Re-writing the History of Australian Tropical Rainforests: 'Alien Invasives' or 'Ancient Indigenes'?

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ABSTRACT

In 1860 in the *Flora Tasmaniae*, J.D. Hooker characterised the vegetation of north-eastern Australia as 'Polynesian and Malayan'. Hooker was arguing against the notion that Australian flora and fauna were so different from that found elsewhere that their origin was only explicable by an act of separate creation. Botanist and geologists following Hooker also highlighted the similarities between Australian tropical rainforests and those of South-east Asia; however a number suggested that despite appearances, the Australian rainforests were not recent arrivals, but were comprised of ancient and distinctive species. From the 1980s, ecologists Webb and Tracey utilised evidence provided by palaeoecological studies and the new theory of continental drift to argue that these rainforests were an ancient and truly Australian environment – a relict of the Gondwanan vegetation that preceded the sclerophyllous vegetation more commonly regarded as uniquely 'Australian'. They represented their findings as overturning previous notions of rainforest as 'alien and invasive'. Their reclaiming of the rainforest as a symbol of nationhood, while involving a re-writing of previous scientific views, played a significant role in the subsequent arguments over the rainforests' conservation.

KEYWORDS

J.D. Hooker, biogeography, rainforest, Queensland, Gondwana

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INTRODUCTION

During the second half of the twentieth century, there was a significant shift in scientific understanding of the origins and history of Australian rainforests. The notion that these rainforests were 'alien and invasive', relatively recent introductions from nearby New Guinea or south-east Asia – a notion attributed historically to Joseph Hooker – was overturned. In its place, a new vision of rainforest as an ancient and truly Australian environment was outlined and promoted. This re-writing of the biogeographical history of the Australian rainforests was not only significant scientifically; it also resonated with potent questions regarding Australian nationhood and identity which would be more fully articulated as these scientific visions were adopted by the conservation movement during the 1980s. However, this was not the 'revolution' it seems to be. In fact, it involved a contemporary re-writing of not only the aims and substance of Hooker's argument, but also of the more nuanced views of some early twentieth century scientists. At a time when rainforests in northern Australia were under threat, their representation as 'ancient and indigenous', and so central to Australian identity and heritage, was a powerful, and useful conflation of scientific and cultural thought.

J.D. HOOKER AND THE AUSTRALIAN FLORA

In 1860, Joseph (J.D.) Hooker had first outlined the evidence regarding the distribution and affinities of the Australian vegetation in the introduction to his *Flora Tasmaniæ*. He took on this considerable task because he believed that it was not possible to understand the flora of a single region without considering its relationship both to those regions surrounding it and – more particularly – to similar species and formations found elsewhere in the world. Hooker's work was based not only on his peerless access to botanical resources from his base at Kew Gardens, but was compiled after a four-year voyage with the *Erebus* and *Terror,* between 1839 and 1843, which had taken him through the southern waters of Antarctica, New Zealand, and Tasmania. By the mid-nineteenth century, according to Hooker, the flora of Australia was:

> justly regarded as the most remarkable that is known, owing to the number of peculiar forms of vegetation which that continent presents. So numerous indeed are the peculiarities of this Flora, that it has been considered as differing fundamentally, or in almost all its attributes, from those of other lands; and speculations have been entertained that its origin is either referable to another period of the world's history from that in which the existing plants of other continents have been produced, or to a separate creative effort from that which contemporaneously peopled the rest of the globe with its existing vegetation; whilst others again have supposed that the climate or some other attribute of Australia has

> exerted an influence on its vegetation, differing both in kind and degree from that of other climates.[1]

Hooker was well acquainted with the ideas of Charles Darwin, a close personal friend with whom he maintained an extended correspondence since their first meeting in 1843. In 1858 it was Hooker, who along with Charles Lyell, had famously encouraged Darwin to publish an excerpt from his 1844 *Essay* on the mutation of species by natural selection in the *Journal of the Linnean Society*, alongside the manuscript sent by Alfred Russel Wallace who had independently discovered the theory Darwin had been nurturing since his first correspondence with Hooker.[2] It is not surprising, then, that in Hooker's discussion of the origin and relationships of the flora of Australia in the *Flora Tasmaniæ*, which was published shortly after, he incorporated and responded to the ideas of Darwin and Wallace, while remaining sceptical of the theory of evolution. He suggested that:

> The Natural History of Australia seemed … to be especially suited to test such a theory, on account of the comparative uniformity of its physical features being accompanied with a great variety in its Flora; of the differences in the vegetation of its several parts; and of the peculiarity both of its Fauna and Flora, as compared with those of other countries.[3]

Like Wallace and Darwin, Hooker had been influenced by Lyell's unveiling of the great expanse of geological time and his exposition of the radical, inexorable, world-wide geological changes which had occurred over that time. Following Lyell, Hooker argued that there were 'two classes of agents, both of which may be reasonably supposed to have had a powerful effect in determining the distribution of plants; these are changes of climates, and changes in the relative positions and elevations of land'.[4] Given the immense time scales involved, and the paucity of – and difficulty of interpreting – geological and fossil evidence, as well as the incomplete state of knowledge regarding the existing Australian flora, Hooker concluded that:

> The problem of distribution is an infinitely complicated one … the mutations of the surface of our planet, which replace continents by oceans, and plains by mountains, may be insignificant measures of time when compared with the duration of some existing genera and perhaps species of plants, for some of these appear to have outlived the slow submersion of continents.[5]

Hooker's counter-intuitive vision of forms of plant life actually outlasting massive geological changes was a precursor to later ideas about the antiquity of elements in the Australian – including Australian rainforest – flora.

Hooker tackled the problem of the origin and affinities of the flora by compiling and statistically analysing lists of the natural orders of plants found in Australia, comparing those which occurred only in Australia with those which also occurred in other countries, and in each case noting where they were found.

This method of 'botanical arithmetic' was devised by Alexander von Humboldt, and was particularly dominant in botanical studies during the first half of the nineteenth century.[6] Hooker concluded that the families found in Australia were almost all also found elsewhere, though to varying degrees. He identified Indian floral elements in the north-west, Polynesian and Malayan in the north-east, New Zealand and Antarctic in the south-east, and South African in the south-west. Although Australia contains little alpine country, Hooker found that mountainous areas were home to New Zealand, Andean, Fuegian and European genera and species. In order to explain his findings, Hooker argued that there must have been former land connections between the southern temperate landmasses. He concluded that:

> the peculiarities of the [Australian] Flora, great though they be, are found to be more apparent than real, and to be due to a multitude of specialities affecting the species, and to a certain extent the genera, but not extending to the more important characteristics of the vegetation, which is not fundamentally different from that of other parts of the globe.

