the Great Ocean Road, Victoria* ~

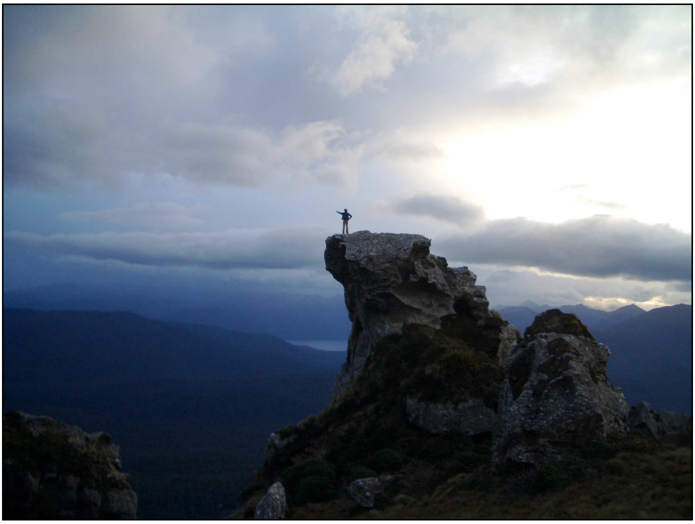
~ *Spear-fishing on Kangaroo Island* ~

~ The fiddle-head of a Cyantheale tree fern branch, New South Wales ~

~ Bob and Lorraine's pet brush-tail possum, Kangaroo Island ~

~ The Moeraki Boulders, on the east coast of New Zealand's south island ~

~ A braided stream near Mt. Aspiring National Park, south island ~



~ The author stands on the Southland border, pointing at Fjordland ~

~ The travel team, on New Zealand's Milford Track.
Clockwise from left: The author, Jordan, Lena, Laken and Katie ~

Chapter 7

Lands of Forgotten Beasts

Since [the Gondwana break-up], extinctions, new radiations, and new dispersals have all but obliterated the old pattern.[76]

What was the old pattern? What can it tell us about the way life once worked and still works today? These are the pressing questions that form the basis of paleontology, the study of deep life. While studying at the University of Otago, I had the privilege of working under Professor R. Ewan Fordyce, a short, energetic brainiac, chair of the Geology Department, and editor of the Journal of Vertebrate Paleontology. He also happened to be the world authority on whale and penguin paleontology. He is a great man, and was kind enough to offer me a position in the university fossil prep lab for the semester.

The prep lab prepares fossils for both graduate research and displays in the Otago Museum, the oldest museum in New Zealand, where I also had the privilege of doing some volunteering during the semester. Occasionally the prep lab also prepares bigger, prettier pieces for display in exhibitions around the world. Most of my time was spent preparing fossil whale skulls, ranging from 60 to 15 million years old, for a major upcoming exhibition in a Japanese museum. It was a truly invaluable experience, and it certainly

[76] Gibbs. *Ghosts of Gondwana.* 198.

prepared me for my exploits, the summer I returned from Oceania, up in Montana.

By the time Captain Luke arrived on the scene, all bright-eyed and ebullient about his upcoming Watson expedition to visit famous fossil localities around the world, Dr. Fordyce had heard me speak about him enough times to invite him into the prep lab as well, as an extra pair of hands as the deadline for the prep work neared. You know you're a hopeless fossil-geek when you start taking grad students out to lunch to talk about foraging habits of moas, or when you leave a uni rugby party early to go to the fossil lab. It helped that the Geology Department had unlimited chocolate milk in its common room, available 24/7 to prep lab volunteers and employees.[77]

Fossils have played a primary and critical role in the effort to compile a fluid sequence of life in the histories of Australia and New Zealand. This is especially true of the rich record of fossil pollen. Palynologists -- god bless them, they look at 100-million-year-old pollen grains all day through microscopes in windowless offices, thumbing through dichotomous keys in a valiant effort to identify the grains down to the family level – provide a nearly continuous record of vegetative succession, a timeline – a starting point – to which fossil hunters can calibrate the rest of their findings.

In his lectures, Dr. Fordyce would often refer to biota living today as the uppermost geologic layer, a way of putting it that certainly reflects the approach of historical biogeographers take to the Deep Story of a landscape. Using this perspective, our pursuit of the history of life gets really interesting and, true to the most glorious virtue of paleontology field work, really messy.

The Oz That Was

Much of our knowledge of it paleo-Australia patchy, but the record we do have suggests quite a history. According to the fossil record, fish first began swimming close to its coasts 435 million years ago. 412 mya, the land was colonized by its first plants. 2 million years later, the first terrestrial fauna appeared: centipedes, primitive spiders, and archaic amphibians.

About 230 million years ago, crocodilians began showing up in the fossil record, looking almost identical to how they look today.

[77] I probably averaged 2.7 cups of chocolate milk a day.

Crocodiles are a classic example of the evolutionary maxim: "if it ain't broke, don't fix it." Another interesting example of evolutionary stasis is a certain Australian species of plant. The Wollemi pine (*Wollemia nobilis*) is a species still around today that was not discovered until 1994. A father and son hiking in the Blue Mountains stumbled upon a stand of 40 or so really odd looking pine trees. The tree stood forty meters high, with fern-like needles, like something out of the Carboniferous. The father alerted the forest service, and botanists celebrated the discovery of the only stand of this pine species left in the world. What *paleo*botanists celebrated was that the leaves and stems of this pine had not changed at all (or if it did, it was imperceptible to both the human eye and the microscope) from plant fossils found in 150 million-year-old Talbrager sediments.[78] For 150 million years, that leaf shape and physiology had worked optimally, finding no need to change. And now, for some reason, there are less than 50 individuals left. Perhaps it should consider evolving; it has held out long enough.

Jump back to the Triassic-age rock, and you'll find giant salamander fossils, over seven feet long, in rock lithified from freshwater lake sediments that were deposited where Sydney now sprawls.[79] A little farther up the geologic time scale you will find plenty of dinosaurs, and big ones at that. Australia is quite famous in some circles for the richness of its dino-era fossil beds. One of fossils more frequently found is that of a huge Saurischian, *Rhoetosaurus brownie*, found in 180 million-year-old rock. Sauropods became numerous again in the fossil record in 99-million year old rock, along with their predator, the *Allosaurus*.[80] Reptiles the size of these sauropods were also haunting the marine depths at Australia's coast at the same time; dolphin-like icthyosaurs also abounded, hunting fish up and down the Australian coast while being hunted themselves by an even bigger terror: the *Kronosaurus*. A type of pliosaur, it reached over 40 feet in length and was most likely the apex predator of the marine ecosystem Down Under.[81]

The most notorious fossil pliosaur out there is one that is literally made of treasure. Australia produces 97% of the world's opal, so it may not be surprising that opal found its way into

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[78] Johnson, David. *The Geology of Australia.* 126-7.
[79] Ibid., 64.
[80] Ibid., 134.
[81] Long, John A. *Dinosaurs of Australia and New ZealandAnd other animals of the Mesozoic era.* Cambridge: Harvard University Press, 1998. Pg. 141.

mineralizing some fossil remains. This phenomenon is surprisingly common in Oz, and the most famous example, oddly enough, is a pliosaur someone named "Eric." Its remains have undergone mineralization in many areas and the result is opalized fossil. A beautiful, 110-million-year-old treasure.[82]

While Eric and other pliosaurs were at large down under, 120-110 million years ago, the first platypi arrived in Australia. These were descendents of synapsids, a lineage that walked that hairy (literally) line between mammal and reptile. Later, South America was the source of Australia's marsupial fauna, around 55 million years ago, in the Eocene, while Antarctica was acting as a land bridge. Just think of *all* the fossils lying under those ice sheets of marsupials that died off before reaching Australia. There is literally an entire continent of life down there about which we know nothing. But that is for another story. Here, what concerns us is that since the Eocene, South American and Australian marsupials have been evolving on there own without any way of checking up on one another. Divergent evolution took it from there, and before long, two entirely unrecognizable cohorts of marsupials flourished on opposite sides of the southern hemisphere. [83]

With all this mention of South America, I would hate for Southeast Asia not to receive its due credit. It is interesting to note that Indonesia and the Malay Peninsula are most likely the means by which several Asiatic biota made their way to the Australian landmass. Such is the case for many species of parrot. Such is the case for pythons from 20-30 million years ago.[84] Such is the case for the dingo.

When we begin looking at rock layers less than fifty million years old, the fossils begin to get more numerous, and our impression of prehistoric Australia becomes a little less incomplete. In its marine layers, a fifty-five-million year old fossil penguin has been found, much larger than the current species inhabiting its coastal dunes, the little blue penguin (*Eudyptula minor*).[85]

Around fifteen million years ago, life in Australia erupted with diversity. We begin here to see basal ancestors of current biotas. For instance, the earliest known kangaroo, as small as a modern rabbit, is fossilized. Despite this miniscule beginnings the Miocene became, in its later stages, an age of gigantism. Most mammalian

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[82] Johnson, David. *The Geology of Australia.* 135.
[83] Berra, Timm M. *A Natural History of Australia.* 225.
[84] Johnson, David. *The Geology of Australia.* 152.
[85] Ibid., 152.

taxa increased in size, and this growth reversed itself only very recently.[86] The kangaroo at its apex, for instance, was a third larger than the largest living Macropod, the red kangaroo. These giant kangaroos, *Procoptodon goliath*, were over 9ft tall at standing height, with correspondingly enormous hind legs. The features of its huge molars suggest that it could reach high enough to browse on trees.[87] This gigantism struck other clades as well: emus stood a whopping 9 feet tall .[88] *Zaglossus*, ancestor to the long-beaked echidna, was a monster. *Megalania*, the giant goanna lizard, was over 23 feet long! Wombats, too, those secretive, hard-rumped burrowers, were twice the size they are now.[89]

The *Diprotodon* was another giant marsupial, standing over 6 ft tall and almost 10 ft long. This monster looked like a rhinoceros-sized cross between a wombat and a bear. But predators grew too, and even the *Diprotodon* was not big enough to feel secure in the Australian Miocene. There was once a marsupial lion, the size of a modern leopard, and its prey was the *Diprotodon*.[90] The only modern marsupial predator of note is the *Thylacine*, also known as the "Tasmanian tiger." It is one of Australia's most recent and tragic extinctions; the last individual in captivity died less than 70 years ago. It had escaped the mainland of Australia via a temporary land bridge to Tasmania about 3,000 years ago, and soon after its mainland stock died out, leaving only the Tasmanian colony as its legacy. Sadly, for it and for us, it was walking into an island-cage from which its population would have no escape, when British colonialists, guns at the ready, stepped foot on Tasmania's shores.

Seemingly out of the blue, there was a continent-wide extinction about 46,000 years ago.[91] During this local mass-extinction, 23 of the 24 genera of terrestrial fauna that happened to weigh more than 45 kg died out. A similar mass-extinction of megafauna happened about 11,000 years ago everywhere else. Why did Australia jump the gun by so many thousand years?[92] Some scientists attribute this mass extinction of massive animals to the immigration of the aboriginal people to Australia, which is thought to have happened between 56,000 and 100,000 years ago. Others

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[86] Ibid., 152.
[87] Berra, Timm M. *A Natural History of Australia.* 247.
[88] Johnson, David. *The Geology of Australia.* 152.
[89] Ibid., 152.
[90] Ibid., 153.
[91] Berra, Timm M. *A Natural History of Australia.* 247.
[92] Johnson, David. *The Geology of Australia.* 153.

have come to suspect climate change, while some suspect a combination of the two.[93]

So, until very recently - within only thousands of years - Australia's biota has been very different from what it currently is today. These lumbering giants of Australia's past put extant species in a kind of curious perspective. Although they are exceptionally odd by today's standards, their own ancestry – with all its gigantism and ambition -- places them in an even starker light.

The Land Before Sheep

Although it is so geographically close to Australia, the prehistory of New Zealand seems strikingly foreign. Fossils in New Zealand date back about 500 million years, but with the landmass's dynamic and violent past, there are few places where any fossils are greatly preserved.

Lucky for me, most of the paleontological action was happening right in the province of Otago, the namesake for my university there. This region is *the* place to go for Miocene vertebrate fossils- fifteen million years back when there was no remarkable topography, there was a single, massive in central Otago: Lake Manuherikia. It was twice size of Lake Taupo, currently the largest lake in the country (and a remnant of an enormous volcanic crater).

The Manuherikia formation is important because its fossils give us an idea of what life was like right after the Oligocene drowning of New Zealand – one of the most mysterious and controversial times in the natural history of these islands. For example, the sediments in deposited in the lake preserved the fossils of a Sphenodontid living in New Zealand 16 million years ago. It is evidence like that, so close in geologic time to the presumed submersion of the landmass in the Oligocene, that suggests tuataras and other fauna may not have been affected by that Great Baptism 25 million years ago.

The earliest fossil beds from these lake deposits were heavy with *Nothofagus* – suggesting there had been high rainfall and cold climates ideal for the growth of beeches. This is strikingly different from the Otago we know today, which is largely desert: comparable in aridity to the Sahara and host to the coldest and hottest temperature extremes of any other Zealandic region.

[93] Ibid., 154.

Like Australia, New Zealand has been host to some outlandish giants (at least relative to the size of their closest living relatives). Take, for example, the giant 6.5 foot-long salamander (*Stereospondyl*) from the Triassic, discovered by Dr. Fordyce himself. Compare this to the two-foot hellbender salamanders of Flint Creek and other southeastern North American streams, some of the largest amphibians extant today. These primitive Mesozoic salamanders roamed the inland lakes of New Zealand's once-flat landscape. There was also a giant gecko (*Hoplodactylus delcourti*), the world largest gecko ever, according to the fossil record, which grew larger than a tuatara and was living on New Zealand as recently as 200 years ago!

Other Kiwi reptiles, on the other hand, shrank in size relative to its close ancestors. Lake Manuherikia was host to the New Zealand crocodile, which grew to no more than six ft long. Discovered only recently, this croc has baffled historical biogeographers. How did the crocodile get here? Had it been living on the Zealandia land mass before the breakup of Gondwana, or did it disperse to New Zealand, perhaps branching from the saltwater crocodile populations in Australia? Fifteen million years ago, the Tasman Sea was 1,000 km skinnier in width – was it small enough for the crocodilians to swim across?

Dinosaur Renaissance

New Zealand's history has a habit of being re-written. Until the late 1970's, paleontologists were convinced that dinosaurs never stepped foot on Zealandia – they were so confident of this, in fact, that they had essentially given up the search. Then, in 1980, an attentive elderly woman named Joan Wiffen was going for a walk in a streambed. Seeing an odd-shaped rock, she bent down and picked up the vertebrate of a theropod (a bipedal predatory dinosaur, like *Deinonychus* or *Tyrannosaurus*).

Her discovery immediately re-wrote the paleobiogeography of New Zealand. Since that fateful day, increased efforts have found fossil evidence of a wide variety of dinosaurs in New Zealand's past, including herbivorous hypsilophodonts, ankylosaurs, pterosaurs, sauropods, icthyosaurs, and plesiosaurs. Oddly, these not-so-terrible lizards of New Zealand are significantly smaller, in general, than closely related species in Australia.[94] The prevailing explanation for

[94] Long, John A. *Dinosaurs of Australia and New Zealand.* 161.

this phenomenon is that the New Zealand dinosaurs were smaller as an adaptation to conserve heat energy in the icy climates of the Antarctic Circle.

Speaking of re-writing natural history: it had also been long presumed that no mammals had ever stepped foot on Zealandia, except for the recent arrival of a couple species of bat. For generations, however, there have been rumors about odd mammal sightings in the wild corners of New Zealand. In his expedition notes, James Cook mentions seeing an otter in one of the South Island's fiords. A similar observation is recorded in the notes of a few explorers from the 1850s and 60s. Were they actually seeing an aquatic mammal, or just a bloated rat from their own vessel?

Kaurehe and *waitoreki* were the names for the otter-like mammal in the tales of several different Maori tribes throughout the southland. In some of these oral traditions, the *kaurehe* was said to lay eggs. Eggs?! Could this be referring to a New Zealand species of platypus that is now extinct?

