Conserving Gondwana Rainforests

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Summary

Bushfires in 2019-20 affected many parts of the Gondwana Rainforests World Heritage Area (WHA) in Queensland and NSW. This, and IUCN's 'Serious Concern' finding in its 2020 assessment report highlighting increasing risks of long-term decline in the WHA's biodiversity values, were catalysts for this report. The report provides an overview of the extent and severity of damage to Gondwana Rainforests from the September 2019 bushfires. It makes initial estimates of weed control costs for restoring fire damaged areas in the WHA in Queensland: these amount to $15-42M over ten years.

Queensland National Parks and Wildlife field operational budget is currently about $150M/annum. This study makes preliminary estimates for improving conservation management in Queensland's historically underfunded National Parks, from Poor to Fair ($278M/annum), Fair to Good ($388M/annum), and Good to Very Good ($510M/annum).

In response to ongoing concerns about the conservation management of the WHA and IUCN's 2020 assessment, it makes preliminary estimates of funding necessary to restore biodiversity values for relict and endangered ecosystems and species, to achieve improved levels of park management (Fair $7M; Good $13M; Very Good $21M/annum). It notes the need for identifying and establishing buffer zones and corridors to build ecosystem connectivity and provide refugia from the impacts of climate change and fires - Gondwana lacks buffer zones and there is a growing need for better connectivity.

It examines the economic contributions and potential revenues from tourism (~$80M/year) and the value (~$309M/year) to adjacent coastal urban areas of clean water sourced from upper- and mid-level catchments via the Five Rivers (*Danggan Balun*). A powerful example of the many ecosystem services (e.g. clean air and water, pollination, soil conservation, sequestering CO_2) provided by Gondwana Rainforests WHA. A continuing supply of clean water for growing urban areas depends on maintaining biodiversity quality and values, in turn this requires increased funding to reverse declining ecosystem quality in Gondwana Rainforests WHAs.

Accelerating climatic changes – higher temperatures, heat waves, less reliable winter-autumn precipitation, more frequent and prolonged droughts – singly and in combination, are mounting threats to the integrity of Gondwana Rainforests WHA, and National Parks and conservation areas across eastern Australia. Advances in regional climate modelling and analyses of historical climatic patterns by CSIRO, BOM and other organisations provide an increasingly reliable basis for deepening concern. It is now apparent that in the coming 30-40 years regional climates will become substantially less favourable for all of Gondwana Rainforests. This strengthens the need for strategic adaptation planning to maximise the probability of Gondwana Rainforests WHA's biodiversity values, with a focus on conservation of relic and threatened ecosystems and species, being properly conserved into the future.

Addressing these challenges requires increased long-term political and financial commitments by Queensland and Commonwealth governments. If not forthcoming further declines in Gondwana Rainforests WHA's conservation values appears inevitable in the near future.

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Annexes

Conserving Gondwana Rainforests

1 Introduction

This report was commissioned by the Queensland Conservation Council (QCC) to provide an overview of the impacts of the 2019-20 bushfires on the Queensland portion of the Gondwana Rainforests of Australia World Heritage Area (WHA).[1] And, following on from this, explore opportunities and alternatives for gaining additional funding for QPWS so as to significantly improve conservation management of WHA values and thereby avoid another critical assessment by IUCN in 2023.

The extent and severity of the fires in three of the major National Parks that form the majority of the Gondwana WHA – Main Range, Mt Barney and Lamington – deepened existing concerns regarding the increasing threats to Queensland's protected area estate and World Heritage properties arising from the impacts of climate change.

While preparing this report, the International Union for the Conservation of Nature (IUCN) produced its third full assessment of the Gondwana Rainforests WHA – downgrading its status from 'Good with some Concerns' in 2017 to one of 'Serious Concerns' in late 2020. Their findings were primarily based on growing concern about conservation of identified biodiversity values (e.g. relict species and ecosystems) – the impact of the bushfires was certainly regarded as important but not their core concern.

Additionally, the uncontrolled fires on K'gari (Fraser Island) WHA, underscored the importance of critically appraising policy, funding and climate change mitigation in Queensland's National Parks and World Heritage Areas. Since 2017, there have been major ecological disruptions in the form of droughts, heatwaves, coral bleaching and fires across four of Queensland's and Australia's most iconic WHAs including the Wet Tropics, Great Barrier Reef, K'gari and Gondwana.

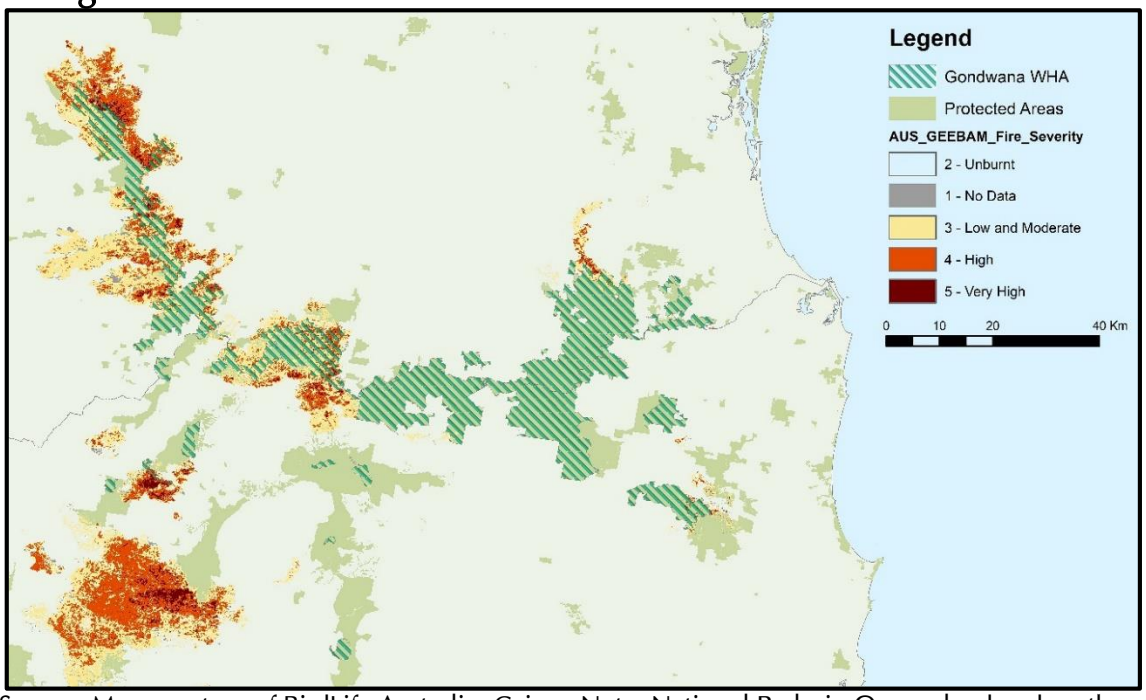
Almost the whole extent of the Gondwana Rainforests WHA is included in Native Title claims by the Danggan Balun People (Five Rivers People) and the Yuggera Ugarapul People; these claims have been awaiting decisions since 2017 (Figure A1.2). An application by the Githabul People for Native Title on their country in Queensland is in preparation. Their Native Title claim in NSW was granted in 2007. When granted these claims will provide a formal basis for Indigenous People to be involved in national park and WHA planning and management, including working as park rangers.

Figure 1 illustrates the overall extent of Gondwana Rainforests WHA in Queensland, the National Parks part of which it is composed and an early assessment of the extent and severity of the fires in late 2019. Approximately 60% of both the Main Range and Mt Barney National Parks were burnt, parts very severely, while only about 5% of Lamington National Park suffered serious damage.[2]

[1] Hereafter just 'Gondwana', but sometimes 'Gondwana Rainforests' or 'Gondwana WHA'

[2] The map in Annex 1 provides a similar overview of the whole of Gondwana Rainforests in Queensland and NSW, including the extent and severity of fire damage and Gondwana's relationships with National parks.

Figure 1 Gondwana Rainforests – Park Areas & Bushfires 2019-20



Source: Map courtesy of BirdLife Australia, Cairns. Note: National Parks in Queensland and northern NSW are pale green areas, Gondwana Rainforests are green striped areas. Areas in successively darker shades of yellow-red indicate the extent and severity of the 2019-20 bushfires.

The borders of Gondwana Rainforests WHA are not contiguous with those of the National Parks of which it constitutes major portions. Although Gondwana does not have an officially gazetted 'buffer zone' there are locations in which the somewhat larger national park provides a de facto buffer zone – see Figure 1 and Table A1.1.[3]

The brief from QCC was to:

- review the current policy settings and funding arrangements of the Gondwana Rainforests WHA within Queensland
- review the findings of previous related reports, audits and studies identifying relevant recommendations and if they have been implemented
- Identify any gaps in information or policy framework and
- provide recommendations for the ongoing maintenance of World Heritage Values including for post-fire restoration (near-term) and improving biodiversity conservation in Gondwana Rainforests WHA (medium-term).