Hooker wrote, aptly, of his viewing the vegetation of Australia in a 'double light' – as simultaneously having characteristics peculiar to it, and taking its place in 'the existing Flora of the globe'.[7]

It is noteworthy that Hooker's conclusions, based as they were on available specimens and existing taxonomic work, were not made by means of an aesthetic assessment of the appearance of vegetation – such as would later lead explorer George Elphinstone Dalrymple to describe the North Queensland rainforests as being 'Indian'.[8] They were, however, based on the expectation that natural classifications, derived from observable features of plants, offered an indication of closeness of relationship which could ultimately be traced back to a common origin. The exact mechanisms of that relationship, and the implications of an attempt to express it through a system of classification, had yet to be fully explored.[9]

Hooker noted that the number of species in tropical Australia appeared to be 'extremely small', and stated that although 'many discoveries may yet be anticipated', the work of collectors such as Cunningham, Mueller, McGillivray and others led him to 'doubt whether future explorers will raise the known number of 2,200 tropical flowering species to much above 3,000'.[10] Despite Hooker's assertions that the tropical regions of Australia were relatively well-examined, at the time of publication of his 'Introductory Essay' in 1860 the North Queensland rainforests had barely been penetrated by botanical collectors or botanists. Nonetheless, Hooker's outline of the origins of the Australian flora, and the tropical flora in particular, was subsequently regarded by many botanists as a useful and accurate account of the affinities of particular floral regions in Australia, and was not comprehensively reconsidered until late in the twentieth century.

By outlining his findings on the biogeography of the Australian flora, Hooker intended to highlight the connections between the flora of Australia and the vegetation found in other parts of the world. He was arguing against a view that Australian flora was so strange, so different, that its existence required a novel kind of explanation. His characterisation of the vegetation of north-eastern Australia as 'Polynesian and Malayan' was not posited in opposition to 'autochthonous Australian' found elsewhere on the Australian continent, as later scientists would come to suggest, but rather sat alongside the diverse range of connections he argued existed between different geographical regions within Australia and other landmasses.

POST-HOOKER, PRE-CONTINENTAL DRIFT

In an article on 'The Origin of Australia', presented to the Queensland Royal Society in 1907, geologist and past President of the Society, Sydney Barber Josiah Skertchly, began by stating that:

> We are indebted to Sir J.D. Hooker for the first comprehensive view of the flora of Australia, and the long years that have passed since the masterly essay "On the Flora of Australia" was published in 1859, have not materially altered the views therein set forth.[11]

However, one significant change had occurred: the notion of a 'truly' Australian flora had gained currency. Skertchly noted the marked differences between the 'Australian' or temperate flora, found at its most diverse in the south-west of the continent; and the 'Asiatic' or 'tropical' flora found in the north-east. He noted the statistical difference in species dispersal, suggesting that only 14% of the species listed in Bailey's *Queensland Flora* also occurred in Western Australia. Moreover, he wrote that:

> mere numerical statements convey but an inadequate conception of the difference between the so-called Extra-tropical and the Tropical floras. It is the general facies that is most striking, and I can best illustrate it by a personal reference. I came to Queensland after spending years in the primeval forests of the Far East, and my first introduction to the Australian forests was in the scrub of North Queensland. To me it was a revelation and somewhat of a disappointment. I knew, so far as the books and specimens can teach, what the peculiarities of the Australian flora were, but this Atherton scrub, this wild tangle of the Barron Gorge, was not Australian at all. It was pure Asiatic "utan rimabau" – the deep forest – I had left in Borneo. The same tall trees with broad shade-giving leaves, the same climbing "rotan" (*Calamus*), and even the insects, gaudy *Ornithopteras* and royal purple *Eupleas*, met me on every hand. It all looked familiar. Some years afterwards, when I had grown accustomed to this flora, I entered W. Australia for the first

> time, landing at Albany from S. Africa. What a revelation it was! At last I saw Australia-Vera: at last I was in a new and strange land …

However, despite giving such emphatic statement of the true 'Australian-ness' of the flora adapted to arid and semi-arid conditions, and the 'Asiatic' or 'Oriental' nature of that found in the tropical regions, Skertchly went on to note that 'The Oriental flora is more Asiatic in general aspect than in number of species actually common to Australia and Asia', which, on his count, were 620 flowering plants and 200 species of ferns co-occurring between the two.[12]

Skertchly argued against the widespread view that the Australian flora and fauna were 'ancient'. He suggested, on the basis of both current distribution of plants and animals, and fossil and geological evidence that in fact they had evolved in relatively recent times in response to changes in climate and sea levels.[13] He painted a vision of the very different 'Australia' that would have been found by a 'Cretaceous Cook', during which time, 'there was no Australian continent at all, but instead, an Archipelago consisting of two main islands, one in the west, the other in the north and east, with a number of smaller islands in between'. The influence of the shallow sea found then in what are now desert areas of inland Australia, which he called the 'Opal Sea' and compared with the Arafura of the present, would have been to moderate the climate to 'temperate to warm-temperate, equable, and the land bathed with plentiful rains'.[14]

Skertchly suggested that there had been a much greater level of uniformity in the Tertiary flora than today, and that allied forms had been found across a wide range of latitudes and climates.[15] This was, he suggested, a flora in which '*the characteristic plants of Australia are but feebly represented*'.[16] Skertchly argued that 'the old universal flora had all the makings of the new flora in it – both the Orientalis and the Vera types – but when the Opal Sea became dry, only certain plants had adaptability enough to battle with the increasing heat and decreasing moisture. The rest died.' He continued:

> But there was a great difference between Australia-Orientalis and Australia-Vera. The former, owing to its mountainous and coastal character suffered less in climate – it has continued to receive fairly, and in parts quite, abundant rain and so a portion of the old flora has been preserved, in spite of its inferior adaptability. This is the Tropical Flora which I prefer to call Oriental. It is as has been said, essentially Asiatic in facies, but the bulk is not specifically identical with the Asiatic flora – it is merely the tropical part of the Universal flora. This portion of our present flora, then, I look upon as a true survival.[17]

Skertchly identified the 'tropical flora' of the north-east of Australia as a relic of a flora much more widespread during the Tertiary, and perhaps established in the Cretaceous era. He went on to acknowledge the more recent incursion of some 'Asiatic' species as a result of the geographical proximity between northern Australia and New Guinea, but his overall conclusions, based on the taxonomic, fossil and geological evidence, belied his immediate response to

the physiognomic similarity between the rainforests of Borneo and those of North Queensland. The tropical flora was not a recent invader, identical with the 'utan rimabau' he had met with in Borneo, but was rather a 'true survival' of the massive climatic and geological changes which had taken place on the Australian continent over tens of millions of years.