While several placental fossils have been found on the Sub-Antarctic islands surrounding New Zealand, most prominently the Chatham Islands, no mammal fossils had ever been found on New Zealand proper -- until almost exactly one year ago from the first draft of this sentence. Worthy et al., 2006,[95] announced their discovery of some teeth of a squirrel-sized mammal in some Miocene deposits of central Otago. And so, after all, the fossil record shows that there *were* in fact mammals other than bats in the woods of New Zealand. Once again, the text books are being re-writ, in this case for a discovery as monumental as Joan's serendipitous creek bed discovery.

How does this new discovery change the fundamental framework in which all evolutionary patterns in New Zealand have been understood? Until now, flightlessness had made sense, because until now, New Zealand's forests had been seen as mammal-less. What was the actual extent of the impact of these newly-discovered native mammals on the ecology and evolution of New Zealand's biota? This is perhaps the newest and most pressing question in Zealandia biogeography.

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[95] Worthy T.H. A.J..D. Tennyson, M. Archer, A.M. Musser, S.J. Hand, C. Jones, B.J. Douglas, J.A. McNamara, and R.M.D. Beck. Miocene mammal reveals a Mesozoic ghost lineage on insular New Zealand, southwest Pacific. *Proceedings of the National Academy of Science of the United States of America:* December 19, 2006. Vol. 103, no. 51, pp. 19419-19423.

Avian Extravagance

While dinosaurs and amphibians are fascinating, they are not so distinctly and iconically Gondwanan as New Zealand's repertoire of ancient birds. It is the *avian* fossils that make the New Zealand bedrock worthy of such note. And rightly so: these long-extinct birds had been so outrageous, it is as if they were searching for the limits of their evolutionary capacity -- daring natural selection to do it's worst.

Most of these paleo-birds were flightless. In its recent history (geologically speaking) New Zealand has seen thirty nine species of flightless birds, eleven of which are still around today. Theirs is an extreme example of ecological release, relayed: several different avian taxa turned flightless at different times, as if passing the torch along. Upon reaching Aotearoa's shores, their ancestors were pleased to find a world without egg-snatching rodents or predatory cats lurking in the underbrush. They all proceeded "to let their hair down." As they became more and more adapted to life on the ground, they became larger, disproportionately heavier – fat even -- and slower in reproduction. Examples include the South Island Goose (*Cremiornis calcitrans*), which was fifteen kilograms in weight and over a meter tall. Another icon of New Zealand's extinct wonders is the South Island Adzebill (*Aptornis defassor*), a giant rail that had a massive curved beak, weighed ten kilograms, and stood at just under a meter.

Of all New Zealand's birds that didn't give up flight, the most notorious is surely the Haast's eagle (*Harpagornis moorei*). The largest eagle in the world, ever. The females were well over three meters across, and weighed approximately thirteen kilograms, which approaches the upper limit of the weight-to-wingspan ratio for flight in eagle-like birds. What's even more impressive than these proportions is the rate at which the Haast's eagle evolved to that size. All Haast's fossils are less than one million years old. A little over one million years ago, it must have dispersed from Australia on the back of a strong and steady wind. Ironically, its counterparts that remained in the Outback evolved into the world's smallest eagle, *Hieraaetus morphnoides*. This is an extremely high rate of divergence, in such starkly polarized directions, that it begs the questions: what is it about New Zealand that made the eagle become so large? And what is it about Australia that made it become so small?

The prevailing explanation for the Haast's gigantism is that this increase in size was driven not only by New Zealand's cool, temperate climates, but also the need to keep up with the increasing size of its favorite prey, which we will discuss shortly.

Chapter 8

The House of Bell

My final month in New Zealand was spent with the Captain. We were the self-monikered Subduction Reconnaissance Team, Oceania Division. On June 10th I left Dunedin for good, determined to make the most of our final days on the far side of the world. Our highest priority: the moa.

The Moa Extremity

A down-covered demon shaped like a bird. [96]

Perhaps the most iconic and legendary example of New Zealand's paleo-oddity is the moa. There were fourteen species of them, the largest ones belonging to the genus *Dinornis*. The female of *D. gigantus* weighed up to *250* kilograms. Its femurs rested two meters high. *Two* meters. Standing erect, its head could reach thirteen feet in height.

The moa family's dynasty on the New Zealandscape endured for at least four million years. It is thought that they were extremely abundant at one point, with a population between four and ten million individuals. And with an animal of such size, such numbers translate to great ecological influence. This reign of the Moa ended, of course, when humans came.

[96] Bergaminin et al. *The Land and Wildlife of Australia.* 148.

The last moa was thought to have died roughly 400 years after the first Polynesian war canoe landed on Aotearoa's shores. To this day, I can not get over the fact that such a monstrous and proterozoic creature was tromping around New Zealand at the same time that King Arthur was assembling his knights of the Round Table. It was also around that time that Maori tribes were realizing how easy it was to capture and eat moas -- by the flock. Several archeological sites throughout New Zealand reveal middens (more like barbecue pits) where Maoris would herd entire stampedes of moas into a huge hole and proceed to cook them en masse. Mass graves were dug during this moa holocaust, each containing hundreds and even thousands of Dinornithine skulls.

Despite this tragic and abrupt end, moas had a pretty good run. They radiated from their sister clade about 18.5mya, possibly after the Oligocene baptism had bottlenecked New Zealand's biota and left several ecological niches vacant.

Why were they so large? One theory suggests that, in having to do without the convenient adaptation of a foregut, the moa's intestines had to be extra long in order to ferment the plants they had at their disposal. As a result, the larger bodies in the population were healthier and more apt to pass on their genes, and evolution banked in that direction. And these birds were indeed large - the largest bird ever to exist, supposedly. To compare, ostrich eggs weigh an average of 1.4 kg. Moa eggs were rarely less than 6 kg. That's over 13 pounds of egg.

The moa played an important part in my semester. Since day one, I was trying to finagle my way into a paleontology dig so that I could see a moa in the dirt for myself. These monstrous birds fascinated me, and I figured that excavating one would give me an unbeatable impression of their full outlandishness. I was fortunate that the Captain sympathized. We made it our monomaniacal goal, our *Moby Dinornis*, to lay hands on a moa remain, pulled freshly out of New Zealand mudstone by our own four hands.

Dr. Fordyce admired our enthusiasm, and pitied our naivety. He prudently connected us with one of his more avid graduate students, Jamie Wood. Our conversation resulted in a weekend expedition to the heart of Central Otago, to the ranch of a man by the name of Ray Bell. We were accompanied by a Sewanee ally, Carey, on furlough from her own investigations of native *Anura* diapause in eastern Australia.

We pulled into the drive of a simple farmhouse in the arid rolling hills of central Otago, only seventeen kilometers from the town of Alexandra and, more notably, only a hundred meters from the Chatto Creek Tavern. The owners of the house were cutting up a deer in the front yard as we pulled in, and they eyed us suspiciously -- even they were the ones with deer blood all over their clothes. According to Jamie, and corroborated by the local tavern owner, the Bells don't take too kindly strangers. They've turned away graduate students before and are known to play ignorant to any questions about moa bones on their property. But the Captain and I had to try.

We approached with caution. There must be something genial about our combined cluelessness and childish enthusiasm, because to our surprise, we lucked out. Maybe it was my goofy longish hair; maybe it was the fact that we had a girl with us; maybe it was something about the fact that the only digging utensils we had on us were spoons…or maybe it was the fact that Luke knew enough about cars to ask some good questions about Ray's red left-hand drive '67 Thunderbird sitting in the garage – whatever it was, Ray Bell and his wife took to us almost immediately. He called me "Lofty." He called the Captain "Indy," as in, Indiana Jones.

He and his wife Joan welcomed us into their home with cups of coffee and plates of delicious homemade scones. We asked him about his ranch and about his experiences with paleontologists. The longer we talked to him, the more we noticed that he answered every yes or no question with the same response: "Eh, why not?"

Can we explore your land? "Eh, why not?"

Can we use your shower? "Eh, why not?"

Can I sit in your T-bird? "Eh, why not?"

Can we have some of that venison? "Eh, why not?"

Why? "Eh, why not?"

And so we befriended Ray and Joan Bell. He opened the back gate and gave us permission to explore as much of their land as we wished. His ranch was centered around a vast, oft-flooded wash that with every rain would expose more and more fossiliferous mudstone from the Lake Manuherikia formation. Unfortunately our first exploration of Ray Bell's land was a bust. The only bones found were those of rabbits and sheep. But it certainly was a blast. But Ray invited us back, and we were quick to return -- the very next weekend, in fact.

Another whole day of searching and digging yielded the greatest accomplishment of my time abroad. We sauntered up to Ray's front door at the end of the day, with what we were positive was a moa femur and three associated bone fragments in one pair of hands, and our digging spoons in the other. We were reserving judgment, though, reserving our elation, until we were positive about what we had. It better not be a cow femur. He opened the door, saw what was in our hands, and exclaimed, "Eh, why not?!"

He took us around to a broken down school bus, opened up the back door and took out a cardboard box full of moa femurs and pelvises. It was the most amazing stash I had ever seen in my life. Grad students would *kill* for this kind of collection, and Ray Bell was keeping it in a cardboard bus in a broken down bus with a leaky roof. Well, when these bones are as numerous as they are the Bell ranch, "why not?"

We compared our femur to his. It was a moa, all right. Spot on. A giant flightless monster. After some email correspondence with Jamie back at the University of Otago, we concluded that this femur once belonged to a stout-legged moa (*Euryapteryx gravis* Owen 1870), also known as the Southern broad-billed moa. *Euryapteryx* has a massive weight-to-height profile, and fed chiefly on broadleaf plants, insects and fruits. It was the dominant species east of the South Island's Alps and in the lower coastal areas of the North Island.

Ray insisted that we take the femur.

"Really? Are you sure?"

"I've already got a bloody bus full of 'em, eh, Lofty!"

We couldn't believe it.

Luke asked one last time, "Are you sure, Mr. Bell?"

"Eh, Indy, why not?!"

So we conferenced with Dr. Fordyce over the phone and emailed him a picture. He gave us his blessing on taking it out the country (but warned us that customs probably would not care what he thought about it, if we were caught).[97] The Moa Mission was completed with overwhelming success. Time to celebrate. That night, Luke and I lodged at the Chatto Creek Tavern, treating ourselves to a real meal and some pints of Speight's. Our moa bone was wrapped safely in my sheepskin, which was wrapped safely in my Swann-Dri, in the Toyota Carat out back. How New Zealand can you get?

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[97] For the curious: the moa femur safely made it through customs (it was furtively wrapped in my Swann-Dri jacket and placed between stacks of birding books in a suitcase we purchased for five New Zealand dollars at an Op-shop on our last day in Dunedin). Upon our return to Sewanee headquarters, the bone was gladly donated to the collections of the Biology department at Sewanee headquarters, and a display will be erected in the new wing of the science building.

The Divaricate Connection

The legacy left by these giant bird-cows can be found within the flora of New Zealand today. The moa's impact on current biota is a perfect illustration of why we must consider the past when contemplating the present. The impact I am talking about is the phenomenon of "divaricate" plants in New Zealand.

Divaricates is a descriptive term for woody plants with small leaves and stems. They are characterized by peripheral, wide-angle branching, with a large number of branch orders and high branch density. A high degree of branch interlocking. Tough wiry stems. Many internal growing tips. No spines.[98] There are some scientists who are convinced that this odd branching adaptation evolved in response to the foraging habits of New Zealand's giant moas. This would mean that these divaricate features evolved into its present form within the last four million years, the amount of time the moas were a dominant presence in New Zealand.

Moas were big, hungry birds, capable of chomping through branches fifteen millimeters thick. Jamie Wood, or correspondent at the Otago geology department, has showed that the eating habits of moas were strikingly different from the other ratites of the world. Moas would chomp on a woody branch by placing the stem cross-ways in its mouth, perpendicular to the direction its beak was pointing, and biting down hard. Jamie knows this because he has found such well-preserved moa remains that their stomach contents were still in tact and in close proximity to the skeleton, mixed in with a heap of gizzard stones. Within the pile were pieces of chunks of branches with similar diameters and the exact same length – this length happened to equal -- you guessed it -- the width of a moa's beak.

The reason, we think, that so many shrubs resorted to divaricate defense is that the branching system makes it very difficult for a moa to reach those stems of preferred biting size, allowing the moas less per bite than the non-divaricate alternatives. This is a compelling idea, and it has been tested, the best it could, in a really cool way. The experiment was this: Some scientists took an emu and observed that it could eat enough broad-leaved plants to survive if it foraged for 9 hours a day. Then, giving the same emu an equal volume of divaricate plant species to eat, they found that it would have needed

[98] Gibbs. *Ghosts of Gondwana.* 162.

to feed for 36 hours each day in order not to starve.[99] This, as you mathematicians know, is impossible.

Though clever, the experiments results were also controversial. For one thing, emus don't eat by chomping branches width-ways in the beaks, as Jamie Wood has demonstrated that moas did. Also, the emu's beak wasn't nearly as strong as that of the mighty moa. The emu may just be too small to be an experimental stand-in for *Dinornis*. But, even with these qualifications, the experiment was still neat.

Another interesting piece of evidence is this: for the most part, divaricate species in New Zealand are more palatable than their soft, broad-leafed, straight-stemmed neighbors, most of which have some sort of unpalatable or even poisonous deterrent to discourage browsers. This implies that most shrub species had *some* way of defending themselves against the moa, one of which could have quite possibly been divarication. Being too rugged and angular to be worth the moa's time, the divaricates didn't need to waste energy on chemical defenses, which eventually evolved away.[100]

Now, the opposition to this explanation for divarication propose this instead: that divaricates are merely xeromorphic- that is, adapted to an extremely arid climate. The boxy, tightly woven plant shape may have prevented desiccation and protected the plant from the high winds and sandstorms common on the Otago plains. So, was it moa browse or xeric environs that selected the divaricates into existence?

The question raises an interesting point that is often misunderstood in evolutionary theory. Things don't evolve for single reasons. To think that is simply to insult the complexity of the circumstances in which things evolve, as well as the complexity of life's reactions to circumstances. There is (almost) always an ecology of reasons that certain traits are selected for above others. So, as author George Gibbs points out, these two hypotheses are not necessarily mutually exclusive. Divaricates probably evolved they way they did as a result of both selective forces -- both moas *and* desert life.

Interestingly enough, there's another plant whose life-cycle was likely shaped by the influence of the hungry moa as well. The juvenile lancewood (*Pseudopanax crassifolius*) has two different leaf shapes; as a sapling, it has tough, spear-like leaves that are less

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[99] Ibid., 165.
[100] Ibid., 164.

conspicuous and palatable than those of most plants in the southland bush. These lancelate leaves have a high tensile strength, which gives them the nickname "wire plants." Similar tests with emus also show that these juvenile morphs of its leaves slow down feeding rates to the point that moas would have starved if they kept wasting their time trying to eat lancewood. But, when the lancewood grows above a certain height – that is, just above a giant moa's *biting height* -- its leaves begin to grow in the form of soft, green, lobed broad-leafs, allowing it to photosynthesize and reproduce effectively. Very clever indeed.

So divaricate plants and the Juvenile lancewoods are two examples of present flora whose ecologies have been shaped by its past. Without holding up these species in the light of deep time, these fascinating life-cycles and traits would remain mysteries, obstructing and in no way lubricating the coherence of life's story. They are examples of how the new pattern is senseless and ridiculous without knowledge of the old.

Chapter 9

In Media Res

One of Darwin's most important philosophical contributions, via his treatises on the theory of natural selection, is that life on earth today is best described not as "in progress," but rather as "in process."[101] It is not working towards some goal, not building up to anything. There is no teleology to evolution. Increasingly complexity does not imply increasing importance. Life, if it can be said to be doing anything, is merely *responding*. It's history is a call-and-response with the land; as such, to be well understood, it must be viewed in the context of the changing life forms and transforming maps of old. We as intellectual beings, having just recently been aware of this grander story, have entered the scene not at the beginning or end of the narrative, but far into the middle of things. It is a story of life and of place, one that requires a broad perspective of time in order to grasp fully.