These are set against the background of a continuing decline in resources allocated by governments for National Parks and terrestrial WHAs in Queensland and Nationally. Medium-term policy direction is also needed to improve use of Gondwana Rainforests (and other parks) for education, increasing their ecotourism potential, and valuing the ecosystem services they provide. These are all activities provided for under IUCN's guidelines for Category II Protected Areas. QCC emphasised primary attention be directed to measures, including increased government funding, needed to improve biodiversity conservation and protection.

[3] Further details on each of the National parks constituting the Gondwana Rainforests can be found in Annex 4.

Lying behind near- and medium-term challenges is the overarching challenge posed by accelerating climate change and its anticipated effects on all aspects of life on earth, most importantly on relative rates of species survival and adaptation and changing balances of biodiversity.

National Parks – Policy and Principles.

The policy of the Queensland Parks and Wildlife Service's (QPWS) is very clear on the intent to establish and manage National Parks, including those forming part of the Gondwana Rainforests WHA:

> The cardinal principle for managing National Parks is to provide, to the greatest possible extent, for the permanent preservation of the area's natural condition and the protection of the area's cultural resources and values. … Protecting a park's natural condition can require considerable action. This is what park management is all about.
>
> Other management principles for National Parks are:
> - to present the park's cultural and natural resources and their values; and
> - to ensure that park use is nature-based and ecologically sustainable.
>
> So parks are managed for nature first. But nature-based recreational use is encouraged, where possible.
> Mining, including oil and gas exploration is not allowed on National Parks.
> Public utilities such as roads and power lines are sometimes located on parks. Often they existed before the parks were declared. Telecommunication facilities are sometimes established on National Parks.
> If these types of development have to proceed, park managers must ensure that any adverse impacts are kept to a minimum.
> A national park is set aside forever. A park or part of a park can only be revoked or cancelled with the consent of Parliament.[4]

IUCN Category

The National Parks included in Gondwana Rainforest are all classified as Category II by IUCN.[5] The following description provides some insight into the varied nature of the WHA:

> The Gondwana Rainforests of Australia (Gondwana Rainforests) is a property comprising 40 individual components, largely National Parks and nature reserves, in north-east New South Wales (NSW) and south-east Queensland. Listed for its biological and geomorphic values, it contains remnants of the once vast rainforests that covered Australia when the climate was cooler and wetter. Despite its name, the property contains a diversity of vegetation communities with varying degrees of fire tolerance. Rainforests generally occur as discontinuous patches surrounded by fire-adapted eucalypt forest and agricultural lands.[6]

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[4] Nature Conservation and Other Legislation Amendment Act 2016 (NCOLA Act). https://parks.des.qld.gov.au/management/plans-strategies/principles

[5] Category II: National park. Protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities. Primary objective: To protect natural biodiversity along with its underlying ecological structure and supporting environmental processes, and to promote education and recreation. See Annex 3 for details.

[6] Gondwana Rainforests of Australia State of Conservation update - April 2020, Commonwealth Department of Agriculture, Water and the Environment, 2020.

Scope of the Report The timeframes of this report are:

- the short-term (2-5 years) activities required for post-fire restoration of the most severely damaged areas and significant investments needed for improving conservation outcomes throughout the four larger National Parks that comprise the Queensland component of Gondwana; and
- the medium- term (5-10 years) planning and funding for management activities needed to improve biodiversity conservation values in the WHA, including dealing with climate change.

In terms of potential aims, it is suggested that by the time of the 2026 IUCN assessment a reasonable and achievable goal would be that Gondwana Rainforests WHA's conservation values have improved to the point where an IUCN assessment considers it has moved from 'Serious Concern' (Yellow Card) to 'Good with Some Concerns' (Pale Green Card). For the medium-term, and in time for the next IUCN assessment in 2029, conservation values might by then have improved to the point of being sufficient to achieve a 'Dark Green Card' signifying a 'Good' assessment.

In brief, restoration will require a significant increase in funding to repair fire damage and prevent further deterioration, e.g. from invasive weeds and feral animals, to restore and stabilise the most severely fire-affected areas and in other areas where conservation quality has declined in the past 5-10 years. Ensuring longer term continuation of 'world class' conservation management necessary for a WHA, i.e. in perpetuity, will require participatory planning, stable and adequate budget commitments by governments, and far-sighted preparations to mitigate and adapt to climate change-related challenges to biodiversity values.

Outline of the Report

The report is presented in ten sections. The following section summarises the effects of the 2019 fires on the Gondwana Rainforests. The third section discusses the 2020 IUCN assessment of Gondwana Rainforests. And the fourth results of modelling estimates of likely costs for weed control, an activity considered an essential post-fire management activity. Section five estimates funding needs for restoring Gondwana Rainforests, within the broader context of the need for greater funding for biodiversity conservation in Queensland's National Parks. In the sixth section attention is focused on preliminary estimates of funding needed to improve conservation values in Gondwana, ideally to a 'Very Good' status. Buffering and connectivity for Gondwana Rainforests is the seventh, and Ecosystem Services and Economic Contributions the eighth sections. The ninth section, Accelerating Climate Change, looks ahead to the likely impacts of climate change. The tenth and final section offers Conclusions and some Suggestions.

2 Gondwana Rainforests and the 2019 Bushfires

The bushfires in SE Queensland occurred in September-October 2019, somewhat in advance of the mega-fires that occurred along the eastern hinterland of NSW and Victoria. The parks in NSW that form the majority – ~300,000 ha - of the Gondwana Rainforests WHA were severely affected, with some 124,000 ha burnt to some degree.

These fires occurred after a prolonged drought over 2017-19 that affected eastern Australia. The lack of rainfall in the autumn of 2019 is considered to be one of the main contributing factors to the severity of the bushfires.

Table 1 below summaries the extent and severity of fire damage in 2019 on the National Parks that comprise the Gondwana Rainforests WHA in Queensland. While the extent of 'very high' fire damage is limited, much of it occurred in forests that had not burnt for possibly 1,000 years, including high altitude 'cloud forests'.[7]

These statistics are from the rapid assessment of fire damage made in mid-2020[8]: Main Range and Mt Barney suffered the most extensive and severe damage. Very high damage – vegetation and canopy totally burnt - occurred in about 2% of total park area, and high damage – canopy scorched or partially burnt - in about 10% of the area. Unburnt areas – with only understory vegetation burnt – and areas with low to moderate damage – understory burnt, canopy scorched - were more extensive, at about 15% and 20% of total park area respectively. As discussed later, these are all areas where weed control is required to ensure preferential regrowth of pre-existing native vegetation and recovery of wildlife habitats.

At the time of writing more detailed analyses of fire damage have not been completed. It is likely these reports will revise initial estimates of the extent and severity of damage given in Table 1 below. A revised analyses would affect the area-based estimates for the costs of weed control and other restoration activities.

Table 1 - Gondwana Rainforests, Queensland - 2019-20 Fire Impacts

Park Name	Park Area (ha)	Total Burnt (ha)	Unburnt (ha)	Low & Moderate (ha)	High (ha)	Very High (ha)	Total Burnt
Main Range	22,865	12,685	4,327	7,985	3,963	737	55.5%
Lamington	20,507	1,007	1,005	868	133	6	4.9%
Mount Barney	11,819	7,453	3,348	4,954	2,281	219	63.1%
Springbrook	2,429	-	13	-	-	-	0.0%
Mount Chinghee	1,255	-	-	-	-	-	0.0%
Numinbah	5	-	-	-	-	-	0.0%
Spicers Gap Rd.	4	5	-	2	2	-	107.5%
Totals	58,883	21,150	8,693	13,809	6,379	962	35.9%

Source: Roff, A. (2020) "Australian Google Earth Engine Burnt Area Map[GEEBAM]: A Rapid, National Approach to Fire Severity", July 2020. DOI: 10.13140/RG.2.2.13434.52167; Data extraction BirdLife Australia, Cairns. Notes: Areas in ha, areas with no data removed from this summary. GEEBAM Classes: Unburnt: Little or no change observed between pre-fire and post-fire imagery; Low and Moderate: Some change or moderate change detected; High: Vegetation is mostly scorched; Very high: Vegetation is clearly consumed. See Annex 1 for an overview maps of Gondwana and GEEBAM bushfire statistics for NSW National Parks and reserves forming the major part of Gondwana Rainforests WHA.

[7] As this report was nearing completion WWF Australia released a report "Defending the Unburnt" identifying priority needs for restoring and protecting post-fire habitats of threatened species and ecosystems. The graphics indicate significant parts of Gondwana Rainforest in Qld and NSW are included in the priority listings. However, the report lacks detail on which specific National Parks and locations have priority.