Skertchly's reaction to the North Queensland and Western Australian flora reflected the background of many colonial observers. During the nineteenth and early twentieth century, many British or European-born botanists and explorers came to Australia with prior experience of India, or of various parts of South-East Asia. As such, the rainforest of the north-eastern coast was a more familiar – if still exotic – form of vegetation than that classed as 'Australian'. The 'Australian' trees, so well-adapted to arid conditions, with their sparse, hard, narrow, vertically-hanging leaves, their peeling bark and dull colouring, appeared alien and strange. This is in stark contrast to the views of those Australian-born scientists of the later twentieth century, who had largely grown up not only surrounded by the 'Australian' flora and with little experience of or exposure to rainforest, but also at a time in which a pastoral landscape dominated by gum-trees was a central national image – a landscape represented as truly and sentimentally 'Australian'. The public re-positioning of rainforest (which had always been considered to have aesthetically 'Asian' overtones) as an 'Australian' flora, and one perhaps even prior in evolutionary terms to the sclerophyll vegetation, thus presents a complex mix of both scientific argument, based on advances in geology, palaeoecology and botany, and an attempt to expand the historical and aesthetic imaginations – and allegiances – of Australians. [18]

Karel Domin, a botanist from Czech University, Prague, visited Queensland in 1909-10, as he felt there was 'no other part of Australia which would be so interesting from the botanical standpoint'.[19] During the visit he undertook fieldwork in North Queensland. Domin followed Hooker in suggesting that the flora of Australia was composed of three main elements 'represented in a very unequal degree in the flora of the different States'. However like Skertchly, his flora now included the 'true *Australian*' element, alongside the 'so-called *Antarctic* element (named by Hooker)' and the '*Malayan* (including the Papuan)' element. He observed that:

> The forest flora consists of true Australian types; the scrub [rainforest] flora for the greatest part of Malayan and Papuan types. The historic evolution of these elements has been *quite diverse*, and we find always that they never come into a friendly contact. They are of quite different character, and on localities where the conditions are not so decidedly in the favour of one of them, there results a *strong struggle* between them.

Domin stated that 'The wet tropical part of Queensland has altogether a true Malayan-Papuan flora, which shows that there was formerly a land or island

connection and an easy way for propagation of this equatorial flora southwards.' He also suggested that:

> it would not be correct to regard Queensland's tropical flora only as a new comer and a recent branch of the regions mentioned above. All we know seems to testify that: –
>
> 1. The tropical "Malayan" flora of Queensland is only a small remainder of a flora spread formerly over large areas, which are now mostly sunken into the sea. Accordingly
>
> 2. The flora does not consist only of the original Malayan types. These made only a base, but it has been transformed in the great number of genera and species, which are known only from the Australian Tropics (endemic in Australia). It seems that the separation took place at a very early epoch, so that the ancestors of the present tropical flora in Australia developed themselves quite independent of the Malayan flora, and originated a large number of new forms. [20]

Like Skertchly, Domin asserted the antiquity and floristic distinctiveness of the so-called 'Malayan' flora, found in the rainforest areas of north-east Queensland – though he attributed this distinctiveness to a long period of isolation from the original, Malayan 'parent stock'. Although Domin, unlike Skertchly, was not a geologist, he also highlighted the significance of geological processes in the shaping and distribution of the flora.

Botanist Desmond (D.A.) Herbert considered the evolutionary history of the Queensland rainforests in his Presidential Address to the Queensland Royal Society, delivered in 1932 on the topic of 'The Relationships of the Queensland Flora'. Herbert began by outlining Hooker's argument, and the methods of statistical analysis on which it was based, stating that:

> An important point brought out by Hooker's analysis was that the families of Australia were almost all also found elsewhere, and though various families reach different degrees of development, many of the largest families here are the largest in the world as a whole.

While accepting that the fossil evidence was scant and difficult to interpret accurately, Herbert suggested that recently discovered leaf impressions found in rocks purportedly dated to the middle Jurassic pointed to the 'ancient nature of angiosperm inhabitation of the continent'. Further, he added that fossil evidence indicated that:

> The eucalyptus and various types now characteristic of both open forest and rain forest were well developed in the early Tertiary. Though the rain forest types are not necessarily tropical, they do indicate warmer conditions than obtain in those localities of the present day.

In consequence of this, Herbert stated that:

> We must commence an enquiry of the relationships of the present flora, therefore, by recognizing that the continent has been inhabited by a diversity of both rain and open forest types since, at least, the early Tertiary, and that their geographical range has, in the past, been profoundly modified by climatic and geological change. In other words, the sifting effect of environment has been operating for a long time, and the mixing of types of various origins, and the elimination of others, has culminated in our present flora.

Herbert went on to consider what might be meant by the 'Malaysian flora', and highlighted the distinction between genera of flowering plants found in the eastern and western regions of Malaysia, and the 'unstable insular area' in which the two types meet and mix, between Wallace's line on the west, and Weber's line on the east.[21] Wallace's line, which runs between Bali and Lombok, and Borneo and Celebes, was identified by A.R. Wallace in 1860 and 'separates two markedly different mammal faunas, solely placental in south-east Asia and predominantly marsupial in Australasia'.[22] Other attempts to define the boundaries between the Oriental and Australasian biotas (of which Weber's line is one) reflect the fact that 'different taxa have managed to penetrate different distances from their continent of origin into the islands of the East Indies'.[23] Herbert suggested that these two lines do not represent 'true biogeographic boundaries', but rather 'approximately define the limits of the two centres of origin and distribution, Sunda Land on the west, and New Guinea in the east'. Herbert argued that the large numbers of endemic genera found in Queensland indicate the 'ancient character' of the palaeotropic element in Australia:

> Eastern Malaysia and Western Malaysia differ considerably from one another, but North Queensland shows a further differentiation from New Guinea, North Australia from North Queensland, and South Queensland from North Queensland. The differences are sufficiently accounted for by the long continued sorting of types by climate without reference to the relative ages of the palaeotropic element in the different areas under consideration … the Australian palaeotropic element is restricted in range by climate and not by age.[24]

In a paper written almost twenty years later, 'Present Day Distribution and the Geological Past', Herbert addressed some of the same issues, and stated some of his conclusions more forcefully. This paper showed a shift in tone to an explicitly nationalist interpretation of the arguments around the evolutionary history of rainforest. Again he discussed Hooker, this time typifying Hooker's presentation of the origins of Australian flora a little more sharply, as being an account:

> of immigrants pouring in from various directions and pushing out the truly Australian plants, and of a very restricted export from Australia … the whole "set-up" being rather similar to the human settlement of this Continent. When these so-called invasion elements are subtracted from the flora, we are left with

> those that are more or less peculiar; they are the autochthonous element and no-one can take them away from us.[25]

After outlining the characteristics of this 'autochthonous element', Herbert used the example of Queensland 'dry scrubs' derived from rain forest types, to show how under pressure of climate, some survivors of a dying flora may provide the base for a new association. He further suggested that it is possible that the 'Australian' vegetation found in sub-humid, semi-arid and desert climates could, in fact, have been derived from a previously extensive mesic vegetation (that is, vegetation adapted to moist conditions). He concluded that it seemed reasonable 'to regard the rain forest types, [and] the beech forests as equally Australian [as sclerophylls]. They are very old members of the flora'. Herbert suggested that both the fossil record and the occurrence of residual rainforest types in places now far distant from the extant forests – such as the *Livistona* (Cabbage Palms) of the MacDonnell Ranges of Central Australia – provide strong evidence that such rainforest vegetation was previously much more extensive than at present. To explain this change in distribution, Herbert adapted the notion of a land-bridge, so enthusiastically utilised by Hooker, and instead suggested that a 'climatic bridge' must, at some time past, have linked areas of the continent which now experience such radically distinct climates, and carry such radically different flora.[26]

The debate surrounding the history of vegetation in Australia has invoked clear (sometimes explicit) metaphorical resonances with concerns about the human history of the continent. In discussions of the origins of the Australian rainforests, broader questions of race, identity and belonging have been raised. Rainforest was regarded as 'invader', and its presence was the result of its success in the struggle for survival against the autochthonous vegetation. Whether this explanation of the rainforests' origin was regarded as scientifically tenable or not, the story itself was seen clearly as a parallel to the European invasion of the continent and the historical processes of colonisation. However, the suggested Asian lineage of Australia's rainforests highlighted Australia's proximity to south-east Asia, and connected this invasion narrative with concerns over the security of Northern Australia, and long-held fears amongst many white Australians of a possible future re-invasion of 'their' lands. A closer examination of Herbert's account suggests that the debate about rainforests' origins could also carry a more complicated and nuanced message. Herbert argued against the notion that the separation of the Oriental and Australasian biotas represented a true biogeographic boundary, and highlighted the fluidity, interpenetration and interrelationship which existed between these supposedly separate 'elements'. As such, Herbert implied that any essentialist understanding of biogeographic identity, any exclusive focus on separation and competition as fundamental to the history of the region, was necessarily false. Further, Herbert suggested that even if the rainforest had originated from outside Australia, given the passing of time, it could eventually be legitimately considered as 'Australian'.

Hooker, Skertchly, Domin, Herbert, and others who discussed the origin and distribution of Australian vegetation prior to the 1960s were attempting to grapple with an often scant and confusing array of evidence. Each responded to the problem of where the various floral elements of Australia had originated from and why they were now found where they were. Answers made reference to changes in climate and landform over geological time, to the rise and fall of mountain ranges and sea levels. Their examination of the rainforest flora of Australia showed that, although it did not appear distinctively 'Australian', in taxonomic terms much of it was not simply identical to that found to the north in Malaysia, or nearby in New Guinea. However, the closeness of Northern Australia to south-east Asia and New Guinea – which had been connected by a land-bridge to north-eastern Australia during the Pleistocene glaciation – and the fact that recent floral arrivals were found on northern shores, further complicated the issue. Explanations were based on an analysis of the patterns of distribution observed in both present and fossil flora, and on a belief in 'the steady state of the earth's crust, its continents and archipelagos in supposedly fixed position'.[27] As such, an important focus was placed on the processes by which plants might have arrived in Australia from elsewhere.

DRIFTING CONTINENTS

By the early 1970s, the acceptance of the idea of continental drift revolutionised scientific understanding of the history of the earth and of life; and necessitated a radical rethinking of the origins and history of the Australian flora. This resulted in a re-appraisal of the way scientists – not only geologists, but also zoologists, botanists, biogeographers, and others – talk and think about the past. As geologist David Johnson states:

> It is important to realise that while we say something happened in Canada or South Africa, that is just because that is where the rocks lie today. In the Archaean these fragments were not assembled as they are today. The crust of the Earth has been moving since it first formed. The atlases and geography we know today are only true for now. In the past the landmasses were totally different shapes.[28]

Writing in the late 1980s, ecologist Richard Schodde reflected on the lack of resonance between the way biogeographers in the 1980s were talking about biological history, and the significance of this changed vision of the Australian continent.

> Pick up any modern text and you will see bird geographers and reptile geographers talking about Antarctic dispersal routes into Australia via Gondwana and Indo-Malayan dispersal routes in via Indonesia. Even current phytogeographic treatises talk about Australia receiving its first stocks of angiosperms by north-west land bridges from Laurasia in the Cretaceous. The point I want to make here,

> and I can't stress it enough, is that whatever biotic elements Australia received before its break from Antarctica in the early Tertiary it inherited from Gondwana. If angiosperms did come into the region from the north in the Cretaceous, they came to Gondwana, and perhaps even the Australian-sector of Gondwana; but not to Australia as such. This point needs absorbing in Australian biogeographic thinking.[29]

To the extent that ecologists, biogeographers and other scientists utilise historical narratives, the theory of continental drift raises some significant historiographical questions: How is it possible to write an historical account which reflects not only the flow of time, but also the movement of the ground on which events were played out? What does such a history mean when its reference to place is set adrift? And at what point is it no longer a history of 'Australia'? The difficulty of separating ecological history from Australian history seems to have been more than a question of geological and terminological accuracy. The rich layers of meaning that biogeography derived from its metaphorical resonance with Australia's human past, seemed to have been abruptly sundered.