The past is the key to the present. Vice versa. The paleo-evolution can be understood only with a masterful comprehension of current ecological processes, and modern ecology makes sense only in the light of evolutionary principles. Thinking of life as "in process" makes paleontology, the study of "ancient beginnings", relevant to the ecologists, and ecology relevant to the ecologists as well. Present and past life is not separable, and in turn looks at both

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[101] His other major contribution, most would agree, and probably the most upsetting, is that natural selection, evolution, and the other laws of nature also apply to us humans. "He is no exception," Darwin wrote of mankind.

fossils and living specimens are equally enriched with the fullness of history.

With that, let us now look at the present-day flora and fauna of Australia and New Zealand. When going through the contemporary biota, let us focus on the same questions that were asked in our exploration of Deep Oceania. Certain features of the current biota become more interesting than others in this particular approach to natural history. We are looking for patterns in oddities and outliers, both intra- and inter-Oceanic, as well as representatives of classic patterns in island life. The most important question we can ask is: what from the past can illuminate these phenomena of the present?

Australia is the land of contrararities…her zoology can only be studied and unraveled on the spot, & that only by a profound philosopher.

-Barron Field[102]

During my final sunset in Australia, I was in the back seat of Bob and Lorraine's white van on Kangaroo Island, squeezed between an Italian and a Frenchman, on the way back to the farm after a beautiful day. In the morning, we had visited some of Kangaroo Island's most secluded and beautiful beaches, looking under the rocks in search of Little blue penguins, the only penguin breeding on the Australian coast. We found many, and I was elated at my first encounter in my life with a Sphenisciformes. In the afternoon, we had met up with Bob and Lorraine's granddaughters, who happened to be crazy identical twins who perfectly embodied the stereotype of the gruff Aussie outbacker. They taught us how to spearfish in the waters off the island's northern cliffs. It was a perfect day, a wonderful last huzzah for me as I prepared to move on to a semester on another daughter landmass of Gondwana.

Instead of pulling into the normal driveway onto their property, Bob pulled instead onto an even bumpier track that took us to the highest point on the farm. Here there was a small rainwater retention pond used for irrigating the vegetable garden. Bob put the car into park and threw me a burlap sack he had pulled from under his seat. He told me to follow him and opened his door. I scurried down the slope of the reservoir in step with Bob and met him at the water's edge. He grabbed a line that ran into the water and began to pull a submerged cage out of the water. I held out my burlap sack

[102] Geographic Memoirs on New South Wales

and into it Bob shook eight large, writhing crayfish. Bob was beaming, with a smile broad enough to be visible under his large silver beard. This was to be my farewell dinner.

After we had all cleaned up and I had bottle-fed the kangaroos the rest of that morning's goat milk, we settled down to the feast, my last meal with this family. They uncorked a bottle of wine made from their own grapes. Patrick, from Bordeaux, who happened to be a winemaker himself, tasted it, nodded enthusiastically. "It is much delicious!" he exclaimed in his viscous accent. Quite the compliment from a Frenchman who owns his own chateau. It was a beautiful night, and throughout the dinner conversation, my mind wandered back through the past month's experiences.

I thought back to my first morning in Australia, in the small town of Katoomba deep in the Blue Mountains. I had escaped the biologically depauperate subway tunnels of Sydney the night before, acting on a sudden impulse to go west. The impulse usually works in the States; maybe it would here, too. I remember stepping out of my room that morning in Katoomba. I remember being blown away by the din of noises coming from above. I remember looking up and seeing the parrots.

Cockatoos & Fairy Wrens

Australia has one sixth of the world's Psitacciiformes, and most of them are endemic. The most common of them, the red-tailed black cockatoo (*Calyptorhynchus banksii*), the galah (*Cacatua roseicapilla*), the beautiful and gregarious rainbow lorikeet (*Trichoglossus haematodus*), and the sulfur-crested cockatoo (*Cacatua galerita*), to name a few, also seemed to be the most abrasively vocal. Common both on main street and in the mountains, these parrots served as constant reminders that I was, indeed, *here*. I had made it.

Australia has over 740 species of birds, 350 of which are endemic. Australian avifauna is mostly of Asian origin, with some notable exceptions, including the Corvids (the crows, corrowongs and magpies) which evolved along with other passerines in the heart of Australia itself, 50-60 million years ago.[103] Some groups which I, as a denizens of Laurasia, had always taken for granted are conspicuously absent: there are no woodpeckers, skimmers,

[103] Berra, Timm M. *A Natural History of Australia.* San Diego, CA: Academic Press, 1998. Pg. 187.

sandgrouse, nuthatches, shrikes, true finches, or buntings. In many ways, parrots have filled in all these gaps. The yellow-tailed cockatoo, for example, has evolved into an ecological replacement for woodpeckers. Considering that it is equipped with a parrot's beak, this is quite an impressive feat of niche shifting.[104] Bark insects, and the bark itself, do not stand a chance against the foraging power of this pecking parrot.

But parrots are not the only exceptional birds of Australia. I would be remiss to not mention the ratites, those closest living relatives of New Zealand's moa. It is a monophyletic clade of flightless birds (including rheas from South America, ostriches from Africa, and, of course, the moa) that are thought to have originated from somewhere in ancestral South America; in fact, their closest living relative is a South American nearly-flightless bird called the Tinamous. The two ratites still surviving in Australia happen to be the two youngest in the clade: emus (*Dromaius novaehollandiae*), which stand up to 6ft tall, and cassowaries (*Casuaris casuaris*), brilliantly colored birds, slightly smaller than the emu but twice as temperamental and occasionally deadly. There are only 1,000 left in the world.[105] Emus grazing in the irrigated fields of New South Wales were a common sight on my train out toward Bourke from Katoomba.

Of all the localities I visited, Kangaroo Island was host to the most beautiful examples of Australia's bird diversity. Superb fairy wrens and Splendid wrens (f. Malurdae) would hop around my feet as I swept the kangaroo poop from the yard into the compost pile every morning. I would often hear and see Kookaburras (*Dacelo novaeguinae*), the world's largest member of the kingfisher order (O. Coracciiformes). High in the air, wedge-tailed eagles (*Aquila audax*), the largest bird of prey in Australia, and huge, white Australian pelicans (*Pelecanus conspicillatus*) flew overhead. In the island's rivers swam giant black swans (*Cygnus atratus*) and the occasional flock of Cape Barren geese (*Cereopsis novaehollandiae*), the closest living relative (and nearly identical in appearance) to New Zealand's long-extinct flightless goose.

The Macropod Efficiency

[104] Bergaminin et al. *The Land and Wildlife of Australia.* 152.
[105] Berra, Timm M. *A Natural History of Australia.* 193.

I won't forget my first sunset in the Outback. It was an all-day train and coach ride to Bourke, a dusty, quiet town full of racial tension and broken glass. It is flanked by a river that demarcates the unofficial boundary of the Outback, which is actually a name derived from the common phrase, "Back O' Bourke." I sat on a dock at this river, during sunset, trying my best to ignore the bushflies that were swarming me.

Depending on when and where you are exactly in Australia, the bushfly (*Musca vetustissima*) can reach plague proportions. The female is particularly bothersome -- mainly because it is about 3 times more abundant than males -- which is the main that populations tend to double and triple in no time at all. These bushflies are responsible for what is known as the 'great Australian salute," which is simply the motion of waving your hand in front of your face to get the bushflies out of your nose.[106]

It has a sporadic yearly distribution: they cannot survive in temperatures below 12 degrees Celsius, so during Australia's winter the flies in the bottom third of the continent all die out. Once spring rolls around, with the newly sprouting grass beginning to increase substantially the nutritional value of cow pies across Australia, bushflies in the northern region of the country increase exponentially in a matter of weeks. Gusty northerlies then carry the plague back down to southern Australia by mid-summer, and to Kangaroo Island shortly after that.[107] Luckily for me, I left the Bob and Lorraine's farm and the country days before the swarm was predicted to hit. I felt that my time in Bourke provided a sufficient impression of these pests; I did not need another.

But that evening, back of Bourke, before the sun had fully set, I spotted the exact reason I was braving those swarms. Across the river and among the eucalyptus trees were three grazing red kangaroos (*Macropus rufus*). Picture perfect. The red kangaroo is the tallest of its family's forty four species (Macropodidae, the "big feet"). In my single months in Australia, I had the great fortune of encountering its second and third largest species as well. I stumbled upon a pair of the second, the eastern grey kangaroo (*Macropus giganteus*), in a far corner of Canberra's National Botanical Gardens, and I bottle-fed two juveniles of the third largest species, the western grey, every morning and night while staying with Bob and Lorraine. Nothing else in my travels these 7-months was so damned cute and

[106] Ibid., 121.
[107] Ibid., 123.

precious as holding those joeys in my lap while feeding them warm goat's milk.

Macropods are truly amazing. They are ecologically equivalent to the ungulates of North America – Australia's deer. This is a great example of ecological convergence but physiological divergence; though they perform the same service for the ecosystem, they could not look or act more different.[108] Kangaroos hop because doing so, at moderate speeds, and with their particular body size and types, running. Their powerful leg muscles allow them to hop up to *thirty* feet in a single bound, pushing speeds of *forty* miles per hour.

The macropods are a glorious demonstration of how weird Australian mammals have become in the blessed absence of those overbearing placentals. Their tail, interestingly enough, provides an alternative means of locomotion at low speeds, like a low gear. At speeds less than 6 km per hour, their muscular tail -- and I mean *muscular* – I mean, *really* muscular– is used as a 5th leg. At other times, during territorial and courtship battles, males support their entire body with their tail as they direct a deadly kick at his opponent's chest. Anyone who has witnessed this sight can attest to its marvel.

There are three hundred species of mammals in Australia, 80% of which are endemic. Australia was without placental invasion for the last 35 million years or so, allowing marsupials to fill every niche they could carve out of the landscape, into those usually occupied by placentals. This culminated in a massive Oligocene radiation, which brought about several neat cases of marsupial–placental convergence: *Thylacines* (otherwise known as Tasmanian Tigers), looked almost exactly like a dog, but is a marsupial; there are marsupial moles (*Notoryctes typhlops*); there was once a Marsupial leopard, whose physiology was almost identical to that of a big cat, except for its being a marsupial.

Even within the marsupial sub-class, there are compelling cases of convergent traits. The best example of this is the phenomenon of rear-opening pouches. Koalas (*Phascolarctus cinereus*) and wombats (*Vombatidae*), the largest burrowing animals in the world, speciated from a common ancestor 25 million years ago whose pouch happened to opened backwards;[109] therefore, these two very ecologically different marsupials have rear-opening pouches. However, the bandicoot, whose marsupial pouch also opens

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[108] Bergaminin et al. *The Land and Wildlife of Australia.* 83.
[109] Berra, Timm M. *A Natural History of Australia.* 232.

backwards, evolve from a distant lineage, far from the koala's ancestral branch on the marsupial tree. Bandicoots are arboreal animals, just as koalas are; their similar ecologies brought about this convergence, directed by persuasions common circumstance.[110]

It's difficult to mention koalas without pausing to mention Eucalyptus trees as well. Of the nation's 15,000 species of angiosperms (80% of which are endemic,[111] including 2,000 endemic species of wildflower[112]), the eucalyptus are perhaps the most iconically Australian. It is a genus of gum trees with over 600 species, which is second in diversity only to the Acacia or "wattle" genus (835 species in Australia).[113]

Eucalyptus trees are the tallest angiosperms in the world. They are unique all the way down to their bark, which has a tendency to slough off into long strips on the forest floor and regenerate itself rapidly. While this may seem like a waste of cambium and a reckless fire hazard, it is actually an ingenious way to fend off parasites and to discourage overuse by koalas.[114] Their leaves are equally ingenious; they are one of the only deciduous trees whose leaves hang vertically from their stem, with photosynthetically productive cells on both sides of the leaf.[115]

I found that eucalyptus dominated the forest canopies of Kangaroo Island -- and each one seemed to have a koala in it. While the island was once teeming with eastern gray kangaroos – which are still around, just not in such ludicrously high numbers – it is now overflowing with koala. It was near plague proportions; a severe koala infestation. The island's eucalyptus trees were actually in a precarious state, over-browsed to an unprecedented degree (unprecedented, at least, in living memory).

Thorns & Frills

I remember with muffled regret all the classic Australian animals I did not get a chance to see – I was either in the wrong place geographically or at the perfect place at the perfect time of year -- but simply out of luck. Most unfortunately, I didn't see any of the

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110 Bergaminin et al. *The Land and Wildlife of Australia.* 81
111 Berra, Timm M. *A Natural History of Australia.* 67.
112 Ibid., 77.
113 Ibid., 77.
114 Bergaminin et al. *The Land and Wildlife of Australia.* 48.
115 Ibid. 42.

dragon lizards (f. Agamidae) that lurk in the Western Australian desert. This family contains 63 species of weirdoes, including the famous frilled lizard (*Chlamydosaurus kingii*), which has an iconic frilled necklace used for defensive displays and mating dances. It is one of the only lizards able to run bipedally, once it reaches a certain speed. But my personal favorite is the thorny devil (*Moloch horridus*), a cartoonishly spiny dragon that is both tiny and harmless. It feeds only on ants of the genus *Iridomyrmex* [116], and can eat over 5,000 ants in a two-hour period. (!) It's most astounding trick is that it never actively drinks water. Overnight, specially-oriented scales and spines along its body somehow direct accumulating dew up the lizard's back and down to the corners of its mouth.[117] Although I did not see them in the wild, I was fortunate enough to see them in the flesh at the end of my pilgrimage to the home of my recently deceased hero and inspiration, Steve Irwin, the "Crocodile Hunter," owner of the Australia Zoo.

After paying my long overdue respects to this fallen hero, I perused the enclosures of his park, spending most of my time among the crocodiles. Irwin was and remains a legend for his devotion to protecting the most ferocious and deadly monsters on offer, particularly the saltwater crocodile. Known to reach up to 23 feet in length and weigh up to 2,200 pounds, the "saltine" is responsible for the most deaths per year of any other vertebrate in the world.[118] r

Treasure Maps for Bio-Gems

I remember the two days I spent in the coastal rainforests of Victoria. I went there with a mission. I was determined. I was going to find a Superb Lyrebird (*Menura novaehollandiae*). This rooster-sized member of the Mimidae, whose eggs are the largest of all passerine birds, is world-renowned for the males' outstanding courtship rituals. These include both ornate and outlandish displays of their lyre-like tail feathers and show-stopping demonstrations of their vocal mimicking abilities. Lyrebirds have been recording doing pitch-perfect imitations of camera shutters, chainsaws, car alarms, kookaburras, and cell phone ring tones. I knew I would not have a chance of hearing or seeing these stunning displays, since their

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[116] Berra, Timm M. *A Natural History of Australia.* 165.
[117] Ibid., 166.
[118] Ibid.., 158.

mating season occurs only during Australia's winter months, but this was a whopper of a passerine, even when silent, and for years I had dreamt of encountering one. I could not pass up the opportunity. And so I wandered for two days in the coastal rainforest, in Sherwood Forest Reserve, just to the southeast of Melbourne, to be more precise, under a canopy of gargantuan tree ferns, listening and hoping for a glimpse of this elusive bird.

Like the eucalyptus, the tree fern is another iconic staple of the Australian forest. Like the whale shark, its name can be confusing; trees are not ferns, nor vice versa. A less misleading name would be "tree-sized ferns". Cyatheales are limited in range to the temperate, moist areas of Malaysia, New Zealand and Australia – in the latter, it can be found only in the southeastern corner. When around these beautiful plants, it does not take much to imagine yourself back in the Carboniferous. Nothing conveys the aura of Gondwana like walking under a Cyatheale canopy. Your walks become prehistoric; your imagination runs wild. In the sedimentary layers beneath your feet are the fossils of proto-avian dinosaurs -- the very forefathers of passerines like the lyrebird -- that once walked under canopies of Cyatheales themselves. I later learned that in the very region in which I was walking that day, amongst the fibrous roots of the tree-ferns I was wandering among, there lurks something far stranger than what my imagination could conjure: giant earthworms. *Megascolides australis*. *Inch-thick* annelids can grow over 10 ft in length.[119] Field ecologists have reported that, while moving through the soil underground, they make a gurgling sound that is audible from above.[120] If I had known that day that these creatures were creeping through the soils of that tree-fern forest, I would have been sure to bring a shovel.