[8] GEEBAM – Google Earth Engine Burnt Area Map. A complementary assessment – Fire Extent and Severity Map (FESM) using a somewhat different methodology was also developed by NSW Department of Planning, Industry and Environment (NSW DPIE). However it does not include a significant proportion of Gondwana WHA in Queensland, hence the two maps and associated data cannot be easily compared. A partial comparison shows the different classes of burnt areas in the FESM assessment differs significantly from that of GEEBAM. No similar analysis is available from the Queensland government.

3 Gondwana Rainforests WHA – IUCN's 2020 Assessment

In 1986 with an extension in 1984 the Gondwana Rainforests of Australia were inscribed on the UNESCO World Heritage Area (WHA) listing based on five criteria:

- Outstanding examples of significant ongoing geological processes (Criterion viii)
- Outstanding examples of relict plant species (Criterion ix)
- Outstanding examples of relict and other vertebrate and invertebrate species (Criterion ix)
- Outstanding examples of ongoing evolutionary processes (Criterion ix)
- Endemic and threatened plants, mammals, birds, frogs and reptiles (Criterion x)

The National Parks constituting the Gondwana Rainforest WHA collectively 'ticked the all boxes' for designation as a WHA. Australia proposed its inscription and became responsible for its stewardship, preservation of its outstanding values of importance for nature and humanity. As is discussed later, although Gondwana Rainforests were inscribed under Commonwealth legalisation, Queensland and NSW are almost entirely constitutionally responsible for funding and management.[9]

In 2000 important management issues were already being flagged by IUCN:

> The main conservation issues include: (i) uncontrolled or inappropriate use of fire; (ii) inappropriate recreation & tourism activities; (iii) invasion by pest species; and (iv) loss of biodiversity. … Funding is considered inadequate to address certain issues like weed and pest control, rehabilitation of degraded areas, and systematic monitoring.[10]

Over the last two decades the latter two issues (iii and iv) continue to be matters of concern in IUCN assessment reports. Based on discussions with knowledgeable experts, the lack of adequate funding by federal and state governments, rather than lack of expertise or dedication by park field staff, remains a critical issue. Although identified two decades ago, these have, after the 2019-20 bushfires become critical, but still lack adequate funding, as noted in the 2017 World Heritage datasheet.[11]

In the 2020 IUCN assessment mention is made for the first time of Indigenous people and Indigenous Land Use Agreements (ILUA) which have been established. The importance of many sacred sites and ceremonial locations was already documented and an overview published in 2008.[12]

IUCN Triennial Assessments

The first full assessment by IUCN of the Gondwana Rainforests was in 2014. At the outset of the report they noted " … in general the values for which the site was inscribed … have been mostly maintained apart from a *decline in some significant*

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[9] As a State Party to the World Heritage Convention the Commonwealth Government has an international obligation to ensure the protection, conservation, rehabilitation and presentation of the area and its transmission to future generations. Department of Environment and Heritage 2000

[10] State of Conservation of the World Heritage Properties in the Asia-Pacific Region: Australia, Central Eastern Rainforest Reserves of Australia (CERRA) - Environment Australia 2004.

[11] Funds are provided by both State and Commonwealth agencies but funding is considered inadequate to deal with threats such as weed and pest control, rehabilitation of degraded areas, and systematic monitoring. World Heritage datasheet in 2017.

[12] "Archaeological sites & Indigenous values: the Gondwana Rainforest of Australia World Heritage Area" McIntyre-Tamwoy, S. Archaeological Heritage, 2008, 1:1:42-49

species." (italics added) IUCN was warning that park management needed improvement. In plain terms, more funding and other resources for conservation and protection.[13]

Their 'Light Green Card' assessment found that "the conservation outlook at this point in time is good with some concerns,"[14] noting the need for assessing each of the eight groups of 41 park components prior to a more comprehensive assessment being made. They observed the "large number of threats from both within and outside the site and potential additional threats brought about by climate change." (ibid)

And although there had been "major management responses to these threats … the unquantified effect of climate change, the threats are still assessed as high." (ibid) Given it is a 'serial property' (i.e. fragmented) they posed an important question: "whether all the component parts are adequately buffered and as connected as possible."

With the second full IUCN assessment in 2017 the overall assessment remained the same - 'Good with some concerns'. The report opened by noting the same issues identified in 2000:

> management responses will be required to address some increasing threats, particularly those posed by invasive species and pathogens and climate change.[15]

The clear implication being that in the interim insufficient attention, including funding, had been available to effectively address the range of issues identified in 2014.

In 2020 the IUCN assessment changed sharply to 'Significant Concern' – a 'Yellow Card' – one step away from being a 'Critical' status 'Red Card'. Naturally, the effects of the recent bushfire figured prominently in the assessment, flagging the additional work and funding needed to restore burnt habitats, control weeds and assess losses to all forms of relict and endangered species.

There were significant differences between the National Parks in the extent and severity of fire damage – two parks in Queensland – Mt Barney and Main Range were extensively (~70%) and severely damaged. Despite the effects of the fire, it remained clear that IUCN was deeply concerned about underlying issues that had remained largely unaddressed during the last two decades – the mega-fires had just made these tasks more urgent and critical.

The biodiversity conservation assessments of the status and trends of park management can be found in the last part of the three IUCN reports. The ratings and accompanying notes, albeit somewhat cryptic, provide the greatest insights into the actual, changing status of biodiversity conservation outcomes across a significant time span. In the case of Gondwana Rainforests they make for sobering reading.

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[13] The IUCN assessments cover Gondwana as a whole and does not distinguish been individual parks or between Queensland and NSW responsibilities. This, implicitly, is because overall responsibility rest with the federal government which signed the WHA agreements..

[14] IUCN World Heritage Outlook: https://worldheritageoutlook.iucn.org Gondwana Rainforests of Australia - 2014 Conservation Outlook Assessment

[15] IUCN World Heritage Outlook: https://test.worldheritageoutlook.iucn.org Gondwana Rainforests of Australia - 2017 Conservation Outlook Assessment.0

To assist tracking changes in values critical for World Heritage status the three IUCN assessments are presented side-by-side in Table 2. A major difference between the assessments in 2014 and 2017 is the increase in detail, the main similarity is the trend of deteriorating ratings for endemic and threatened plants, mammals, birds and frogs, and the increase in levels of concern for these from 'Low' to 'High'. In the 2020 assessment almost all ratings increase sharply to 'High Concern', except for frogs where it continued to be 'Critical'. In addition, the trend for relict plants species is no longer 'Stable' but now joins that for relict vertebrates and invertebrates - a deteriorating trend.

This summation by IUCN captures the essence of the situation at the end of 2020:

> The fires dramatically changed the conservation outlook for the Gondwana Rainforest of Australia, and it remains to be seen whether the natural ecosystems and ecological functions are sufficiently resilient to recover from this previously unexperienced perturbation. … However, there is the lingering prospect that the catastrophe is a clear sign of the impact of climate change on weather patterns, and that these changes will not be reversed easily. The Gondwana Rainforests exist as refuges where many deep phylogenetic lineages persisted during episodes of past climate fluctuations. The conservation management challenge is to support and maintain that resilience into the future. (ibid)

In brief, the majority of biodiversity conservation outcomes indicate that biodiversity values continue to decline, some at an accelerating pace. Without significant and continuing increases in funding, especially salaries for qualified and experienced field-staff and resources for undertaking essential work, it is increasingly likely relict and endangered species may become extinct in the medium-term. Such an outcome would defeat the purpose of establishing both the national park under Queensland's Nature Conservation Act 1992 and declaring the Gondwana Rainforests WHA, protected under the Commonwealth's Environment Protection and Biodiversity Conservation (EPBC) Act 1999.

Table 2 - Gondwana Rainforests - State and Trend of Conservation Values

Gondwana Rainforests Outstanding Universal Values	2014		2017		2020	
	Rating	Trend	Rating	Trend	Rating	Trend
Outstanding examples of significant ongoing geological processes	Good	Stable	Good	Stable	Good	Stable
Outstanding examples of relict plant species	Data Deficient	Stable	Data Deficient	Stable	High Concern	Deteriorating
Outstanding examples of relict and other vertebrate and invertebrate species	Data Deficient	Deteriorating	Data Deficient	Deteriorating	High Concern	Deteriorating
Outstanding examples of ongoing evolutionary processes	Low Concern	Stable	Low Concern	Stable	High Concern	Stable
Endemic and threatened plants	Low Concern	Stable	Low Concern	Stable	High Concern	Stable
Endemic and threatened mammals	Data Deficient	Deteriorating	High Concern	Deteriorating	High Concern	Deteriorating
Endemic and threatened birds	Low Concern	Deteriorating	High Concern	Deteriorating	High Concern	Deteriorating
Endemic and threatened frogs	Critical	Deteriorating	Critical	Deteriorating	Critical	Deteriorating
Endemic and threatened reptiles	Data Deficient	Stable	Data Deficient	Data Deficient	Data Deficient	Data Deficient

Sources: IUCN World Heritage Outlook: Gondwana Rainforests of Australia – 2014, 2017 and 2020 Conservation Outlook Assessments.