RE-WRITING THE HISTORY OF THE AUSTRALIAN TROPICAL RAINFORESTS

In the 1959 paper with which he had begun his ecological career, Len Webb had described the tropical rainforests of Australia as 'a predominantly Indo-Malaysian flora' and used the contrast between it and 'the autochthonous flora characterised by sclerophylls' as a basic division within his classificatory system.[30] Twenty years later, around the time of his retirement from CSIRO, Webb wrote, in a chapter he co-authored with Geoff Tracey,

> The rainforest habitats preserve a remarkable wealth of endemic and, in some areas, primitive biota, as well as exhibiting strong affinities at the generic level with surrounding countries that were continuous with the Australian land mass in Gondwanic time. Although the processes of evolution and community development responsible for the patterns of Australian rainforests are being unravelled only now, evidence already forthcoming indicates a need for revision of traditional concepts in Australian phytogeography that previously regarded the floristic elements of the northern rainforests as alien and invasive.[31]

Webb and Tracey pointed to three recent events which had provided the opportunity for a new consideration and understanding of that question. Firstly, the intensive ecological surveys of rainforests which had been undertaken in Eastern Australia during the 1960s and 70s, and the use of 'modern numerical and analytical techniques enabling the processing of large data sets to give a comprehensive floristic typology and habitat correlations'. Secondly, the palynological studies which 'furnish an exceptional chronicle of tropical vegetation

during the last 80,000 to 100,000 years of the late Quaternary period'. And finally, the 'new and now firmly established evidence for continental drift and an ancient Gondwanaland flora'.[32]

In an interview, recorded for the National Library of Australia, Geoff Tracey recalled that it was during field work for the Australian Phytochemical Survey, which he commenced in 1949, that he and Len Webb began to be puzzled by distribution patterns of species, genera and families of rainforest plants. The patterns they observed did not accord with what Tracey regarded as the accepted notion of rainforest species as recent arrivals, unrelated to the truly 'Australian' flora. As they searched for a particular alkaloid in a genus, related species would be found across a range of environments: in wetter rainforests, dry eucalyptus woodlands, and bottle tree scrubs. On the other hand, there were a number of genera and species – including some endemic angiosperms with primitive morphological traits – which 'didn't ever leave the wet rainforest'.[33] As they continued to collect data and apply a range of methods of analysis, their findings continued to support their sense that what they were examining were not scattered invasive elements, but rather an 'archipelago of refugia', the distribution and composition of which reflected processes of climatic and edaphic sifting over – in some cases – many millennia.[34] Webb and Tracey concluded, as Herbert had before them, that the rainforests were restricted by climate and not by age. They argued that, although the rainforests did contain some newer arrivals, they were in fact largely relict populations of a previously-dominant form of vegetation. As Geoff Tracey put it, 'when this theory of plate tectonics was actually acceptable, the whole thing fell into place …'[35]

Webb and Tracey eventually decided to publish their conclusions in the new edition of a European volume, *Ecological Biogeography of Australia*, which was to be released in 1981. The 1959 edition, *Biogeography and Ecology in Australia*, had been 640 pages long, and had barely mentioned Australian rainforests. The new edition offered a clear indication of the extent to which knowledge of the Australian environment had increased between the 1960s and 1980s: it was over 2,500 pages long, and comprised three volumes. Len Webb was invited to contribute a chapter, and he and Geoff Tracey thought a prominent European publication was an ideal place to muster the evidence, and outline their interpretation of the origins and evolutionary history of Australian rainforests. According to Tracey, 'you could publish scientific articles in Australian literature, but no scientist worth his salt anywhere else in the world would ever read them.'[36]

In 'Australian rainforests: patterns and change', Webb and Tracey attempted to apply their ecological understanding of the ways in which rainforest environments respond to disturbance in the observable short-term to the longer, middle-late Pleistocene record of vegetation history provided by Peter Kershaw's analysis of palynological evidence from crater lakes on the Atherton Tablelands, and the new model of geological history provided by the theory of continental drift.[37]

They distinguished between two forms of change which occur in all vegetation communities. The first were progressive successional processes in which change is initiated by disturbance, but rainforest communities return to a predictable 'terminal community', similar in structure and species composition to the community which existed prior to the disturbance. The second encompassed longer-term changes through which communities evolve unpredictably, and which involve adaptation, migration, extinction and speciation. Webb and Tracey recognised that the distinction between the two types of change is not always clear, and that the 'extent and duration of disturbance … the ecological stability [of the original community]; and the area and location of the disturbed community in relation to other communities' all determine the new patterns of community development which result from change.[38]

Webb and Tracey divided the rainforests of Australia into 3 floristic regions: the cool forests of the south-east (A), the warm and moist forests of the north-east (B), and the warm, drier forests of the north and sub-coastal regions (C). Their floristic region B corresponds with the wet tropical rainforest region of north-east Queensland. They argued that floristic regions A and C do not represent 'transitions' or 'attenuations' of the tropical rainforest along a gradient of decreasingly favourable temperature or rainfall, as has sometimes been suggested, but rather the three regions:

> approximate 'core areas' somewhere near where ancient widespread floras from Gondwanaland crystallized under different climatic-edaphic-topographic conditions, accompanied by the interplay of seed and pollen dispersal systems. Ecological differentiation and geographical isolation would have favored independent lines of evolution. [39]

They further divided each of these regions into overlapping 'phytosociological or vegetation provinces', characterised by a range of indicator species, and closely correlated to particular climatic regimes.[40] They interpreted the distribution of some genera and species across provinces as implying 'a long and complex history of climatic-edaphic-topographic sifting often accompanied by fire'. On the other hand, the occurrence of many species as endemics in particular floristic regions was regarded as demonstrating 'a long history of segregation to permit species differentiation'.[41] They concluded that:

> biogeographical subdivision often comes to rest on the distribution of relict and narrowly endemic species at a level that corresponds to refuge areas and areas of minor isolation. The subdivision also reveals groups of relatively small and widely separated patches of rainforest with strikingly similar botanical composition. Vegetation classification therefore raises problems of origin and adaptation and of community dynamics on different time scales in habitats of different size and distribution. [42]