Although I did not hear any such earthworms on my walk, I did at one point hear a large amount of rustling in the dense brush to my left. It was late in the day and my morale was beginning to waiver. Upon hearing the noise I immediately stopped, and tried not to move a muscle for the next several minutes. Tentatively, two shy lyrebirds, a male and female pair, beautiful and just as I had imagined them, edged out onto the trail. Foolishly, I thought I could reach for my camera unnoticed, and with a jolt the pair dashed off into the brush to my right. I took chase, hoping for one more look. For over a hundred meters I followed, keeping the lyrebirds just in sight

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[119] Ibid., 116.
[120] Ibid., 116.

as I tried to maneuver the dense understory. I could see them dipping along far ahead, with a dexterity and grace only those with an evolutionary history of doing so could ever achieve. They were silent, but they were there. More real for me than they had ever been before. Giving up the chase, heart still pounding – out of excitement, not exertion – I look around. Something about that forest of tree-ferns and eucalyptus seemed deeper now. I was deeper into it. It held some new dimension, thrown into focus by the appearance of that bird. I was ecstatic. I was also lost; where had those birds led me?

It was nightfall before I found the reserve's exit.

The Monotreme Miracle

Serendipitously, it was in another tract of that same coastal forest that I stumbled upon my first echidna (f. Tachyglossidae). Echidnas and their allies are incredibly important pieces in the puzzle of Australia's natural history. They are monotremes, a subclass of Mammalia that is endemic to Oceania. Other than a small population of long-beaked echidnas (*Zaglossus bruijni*) found in Papua New Guinea, this subclass, composed of just two other species, are found only in Australia.

If you recall the rule of endemism (higher-order endemism suggests longer isolation), you can see why the monotremes are huge deals for anyone interested in tracing the story of life through deep time. Their history in Australia goes back 120 million years. There have been monotreme fossils found in both Patagonia and Antarctica, meaning that like the tuatara, the monotremes are paleoendemics, stranded relics of a previously cosmopolitan past. Being so ancient and largely unchanged, they bare fascinating similarities to their reptilian synapsid ancestors. "Monotreme" is a word that transliterates to "single-hole," which refers to the fact that females have not a vagina -- as all marsupial and placental mammals do -- but a cloaca, which takes care of all discharges: digestive, excretory, and reproductive.[121] Their body temperature is only 89 degrees Fahrenheit, about nine degrees lower than most mammals and reflective of its exothermic heritage.[122] Due to this low body temperature, the males lack the need for external testes. Also, the

[121] Ibid., 218.
[122] Ibid., 218.

orientation of their pectoral girdle, the rather simple skeletal structure of their skull, and their shoulder joints are also strikingly reminiscent of their reptilian bloodline.[123]

I came upon the echidna during a romp through the bush on the outskirts of Dandegong Ranges National Park, near Melbourne, on the night before my encounter with the superb lyrebird. I had taken the subway out to the last station, hopped off and made straight for the bush. After setting up camp and getting some pasta in my stomach, I set out on one of my nightly patrols; part of an attempt to see as many species of possum as possible in my two weeks on the mainland. To stumble upon a foraging echidna was indeed an unexpected but welcomed surprise. Over deep time, the echidna, or "spiny anteater," has lulled itself into a sense of security with its spiny armor. It has become a careless, sauntering buffoon of a forest dweller. I heard the thing twenty feet before I came upon it. When I made my presence known, the echidna simply arched its back, protruding its spines out even more, and dug itself into the leaf litter. I reached down and poked it. It didn't move. It didn't do a thing. I tried to roll it over; it was surprisingly difficult, it must have been clutching to some roots underneath it. I watched it for some time. If I stayed perfectly still for more than 20 seconds, it would assume I had left – or perhaps it forgot I had been there -- and resume its search for soil invertebrates. But the second I shifted weight he would ball back up into an unmovable coil.

Back at camp, I lay on top of my sleeping bag, wedged in between two Eucalyptus trees, reflecting on the encounter. Hours later, I was almost asleep when an inquisitive brushtail possum walked up to my open tent flap and peered into my makeshift shelter. The possum patrol was a success after all. I closed my eyes, never dreaming that the next day I would in fact find a lyrebird.

"A land of contrararities…"

Of Venom & Fangs

Solvitur ambulando
"It is solved by walking."

My second encounter with an echidna occurred while I was on a run through a pine plantation on Bob and Lorraine's property.

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[123] Ibid., 218.

This one too practiced the same bumbling but seamless defensive behavior. Being light out, I was able to follow it from afar for several minutes as it moved from tree base to tree base in search for soil critters. It was while on morning walks and runs such as these that I came to familiarize myself more and more with the biota of Kangaroo Island. It was here that I learned my most needed lesson: that learning about a landscape simply takes time -- and a bipedal pace. Bikes and cars will never do.

The unique, dense biota of Kangaroo Island made this lesson particularly rewarding. Koalas, kangaroos, goannas, birds, and endemic insects. Whenever I wasn't looking up in the sky for superb fairy-wrens, I was looking down and seeing the ants. Australia has a little more than 67,000 native species of insects, and 5,000 of those belong to the ant family, Formacidae.[124] Termites in Australia are almost equally diverse, with far more impressive structures. Western Australia is dotted with termite towers that reach over twenty five feet in height. Remarkably, some of these were oriented by their Isopteran engineers to be oriented along a North-South axis – a strategy to minimize the amount of sunlight on the broad faces of the nests! No such towers could be found on Kangaroo Island, but there were plenty of three-to-five-foot high nests to keep me marveling.

The ceiling corners of my trailer would sometimes host huntsmen or funnel-web spiders, both of which are poisonous but not deadly for humans (with the exception of the Sydney funnel-web spider – common in the gardens and lawns of homes in New South Wales, it is one of the deadliest spiders in the world).

That second echidna was certainly not the end of my wildlife encounters. Poisonous snakes occasionally revealed themselves at unsuspecting moments and in unexpected places. Australia has 167 species of snake, and a vast majority of them are venomous; this country is the only biogeographic region in which venomous snakes greatly outnumber non-venomous ones. Many of them are among the most dangerous on earth, several making the Top Ten list for world's most venomous snakes.

One day, Bob found that list's number four, the Eastern tiger snake (*Notechis scutatus*), attempting to sneak its way into the cooler interior of my trailer. Had it been successful, that night might have been deadly for me. The tiger snake is extremely aggressive, responsible for the most deaths annually than any other snake in

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[124] Ibid., 119.

Australia.[125] Bob was compelled to kill the snake, in the protective interests of his turkeys, kangaroos and wife, but before he did he allowed me to watch it for some time.

Australia is not for the paranoid. I had to consistently calm my suspicion that everything there had been designed specifically to kill me. It is a rugged place; the late "Crocodile Hunter" was by no means a man of exaggeration. But even among the ranks of Australia's deadliest there are beautiful and creative creatures, species struggling in some of the must rugged and malicious environments on earth.

Glossy Black

My most treasured Kangaroo Island encounter occurred my last morning with Bob and Lorraine, just before that memorable day of spear-fishing, beach-combing and crayfish harvesting. I had already known of this species' extremely endangered status on Kangaroo Island, well before I had even left for Australia. Lorraine mentioned that she may have seen one on the far corner of her property, about ten years back. The chances of seeing one for myself were so low that I made sure to withhold any hope or expectation. But that was no reason not to try.

So that morning I woke up well before sunrise, brewed up some black tea, grabbed binoculars, and made for that far corner of the farm. On the long walk through pre-dawn to the top of the property, my mind wondered in and out of the present, to and from memories of friends and family halfway around the world. I had a habit of keeping my mind busy with speculations of what New Zealand would be like and predictions of what my chores might be for the day on the farm later that day. Soon enough I arrived at the corner of the property, where an abandoned reservoir was being repopulated by sapling Eucalyptus. As the sun broke above the horizon, I saw the silver-eyes and fairy wrens emerge from their roosts for their morning chorus and forage. Taking a sip of my tea and a piece of toast from my pocket, humming to myself, I joined them.

While listening and watching for the diagnostic signs of the rare parrot I had come to see, I wondered whether I should walk around

[125] Ibid., 180.

the field or stay inconspicuous among a eucalyptus understory. An hour passed with no sign, and I reluctantly accepted that I could not put off my morning chores any longer. I stood up, gathered my tea cup, brushed off the crumbs. It was then, as I took my first step, that I heard it: the distinctive, haunting squawk I had been waiting for. I had worried on my walk out there that, when the time came, I would not be able to distinguish between the call of common red-tailed black cockatoo and its extremely rare relative, the glossy black. But no. What I heard there in mid-step was distinctly different and instantly recognizable. I swung around, searching frantically for the source of the call. After a few suspenseful moments, the glossy black cockatoo (*Calyptorhynchus lathami*) appeared above the pine canopy. It beat its wings in a gracefully slow gate, practicing its unique flight pattern I had read so much about in Lorraine's birding books back at the farmhouse. It was unmistakable. Within seconds, it was gone; but it had been there, I had been there, and the landscape was not the same.

This cockatoo's rarity is due to the extreme abundance of an invasive insect. The Ligurian bee would visit Bob and Lorraine's farm in small swarms daily. These are Italian bees that were brought to Kangaroo Island for their honey. They are an attractive species to work with; they tend not to sting. Because of the stark lack of water in South Australia, Ligurian bees willingly travel great distances to a source of it; one such source were the water bowls of Lorraine's pet kangaroos. Each morning, just after dawn, trains of these bees would begin arriving at the water dishes. And each night, just before dust, they would depart, one by one, returning to their nests, which are established in rotting eucalyptus trees — the very place that glossy black cockatoos require for nests of their own. This native cockatoo was being evicted by these invasive insects. Their future, many fear, seems dim.

The image of that cockatoo rising elegantly above Bob and Lorraine's pines, now ingrained for perpetuity in my memory -- along with encounters with the little blue penguin, the red kangaroo, the short-beaked echidna, the eastern tiger snake and the Superb Lyrebird – it all streamed through my mind again and again on that final night on the farm. There I was, in the middle of life. The Australia I came to know was a land of dangerous and beautiful treasures, biogems of an ancient and continuing landscape.

As I cracked the shells of the steamed crayfish, in fellowship with Bob, Lorraine, Leonardo and Patrick on that final Australian night, I was already teetering with contemplative gratitude and wine-induced sentimentality. It was only after I had settled into my flat in New Zealand and had begun some deeper research into the natural history of Australia that I understood the full glory of that meal:

The Australian freshwater crayfish is notable not for its freakish size -- as is the giant earthworm -- or its outstanding displays -- as is the lyrebird -- but for its outstanding biogeographic value. Its family, the Parastacidae, has a spotty worldwide distribution, found only in the freshwater streams of Australia, Madagascar, South America, and New Zealand. That's right, a *freshwater* crayfish. Unable to survive -- let alone disperse across – bodies of saltwater. Yet they can be found on four different landmasses, all of which are separated by oceans. This fact, at face value, is a ghastly paradox. But of course, with our minds attuned to deep time, we are able to remember that Australia, New Zealand, South America and Madagascar were all, at one point, unified components of Gondwana.

The Parastacidae are one of the biologic record's strongest cases for the tectonic split of Gondwana. Ever since Australia's isolation from the supercontinent, its resident Parastacids have speciated into 110 species within 9 genera.[126] I am not sure of the genus or species we feasted on that last night at Bob and Lorraine's, but I do know that it was delicious.

To know that my final meal in Oz was also a glorious salute to the longevity and endurance of Gondwana's true ghosts – that is indeed a treasure.

[126] Ibid., 116.

~ The Kepler Track, New Zealand's Fjordland ~

~ Dr. R. Ewan Fordyce, premier paleontologist and chair of Dept. of Geology, University of Otago ~

~ *The vessel* ~

~ *Comparing moa femurs with Ray Bell, central Otago* ~

~ *The Captain, holding a stunned pukeko* ~

~ *The lush understory of a* Nothofagus *forest, near Paradise, NZ* ~

~ R.O.C, L.V.C., *the Captain, and author, our first morning reunited* ~

~ *A flock of royal albatrosses circle a trawler off the Otago Peninsula* ~

Chapter 10

The Importance of Origins

One important consequence of thinking in deep time is that our maps of the world are no longer permanent charts we once thought they were.[127]

The debate that is doubtlessly the most notorious subject of historical biogeography is that of, "Dispersal or Vicariance?" It's a question of origins. The scientific origin myth of Oceania's biota.

As I mentioned before, one important consequence of linking dynamic life (evolution) to a dynamic earth (tectonics) is that the maps we use to talk about animal distributions are constantly changing. This, to me, is the beauty and power of historical biogeography, embodying that link between those two breakthroughs in the philosophy of natural science, evolution and tectonics. For historical biogeographers, this is where the fun begins.

Population distributions are no longer a matter of snapshots; instead, they are a moving image. The acceptance of tectonics raised began the great Dispersal/Vicariance debate, and the most hotly contested arena, from the start, was Oceania. Had the biota always lived there, and they just rode their respective landmasses from Gondwana to their current global positions (i.e., vicariance, a piggy-back ride through deep time; biogeographers who support this theory refer to New Zealand as "Moa's Ark") or, did the biota arrive

[127] Gibbs, *Ghosts of Gondwana.* 59.

on their own accord, by dispersal, essentially an act of fortuitous heroism? Credit for the grand expansion of a species' range is often owed to only a few select individuals who faced dire enough circumstances and had strength enough to persevere to the nearest alternative source of food, shelter, or spouse. So: Dispersal or Vicariance? Was Oceania the "fly-paper for the Pacific" or a "time capsule for Gondwanaland?"

The debate is heated, and the majority opinion has oscillated sides over the decades as new fossils and new pieces of molecular evidence accumulate. From our current vantage, truth be told, the more molecular data we accumulate, the less good it looks for the supporters of Moa's Ark. Was Moa's Ark just the most convenient, if fantastic, answer for New Zealand's mysteries? But for the intellectually adventurous naturalist, the Dispersal hypothesis is not without its own share of derring-do.

First, however, let's consider what remains of the compelling evidence for Moa's Ark. The most eye-catching are the numerous cases of order and family-level endemism that we can find in the uppermost geologic layer of earth, like those freshwater Crayfish of Kangaroo Island. The original theory asserted that the New Zealand ark passengers included moa, kiwi, frogs, the tuatara, geckos, flightless wrens and flightless ducks. Some of these are still supportable, but most are not. Suffice it to say, determining "why" and "why not" in biogeography is not as easy as originally thought.

Today, the most convincing pieces of evidence for the ark hypothesis are fungus and freshwater insects. Every *Nothofagus* tree present in New Zealand, Australia and Chile - three different daughters of Gondwana - survives only because of an obligatory symbiosis with the same strawberry fungus (genus *Cyttaria*). This probably isn't a coincidence; it's almost certainly Gondwana's fault.

The nation's high freshwater invertebrate diversity is another point for vicariance theory, because freshwater invertebrates simply cannot disperse across seas. Most New Zealand freshwater invertebrates haven't even reached the Chatham Islands, the country's closest Sub-Antarctic neighbor, and they have had four million years to do so. Such invertebrates are the true heirs to Gondwana.

And if they took the Ark, why could others have too?

The *Nothofagus* Conundrum

There are examples that tell us that an "either/or" question like "vicariance or dispersal" may be inherently problematic. Time and again naturalists have been shown that the story of life has several different plotlines mucking up their clean, conveniently dichotomous outline of the world's order. The study of the Zealandic biota's origins has served as a humbling reminder that the evolution's tendencies and motivations are much more multilateral than previously supposed. These examples indicate that contemporary biota are probably the result of a complex combination of both vicariance *and* dispersal events.