4 Near-Term Priorities – Weed Control

Weed control, alongside feral animal control, has been identified as a continuing priority, both by QPWS and IUCN in Gondwana Rainforest WHA. In the post-fire context it has become even more important, this has been recognised by some additional funding being provided by state and federal agencies. Based on limited information some $4M was provided, but there is no detailed information available on how this had been allocated. It is well accepted that successful weed control is one of the key management activities required for ensuring native vegetation, habitats and niches, hence micro-climates and wildlife, remain viable and dominant in the WHA.

The results of the state-wide survey by Cragie and Pressey (2018) indicate spending on parks in SE Queensland ($7.30/ha/yr) is only half the state average of $14.7/ha/yr. In addition there is an urgent need for funding significant post-fire weed control. The need for improved weed control, as noted by QPWS, IUCN and Cragie and Pressey (2018), cannot be achieved without substantial and continuing increase in park budgets for this and other park-level biodiversity conservation and management activities, as distinct from budgets for visitor facilities.

Making cost estimates to facilitate developing policies and setting priorities has proved difficult due to significant variations in the extent and severity of fire damage in each park ecosystem, plus major differences in topography, ease of access and working conditions. Details of the methodologies used are provided at Appendix 1.

Table 3 summarises estimates of weed control for the three Gondwana WHAs. It assumes governments consider conserving and protecting biodiversity in Gondwana WHA sufficiently important to plan for the decade ahead, i.e. 2022-32.[16] This would be wise, given the recent assessment by IUCN, and the likelihood that without significant and continuing investments the world heritage values of Gondwana Rainforests will continue to decline. This would also result in its value and attractiveness for education and research, hence anticipated income streams from ecotourism and ecosystem services, declining. A substantial reduction in the WHA's biodiversity values raises the possibility the next IUCN assessment (2023) might rate Gondwana as 'Critical'. Aside from the consequences for survival of relict species and ecosystems, this would be cause for national and international embarrassment.

For the three fire affected major National Parks that constitute Gondwana Rainforests the estimated cumulative investments needed for weed control over ten years range from $15.2 million (low) to $41.9 million (high). On an annual basis in the initial year the estimated range is $3.3- $8.9 million, declining steadily each year, so that by the tenth year the estimated range is $1.0 to $2.7 million/annum.

These preliminary estimates are separate from and in addition to regular annual budget allocations for park management in Gondwana Rainforests. They are also separate and different from the estimates for improving park management from Poor to Fair, Fair to Good, and from Good to Very Good, described in the following section.

Noting the 2020-21 Queensland annual state budget is about $65 billion, the level of investments necessary to maintain the Queensland part of the Gondwana Rainforests

[16] NB. Springbrook (6,558 ha) and Mt Chinghee (1,260 ha) National parks were reportedly not damaged in the 2019 bushfires and have not been included in these estimates of post-fire weeding costs.

WHAs biodiversity values are very modest, especially when compared to budgets for transport infrastructure ($6.3 billion). They also have favourable estimated benefit-cost ratios (CBR) from investments in ecotourism and ecosystems services (see below).

Table 3 - Gondwana Rainforests - Weed Control Cost Estimates Summary

Main Range National Park	Park Area Burnt (ha)	No of Years	Low Estimate	Medium Estimate	High Estimate
	12,685			Annual Totals ($)	
	Year 1	1	1,975,401	3,570,210	5,363,740
	Year 2	1	1,382,781	2,499,147	3,754,618
	Years 3-5	3	987,701	1,785,105	2,681,870
	Years 6-10	5	592,620	1,071,063	1,609,122
	Cumulative Cost (10 years		9,284,386	16,779,986	25,226,591
Lamington National Park	Park Area Burnt (ha)	No of Years	Low Estimate	Medium Estimate	High Estimate
	1,007			Annual Totals ($)	
	Year 1	1	184,162	281,603	440,075
	Year 2	1	128,913	197,122	308,052
	Years 3-5	3	92,081	140,802	220,037
	Years 6-10	5	55,249	84,481	132,022
	Cumulative Cost (10 years		460,405	704,008	2,070,363
Mount Barney National Park	Park Area Burnt (ha)	No of Years	Low Estimate	Medium Estimate	High Estimate
	11,819			Annual Totals ($)	
	Year 1	1	1,165,178	2,040,265	3,099,858
	Year 2	1	815,624	1,428,186	2,169,900
	Years 3-5	3	582,589	1,020,133	1,549,929
	Years 6-10	5	349,553	612,080	929,957
	Cumulative Cost (10 years		5,476,335	9,589,246	14,580,133
Gondwana Rainforests WHA			**Overall Cumulative Total - 10 years ($)**		
	Main Range	10	9,284,386	16,779,986	25,226,591
	Lamington	10	460,405	704,008	2,070,363
	Mount Barney	10	5,476,335	9,589,246	14,580,133
Cumulative Cost (10 years)			**15,221,125**	**27,073,241**	**41,877,087**

Source: Authors' estimates based on GEEBAM (ibid) fire extent and severity data.

5 Restoring World Heritage Conservation Values

This preliminary analysis of funding necessary for restoring the Queensland part of the Gondwana Rainforests WHA's biodiversity values is set against the broader background of the needs of Queensland National Parks for greater investments specifically allocated

for improved biodiversity conservation, and for improving visitor facilities. The analysis draws on information gleaned from two studies: Craigie and Pressey 2018 and QTC 2018.

The Craigie and Pressey (2018) study of a sample of 41 Protected Areas (PAs) in Queensland showed shortfalls in funding were leading to inadequate management and conservation of biodiversity values. Survey methods used by the authors are given at Appendix 1.

The passage below sums up the study's findings:

> The management objectives for PAs in Queensland are diverse, but the cardinal principle is that PAs must be managed for the permanent preservation of their natural and cultural values. We have found that this cardinal principle was no longer guiding the allocation of management resources across PAs in Queensland. Instead, in the face of declining management budgets, visitor-related management activities were being prioritised at the expense of activities directed at the persistence of biodiversity. This new analysis highlights and quantifies what many managers have known for some time: that more funding is required and that funding needs to be directed more effectively to specific activities if QPWS is going to fulfil its primary responsibility in the long term. (Cragie & Pressey 2018:20)[17]

Park management activities fall into two broad categories: protecting biodiversity values and maintaining or expanding visitor facilities. QPWS accords these equal priority (NPRSR 2015).[18] The 2018 study revealed park managers lacked sufficient resources to carry out all the activities considered as essential and have to make trade-offs between these two categories of activities. Overall, visitor facilities have received the majority of available funding – on average, some 70% of funding each park management team is allocated annually, i.e. significantly less than half is allocated to biodiversity conservation.

The authors note:

> These new data show that the effects of budgetary shortfalls could be having a disproportionate and somewhat cryptic negative impact on biodiversity protection. … to the detriment of biodiversity conservation - are being made in other protected areas as in those covered by our study, figures on overall shortfalls in management spending will underestimate the shortfalls for activities directed at the persistence of biodiversity. (ibid p.2)

The WHA portion of parks composing Gondwana Rainforests in Queensland are smaller than the total extent of the National Parks: Main Range (22,865 ha of 30,171 ha), Springbrook (2,429 ha of 6,558 ha) and Lamington (20,507 ha of 21,176 ha) - included in the study. These three parks and their performance ratings are given below.

Table 4 shows the estimated difference in full-time equivalent (FTE) staffing and funding for a park to improve its performance. For example, Main Range from Fair to Good would require an addition of 4.3 FTE staff and a doubling of average annual funding.

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[17] Cragie, I.D. and Pressey, R.L. (2018?) "Fine-grained data and models of protected-area management costs reveal cryptic effects of budget shortfalls." In press.

[18] NPRSR (2015). NPRSR Annual Report 2014-2015, The State of Queensland (Department of National Parks, Sport and Racing) 2015

For Lamington to improve from Good to Very Good would require an estimated addition of 10.7 FTE staff and about three times as much annual funding.

On average, these three parks require slightly more than one more FTE staff member and continued current annual funding to improve from Fair to Good. To improve from Good to Very Good – a reasonable expectation for a national park in a WHA - it was estimated that overall about 10 more FTE staff and possibly three times as much annual funding would be necessary. Main Range stands out as requiring a significantly greater increase in FTE staff (19 more staff) and about a sixfold increase in annual funding.

Table 4 - Gondwana Rainforests – Performance and Short-Falls (2018)

Performance	Poor to Fair		Fair to Good		Good to Very Good	
Park Name	FTE Shortfall	Currently funded (%)	FTE Shortfall	Currently funded (%)	FTE Shortfall	Currently funded (%)
Springbrook	-0.63	168.81	0.17	90.01	0.28	54.55
Lamington	-0.22	101.84	6.5	64.93	10.73	39.35
Main Range	4.33	48.14	11.21	26.38	18.49	15.99
Gondwana Mean	1.16	106.26	5.96	60.44	9.83	36.63
Queensland Ave.	1.05	58.33	4.68	23.86	7.72	14.46

Source: Cragie, I.D. and Pressey, R.L. (2018) Supplementary Table 3. Funding shortfalls by protected area. Note: The last two lines in the table are mean values for Gondwana and the average for all 41 of the National Parks included in the study.