Webb and Tracey identified a range of types and probable locations of refugia which would have sheltered wet rainforest communities during periods of climatic stress, particularly from the impact of increased fires associated with drier conditions – these included the summits and gullies on the upper slopes of cloudy wet mountains, very wet lowlands, deep moist gorges of coastal lowlands, and the fringing areas alongside permanently flowing rivers.[43] Webb and Tracey argued that such sites have acted as nuclei for the subsequent re-expansion of rainforest areas which, as the palynological work of Peter Kershaw on the Atherton Tablelands demonstrated, has occurred repeatedly when an unfavourable climate has shifted to one more suited to support the growth of rainforest vegetation.[44] Webb and Tracey suggested that in tropical north-eastern Australia such refugia had allowed 'narrow endemics including primitive angiosperms … to survive in a kind of Noah's Ark situation…' They noted that:

> despite the greater concentration of primitive genera and species in south-east Asia, there is a far greater concentration of primitive families in Australasia. This suggests that the refugia now centered in this region are of great antiquity, extending to the Cretaceous or earlier when many primitive angiosperms originated … and Gondwanaland was still entire.[45]

While the extent and nature of endemism provided one plank to their argument, they also undertook an analysis of the distribution throughout the world of non-endemic rainforest genera found in Australia, and concluded that the floristic affinities of such genera:

> with other tropical countries are consistent with derivation from a Gondwanaland flora for which the land mass that is now Australia also provided a substrate. It seems no longer valid to label taxa also found in India and Indomalesia as 'invasive elements'. It also seems unnecessary to accentuate the role of long-distance seed dispersal throughout this part of the southern hemisphere, although dispersal over moderate distances may have occurred.[46]

Finally, Webb and Tracey concluded that 'the traditional concept that two invasive floristic elements – one from south-east Asia to the north, and the other from Antarctica to the south – form the core of Australian rainforest vegetation is no longer tenable'.[47] They characterised the contemporary patterns of Australian rainforest vegetation as a series of 'chequered layers', of which the base is the 'floristic matrix inherited jointly with other countries from Gondwanic times'. Upon this base has been overlain 'a shadowy mosaic woven from the phylogenetic development of communities in prehistorical and geological times', which remain as fragmentary relicts across a number of locations, such as in the 'ever-moist summits and gorges of the north-east'. The upper and most recent layer they identified as:

> the product of natural disturbances (and most recently white man) in historical times. It is often starkly variegated, ranging from low herbaceous pioneers to

> advanced secondary growth and broken-canopied forests disrupted by cyclones, as the result of ontogenetic development and recent succession.[48]

During the course of their field work, Webb and Tracey had witnessed the consequences of such 'natural disturbances' time and time again. While they struggled to untangle the ancient history of the rainforests, a more immediate transformation of these forests was occurring before their eyes. Poet and activist, Judith Wright, was a close friend of Len Webb, and she recalled how he returned to Brisbane from field trips 'imbued with the tragedy' of the destruction which was being wreaked, as:

> the rainforest continued to be felled and burned, and plants and animals unknown, or almost unknown, to science, and never to be replaced, went up in smoke. Progress was the cry and progress we got, no matter how destructive and planless.[49]

As Webb and Tracey traced the long evolutionary history of Australian rainforests, they were also brought to confront directly the dramatic recent transformations which had accompanied European settlement and the ongoing clearing of rainforest. The changing history of the rainforests no longer held as a metaphor for the European colonisation of the Australian continent, as had earlier been suggested by D.A. Herbert; it was its stark outcome.

During the course of his long friendship with Wright, Webb shared with her the sense he had developed of the forest. In 1983, the year in which a local council bulldozed a haphazard and controversial road through some of the last remaining lowland rainforest north of the Daintree River, Wright sent him a poem, 'Rainforest'. The poem emerged from their discussions over a number of years, and expressed their belief that 'the forest, like the world generally, could be properly understood only by those who had experienced and shared in its life'.[50] She wrote:

> We with our quick dividing eyes
> measure, distinguish, and are gone.
> The forest burns, the tree-frog dies,
> Yet one is all and all are one.[51]

From the early 1980s fervent lobbying began for the legal protection of the North Queensland rainforests. Conservationists drew strongly (though at times loosely) on the work of Webb and Tracey, highlighting that:

> Refugia, areas where rainforest has existed continuously for some 200 million years, have been identified in this region. Primitive plant families, amongst the first flowering plants to evolve on earth, have surviving representatives. Botanists regard the area as a living museum.[52]

The construction of what became known as the Daintree road was the catalyst by which the North Queensland rainforest emerged into national consciousness in

Australia. Although protests did not prevent the road from being built, concern for the future of the rainforest was strong, and the campaign for its protection continued after the road's completion. While the beauty and recreational values of the rainforest provided impetus for the campaign, it was the sense of its antiquity and growing significance to science that clinched the arguments. On 5 June 1987, a month before the federal election, the Australian Government nominated the Wet Tropics for World Heritage listing. [53]

CONCLUSION

Scientific understanding of the evolutionary history of the Australian vegetation on the geological time scale has been shaped by two revolutions: the first, in biological thought, was ushered in by Darwin and Wallace in the mid-nineteenth century; the second, in geological thought, was introduced by Wegener at the beginning of the twentieth century, and then gradually confirmed by force of evidence. Both of these revolutions highlighted the ubiquity of change in the natural world: not only are species mutable and historical entities, but the continental landmasses, which give shape to the world such species inhabit, have also changed dramatically over geological time. In the words of botanist Jeremy (J.M.B.) Smith:

> Vegetation is vibrant with change – with short-term fluctuations, medium-term successions and longer-term evolutionary changes; its constituent taxa are ever able to migrate wherever conditions in some way change to allow it. This dynamism needs to be superimposed over the palaeogeographical picture of slowly sliding continents, upthrusting and downwearing mountains, the rise and fall of land and sea, and the changing picture of world climates. The resultant pattern of kaleidoscopic complexity is simplified in appearance only by the paucity of the fossil data…[54]

While an examination of previous writings on the biogeography of Australian rainforest shows that Webb and Tracey's writing of the history of Australian rainforests as 'ancient and indigenous' was not the unambiguous revolution that it was represented as being, they were nonetheless the first scientists to have based their conclusions on detailed, extensive botanical fieldwork in the rainforests of North Queensland, and knowledge of the mechanism of continental drift. Their fieldwork inspired them to apply in detail the ecological principles of change they had uncovered to the longer-term evolution of rainforest communities.