Nothofagus, the genus of beech trees dominating the wettest swaths of New Zealand, has large, heavy, short-lived seeds. As such, these seeds are unable to disperse long distances, so the presence of *Nothofagus* in New Zealand, Australia and South America is certainly not the result of dispersal. Its critical symbiosis with the strawberry fungus evidence supports this. Beech trees probably spread out from some Gondwanan point source, eventually to inhabit nearly every austral landmass today before the supercontinent disbanded. So New Zealand almost definitely had truly Gondwanan *Nothofagus* trees in its early history.

However, recent molecular analysis has found New Zealand beeches to be very closely related to a certain Australian species, with an time of divergence estimated to be just 35 million years ago. This means that while the Tasman Sea was still in the process of widening, Australian beeches somehow managed to disperse over to the New Zealand landscape and out-compete New Zealand's truly-native, authentic Gondwanan beeches. As a result, New Zealand's current beeches are still Gondwanan (as Gondwanan as any Australian species is) -- but not quite so *Zealandic*, tainted by a scandalous Eocene invasion from Oz. A subtle but important distinction, one that makes room for both vicariance *and* dispersal in the Nothofagus' story.

So with the beeches out of the running, that leaves moas, frogs, and wrens as the only candidates backed up by molecular analysis as real "Ghosts of Gondwana." While dispersal and invasion were a lot more prominent than the Moa's Ark enthusiasts had originally thought, it is certainly still the case that some of New Zealand's biota are the real-Gondwanan-deal. But Oceania's biota can not be grouped under either side in its entirety. It is a complex mix, a mysterious composition, a compelling conundrum. The debate rages on still, over which mechanism is *most* responsible. Mostly dispersal, or mostly vicariance?

The Oligocene Caper

The classic argument of those who don't support the Moa's Ark hypothesis is that the Oligocene Baptism would have submerged most of the pre-Oligocene fauna, drowning any survivors of the original Gondwana gang. So *something*, secondarily Gondwanan, had to have repopulated the landmass. Rebutting this argument requires a closer look at the severity of the Oligocene flooding. Was it really so severe? Did New Zealand really have two creation stories, one pre-Oligocene, one post?

There is compelling evidence in support of total or near-total submersion. First of all, New Zealand's Oligocene topography was very low relief. Probably, hills nowhere exceeded 300 meters in height. Even a modest change in sea level would have been drastic. To make matters worse, the Zealandia tectonic block certainly wasn't as buoyant as it could have been. Ever since its foundational, dense terranes were separated from Gondwana about 70 million years ago, it has had a tendency to sink.[128] Plate buoyancy is also influenced by its proximity to a tectonic spreading center; the farther it moves from it, the cooler and less buoyant it becomes. This predisposition to sink, combined with its low relief, suggests that total submersion was entirely possible.

The fossil record agrees. Almost all exposed Oligocene rock in New Zealand has marine fossils in it. But unfortunately, outcrops that record the paleoecology to either side of the supposed period of submersion are nonexistent; this data would be very helpful indeed. What the fossil record does show is a dramatic spike in species radiation, for both invertebrates and vertebrates, in post-Oligocene deposits. Such radiations usually occur as a result of newly available ecological niches made vacant by a mass extinction. The observed radiation would be a very typical response to an event like continental submersion.

On the other hand, there is also compelling evidence against the notion of total transgression. While the faunal fossil record may be patchy and discontinuous for the Oligocene, the plant record is strikingly coherent. This floral fossil record shows that there is no

[128] Ibid., 100.

significant change in the plant community composition during the entirety of the alleged Baptism. If the plant community was not affected, perhaps the Oligocene transgression was not so dire after all, right?

Let's take a closer look at the kauri. In the late Mesozoic, Kauri (genus *Agathis*), an Araucarian conifer, used to range over both hemispheres, according to the global fossil record. Molecular analysis shows that the modern New Zealand kauri is the oldest living tree among those remaining of that genus, by a large margin. So, it would not have been possible for New Zealand's kauri to die out in the Oligocene flooding then get replaced by some Australian version of it without being detected. This cannot be another *Nothofagus* conundrum. The kauri in New Zealand has been there since the beginning, without the help of its relatives in Oceania. This is a sound strike against total transgression.

The fossil record has more to say: the fossils of New Zealand's fourteen order- or family-level endemic vertebra are not found anywhere else in the world's fossil records within the last 25 million years. This suggests that dispersal -- or re-dispersal from a neighboring population -- could not have re-supplied New Zealand after the flooding; there simply were not any neighboring stocks from which to draw. Another strike against total submersion. New Zealand was on its own out there in the sub-Antarctic, and however its biota survived the transgression, it probably did so without help.

The Anura Conspiracy

Bouncing silently around the forest groves of the New Zealand landscape are seven species of frogs. Four of them are currently endemic; the other three were introduced from Australia fairly recently. Those four endemics are markedly different from the three introduced ones. First of all, the native species have neither ear drums nor vocal chords. They are nocturnal. They are remarkably small, with highly cryptic camouflage. They are also extremely long lived (at least for frogs, up to 32 years). A female will lay only 20 large eggs a year, and 3 of the 4 endemic species are able to live their entire life without dependency on a body of water.[129] These frogs were so stealthy that the Maori, who lived intimately with the land for 1,000 years before British imperialists arrived, had no idea there

[129] Ibid., 155.

were any frogs in New Zealand at all.[130] Yet by the 1850's, news of these frogs' existence from naturalists like Joseph Banks had reached the ears of Charles Darwin all the way back in Britain. Darwin, the great comparative taxonomist and evolutionary theorist that he was, immediately recognized striking similarities between these New Zealand frogs and the *Ascaphus*, a tailed frog from the forests of North America. In one of his notebooks, he jotted down, presciently, *"perplexing…a strongish fact for continental connection."*

True to form, Darwin's intuitions were near the mark. Despite their global separation, the New Zealand and North American frogs are each other's closest kin. The New Zealand frogs and the North American *Ascaphus* are distant members of the same taxon, one that is the sister group to all other frogs and toads. Genetically speaking, these frogs from opposite sides of the earth were "similarly odd" – their vertebrae were hollow at both ends, like a fish (a condition known as *amphicoelous*). They shared an ancestor 180 million years ago, a time in which this ancestral frog was once cosmopolitan throughout Pangaea, in both Laurasia and Gondwana. So, yet again, deep biogeography unveils new explanations for Oceania's uniqueness, while contributing simultaneously new dimensions of its oddities.

If we are to see the landscape for all the enlightening mystery that it can be, we must keep the mystery of dispersal, vicariance and submersion in mind while we explore the current biota of Zealandia.

[130] This is concluded from their lack of mention in the usually exhaustive oral histories of tribes around the islands.

Chapter 11

Moss & Beech

"The number of different kinds of native plants growing wild in New Zealand today is now exceeded by the number of introduced alien plants that have escaped the boundaries of our gardens."[131]

Although the native flora of New Zealand are on the verge of being overrun by these "aliens", there are still some beautiful native species that can be found in the untrammeled corners of the forests; the *Dracophylium*, the mountain daisies, the native bluebells and the gentians, among others. Even before waves of introduced flora began arriving with European immigrants, these natives had already been through a lot, especially the alpine species: rapid mountain uplift, crazily fluctuating climates, repeated periods of glaciation, and a long queue of hungry flightless bird species. Though bleached and wiry and stunted in growth they may be, so far they have overcome – or at least endured. Surely the brilliance of the mountain daisy's florescence is a testament to the resilience of these plants. But will they survive the current onslaught of the invasives?

If we had to bet which native would survive this current age of extinctions, I would go all-in on *Hebe*. Remarkably, this one genus of plants has adapted to nearly every topographic region that Zealandia's tectonic history has thrown at it. In the 10 million years since the ancestral *Hebe* seed established itself somewhere on the rolling hills of New Zealand's Miocene landscape, it has diverged

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[131] Gibbs, *Ghosts of Gondwana*. 10.

into over 120 species. If any plant genus can survive humanity's paroxysmal impact on the land, *Hebe* can.

There is something defining and unique about most of New Zealand's plants. It's a solidarity that runs deep; it is even apparent in their color. They exude a different kind of green than any other plant community I have seen, a signature hue that is stark and distracting for your first few days in the bush.

Perhaps, the most fascinating aspect of New Zealand's flora is its prehistoric ambience. Stepping into a lowland beech forest, one feels as though he or she is stepping back in time (or for us Tolkein fans, into the Third Age of Middle Earth). Luckily for biophiliacs, invasives and irresponsible forestry haven't fully rid the New Zealand landscape of its most ancient – and I do mean ancient -- gems. Some even render the term euphemistic: on Ulva Island, that world-renowned birding Mecca in Stewart Island's lagoon, I stumbled upon *Tmesipteris*, which, according to fossil evidence, hasn't changed leaf shape or any aspect of its physiology in the last *400 million* years. *Tmesipteris* is the closest living relative to the first leaved plants in evolutionary history. With species like this peppering the forest floor, the woods assume a grave tone of timelessness one must breathe in to understand.

Though much about these forests are ancient, they also have an impressive history of change. In times of warmer climatic conditions, beech was not the dominant species; instead, towering members of the Proteaceae family reigned supreme. These flourished on the daughter landmasses of Gondwana for 90 million years, with their heyday in the Eocene and Oligocene, at which point New Zealand harbored fifteen types of Protea; nowadays, however, it has but two: the *Rewarewa* and *toru*. In those places that were too difficult for last century's loggers to reach, their groves still dominate North Island forests.

The most towering and iconic tree in New Zealand's ancient forest is surely the *kauri*. Made famous by its highly valuable gum, this massive, jurassic tree was once so dense that it carpeted all the North Island and even the South Island's upper half. The Captain and I, as we crept our way reluctantly toward Auckland for our flight home, spent a contemplative afternoon in a kauri grove of the Coromandel Peninsula. One can't help but imagine giant eagles flying just above the kauri forest, peaking through breaks in its canopy for unsuspecting *Dinornis* chicks.

The Monoecious Practicality

But one does not have to daydream to find thrills or enticements in this flora's natural history. Many cases pose tantalizing mysteries, many of which are excellent examples of how the "Island Syndrome" has manifested itself in the flora of Oceania. One sweeping oddity in New Zealand's flora is this: most of New Zealand's non-Gondwanan plants, the species that arrived by dispersal at one time or another, are almost always monoecious, meaning hermaphroditic -– an individual of a species will have both male and female flowers on itself at any one time (as opposed to dioecious plants, which bear only one sex of flower).

Monoecious plants have self-compatible reproductive systems, allowing a single individual to disperse to a new habitat and potentially establish an entirely new population by fertilizing and reproducing itself. It is a form of weeding out, literally – a prime example of Island Selection, a phenomenon that only recently has begun to be studied.[132] Other island systems around the world exhibit the same small proportions of dioecy, including Hawaii and the Galapagos Islands. [133, 134]

It only makes sense that a dioecious seed would have no way of reproducing if it managed to disperse and establish itself alone in a foreign habitat. Those thought to be Gondwana relics, however, tend to be either dioecious or equal parts mono- and dioecious.[135] Again, it only makes sense; but it's none the less fascinating for it.

Blame the Fault

What follows is perhaps the most ostentatious demonstration that tectonics influences not only broad global biogeographic patterns, but local population distributions as well. It is also an example of how the tectonics revolution has advanced our understanding of New Zealand's biogeography.

The effects of shifting tectonic plates on distributions are still visible in the distributions of the country's "narrow endemics." Narrow endemics are species that are not only unique to a certain geographic region, but also are so inflexible in their adaptations for

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132 Whittaker and Fernández-Palacios. *Island biogeography*. 177.
133 Carter et al 1986
134 McMullen 1987
135 Webb and Kelley 1993.

survival that they couldn't survive anywhere else – not even a few miles away -- if they tried. Consider the large alpine daisy. *Celmisia petrei*. Think back to pre-Oligocene New Zealand. According to the fossil record, the daisy was evenly distributed throughout most of New Zealand. But today, in 2007, the population exhibits an peculiar, alternating range, like the offset pattern of two rows on a checkerboard. Even more peculiar is that this is by no means unique to the alpine daisy. Seventy other species of flora, algae and insects – all of whom happen to be narrow endemics -- have a similarly disjunctive distribution.

Until biogeographers started incorporating tectonics into their equations, this was simply dumbfounding. They then realized that the axis along which these populations alternate exactly overlaps the Alpine Fault. As this dextrally moving fault crept along, the daisy population was split down the middle; over the last 5 million years, the daisies on the Australian plate moved northeast and the daisies on the Pacific plate moved southwest. Being a narrow endemic, the daisies did not adjust their ranges back to their original, "absolute" positions and instead went along for the tectonic ride.

However, as always, there is an alternative theory. In the Miocene, several parts of the landscape were still submerged after the deepest plunge of the Oligocene Baptism. Some sedimentary evidence suggests that the parts of the land where these narrow endemics are no longer living correspond to those parts that were under water.

Then there's the other possibility, that is another case in which both factors, tectonics *and* fluctuating sea levels, contributed to these narrow endemics' current distributions. And, like most biogeographic mysteries, recent glaciation may have had a major part to play as well. The Pleistocene ice ages could have sculpted the ranges of these narrow endemics like they did the great glacial valleys all along the Alps. Even flexible, quickly adapting plants like Hebe could not outrun the glaciers; its distribution, along with species like the Westland beech, have been broken up in odd patterns by tributaries of glaciers radiating from the South Island's peaks. It seems that everywhere one looks in New Zealand's flora, the palimpsest of deep time underwrites it all.

The Insect Dependency

Insects have historically played a major role in floral evolution everywhere, and New Zealand is no exception. New Zealand is home to about 20,000 species of insects. As mentioned before, this number of species includes hardly any termites, ants, or butterflies, and this is due largely to the Oligocene submersion and its recent bouts of glaciation. Unfortunately, paleontologists have not yet found any fossil outcrop that tells us if pre-Oligocene New Zealand resembled its ant- and termite-rich neighbor, Australia, but it is general consensus that it did. Today, there are only 10 native ant species still in the country, and only 11 native butterfly species. Where New Zealand does stand out is in its collections of beetles (Coleoptera) and weta (Orthoptera: Anostomatidae (26 species) and Raphidiophoridae (50 species)).

Weta look like enormous, weird, juicy crosses between a cricket and a cockroach. They hold are considered to be the largest grasshoppers in the world. The giant weta (genus *Deinacrida*, meaning "terrible grasshopper"), also known as Wetapunga, can weigh up to 70g when loaded with eggs –heavier than a sparrow – one of the heaviest Orthopteran genii on earth. They can also reach lengths of over twenty centimeters, which is almost a foot in length. This dwarfs New Zealand's largest beetle, the Huhu (Cerambycidae: *Prionoplus reticularis*), which happened to be the first insect I collected while in the country. It grows "only" to a length of ten centimeters.

A wealth of other insect taxa did successfully survive the notorious Oligocene submersion, and thankfully so, for many provide fascinating windows into the past. There is the endemic fly family, Mystacinobiidae, and it contains one species, the New Zealand batfly (*Mystacinobia zealandica*). It is completely wingless. Over millions of years, it has evolved to depend entirely on the New Zealand short-tailed bat, whose roosts are the only viable habitat for these batflies. A close relative of the batfly is the New Zealand sandfly (*Austrosimulium spp.*), who once survived only in the plumage of moas and penguins but now thrives on the flesh of humans and brushtail possums. They are actually a member of the blackflies (Simuliidae), but Captain Cook called them sandflies in his journal and the name stuck. Even though only the females bite, these sandflies are a plague to the New Zealand outdoorsman. Infamous among trampers and fly-fishermen, these sandflies serve to remind visitors, "New Zealand is nice, but it's not Eden. Stay where you are." When you awake in the morning you can look out your tent flap and see a swarm of the buggers waiting for you to emerge. Their hoards are especially thick around water, because their eggs are laid on the banks of fjords, lakes, and slow-moving streams. They are Fjordland's entrance fee. But it's worth it.