Based on park managers' evaluations, visitor facilities are relatively well provided for compared to biodiversity conservation, though both are affected by declining annual budgets. Comparing resources available for conservation management with those for visitor facilities illustrates the current imbalance between the two, given that in principle QPWS policy accords them equal priority.

The estimates in Table 5 below are for all 41 parks included in the 2018 study. This clearly indicates National Parks are underfunded by roughly the same degree as Gondwana for achieving and maintaining a 'Good' standard.

Table 5 – Queensland PAs – Staff and Funding Shortfalls (2018)

Performance	Poor to Fair		Fair to Good		Good to Very Good	
Park Name	FTE Shortfall	Currently funded (%)	FTE Shortfall	Currently funded (%)	FTE Shortfall	Currently funded (%)
Conservation	2.59	89.56	7.29	39.76	14.08	24.96
Visitor Facilities	-1.29	137.58	0.83	86.25	5.41	59.66

Source: Based on Cragie, I.D. and Pressey, R.L. (2018) Supplementary Table 2.

For PAs to improve from 'Poor to Fair' it appears, on average, no additional funds are needed for visitor facilities, they are 'overfunded' but additional funds are required for conservation. Funding needed for conservation become greater for improvements to advance from 'Fair' to 'Good' or to 'Very Good', and additional funding would also be needed for improving visitor facilities – see Table 6.

Table 6 – Queensland National Parks – Additional Resource Estimates

Type of Management Activity	Actual 2016-17 Funding ($M)		
Visitor facilities 70%	105.7		
Biodiversity Conservation 30%	45.3		
Total Operations Budget 2016-17 ($M)	**151**		
	Estimated Additional Annual Funding		
	Poor to Fair	Fair to Good	Good to Very Good
Visitor Facilities ($M)	76.8	122.6	177.2
Percentage Change	73%	142%	297%
Conservation ($M)	50.6	113.9	181.5
Percentage Change	112%	286%	727%
Estimated Additional Funding Required ($M)	**127.4**	**236.5**	**358.7**
Percentage Change	84%	157%	238%
Total Estimated Annual Expenditure (M)	**278**	**388**	**510**
Percentage Change	184%	257%	338%

Source: Author's estimates, based on QTC (2018)[19] and Cragie and Pressey (2018). Notes: Total estimated Annual expenditure is current annual expenditure ~$151M) plus estimated additional expenditure to improve management by one level, e.g. from Fair to Good.

State-wide, using both independent analyses, to improve all parks from 'Poor' to 'Fair an estimated additional total annual allocation of about $278M is needed; to improve all parks from 'Fair to Good' about $338M needed annually; and to improve from 'Good to Very Good' about $359M annually. These very preliminary state-wide estimates are for planning purposes only, as there are wide variations between park ecosystems and conditions; these estimates require park-specific adjustments.

6 Conserving Gondwana Rainforests

Further to the 2020 IUCN assessment it is now unambiguously apparent that lack of management funding has been and continues to be a major contributor to declines in biodiversity conservation in Gondwana Rainforests. When the expenditure data for 2016-17 used in the QTC analysis is combined with that from Cragie and Pressey's 2018 survey of park rangers, the two analyses estimate only about 30% of the total budget is devoted to biodiversity conservation activities. This is despite their different methods, see Appendix 1 for details. These estimates were made well before the bushfires of 2019-20.

The estimates in Table 7 are based on Cragie and Pressey's survey-based estimate and QTC's budget-based estimates of 30% or $5.9M of the $19.6M in the 2016-17 budget allocated to SE Queensland for biodiversity conservation. Both estimates were made at about the same time. The three Gondwana parks surveyed have an area of 45,801 ha or about 78% of the total WHA area – Mt Barney and two smaller parks were not included in the survey. Hence additional funding required for improvements is adjusted using the mean values for the three parks applied to the whole Gondwana Rainforest WHA.

[19] Queensland Treasury Corporation (2018) "Queensland protected area financial strategy report." 1st November 2018. Presented to Parliament 8th September 2020.

Table 7 – Gondwana Rainforests - Estimated Additional Funding Needed

National Park	Poor to Fair ($M)	Fair to Good ($M)	Good to Very Good ($M)
Springbrook	3.48	6.53	10.78
Lamington	5.77	9.06	14.94
Main Range	12.21	22.29	36.77
Gondwana Mean	5.53	9.73	16.05
Gondwana Overall	**7.11**	**12.51**	**20.63**

Sources: Based on Cragie and Pressey 2018 and QTC 2018. Author's estimates. Notes. These are estimates of annual funding requirements based on the three parks surveyed and then adjusted to allow for Mt Barney which is somewhat (~10%) larger than Lamington.

Using the example of the level of funding required to improve conservation from 'Fair to Good' for Gondwana overall, it is estimated about $12.5M per annum would be required, as compared to the current expenditure estimate of $5.9M per annum. To achieve a 'Very Good' standard of conservation would require increasing annual conservation funding to about $20.6M. These are very preliminary estimates of the scale of underfunding in 2018. Lack of funding for conservation goes a long way to explaining IUCN's 'Serious Concern' about the state of conservation of Gondwana Rainforests – noting their assessment focused on species, not landscape, conservation.

The estimates clearly indicate current levels of funding are well below what is required to improve conservation management from 'Poor to Fair'. To improve it from 'Fair to Good' would require about doubling (113%) annual funding, to improve it from 'Good to Very Good' – a standard considered appropriate in a wealthy nation and state to improve and maintain conservation values in a WHA– would require significantly more than doubling - an increase of some 251% to about $20M per annum.

7 – Buffering and Connecting Gondwana Rainforests

Connectivity between protected and other areas, and widespread use of buffer zones, are now considered integral to effective landscape scale conservation[20] Buffer zones and corridor links are important for providing connectivity and additional protection for safe and rapid access to refugia for wildlife, and protecting wildlife and ecosystems within parks from incursion by feral animals and alien, non-native plant species. The importance of both will almost certainly increase with changing climate and in the case of wild fires and/or drought conditions.

The UNESCO guidelines for World Heritage Areas strongly recommend identifying buffer zones and ensuring connectivity between a park and surrounding ecosystems and between sections of a WHA.[21] However, neither buffer zones or ecosystem connectivity links have been identified or incorporated in the design and management of Gondwana Rainforests.

Tanner-MacAlliser et al (2017) analysed the suitability of land uses in adjacent habitats for biodiversity conservation and classified them as compatible, semi-compatible or

[20] See: Fitzsimons J et al (2013) Linking Australia' s Landscapes, CSIRO Publishing; Worboys G et al (2010) Connectivity Conservation Management, Earthscan; Crooks K & Sanjayan M (2006) Connectivity Conservation, CUP; Hilty J et al (2006) Corridor Ecology, Island Press.

[21] 2019 UNESCO "Operational Guidelines for the Implementation of the World Heritage Convention." p.103-7.

non-compatible.[22] This analysis showed that, on average, for the four main parks, only 15% was compatible, 38% was semi-compatible and half (50%) non-compatible. However, there were wide differences between the individual parks with Main Range having the least (2%) and Lamington and Mt Barney the most (34-38%) of compatible land uses adjacent to the Park. See Annex A1.3.

No data identifying areas for potential connectivity linkages between Parks and adjacent ecosystems or land uses could be found. Given the shapes and area-boundary ratios for each Park (see Annex A1.3) it is likely establishing these would make an important contribution to biodiversity protection and conservation.

Identifying locations where buffer zones and corridor linkages are most needed will substantially increase biodiversity protection and conservation for the Gondwana WHA. Noting the long history and substantial investment in regional conservation and natural resources management in Queensland[23], discussions between these organisations, local councils and other community and Indigenous organisations and landowners adjacent to the Gondwana WHA may be worthwhile. Where local government and private land owners are willing to consider nominating suitable areas for either buffer zones or connectivity links, these could then progress to developing protocols for implementing conservation-sensitive management of these areas with modest additional funding.

8 - Ecotourism, Ecosystem Services and Economic Contributions

The primary purpose and benefit of National Parks is to conserve biodiversity in perpetuity as a public good, hence their legal standing as a Protected Area.[24] For WHAs like Gondwana Rainforests the IUCN makes clear that all other considerations are considered to be of secondary importance. These are often called co-benefits, and they are important in themselves as they may provide educational, research, recreational and economic opportunities that depend on protecting the integrity of scientifically identified biodiversity values.