Webb and Tracey presented the rainforests as a complex, ancient, and ever-changing Australian environment in which current distribution in space could be investigated to reveal 'antiquity and innovation in time'.[55] The mixing of historical and spatial imagery in their depiction of the patterns of rainforest vegetation is striking: it reveals their understanding that, in the context of geo-

logical, evolutionary and historical change, it is the rainforests themselves which offer a thread of continuity. However, Webb and Tracey's investigation of the long evolutionary history of the rainforests, undertaken as it was on the basis of detailed fieldwork, also brought them face to face with the rapid, dramatic and ongoing changes caused by European colonisation and large-scale clearing of rainforest areas. This encounter would lead Len Webb, in particular, to become a leading advocate for their conservation.

Since the 1980s, increasingly detailed palaeoecological evidence has enabled researchers to trace, to finer levels of spatio-temporal resolution, the history of tropical rainforests in Australia. This evidence has led scientists to focus on the interrelationship between rainforests and people: in particular, the role of Aboriginal burning in maintaining rainforest boundaries, and the processing and consumption by Aboriginal people of a diverse range of noxious rainforest plants. Scientists are increasingly finding that rainforests are far from the ancient, stable, unchanging environment some conservationists have presented them as. Rainforests are dynamic systems that have changed in species composition, geographical location and extent, in response both to human activities over thousands of years, and to climatic change over millions. As the past of the forests comes into clearer focus, their future remains in question. How the rapid shift in climate that many scientists claim is already underway will impact on the limited areas of tropical rainforest remaining in Australia is an open question.[56]

NOTES

[1] J.D. Hooker, *The Botany of the Antarctic Voyage of H.M. Discovery Ships Erebus and Terror, In the Years 1839–1843, Under the Command of Captain Sir James Clark Ross, KT., R.N., F.R.S. & L.S., etc*. Part III. *Flora Tasmaniæ*, Vol. I. Dicotyledones (London: Lovell Reeve, 1860), xxvii.

[2] Charles Darwin, 'On the tendency of species to form varieties, and on the perpetuation of varieties and species by natural means of selection', *Journal of the Linnean Society of London (Zoology)* 3 (1858): 45–62. It was Darwin's reading of Wallace's article, on which Wallace had sought his opinion, which provoked him at last to publicly present his own theory. For further details see J.L. Brooks, *Just before the Origin: Alfred Russel Wallace's Theory of Evolution (*New York: Columbia University Press, 1984).

[3] Hooker, *Flora Tasmaniae*, ii–iii.

[4] Ibid., xvi–xvii. On Lyell, see Janet Browne, *The Secular Ark: Studies in the History of Biogeography* (New Haven: Yale University Press, 1983), 102–7.

[5] Hooker, *Flora Tasmaniae*, xxii.

[6] Browne, *The Secular Ark*, 59.

[7] Hooker, *Flora Tasmaniæ* , xxvii.

[8] George Elphinstone Dalrymple, *Narrative and Reports of the Queensland North-East Coast Expedition, 1873* (Brisbane: Government Printer, 1874), 30.

[9] Hooker, *Flora Tasmaniæ,* iv, xii. David L. Hull, *Science as a Process: an Evolutionary Account of the Social and Conceptual Development of Science* (Chicago: University of Chicago Press, 1988), 102.

[10] Hooker, *Flora Tasmaniæ,* xl. None of the explorers listed had collected extensively in North Queensland rainforest areas – Mueller at this stage had not yet settled Dallachy into his role in Cardwell. A century later, botanist Nancy T. Burbidge, in 'The Phytogeography of the Australian Region', a work which closely followed Hooker's approach, wrote of the North-East Queensland region: 'Unfortunately there is no detailed account of the flora of the area and this analysis has had to be based on scattered records in taxonomic and more general botanical papers…' Nancy T. Burbidge, 'The Phytogeography of the Australian Region', *Australian Journal of Botany* 8 (1959): 134.

[11] Sydney B.J. Skertchly, 'The Origin of Australia', *Proceedings of the Royal Society of Queensland* 21 (1908): 66.

[12] *Ibid*., 67–8.

[13] This is in contrast to the views of Hooker, who argued that the peculiarities of the Australian flora led to the conclusion that it was 'a very ancient one'. Hooker, *Flora Tasmaniæ,* cii. Skertchly in part was opposing the notion that evolutionary processes are by necessity gradual, and believed that the fossil record suggested that at some times, and under some conditions such as changes in climate, the process of speciation was much more rapid and diverse than Hooker suggested. Skertchly, 'The Origin of Australia', 81.

[14] *Ibid*., 57–8.

[15] This idea of a uniform flora at an earlier period of life's history stretches back to the work of Brongniart and de Candolle in the early nineteenth century, and was widely debated during the mid-nineteenth century. It is discussed by Browne, *The Secular Ark*, 94–102.

[16] Skertchly, 'The Origin of Australia', 69–70.

[17] *Ibid,* 77.

[18] Those who came with prior experience of the tropics include Skertchly, who spent time in Borneo E.N. Marks, 'Skertchly, Sydney Barber Josiah (1850–1926)', *Australian Dictionary of Biography*, Volume 11 (Melbourne: Melbourne University Press, 1988), 621–2. Explorer George Elphinstone Dalrymple and botanist John Dallachy both came to Australia after managing coffee plantations in Ceylon – C. G. Austin, Clem Lack, 'Dalrymple, George Augustus Frederick Elphinstone (1826–1876)', *Australian Dictionary of Biography*, Volume 4 (Melbourne: Melbourne University Press, 1972), 9-10; Alan Gross, 'Dallachy, John (1808?–1871)', *Australian Dictionary of Biography*, Volume 4 (Melbourne: Melbourne University Press, 1972), 6. For details on environmental symbols of nationhood, see Thomas Dunlap, *Nature and the English Diaspora: Environment and History in the United States, Canada, Australia and New Zealand* (Cambridge: Cambridge University Press, 1999), 100–102.