The other renowned Dipteran of New Zealand is the glowworm (Keroplatidae: *Arachnocampa luminosa*). The larvae of this species inhabit ledges overhanging bodies of water and are especially populous in the cave systems of the North Island and Fjordland. Their main source of food is the mayfly, which they lure into the traps in a fascinating way: each glowworm lowers about seventy sticky lines from the cave ceiling, letting them droop down close to the water's surface. The silk of these threads is infused with an enzyme that emits an attractive soft-green light irresistable to mayflies. Like moths around a lightbulb, these unsuspecting prey fly haphazardly towards the lights and get tangled up in the sticky lines. The glowworm larva proceeds to pull in the line by ingesting it, recycling its luminescent silk for its next batch of trapwires. The larva then goes onto to consume the hapless mayfly at its leisure.

"You know why a glowworm never grumps? Because how can you be grumpy when there's sun shining out of your butt?"

–Jan[136]

So what do New Zealand's insects have to do with the flora? Begin with the general pattern that many species have predominately white or drab-green florescences. These flowers are also notably small, radially symmetrical and unspecialized. They certainly aren't exceptional or attractive in the conventional sense. If it weren't for the fact that this pattern is starkly different from the tropical, brightly colored flora of other South Pacific islands and Australia, one might call the flowers of New Zealand lame, maybe even boring. But no, it is precisely their relative peculiarity that makes them interesting. This drabness was conspicuous enough that early explorers noted the phenomenon in their travel logs. Joseph Hooker, in 1853, wrote that the New Zealand "forests abound…in plants with obscure green flowers."[137]

In the alpine regions, 70% of the flowers are white or near-white. Oddly, in the lower altitudes, it's only 35%. Until the

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136 A memorable proverb from a sage friend, the roommate of Will, my hitch-hiking partner.
137 Gibbs. *Ghosts of Gondwana.* 168.

changing character of New Zealand's land was brought to the attention of ecologists, this phenomenon was a botanical mystery. Why this odd convergence in flower color? And why do these angiosperms all tend to have clumped florescence, like little clumps of cauliflower? Why are other Oceanic flowers significantly larger and more colorful in comparison?

One rule from mainland botany is that if a plant's florescence is inconspicuous, it is probably not pollinator-specific. Drab species surely don't attract a specific species of bee or butterfly if they can't stand out among other white flowers in the forest. The general evolutionary trend for mainland flowers is to form a species-specific pollination mutualism, and New Zealand flora are clearly going against that grain.

It turns out that New Zealand's highly dynamic topography held the key. As we've already established, place matters. Deeply. There must be *something* about the landscape and how it has changed over time that is causing this phenomenon. In the case of New Zealand's changing landscape, to be species-specific was more of a fatal trap than a guarantee of pollination. The last five million years of New Zealand's history, remember, has been riddled with massive tectonic collisions, practically instantaneous mountain building, destructive earthquakes, scouring afflictions of glaciation, violent volcanism, and unpredictable climate change. Often the land and climate would change faster than many species could keep up. Remember also that, generally, the higher the trophic level and the larger the body size of an animal, the more precarious its survival is; it's teetering too high on a stack of ecological relationships to keep balance if the ground starts shaking. It would be evolutionarily stupid for a plant species to evolve to attract a single species of pollinator, one that might have its ecological carpet ripped out from under it at the slightest drop of the mercury. Rather, it is a much safer bet to play to the general crowd; *something* would survive the New Zealand roller coaster, so why burn bridges by specializing or target-advertising? These non-descript white flowers are strategically generalist. Stick with the low-risk, steady-yield investments: those insect species that were small and resilient enough to survive the turbulence of deep time.

Contrary to the trends in more stable landscapes, selection has been for despecialization.[138] Depending on insects in general is fairly safe bet, considering that they are among the most quickly-adjusting

[138] Barrett 1996

taxa to changes in island conditions. They are often some of the first to re-colonize drastically changed landscapes. But for some New Zealand flora, this was still not good enough; at some point in their evolutionary histories, they abandoned cooperation with insect pollinators altogether and became anemophilic or wind-pollinated.[139]

The Viviparity Principle

While most of New Zealand's plants rely on generalist insect pollination, and many other simply rely on the wind, a few risked some highly specific pollinator relationships. One example is *Hoplodactylus*, a terrestrial genus of gecko.[140] The absence of many the larger pollinators characteristic of continental forests (bumblebees, hummingbirds, etc.) has provided opportunities for others, not usually cast in such roles, to stand in. *Hoplodactylus* is one such group of animals; several species of forest floor plants have grown to rely on these geckos for their reproductive success.

New Zealand herpetologists have found 47 lizard species in the country, 35 of which are geckos. All of these, except one (an Australian skink that lives only in Auckland urbania), are endemic. While the geckos are thought to have been a passenger on Moa's Ark, having evolved originally on intact Gondwana (their closest relatives reside, predictably, on New Caledonia[141]), all of New Zealand's skinks arrived via dispersal, millions of years ago, from adjacent landmasses.

The world's geckos tend to have interesting reproductive abilities. Some are capable of parthenogenesis; they can reproduce asexually. Such geckos are quite common in islands,[142] which, like the monoecious plants, simply makes sense.[143] Regarding New Zealand's reptiles, the most notable feature is that all except one species are viviparous; while almost all other lizards in the world lay eggs, the New Zealand lizards give live birth.

Throughout the evolutionary history of the Reptilia, viviparity has been a frequent adaptation in cold climates, and with the icy and high-latitude history of New Zealand's march away from Gondwana, it is no surprise that this strategy has surfaced here too. For an

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139 Whittaker and Fernández-Palacios. *Island biogeography*. 178.
140 Whitaker 1987
141 Gibbs. *Ghosts of Gondwana*. 145.
142 Hanley et al. 1994
143 Whittaker and Fernández-Palacios. *Island biogeography*. 178.

ectothermic vertebrate like a lizard, for which proper juvenile development depends entirely on the control of temperatures during prenatal development, a momma gecko has a better chance of keeping embryos warm when she can carry them within her rather sit on their eggs.

"The archipelago of NZ has been a hotbed of evolutionary achievements - novelties, remarkable adaptations, richness where you might not expect it, and unexpected absences."

~ Gibbs

Of course, acquiring such novel survival strategies was not a deliberate, planned move on the part of the plant or lizard The evolutionary trend away from specificity and towards generalism in New Zealand plants was not devised. It was merely convenient and serendipitous that the necessary mutations randomly occurred as selective forces were complementarily influential. Remembering this, the quirks of New Zealand's biota are all the more phenomenal.

All too often we elevate evolution as this prescient, all-knowing and ever-resourceful force that performs highly "intelligent" feats of design, things like viviparity and parthenogenesis in cold climate lizards – when, in cold, hard fact, these lizards are merely the result of millions of mutations and competitive selections that may have hurt many more throughout evolutionary history than they helped; when, in cold, hard, fact, it was the landscape, the *context* calling the shots; when, actually, in praising evolution's ingenuity, it is like lauding the unintelligible kid with the dunce cap in the back of the class for getting one question right out of a hundred.

It is entirely too tempting, in the story of deep time, to speak of evolution as a rounded, fully dimensional character. Implicating such intention and activity is often difficult to avoid. Evolution is a phenomenon that does not fit well with the constructs and syntax of our language. English itself evolved while deeply ingrained in the natural theology of societal worldview. Accurately communicating the serendipity and happen-stance of evolution is difficult, even for the best writers out there. Darwin's idea puts even the linguists to task. Will our ways of speaking ever adapt to accommodate our grandest ideas? Can our words keep up with the world?

Success stories like viviparous lizards and dioecious plants must not be cheapened by irrational applause for the merit of the process. Evolution, in fact, is an awfully conservative, finicky, and heartless system. No, our wonder should not lie in evolution's inherent ingenuity, but in the remarkable fact that it actually works, in spite of itself. In the realization that life, via the evolutionary process, is allowed a dialogue – a dance – with place, that life, ultimately, is a vast and unfathomably involved history of the earth – its rocks, its plates, its ice, its lava, and its changes. Life, the upper-most geologic layer – not because it will one day be a fossil bed, but because, in living as it does, it is a manifesto of all that came before. And evolution, despite its indifferent senselessness, allows us that great honor.

So many different histories, so many ingenious evolutionary inventions, and so many heroic tales of improbable survival are on display in New Zealand. A tramp through these woods was not only welcomed exercise for my long legs, it was also a cherished chance for my mind to stretch itself, wrap itself around all these interwoven histories, along paths wide enough for my intellect and imagination to advance side-by-side. It is a different sort of fantasy that holds you when the world of your daydreams was actually present at one time, there where you are walking and watching. You are walking through more than one landscape at once; millions of years of previous habitats, sometimes submerged in the deep ocean, sometimes smothered by a river of ice, are there beneath your feet. Through an awareness of these lost worlds, the present one grows deeper, and your imagination becomes rooted, inextricably, joyously, to place.

Who says there is no room for imagination in the scientific process?

"There is a simple grandeur in the view of life with its powers of growth,
assimilation and reproduction, being originally breathed into matter
under one or a few forms, and that whilst this our planet has gone circling on
according to fixed laws, and land and water, in a cycle of change,
have gone on replacing each other, that from so simple an origin,
through the process of gradual selection infinitesimal changes,
endless forms most beautiful and most wonderful have been evolved."

~ Darwin

Chapter 12

The Avian Experiment

These islands were left with a natural experiment
in which birds could call the tune.
- George Gibbs

More than anything, New Zealand is a land of birds. Of kiwi and moa, albatross and penguin, flightless parrot and flightless duck. It was the birds that made memorable those morning walks, the trips to the beach, the alpine passes, those night hikes. Since time immemorial, these islands have been a unique laboratory in which the various capacities of avian physiology could be pushed to their limits.

It is interesting that the only native mammals of New Zealand are also birdlike. The main islands have only two native to their name, and they can't exactly be called terrestrial. Both are bats, of the mammalian order Chiroptera. The short-tailed bat (*Mystacina tuberculata*) and the long-tailed bat (*Chalinolobus tuberculatus*). Both of these flying rats are the descendents of the noctilionoids, whose evolutionary origins are in South America, where they are still well represented.[144] But neither of these bats were passengers on Moa's Ark. Evidence suggests that they arrived via two distantly separated dispersal events. Both events included a dispersal from Australia, but the ancestral short-tailed bat arrived much earlier than that of the long-tailed. This makes sense when looking at the short-tailed bat's highly peculiar behavioral ecology. While the long-tailed bat, having arrived relatively recently to New Zealand, is essentially the

[144] Gibbs. *Ghosts of Gondwana*. 30.

same in ecology and physiology to its Australian ancestor, the short-tailed bat has been through some severe ecological release. They hardly ever fly. Instead, they forage by crawling around on the ground, burrowing under beech leaf litter in search of microinvertebrate prey. The short-tailed bat has emulated the same evolutionary pattern as that of New Zealand's flightless birds; it has begun to abandon its flight capabilities in light of the forgiving New Zealand landscape. What is it about New Zealand? Is the air heavier? *What?*

As we already know, it's the rodents – or lack of them. Flying may seem fun, but it's both risky and costly; if life can safely be carried out on the forest floor, then so be it; in evolution, practicalities overrule whimsy. The short-tailed bat is even a lek breeder, just like the kakapo (which I will discuss shortly). Lekking tends to evolve when important resources are indefensible, as in they are everywhere and practically infinite. The long-tailed bat, by contrast, has nothing comparatively remarkable in its ecology. The inertia of its life on marsupial-infested Australia is still holding it back.

Flightless in Fjordland

The high numbers of flightless birds are a result of the same unique feature of New Zealand's landscape. The weka (*Gallirallus australis*) is a predatorial flightless rail whose habitat has been reduced to a few forests on the North Island, Fjordland and Ulva Island in the bay of Stewart Island. It was on Ulva Island that I first encountered the weka. I was sitting at the edge of a clearing, gazing into the sunlight subcanopy and gaping at the display: huias, saddlebacks, red- and yellow-crowned parakeets, cuckoos, and New Zealand robins were fluttering energetically about the sunlit branches. Endangered birds, endemic birds, birds brought back from the brink of seemingly inevitable extinction, all before your very eyes. In the trail behind me a pair of women walked by, and one clambered loudly over to me and tapped my shoulder.

"We just found two kiwis on the beach! Down that way!" she told me through her French accent, frightening the robins away. "You must go see them!"

With my birds in that clearing frightened away for the time being, I followed her advice. I had read that Stewart Island kiwis are known to be more active in the day than others species; they are typically crepuscular, feeding strictly at dawn and dusk. But the beach, in broad daylight? There's no way, I thought. But of course, there's no way I would not go investigate either. So I hurried down the track to the beach, broke out on the dunes and scanned the shoreline. I immediately saw the two small brown birds to which she was referring. I also immediately saw them for what they were: not kiwis, but weka. To the untrained eye, they may look similar at first, but a second look will unveil their many differences.

So, unfortunately, my first encounter with a weka was marked with disappointment and frustration, rather than the jubilation this species deserves. But as the day wore on, I encountered three more weka, all of whom approached me precociously and without hesitation; to them my presence was just as curious and harmless as their was for me. With each encounter, my appreciate for the weka grew. Ulva Island wekas are uniquely different from those on the South and North islands, because everywhere else rats and possums have usurped the weka's traditional niche as the predator of shorebird eggs. In the rat-less landscape of Ulva Island, the weka has been able to reclaim its evolutionarily-entitled role as the ecosystem's chief oviraptor.

The second flightless bird I stumbled upon in New Zealand occurred under more artificial circumstances. It was at the weekend preceding the start of the semester. I was determined to take advantage of the last 3 day break we would have until Easter, as were three acquaintances of mine, Pat, Katie and Will. On Thursday afternoon, we boarded a coach for Fjordland, to the town of Te Anau. Two days and 67km later, we had completed the aforementioned Kepler Track. This being our first introduction to the alpine tracks of the South Islands southwest, we were utterly blown away and utterly exhausted. Trudging back to Te Anau along a pathway that bordered the town's massive namesake lake, we stumbled upon a small conservation sanctuary – chain-link enclosures with ponds and dense brush its attractions could utilize for shelter. Its most popular resident: the South Island Takahe (*Porphyrio hochstetteri*).

A thick-set and stumpy bird, this iridescent rail looked prehistoric. In 1898, after decades of thorough deforestation and hunting by Fjordland's settlers, the takahe given up as extinct. But fifty years later, in 1948, a healthy population of takahe was discovered in the far reaches of a remote fiord valley that had never before been explored by man or woman. Much to the delight of the world's birders, the takahe was resurrected. I can't help but wonder:

what else lurks in those unexplored corners of the Fjordland's 3 million plus acres?

Since the takahe's re-discovery, the Department of Conservation has worked intensively to build up this rail's tenuous population, and in recent years they have been increasingly successful. In 1990 there were only 130 still living. Now there are 250. It may not be much, but it is certainly better than being extinct.

Mid-Air Collisions

The takahe has one close living relative in New Zealand, and it is called the pukeko. It was the first bird I saw when I arrived in Auckland in early February and it was the last bird when I flew out in July. That last sighting was certainly more memorable than the first, mainly because we accidentally hitting with our car. We were on the North Island's Coromandel Peninsula; the Coromandel region is one of the most beautiful and lush areas of the North Island, complete with virgin *kauri* stands, seafood shanties and Buddhist monasteries. It was our last night on the road after a month since leaving Dunedin. We had originally planned to venture next to the *kauri* stands north of Auckland, but by the morning the peninsula had convinced us to stay. The night before, we had parked for the night under the Southern Cross at the dead end of the road that takes you to the very top of the peninsula. After an impressive beach bonfire and a whirl-wind display of shooting stars, we fell asleep under large oaks that were growing on the dunes of an isolated pebble-beach. It was an immense night, followed by a sensational morning.