Gondwana Rainforests are in an unusual geographic situation, as compared to many WHAs. Immediately to the east - less that 20 km away from Springbrook and Lamington National Parks - are expanding coastal urban areas, while to the west are sparsely populated broad valleys with grazing and agricultural areas dotted with small communities. The parks closer to the coast are most accessible and visited. In its 2014 and 2017 assessment IUCN noted inappropriate adjacent urban land use as an issue of concern[25], hence their emphasis on buffer zones.

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[22] Compatible (National park, dam/reservoir, production forestry), semi-compatible (plantation forestry, residual native cover) and non-compatible (residential, livestock grazing cropping, intensive animal production).

[23] See NRM Regions Queensland at https://www.nrmrq.org.au

[24] NPWS Principles - https://parks.des.qld.gov.au/management/plans-strategies/principles
IUCN defines the Primary objective of Category II National parks, such as Gondwana Rainforests, as follows: "To protect natural biodiversity along with its underlying ecological structure and supporting environmental processes, and to promote education and recreation." The IUCN definition and guidelines for Category II can be found in Annex 3.

[25] Sources: IUCN World Heritage Outlook: Gondwana Rainforests of Australia – 2014 and 2017 Conservation Outlook Assessment.

Estimates of economic contributions parks make to local or regional economies often focus on quantifying benefits from tourism. Gondwana Rainforests are adjacent to the growing urban conurbations of Brisbane City, the Gold Coast and Logan City with a combined population in 2019 of over three million. These urban areas provide accommodation and other tourism and recreation facilities for visitors to Lamington and Springbrook WHA and other parks in the immediate region.

This section explores potential for tourism, the revenues it might generate and ideas for how to increase revenues, including by charging entrance and other fees. Gold Coast and Logan urban areas rely almost totally on water from the catchments of the Five Rivers flowing from Gondwana Rainforest's catchments. The monetary value of this indicates the scale of ecosystem services that rely on the integrity and conservation values of Gondwana Rainforests, and their vulnerability to inadequate park management.

Tourism Potential

A recent study (Driml et al 2020) estimated that visitors to Queensland National Parks spent some $3.7B (billion)/annum on park-related activities, about a quarter by Queensland residents and about half of this total in SE Queensland.[26] Of the total amount spent some $2.6-0.4B/annum was directly attributable to access to National Parks.

To gain these economic benefits the Queensland government spent an average of $98.6M/annum (2012-18) on National Park capital and operational costs.[27] The partial asset value, i.e. not including ecosystem services (see below) or non-use benefits, just for Queensland resident-visitors was estimated at $238 million annually, and some $5.8-$8.4B over a 30-50 year time frame. The authors calculated the benefit-cost ratio (BCR) for Queensland resident-visitors at 3.9-6.3:1 – i.e. the state's economy benefited by $3.90-$6.30 for every $1.00 spent on park management – excluding any ancillary benefits such " … as conservation, health, and other environmental and social benefits." National park tourism also generated some 2-3,000 jobs state-wide (ibid).

These estimates make it clear that investment by the state government in National Parks is highly beneficial for Queensland's residents and the state economy.

Unlike many other jurisdictions, Queensland does not charge entry fees at National Parks, nor does it collect statistics on the number of visits. Charging visitor fees would automatically provide visitor statistics. Consequently, there is a lack of park-specific information on how many people visit parks, when visits occur, how long people visit for or why they visit.

The QTC (p. 28) analysis suggests charging a modest day-visitor entry fee ('conservation charge'), increased camping fees, and revising commercial operator fees. They used revised 2012 estimates of about 33 million visitors/year. Steady implementation of their

[26] Driml, S., Brown R., P., C., Moreno Silva, C. (2020). Estimating the Value of National parks to the Queensland Economy. School of Economics Discussion Paper Series 636. School of Economics, The University of Queensland. http://www.uq.edu.au/economics/abstract/636.pdf.

[27] This is substantially lower than QTC's estimated government spending for 2016-17 of $151 million/annum. Driml, S., Brown R., P., C., Moreno Silva, C. (2020). Estimating the Value of National Parks to the Queensland Economy. School of Economics Discussion Paper Series 636. School of Economics, The University of Queensland. http://www.uq.edu.au/economics/abstract/636.pdf.

proposals would increase revenue from some $26M/annum to about $106M/annum: an additional $80M/annum. They proposed a scale of fees, e.g. $10/car/day, $70 annual pass, $8 parking, camping $10-15/person/night, and 5% of revenue for commercial operators.[28]

The OTC study found that 'visitor fees' are relatively inelastic, i.e. introducing or increasing fees does not lead to a proportionate reduction in the number of visitors. This suggest introducing fees would not discourage visitors but would provide additional revenue for improving park management. However, there are at least two caveats. Increasing visitors requires additional funding for providing and maintaining visitor facilities, and more visitors may, if caution is not exercised, lead to degradation of biodiversity in the more popular parts of parks.[29] Moreover, recent analyses confirmed that park rangers do not have sufficient time and other resources to devote to essential conservation (or research or educational) activities.

However, opportunities for education, science and recreation and tourism are ecosystem services that Gondwana Rainforests also provide. These co-benefits from the WHA make significant contributions to local, regional and state economic activities and incomes. A similar illustration of the co-benefits from the range of ecosystem services can be found in the economic significant of the Great Barrier Reef WHA to Australia's tourism industry.

Ecosystem Services

There are a broad range of ecosystem services – e.g. clean air and water, pollination, soil conservation, sequestering CO_2 - provided by Gondwana Rainforests that are rarely accounted for when considering its value to Queensland communities or the economy. Doing this comprehensively would require a major research project. Here we limit such accounting to a valuation of water sourced from the WHA to service nearby urban areas.

Significant parts of Gondwana WHA overlap what Indigenous People call *Danggan Balun* or the Five Rivers watersheds – see Figure 2.[30] The many clans that constitute the Yugambeh People have been living in this area for some 23,000 years.[31] These watersheds provide clean water and other ecosystem services for the increasingly densely populated coastal plain encompassing Logan City, Gold Coast City and Scenic Rim Region Local Government Areas (LGA), with a combined and growing population in 2019 of about one million.[32] The Scenic Rim Region encompasses almost all

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[28] The analysis and recommendations by QTC were regarded by some well-informed observers as a political rationale to justify establishing tourist resorts within National parks – this occurred almost immediately after the report was submitted to the government.

[29] With one exception (Fraser Island, K'Gari) all national park income from visitor fees or other sources goes into consolidated revenue and does not benefit the park concerned or increase QPWS's budget allocation. As a consequence all National parks in Queensland depend solely on state government budget allocations plus possible federal grants.

[30] The Five Rivers includes: Logan, Pimpana, Coomera, Albert and Nerang rivers. These are briefly discussed in a separate section on ecosystem services.

[31] Holmer, Nils M. 1983. Linguistic Survey of South-Eastern Queensland. Pacific Linguistics Series D, No. 54. Canberra: ANU

[32] Logan: population 334,358 (2019), area 958.1 km , density 356.9/km , growth 2.06% pa ; Gold Coast: population (2019) 620,518, area 1,334 km , density 476.3/km , growth 2.56% pa; Scenic Rim: population 43,625 (2020), area 4,243 km , density 10.28/km , growth 1.6% pa. Water supply: Logan 21

Gondwana WHA. The upper catchments of Logan and Albert rivers include significant portions of the WHA - Lamington, Mt Barney and Main Range National Parks - on which Logan City depends for water; the upper catchment of Nerang River is the main water source for Gold Coast City. These three LGAs are socially, environmentally and economically important for SE Queensland, especially for tourism, accommodation and social facilities.

Figure 2 – Danggan Balun – Five Rivers

Rapid population growth and expansion of urban areas into the hinterland and lower slopes of the Scenic Rim uplands has progressively cleared forested catchments and wildlife habitats, much of which borders the WHA, with potential to reduce secure provision of clean water supplies.[33] Land clearing is rapidly degrading or destroying critical habitat for koalas and other endangered species. Urban population is increasing at ~2% pa with demand for clean water likely increasing somewhat faster in the future. Recent evidence suggests demand is already close to the maximum feasible supply, taking into account the capacity of large storage dams. Future reductions in upper- or

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Gl/yr, value $109M; Gold Coast 58 Gl/yr, value $158M/yr. Combined (approx.) 78 Gl/yr, value $309M/yr.

[33] According to BOM, in recent years (2015-21) state-wide accessible water volume has declined by about 25% from ~8,000 to ~6,000 GL.

mid-catchment natural water storage capacity and dry-season flows caused by urbanisation and/or rainfall reductions (e.g. droughts) are quite likely.