[19] Karel Domin, 'Queensland's Plant Associations: Some Problems of Queensland's Botanogeography' *Proceedings of the Royal Society of Queensland* 23 (1910): 58. See also A.D. Chapman, 'Domin and Danes in Java and Australia, 1909–1910', in P.S. Short (ed.), *History of Systematic Botany in Australia: Proceedings of a Symposium held at the University of Melbourne, 25–27 May 1988 (*Melbourne: Australian Systematic Botany Society Inc., 1990), 159–63.

[20] Chapman, 'Domin and Danes in Java and Australia', 72.

[21] D.A. Herbert, 'Presidential Address: The Relationships of the Queensland Flora', *Proceedings of the Royal Society of Queensland* 40 (1928): 10–12.

[22] J.M.B. Smith, 'An Introduction to the History of Australasian Vegetation', in J.M.B. Smith (ed.), *A History of Australasian Vegetation* (Sydney: McGraw-Hill Book Company, 1982), 12.

[23] J.H. Brown and A.C. Gibson, *Biogeography* (St Louis: The C.V. Mosby Company, 1983), 234.

[24] Herbert, 'The Relationships of the Queensland Flora', 12, 14–15.

[25] D.A. Herbert, 'Present Day Distribution and the Geological Past', *Victorian Naturalist* (April 1950): 228–9.

[26] *Ibid*., 230.

[27] R. Schodde, 'Origins, Radiations and Sifting in the Australasian Biota – Changing Concepts from New Data and Old' (Nancy T. Burbidge Memorial Lecture, 1989), *Australian Systematic Botany Society Newsletter* 60 (September 1989): 3.

[28] D. Johnson, *The Geology of Australia* (Cambridge: Cambridge University Press, 2004), 73.

[29] Schodde, 'Origins, Radiations and Sifting of the Australasian Biota', 5.

[30] L.J. Webb, 'A Physiognomic Classification of Australian Rain Forests', *Journal of Ecology* 47 (1959): 551–2, doi: 10.2307/2257290.

[31] L.J. Webb and J.G. Tracey, 'The Rainforests of Northern Australia', in R.H. Groves (ed.), *Australian Vegetation (*Cambridge: Cambridge University Press, 1981), 67.

[32] L.J. Webb and J.G. Tracey, 'Australian Rainforests: Patterns and Change', in A. Keast (ed.), *Ecological Biogeography of Australia*, vol. 1 (The Hague: W. Junk, 1981), 607–8.

[33] Interview with Geoff Tracey, National Library of Australia (hereafter NLA) TRC 2845/46: 3.1.9. As Adam points out, 'Referring to living taxa as primitive does not necessarily imply that they are ancestral, but rather that they possess a larger number of primitive traits than other taxa.' P. Adam, *Australian Rainforests* (Oxford, Clarendon Press: 1992), 158.

[34] Webb and Tracey, 'Australian Rainforests: Patterns and Change', 609. Edaphic sifting refers to the influence of soil type on vegetation formations.

[35]Interview with Geoff Tracey, NLA TRC 2845/46: 3.1.10. However, while continental drift had the status of geological orthodoxy by the early 1970s, it took botanists – many of whom responded to these developments with 'outright rejection' – a little longer to accept the new theories than it did geologists. J.M.B. Smith, 'An Introduction to the History of Australasian Vegetation', 2. For a more recent and detailed overview of Australia's rainforest past, see R.J. Morley, *Origin and Evolution of Tropical Rain Forests* (Chichester: John Wiley and Sons, 2000), 225–35.

[36]A. Keast, R.L. Crocker, C.S. Christian (eds.), *Biogeography and Ecology in Australia* (The Hague: W. Junk, 1959). Interview with Geoff Tracey, NLA TRC 2845/46: 2.1.6–7.

[37] A.P Kershaw, 'A Late Pleistocene and Holocene Pollen Diagram from Lynch's Crater, North-Eastern Queensland, Australia', *New Phytologist* 77 (1976): 469–98, doi: 10.1111/j.1469-8137.1976.tb01534.x.

[38] Webb and Tracey, 'Australian rainforests: patterns and change', 628.

[39] Ibid., 637–8.

[40] Ibid., 642–5.

[41] Ibid., 649, 651.

[42] Ibid., 654.

[43] Ibid., 654–61.

[44] Ibid., 663.

[45] Ibid., 661.

[46] They concentrated their analysis on genera as knowledge of species distribution for the region continued to be inadequate, and many species remained unnamed and some undescribed. Webb and Tracey, 'Australian Rainforests: Patterns and Change', 668–669.

[47] Ibid., 672.

[48] Ibid., 676.

[49] Judith Wright, *The Coral Battleground* (West Melbourne: Thomas Nelson, 1977), 3–4.

[50] Veronica Brady, *South of My Days: A Biography of Judith Wright* (Sydney: Angus & Robertson, 1998), 429.

[51] J. Wright, 'Rainforest', *Collected Poems 1942–1985* (Sydney: Angus & Robertson, 1998), 412.

[52] R. Hill and M. Graham, 'Greater Daintree National Park' in J.G. Moseley and J. Messer (eds.), *Fighting for Wilderness. Papers from the Australian Conservation Foundation's Third National Wilderness Conference, 1983* (Sydney: Fontana/ACF, 1984), 9.

[53] See Rainforest Conservation Society of Queensland, *Tropical Rainforests of North Queensland: Their Conservation Significance* (Canberra: Australian Government Publishing Service, 1986), on the basis of which the Australian Heritage Commission recommended World Heritage Listing.

[54] J.M.B Smith, 'An Introduction to the History of the Australasian Vegetation', 27.

[55] Webb and Tracey 'Australian Rainforests: Patterns and Change', 676.

[36] On Aboriginal use of rainforest plants see R. Cosgrove et al., 'The Archaeology of Australia's Tropical Rainforests', *Palaeogeography, Palaeoclimatology, Palaeoecology*, 251,1 (2007): 150–73, doi: 10.1016/j.palaeo.2007.02.023. On rainforests and fire, see D.M.J.S. Bowman, *Australian Rainforests: Islands of Green in a Land of Fire* (Cambridge: Cambridge University Press, 2000). For a detailed analysis of human impacts on tropical rainforest over the past 700 years and a discussion of the implications of climate change see Simon G. Haberle, et al., 'The Impact of European Occupation on Terrestrial and Aquatic Ecosystem Dynamics in an Australian Tropical Rain Forest', *Journal of Ecology* 94,5 (2006): 987–1002, doi: 10.1111/j.1365-2745.2006.01140.x.