We woke during a red sunrise to the screeching cries of gannets. It turns out that a small colony of these huge, beautiful seabirds (*Morus serrator*) was situated high on the outcrop of the bay. While watching the gannets feeding in the still waters of glassy south Pacific, we too were feeding, picking at toast, *Weet-Bix*, avocado and hard-boiled eggs. We were stalling as long as we could before we had to drive into the Auckland sprawl. Driving back out the same road we had come in on, we realized that we simply could not leave the Coromandel so soon. The Captain knew of a campsite he had once frequented, back when his family were residents here, twenty years ago. We asked around and eventually found it.

It was dark by the time we reached the gravel road that led to the campground's entrance. We were both exhausted from a day of hikes, conversation and more sleep deprivation. We were also starving. Suddenly, out of the thick black of the night, a blue flash hurled itself out from the left side of the road. It crashed with a dull thud against our windshield. Just as suddenly, the blue flash was gone. Captain Luke slammed on the brakes. The racket jolted me out of my dazed nodding. We hopped out of the car and found, twenty feet away in the grass of the right gutter, a pukeko. Similar in appearance to takahes, pukekos are threes time lighter and have extraordinarily long toes. The animal's iridescent purple feathers shone in the headlights of our car. It was not moving. I was concerned. Luke was ecstatic.

"Dinner!" he cheered.

He moved to pick it up, and the second he touched it, the bird jolted, kicking its legs frantically. It seemed unable to stand. Unsure what to do, Luke rested his hands on it and tried to keep it from getting hurt any further. He wrapped his fingers around its legs and lifted the bird to his chest. The bird stared at us, frozen stiff, and we imagined the fear in its eyes. Its neck was kinked in a way that could only be bad.

Molecular analysis has shown that the takahe and pukeko in New Zealand are a result of three separate invasions from Australia. The first invasion, approximately two million years ago, evolved into the South Island takahe that I saw in the Te Anau sanctuary. A few hundred thousand years later, an intrepid individual from the same Australian stock dispersed again, this time establishing a population on the North Island (the North Island takahe, as it came to be, is now extinct). The most recent dispersal event, again from the same Australian ancestor, gave rise to the pukeko, which, unlike the two takahes, still has the ability to fly.

To cross the Tasman Sea on three separate occasions demonstrates just how tough that Australian ancestor must have been. Talk about insatiable wanderlust. That night, the same thick-skin was exhibited once again. The flash from my camera must have brought the pukeko's mind out of its stunned state. The bird shook its head, somehow resolved the kink in its neck, gave a hearty kick to release itself from Luke's grip, and flew over a cattle-fence and out of sight. A quick recovery for such an impact; our windshield was worse off from the collision, with a crack across the lower third of the pane.

The Kea Caveat

A significant result of evolving in a landscape without predators, other than being flightless, is that most bird species in New Zealand are highly extroverted. Perhaps a better word to use is cheeky. They are certainly not shy. Tramping in the beech forests of the Southern Alps, it is not unusual to be followed by fantails (*Rhipidura fuliginos*) and New Zealand robins (*Petroica australis*) who love feeding on the soil invertebrates you stir up as your hike down the trail. Often they will follow you just within four or five feet of your arm's reach, for minutes at a time. But the most outrageously rude of New Zealand's roster of cheeky birds is the kea (*Nestor notabilis*), the world's only alpine parrot.

This bird is such a destructive nuisance to hikers, climbers, and anyone else in the Southern Alps that they have found themselves onto the caveats of travel guides, Lonely Planets, and Department of Conservation websites. It has been known to destroy backpacks, eat lunches, tear the rubber linings off car doors, tear windshield wipers to pieces, and eat hiking boots. But beyond these frustrating habits, the kea really is a beautiful bird.

The presence of parrots and their allies in New Zealand are a result of two separate invasions. The first invasion occurred approximately 70 million years ago, just after Zealandia was separated from the rest of Gondwana. This ancestral parrot diverged into the three species of parrot living in New Zealand today: the kea, the kaka and the kakapo. The second invasion occurred only a half million years ago. A small population of parakeets came over -- not from the likely source of Australia -- but from the impressively distant New Caledonia. Parakeets, apparently, are exceedingly good ocean fliers, the squawking Amelia Earharts of the avian world. These parakeets diverged into New Zealand's two extant parakeet species, the red-crowned (*Cyanoramphus novaezelandiae*) and the yellow-crowned parakeet (*C. auriceps*).

It turns out parakeets are not the only species whose ancestors had dispersed such great distances. Through genetic analysis, we now know that cicadas arrived in New Zealand from two different source populations, one in Australia and one in far off New Caledonia.

Parrots of the Understory

A close relative of the kea is the kaka (*Nestor meridionalis*). However, judging by its behavior, you'd think it was descended from monkeys. The kaka is an arboreal, semi-flightless parrot. Only able to fly short distances between vines and trunks, the kaka is a colorful, attractive bird with acrobatic dexterity. It climbs up and down woody branches and trunks in search of any leaking sources of phloem from the bark of trees. If no such blemishes are available on the woody surface, the kaka can easily strip pieces of bark off in order to get at the sugar-rich sap inside. While on Ulva Island, I saw these strips of bare wood long before I saw the kaka itself. My mind was on the forest floor, in search of kiwis and wekas, paying little attention to the action above me…until a strip of bark fell on my shoulder and I saw the vine to my left shake subtly. I looked up, and there was the kaka. With total disregard to my presence, it climbed and swung from vine to vine with a grace that would impress a lemur.

This kaka needed to strip the bark off the branches of perfectly healthy trees because its usual food had been eaten by an unwelcome insect. Just as the invasive Ligurian bee was endangering the glossy black cockatoo in Kangaroo Island, the kaka has been marginalized by the common wasp (*Vespula vulgaris*). Conventionally, the kaka's main source of honeydew is made available with the help of a scale insect that lives in the bark of the forest subcanopy trees. This scale insect feeds of the sugars in the tree's phloem, and all unneeded sacharrides are excreted out of its anal tube, which protrudes beyond the outer layer of bark. Honeydew accretes at the end of these tubes as delectable dewdrops, awaiting slurping up by the kaka. You can tell which trees are parasitized by the scale insect because their bark looks black (a black algae also thrives on the secreted honeydew). Less than about 100 years ago, the kaka's only competition for this excreted honeydew was this black algae. But early last century the common wasp was introduced to the New Zealand coastal forests, and they needed their sugar fix too. As these wasps' numbers increase, the kaka's numbers are dropping steadily.

The other New Zealand parrot is the kakapo (*Strigops habroptilus*), without a doubt my favorite NZed bird. This is a fat, flightless parrot that once densely inhabited Fjordland's beech forests. Now, it is nearly extinct. This bird has a wealth of records to its name. It holds the following world records:

1. Heaviest parrot
2. Best camouflaged parrot
3. Only flightless parrot
4. Most promiscuous parrot
5. Slowest breeder of all parrots
6. Only nocturnal parrot
7. Most sexually dimorphic parrot
8. Rarest parrot (only 200 left)

This is truly a bird of superlatives, and perfectly embodies the degree of lee-way permissible in historically predator-less and mammal-less forests. It is also a foreboding example of the precarious circumstances facing New Zealand's biota, in light of the geologically recent invasions of rats, possums and primates.

Penguin & Kin

Dunedin's proximity to the sea afforded me several opportunities to see some of the most amazing birds a trip to New Zealand can offer. It was under the auspices of Professor Fordyce that I first fell in love, academically, with penguins (O. Sphenisciformes). Being the world expert on penguin evolution *and* the discoverer of the world's oldest and largest penguin fossil, he spoke to me excitedly about their evolutionary history before I ever had a chance to find them. He would find me in the hall and hand me papers that he and his colleagues had published in the 1980's and 90's, and occasionally, when he was in a particularly enthusiastic mood, he would take me into the cavernous basements of the Geology Department and pull out drawers full of penguin metatarsals, beak fossils and wing elements. His eyes would glow and he would begin to talk faster and faster, ending ever thought with his usual "that's fantastic!"

The fossil Fordyce is best known for is that of *Waimanu manneringi*, a 60-64 million-year old fossil that shows signs of being the intermediate body form between modern penguins and their volant ancestors. 40 million years ago, as the world's temperatures cooled, the *Waimanu* stock diverged into the modern lineages: 6 genii of the family Spheniscidae. One of these genii, *Megadyptes*, could be found very close to Dunedin.

A road bike ride's away from my flat, at Sandfly Bay on the seaward shore of the Otago Peninsula, is a colony of yellow-eyed penguins (*M. antipodes*). Too many times over the course of the semester I came out in the late afternoon to watch these animals emerge from the ocean and slowly waddle their way up the impossibly steep tussock dunes where they make their nightly roost. Having to weave their way between sleeping Hooker's sea lions and mats of stinking kelp, these penguins were absolutely enthralling. Although they are as fast and agile as torpedoes in the water, on land they are clumsy, vulnerable, awkward and hilarious, the product of sixty million years of evolution. Perhaps that most amazing aspect of the penguin's evolutionary history is this: the closest living relative of the penguins happens to be the world's largest bird and its best flyer: the albatross.

If you continue to the end of the Otago Peninsula, you reach Tairoa Head, a point with a lighthouse, gorgeous cliff-faces and one of the world's only publicly accessible royal albatross colonies (*Diomedea epomophora*). If you come out there on an extremely windy day, depending on the time of year and just how strong the wind is blowing, you just might see one. The first time I went out there I kept mistaking the black-backed gulls circling the visitor's center for albatrosses. I had no idea what I was looking for. Would I recognize the albatross when I actually saw one? Isn't it just a biggish seagull?

Then I saw it. Rising swiftly, like an aircraft, over the far end of the cliff, flying straight at me. It began circling the visitor's center, and when it approached the lighthouse I assumed I would see it fly in front of the tower. My eyes had fallen for this gigantic bird's optical illusion. Albatrosses are always much farther than they appear. As it flew *behind* the lighthouse, my eyes quickly corrected themselves, and my mind quickly came to terms with just how large this bird is. Royal indeed.

The royal albatross has the second largest wingspan of any albatross species -- about 11 feet -- and therefore of any bird in the world. The largest belongs to the Wandering albatross (*D. exulans*), with a wingspan of over 12 feet for some adults. I had the fortune of seeing these monstrosities flying during my Kaikoura whale-watching experience. You would not think that a one-foot increase in wingspan makes a difference, but it does.

Chapter 13

Quest for the Kiwi

Absence of evidence is not evidence of absence.[145]

The most iconic and weird of New Zealand's birds, indeed of all of Oceania's biota, is the kiwi. While the platypus of Australia's lowland rivers and streams seems like a careless combination of random body parts from all sorts of animals, no such comparison can be assembled for the kiwi (O. Struthioniformes). It is wholly original. Uniquely odd. It is a hyperbolic example of the principle of ecological release, that island tactic that has come up time and time again throughout our exploration of Oceania. One writer deemed the kiwi "the world's most improbable bird," another, an "honorary mammal."

There are six living species of kiwis, grouped into a single genus, *Apteryx*. They are about the size of a chicken, and the largest is the Great Spotted Kiwi (*A. haastii*); their predecessors used to be much larger. The kiwi's weirdness isn't due simply to its odd, globular shape or stringy down feathers. The kiwi's bones are marrow-filled, heavy, most likely the result of millions of years of flightlessness. For a bird, it has an extremely low body temperature. It has leathery skin. It is the only bird with nostrils at the end of its beak instead of at the base.

Over the course of deep time, kiwis evolved to be smaller, thus more maneuverable on the forest floor. But the size of its egg did not keep pace. The result is that the diminutive kiwi lays gigantic

145 Gibbs. *Ghosts of Gondwana.* 63.

eggs, eggs equivalent to six of a hen's. It is said to be "the single most notable fact about kiwi biology: these little birds lay humongous eggs."[146] This single egg is gestated in the female for 30 days, then incubated by the male for 80 days after it is laid. When the kiwi chick hatches, it is able to fend for itself within a matter of days.

Old Doubtful

One of the few solid goals I had before I stepped foot in New Zealand was to find a kiwi. It became the fixation of many a weekend in the New Zealand bush, as monomaniacal as my quest for a moa bone. It was the main reason I ventured out to Stewart Island, where the largest population of kiwis can be found. In one far corner of Stewart, there is a "kiwi hotspot," in which the chances of encountering one are over 80%. Unfortunately, a delayed ferry and a bad storm prevented me from making it to there. But I was desperate. I woke up at 2 am and walked the entirety of the Rakiura track, one of New Zealand's Eight Great Walks, with my headlamp dimmed, in hope of finding a kiwi on or near the trail. But all I saw were pair after pair of beady eyes staring at me from the forest floor and the trees above: brushtail possums, the reason for the kiwi's recent decline. I saw dozens of them that night. I spent the next day on Ulva Island, all day, searching its darkest corners – and even the beach, to my frustration and disappointment – for signs of the kiwi.

I remember my one night on Doubtful Sound. The study-abroad group had arranged an overnight cruise for all of the program's Dunedin-based students. It was a beautiful, vast, rainy day on the sound. We kayaked, we swam, we watched Southern bottlenose dolphins porpoising along, New Zealand fur seals basking. That night, we feasted. Compared to the food I had been cooking for myself throughout the semester, I was in heaven. I remember eating too much and feeling sick, lying on one of the couches, talking with the ship's naturalist and reading natural history books on whales and penguins. So full, in fact, that I could not sleep, I wondered the decks late into the night. Standing at the bow of the ship, I listened to the immense silence of the Sound, lost in it, for more than an hour. Just before I turned to go inside, I heard it. The silence had been broken by the long, eerie trill of a kiwi from

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[146] Quammen, *The Reluctant Mr. Darwin,* pg. 54.

somewhere on the glacial valley's forested walls. I recognized the call instantly, having studied their calls with an acoustic field guide for weeks back in Dunedin. I stopped in my tracks and listened intently. A moment later, the kiwi repeated itself. I was on a boat, the kiwi was somewhere in the forest dark, and there was no way I could get to it. My mind considered momentarily taking a kayak to the shore and investigating. But I'm glad I didn't try. For one thing, I would have never found it. For another, in that sacred moment, alone, overlooking Doubtful Sound, simply hearing that kiwi was probably more precious than any glance at it through field glasses. It was there, it was active, it was calling for its mate. I had heard the kiwi.

Milford, Franz, & Josef

The next weekend, I was on the Milford Track with my usual group of hiking friends, still reeling from my harrowing whale-watching and hitchhiking escapades. I was in the back of the group as we crossed a large, sediment filled glacial valley with mile-high walls. Crossing a sandy alluvial fan beside a braided stream, I looked down at my feet and saw kiwi footprints. I followed the tracks' sporadic path, in and out of plumes of tussock grass. While the difference between weka and kiwi tracks are indistinguishable for an inexperienced tracker like me, the circular bore-holes I saw, which the kiwi makes with its proboscis-like beak, were unmistakable. Quickly my mind ran through the possibilities: could I wait here until nightfall to see if the kiwi returns? Can I catch up with the group, make it to the hut, eat dinner then hike back down that night to try my luck? I was paralyzed with indecision. For better or worse, the choice was made for me; it began to rain. I would make for the hut; then, if it let up, perhaps I could return at dusk.

As it turned out, the rain did not let up all night. Disappointed and exhausted, I took off my boots and began to boil water for my pasta. Lena, Katie and Jordan were settling down with there own dinners, having a great time. As I was finishing the pasta, Pat, who had been changing in the bunkroom next door, ran into the kitchen and whispered frantically, "*Eric, there's a kiwi out here!*" I bolted to the window and my gaze followed Pat's trembling finger out to the grass lawn in front of the bunkroom. There was something moving out there; I could just barely distinguish its dark form from the forest edge behind it. I produced my headlamp, turned it on and pointed in the direction of Pat's finger. Alarmed by the spotlight directed at itself, the weka bolted into the underbrush.

By my final month in New Zealand, my interest in spotting the kiwi became monomaniacal. Luke and I had packed up our meager belongings and packed ourselves into his trusty, tiny, borrowed Toyota Starlet Carat. We already had our moa femur. Now nothing could distract me from my kiwi-mania.