The overall value of these ecosystem services to the community is difficult to quantify directly. However, one, albeit incomplete estimate is the monetary value of water supplies to the Logan and Gold Coast LGAs which rely almost totally on the Five Rivers catchments for their water. The two LGA purchased water worth about $309M in 2014-15 – this will have increased since. On an area basis, assuming rainfall runoff and groundwater from these catchments in Gondwana are the main source of potable water for downstream communities, suggests the monetary value of this ecosystem service alone could be as high as $5,000/ha.[34]

Rising demand from increasing urban population and economic activities will lead to an increase in the value of all ecosystem services provided by Gondwana Rainforests. Urban water services are already worth significantly more than potential revenues from introducing visitor fees (~$80M) or annual state-wide government expenditure on Queensland's National Parks (~$150M).

9 - Accelerating Climate Change

Australian climate scientists have divided the continent into a series of 'clusters' in order to develop regional scale analysis tools and projections[35]. Attention here is focused on the 'Eastern Australia NRM Supercluster' which includes all the Gondwana Rainforests. More detailed modelling has been done for individual eastern NRM regions, e.g. SE Queensland and Northern Rivers, as part of Australia-wide studies of climate change by Dowdey et al (2015). [36] BOM's (2020) temperature and precipitation observational data is more up-to-date.

The likely incidence of extended droughts and severe wildfires affecting eastern Australia is a critical factor for Gondwana Rainforests.

Emergent Climate Change.

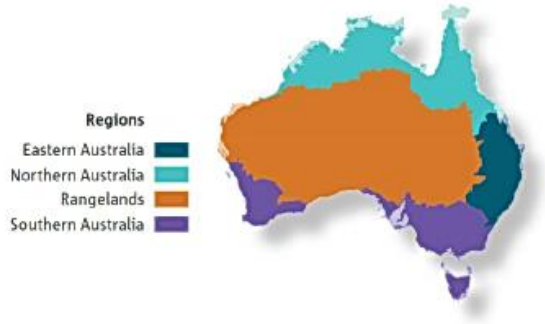
In 2012 the temperature (and climate) of Australia and Eastern Australia 'emerged' from historical trends when the curve of rising annual average temperature no longer overlapped the variance of the 1850-1900 baseline, exceeding it by more than two standard deviations. Temperatures have continued to rise since then, and in 2020 exceeded the baseline by about 1.8°C. (Figure 3). These recent measurements (not models) confirm the validity of earlier modelling of climate change on the east coast made by Downey et al (2015).

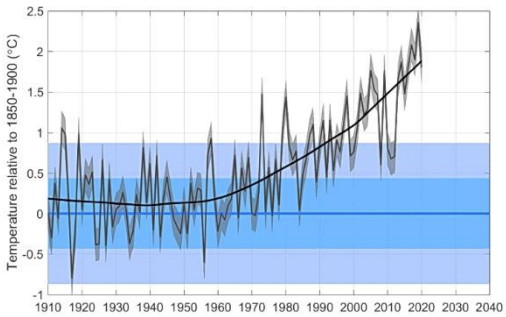
[34] Approximate area of Gondwana Rainforests (55,000 ha), value of water $309M = ~$5,000/ha. Headwaters of the five catchments are in the WHA, which is about 11% of the total catchment area (~484,000 ha).

[35] See Climate Change in Australia at https://www.climatechangeinaustralia.gov.au/en/overview/about-site/citation/

[36] Dowdy, A. et al. 2015, East Coast Cluster Report, Climate Change in Australia - Projections for Australia's Natural Resource Management Regions: Cluster Reports, eds. Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia.

Figure 3 – Australian NRM Superclusters and Temperature Emergence





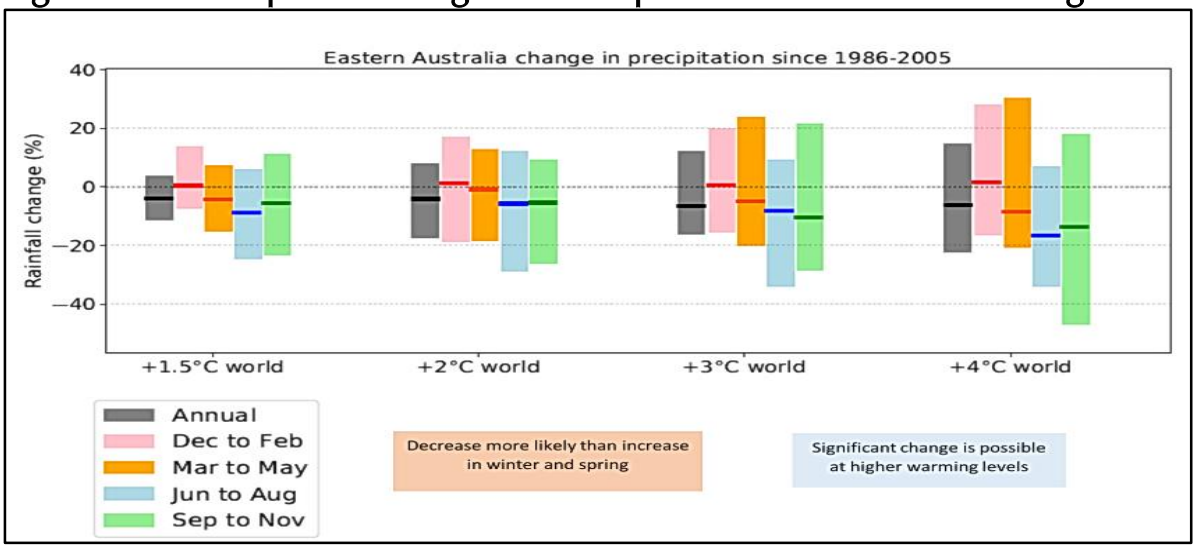
Australia Natural Resource Management (NRM) Superclusters	Eastern Australia Temperature Emergence 1910-2020

Source: "Warming levels projections – average temperature and rainfall Technical Note 2 – emergence of temperature." BOM. For Queensland: Two standard deviation range separated from pre-industrial range: 2016. Last year possibly within 2 standard deviations of 1850-1900 climate: 2011. (ibid)

There is very high confidence (i.e. 95%) temperatures will continue to follow a rising trajectory. There is less certainty about future precipitation. The latter is a critical factor for the health and resilience of Gondwana ecosystems, especially for the higher, cool temperate cloud forest habitats dominated by Antarctic beech (*Nothofagus moorei*) and riparian habitats on which many amphibian and reptile species depend.

Figure 4 illustrates anticipated changes in precipitation for Eastern Australia at different levels of global warming - by 2020 eastern Australia had already warmed by almost 2°C. Average seasonal precipitation for June to November – winter and spring - are likely to decline as warming continues. Even slightly lower average precipitation in winter and spring, combined with higher spring and summer temperatures, leads to lower soil (and plant tissue) moisture and heightened risk of wild fires.

Figure 4 – Anticipated Changes in Precipitation with Climate Change



Source: BOM – Changes in Average Rainfall at Global Warming Levels. Note: Coloured bars indicate 10%-90% model range, and dark lines median precipitation.

A recent study of likely impacts of climate change specific to Gondwana Rainforests was prepared by the National Environmental Science Program Hub (NESP 2019). They summarised their findings as follows:[37]

- Increased average temperatures in all seasons (*very high confidence*).
- More hot days and warm spells with a substantial increase in the temperature reached on hot days, the frequency of hot days, and the duration of warm spells (*very high confidence*).
- Uncertain rainfall change with the mean of the models projecting a modest decrease, strongest in winter (low confidence). There is a suggestion of a possible modest increase in summer rainfall in the northern part of the region in summer (*low confidence*) but the spread across models from increases to decreases is very large, irrespective of average rainfall changes, extreme rainfall events will increase in severity.
- Higher surface solar radiation (i.e. decreased overall cloud cover), decreased relative humidity (although modest in winter) and higher evapotranspiration in all seasons. (italics original)

Prolonged Droughts

In the last two decades, as climate change has become more apparent, including two prolonged droughts, there has been considerable research exploring their likely frequency and duration, especially for highly populated and intensively farmed eastern Australia. The severe drought of 2017-19 was followed by mega-bushfires in eastern Australia, following extremely low winter-autumn rainfall – the driest November on record – the drought continued in some areas and was regarded as worse than the Millennial Drought of 2001-09.[38]

The instrumental climate record for eastern Australia is limited to about 120 years, which is too short to determine how frequent and severe droughts may have been in the deep past or anticipate the severity of future droughts. Palmer et al (2015) constructed a 'Drought Atlas' back to 500 CE.[39] Since European occupation in 1788 there have been a number of droughts more severe than the one that ended in 2019.