Our loose plan was to drive up the West Coast of the South Island, take the ferry across the Cook Strait, and cram in as much North Island reverie as possible before our flights home. Somehow, nearly every night along that meandering journey, we had managed to arrive at a well-known kiwi locality at just after dusk. I had notes from four field guides, pamphlets and locality guides from each Department of Conservation office we passed, as well as advice from the paleoornithology students at Otago. No more excuses.

We arrived at a coastal lowlands forest just north of the Franz-Josef Glacier. Here was one of the only forests in which the Okarito Brown kiwi (*A. rowi*) resides. We arrived at dusk, and soon began seeing the stately *"Kiwi Crossing"* road signs more and more as we drove on. For the kiwi's protection, the speed limit was knocked down to fifteen kilometers per hour. We drove to the road's end without seeing anything but three brushtail possums. We turned around and continued driving slowly, leaning our heads out the window and with the high beams on. There was a parking lot ahead where we could get out of our car and walk around, and as we pulled into it an excited elderly man ran up to our window. His headlamp was bright and kept us from actually seeing his face, but we heard his thrilled whisper loud and clear:

"I just saw a kiwi! Crossing the road, 25 meters down the way, about a minute before you pulled through."

The Captain, who, despite his general disinterest in birds, was never one to take a mission lightly, clutched the steering wheel more tightly.

"Did you see where it went?!" he pressed. The man responded that it ran into some long grass and was long gone. Luke slumped back in his seat.

Instinctively, I asked, "Are you sure it wasn't a weka?"

We parked and set out into the forest. Three hours later we returned with fourteen possum sightings, but no sign of the kiwi. On to the next kiwi site.

Urea & Jade

Two days later, we were in Hokatika, the jade capital of the world, a small seaside community with a jade-jewelry store on every corner. Jade is a gorgeous, deep greenstone rock. It is highly mafic, expelled from deep within the earth by violent volcanic activity. Several large rivers, whose headwaters are in the upper regions of volcanic peaks of the Alpine Fault, open out into the ocean within walking distance of Hokatika, depositing the otherwise inaccessible jade right on the beach. As a geologist, Luke highly anticipated our arrival to this part of the country. We decided to divide and conquer: he would spend a day hunting for and carving some jade, and I would devote the time to resolving my kiwi hunt.

After a fortuitous inquiry at the Hokatika office of the Department of Conservation, I arranged to meet up with a DoC officer the next morning in her hometown of Blackball. The hamlet borders a forest with an unusually dense kiwi population. It was the best chance I would have. This DoC officer was serious about kiwis. She had a two kiwi tracking dogs, one a seasoned veteran and the other a younger, a clumsy hound that she continually referred to as a "PIT," or, "puppy-in-training." In addition to inviting me along, she was showing around a wildlife manager and forestry officer from Scotland. There I was, with the most determined, qualified and equipped partner I could hope for in a kiwi patrol. The kiwis we were looking for were apparently part of a multi-year study; they had radio anklets on their legs, allow trackers to pinpoint the exact locations of individuals kiwis – if they were within range. She explained this whole deal to me as she pulled two sets of radio telemetry equipment from her pack. She handed one set to me. These kiwis were as good as found.

A five-hour hike later, we had found no kiwi. We had, however, discovered a long-abandoned gold mine. We had also found that the "puppy-in-training" had a long way to go before it can be of any help at all in the hunt. Also, we found that one of the radio telemeters did not work properly. But we found no kiwi.

We did, however, find its poop. The veteran tracking dog found it first, and his tail began wagging uncontrollably. The DoC officer told me to smell it.

"Excuse me?"

"If it smells strongly of ammonia, we know it isn't from a weka."

I smelled it: ammonia. I touched it: it was fresh. We switched on our radio antennae and listened for the rhythmic sonar blip that would mean a kiwi was within range. Nothing but white noise.

I had heard its call; I had seen its tracks; I had smelled its urea. But in the end, I departed New Zealand without seeing a kiwi.

Kiwi *Gravitas*

The kiwi represents one of the most pressing and puzzling issues of historical biogeography in Oceania. The origin of ratites, which, remember, are a related group of flightless birds in the southern hemisphere, has been highly debated for over a century. At the heart of this debate is that age-old question: Dispersal or Vicariance? Although the kiwi's order-level endemism suggests that its ancestors must have undergone an extremely long period of isolation, molecular analysis shows that the kiwi's lineage is actually quite young.[147] This is the great paradox of the kiwi. Not only does molecular evidence suggest that the kiwi is not a true "ghost of Gondwana," but it also not a close relative of the moa, the only other ratite on New Zealand and almost certainly the captain of the Ark.[148] But it's thought that kiwis arrived on New Zealand much more recently.[149] This is supported by the fossil record, which reports no traces of kiwis or kiwi ancestors any bedrock older than the Oligocene. What part, if any, did the Oligocene drowning play in this conundrum? Whence came the proto-kiwi?

The kiwi paradox seems to unite nearly every puzzle of historical biogeography in Oceania. If indeed the kiwi was not a member of "Moa's Ark," it must have dispersed. But how can a flightless ratite cross the Tasman Sea? This just doesn't make sense. The fossil record shows no evidence that the kiwi was ever Volant – it could not have flied here *then* withered into the fat ground-chicken it is today. Either there was once, somehow, an island hopping kiwi that could survive for months floating on fallen logs as it crossed the

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[147] Cooper A, Lalueza-Fox C., Anderson S., Rambaut A., Austin J., Ward R. 2001. "Complete mitochondrial genome sequences of two extinct moas clarify ratite evolution." *Nature*. 2001 Feb 8;409(6821):704-7.

[148] van Tuinen M, Sibley CG, Hedges SB. "Phylogeny and biogeography of ratite birds inferred from DNA sequences of the mitochondrial ribosomal genes." *Mol Biol Evol.* 1998 Apr;15(4):370-6

[149] Cooper A, Mourer-Chauviré C, Chambers GK, von Haeseler A, Wilson AC, Pääbo S. 1992. "Independent origins of New Zealand moas and kiwis." Proc Natl Acad Sci U S A. 1992 Sep 15;89(18):8741-4

South Pacific, or the principles of molecular genetics are just plain wrong.

Or, as is most likely the case, there is still something missing.

That key piece of evidence has just not been found yet. There must be more still in the ecology of the kiwi, in the bedrock of Zealandia, and in the natural history of neighboring islands that can fill in the gaps of the story of the kiwi. A humbling reminder that the pursuit of historical biogeography is -- and always will be -- riddled with mystery, after mystery, after mystery.

> *The fascinating search for biogeographical data, which has had us looking at everything from the prehistoric juggling of vast supercontinents to the mecleotide sequences contained in the infinitely small molecules of DNA, has not been able to produce a simple explanation for the biota of New Zealand. Far from it.* [150]

Until we have some answers, the kiwi will continue to serve as a symbol for the unsolved mysteries of deep biogeography, a lingering reminder of the complexities and limitations still rife within our tale of the earth. Truly, there remains as much *Incognita* in that far corner of the world as there was when Cook, Tasman, Flinders, Banks, and Darwin began mapping it. Perhaps the most formative piece of knowledge that I gained in my seven months abroad was this: while the Age of Exploration may have ended with the filling in of the all the gaps in our world map, the Age of Discovery is by no means over. Nor shall it ever be – so long as landscapes like Oceania's still have some wild places left.

The last sin I would ever want historical biogeography, or any branch of science for that matter, to commit is to simplify the earth's complexities, and that of its uppermost geologic layer, to the point that we delude ourselves into claiming we've "got it." That's scare-crow science, just as cowardly and deceptive as it sounds. Rather, I want to *comprehend* a landscape, in all its overwhelming complexity and enriching history, in all its abiding mystery and vexing questions. A landscape will never run out of mysteries. Deep biogeography is just one of many integrative and holistic approaches that facilitate that kind of synthesis.

Not all treasure hunts end as "successfully" as did my encounters with the sperm whale, the glossy black cockatoo, the red kangaroo, the superb lyrebird, or the echidna. Sometimes treasure-

[150] Gibbs. *Ghosts of Gondwana.* 199.

hunting for biogems does not yield the prizes you hope it might. But one can certainly not call an "unproductive" quest a "failure," just as no one can say misadventure is not without its own thrills. The goal is not to collect checkmarks on a birdwatcher's list, or to gain bragging rights; it is to understand the relationship of a species with its place. And the best way to do that, usually, is to see it with your own eyes. Such engagement with the landscape is no acquisitive game; it is intellectual adventure. It requires investment, not profit.

The more we know about nature, the neater it seems to us. You cannot understanding some aspect of an animal's history or a tectonic event without having it change, however slightly, your view of the landscape. Stumbling into that echidna that Victorian night changed things. Seeing the flight of the glossy black that morning did too. As did hearing the call of the kiwi, that lonely night on Doubtful Sound. Findings its poop in the woods of Blackball later that year brought a *gravitas* to that landscape that, in a way, would have been diminished if I had actually seen the kiwi. The sad truth is, the kiwi is not common. It is elusive and secretive - as mysterious as its own biogeographic history. Seeing it would have been misrepresentative. It would not have fit. Maybe I'm just consoling myself. But in retrospect, I can write with confidence that I do not feel depleted. All those hours of searching were not wasted. I may not have seen a kiwi, but I *looked* for one. That's what counts.

Besides, the hunt is not over. I have all the more reason to go back.

Chapter 14

Pressing Play

The case of the kiwi, that "honorary mammal", is a synecdoche for Oceania's biota as a whole. Just as the kiwi is so *distinctly* unique that it has no living comparison, so too does the biota of Oceania stand out in the biosphere as a whole. Any analogies between other life and Oceania's anomalies – its kangaroos, platypi, thorny devils, kakapos, and kiwis -- are nothing less than a stretch. They can never do without some level of abstraction. It is a singularly odd place, a place that breaks evolutionary molds and ecological paradigms. In my eyes, this translates to a place of extraordinary value. Anywhere with such a consistent deep-history of biogems and phenomena deserves the reverent enthusiasm of the scientific community and the public alike.

Like its biota Oceania's land is equally unique. This is no coincidence. One begets the other. Life and place are reflections of one another. Together they merge to contribute to an entire world, a teeming habitat, a beckoning wilderness.

Just as its life is best explained through story rather than with species-area curves, the landscape of Oceania is portrayed better, not as an album of snapshots, but as a time-lapse. A story. This is our means of accessing its wonders. Not with mere facts and photographs, but with movement. Drama. It is a winding series of intricate events, incomprehensibly involved, inextricably complicated, full of surprises and cliffhangers, unfolding as deep time marches along, relentless and inevitable, woven into a vast ecology of causality and circumstance. It is a story self-evident in the ecologies of modern biota. It is out there, among the fossils too, hewn in the very rock. All that has built up to our living world is projected, there, upon the crannies, folds, valleys, beaches, fjords, feathers, foliage, scales, teeth, and flukes. It is the land itself that contains the plot points and family trees of the story of life. Life, and place, and time, forever braided, endlessly entwined. At times, it can be wacky. "Everything is interconnected and uneasily balanced."[151]

And the story will go on. It must go on. Hold on tight.

Read the story for yourself some time. Go for it. Get *out there*. Look around. Explore. Exalt. It just takes wide eyes, restless feet, and camp stove. Give yourself time. Do some intellectual orienteering. Stake out the best vantage. Muster enough *enthusiasm* to see past the snapshots, past all the immediacies, beyond into the swirling, billowing clouds of ancient skies and forgotten worlds.

It is best if you see it for yourself, with your own eyes. Seek, and you shall find. Look, and you will see.

Again, the key is movement. If you want a sense of a place, walk across it. If you want a feel for its resident life, seek it out. Tromp, dig, search, investigate, pursue.

With the tools and insights of ecology, geology, island biogeography, paleontology, and genetics – the story of life, as we are telling it, draws ever closer towards that Grand Coherency. Like so many other parts of our experience, nature's is a pageantry that only makes sense when viewed holistically, both from up close and from afar, at times with meticulous rigor and at others in sweeping fast-motion panoramas. And suddenly, when approached thus, the kiwis, playtpi, the tuatara and all the other ancient *incognita's* down there -- despite their utter weirdness – they begin to belong. They begin to adopt a sensible niche in our minds, on our lands, in our collective history. And this knowledge cheapens nothing. They are none the less odd, unique, or compelling to us for it. Far from it. If anything, they are even more extraordinary, now that they have a story.

Forests demand a new reverence when you know what lurks and lurked within them. Waters gain volume when you know what swims in them, what once swam in them. Likewise, the present is given an invaluable and enriching depth when you consider its past. We see how they fit, or wonder at how they might, and we rejoice. Contemporary life does not stand alone; like ourselves, it is inexplicable and incomplete without its past.

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[151] David Quammen, *The Reluctant Mr. Darwin*. pg. 45.

Oceania is chock full of places where you can't help but feel this exorbitantly eventful history: the glacial valleys of Fjordland, the dry expanse of the Australian outback, the coral isles, that Fijian blue water…In Oceania, the story of life replaces any need for imagination or myth. Or, put another way, it is where imagination is put to its highest use. Life itself, it reminds us, is fantastic enough.

The narrative is always changing course, wavering its pace, and trading out its characters, infinitely more patiently than any of us could ever comprehend; our perspective is too restricted by our mental faculties, our geologically infantile existence. It is a story that goes on constantly, under our very noses; the clouds are moving, though we may not detect it, and they continue moving even when we turn our gaze from the heavens.

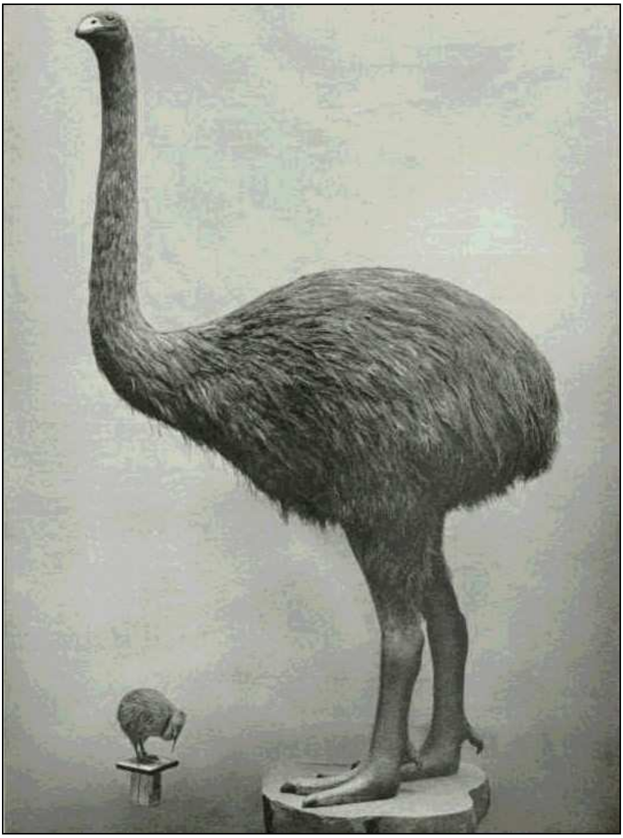
With an astute naturalist's eye and a keen sense of adventure, the intricate narrative of life on earth begins to unveil itself. The present lights the shadows of our past, the past puts the present in sharp relief. Slowly, we work to compile more and more snapshots of the story of life in the landscapes that we study. Eventually these disparate images may fuse into a single animation -- a time-lapse -- overwhelming, emergent, and revelatory.

To travel to this region of the world is to be constantly reminded that of the beautiful, inextricable link between life and place. In understanding this, the past finds a renewed presence, and land a new dimension, and yourself a new world, something in which to engage, to find, to lose yourself. Life itself – its story -- is fantastic enough. What else do we need? What else could we want?

Except, perhaps, to share it. To pass it on.

If there is any enduring lesson that Oceania can continue to teach us, it is that discovery depends, always, upon holding a place in the scientific method for imagination, wonder, and above all, a sense of adventure.

After all, in the words of Ray Bell, "Why not?"



Above all, however, the attempt is to show that the earth, in and of itself, has direct meaning for every man; that human life is bound to take place beyond the rim as well as within the canyon, and that all environments have the potential of being home.

~ David Leveson
A Sense of the Earth

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