It is surprising that Gondwana Rainforests have been able to withstand so many periods of severe and often prolonged summer drought. Rainfall was well below average when James Cook sailed past in 1770, and there was a mega drought all across eastern Australia in the years (1791-93). immediately after the European invasion. Many long

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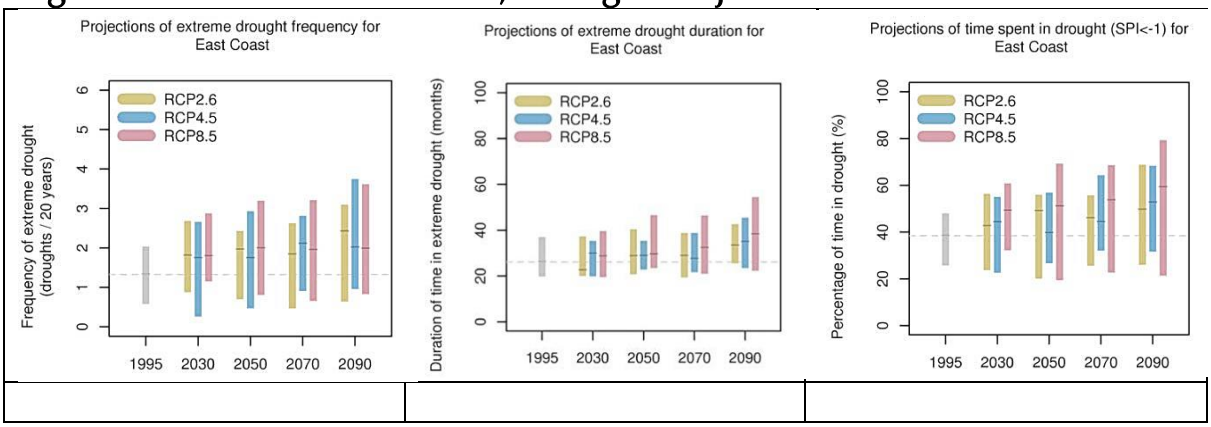
[37] NESP Earth Systems and Climate Change Hub. 2019. Climate change impacts on the Gondwana Rainforests of Australia (workshop report), Earth Systems and Climate Change Hub Report No. 8, NESP Earth Systems and Climate Change Hub, Australia.

[38] Summer drought conditions during the Australian millennium drought (~1997–2008) were not as severe as either the Federation drought (?1895–1902) or the World War II drought (?1937–1945). Palmer JG, Cook ER, Turney, CSM, Allen, K, Fenwick, P, Cook, BI, O'Donnell, A, Lough, J, Grierson, P, and Baker, P (2015). Wikipedia provides a useful summary of droughts dating back to early European settlement in the 18-19th century.

[39] An accompanying video illustrates wet and dry southern (austral) summer seasons (Dec-Jan-Feb) – the most stressful period for forests and crops. Palmer et al (2015) "Drought variability in the eastern Australia and New Zealand summer drought atlas (ANZDA, CE 1500–2012) modulated by the Interdecadal Pacific Oscillation. Environ. Res. Lett. 10 (2015) 124002 doi:10.1088/1748-9326/10/12/124002. A time-series video from the Palmer Drought Severity Index (PDSI) for the period 1500-2012 CE illustrates detailed annual summer rainfall and drought patterns from the 'Eastern Australia and New Zealand Drought Atlas' (ANZDA).

periods of low summer rainfall and drought occurred throughout the 19th century and into the 20th century.

Figure 5 – East Coast Australia, Drought Projections to 2090.



Source: Dowdy et al (2015). Notes: These graphs are for extreme drought and confidence is low for all but RCP 8.5 projections for 'time spent in drought' for which there is medium confidence.[40]

Figure 5 graphs the projected frequency, duration and time in drought for the most likely global climate trajectory: it points to more severe droughts for east coast Australia in the decades ahead. Taken together with Palmer et al's (2015) multi-century drought analysis strongly suggests droughts will be a growing threat to Gondwana Rainforest's biodiversity values.[41]

Increasing Heatwaves

Heatwaves:

> [are] … unusually high temperature events that occur for at least three consecutive days with major impacts to human health, economy, agriculture and ecosystems." (Transcoso et al 2020)[42]

These are expected to become more frequent and intense in SE Queensland in the future. They will exacerbate stresses caused by increasing temperatures in eastern Australia and on Gondwana Rainforest ecosystems and biodiversity values.

This conclusion is based on a recent analysis by Transcoso et al (2020) for SE Queensland and two other areas in the state for 1.5°C, 2°C and 3°C global warming. All four metrics used to compare heatwaves are expected to increase significantly by about 2040 and continue to do so this century.[43] Figure 6 shows model results for 2100 for SE Queensland and two other distinct regions, the tropical region includes the Wet Tropics WHA. There is a substantial increase in heatwave metrics for global warming of >2°C;

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[40] Dowdy, AJ, Grose, MR, Timbal, B, Moise, A Ekström, M, Bhend, J and Wilson,L. (2015) Rainfall in Australia's eastern seaboard: a review of confidence in projections based on observations and physical processes. Australian Meteorological and Oceanographic Journal 65:1 October 2015 107–126

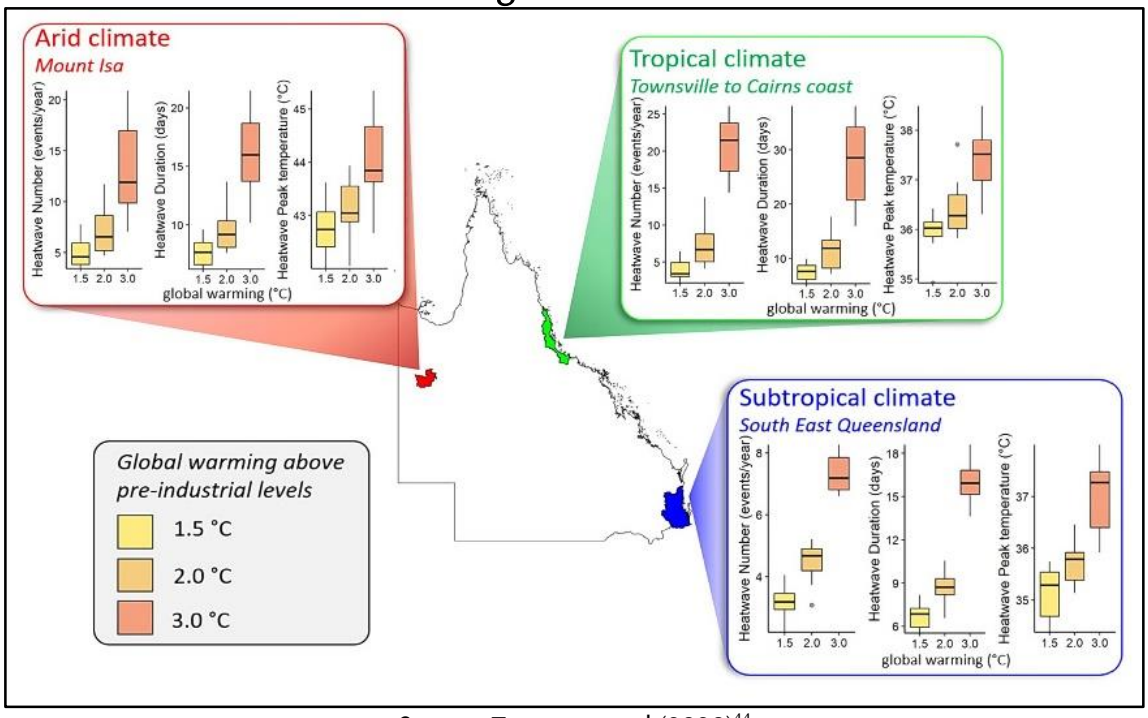
[41] While the focus of attention is on the portion of Gondwana Rainforests in Queensland, national parks in NSW that make up the majority (~300,000 ha) of the Gondwana WHA face similar climatic threats.

[42] 2020 Trancoso, R, Syktus, J, Toombs, N, Ahrens, D, Koon-Ho Wong, K, and Dalla Pozza, R. "Heatwaves intensification in Australia: A consistent trajectory across past, present and future." https://doi.org/10.1016/j.scitotenv.2020.140521

[43] The four metrics per decade are: peak temperature change, number of events, percentage frequency increase and event duration (Transcoso et al 2020).

noting that Australian east coast average annual temperatures are already about 1.8°C above baseline values.

Figure 6 – Heatwave metrics - Impacts of 1.5°, 2.0° and 3.0 °C of global warming above baseline.



Source: Trancoso et al (2020)[44]

10 – Conclusions and Suggestions

There are two main threats to Gondwana Rainforests arising from climate change – one catastrophic, one incremental:

- Fast: larger and more frequent fires disrupting/destroying a wide range of habitats and niches very rapidly, possibly leaving 'islands' of unburnt vegetation and refugia in gullies and other locations; and
- Slow: an increasingly wide range of species and taxa, whole multi-dimensional ecosystem assemblages, no longer having evolutionary 'time and space' to adapt to climate change, especially increased temperatures, declining precipitation, droughts and more frequent heat waves.

Preparing for both of these possibilities requires significantly increased near- and long-term funding by responsible federal and state governments. Only then will park and wildlife agencies have the financial resources and trained personnel essential for taking action to maximise adaptation preparations. For Gondwana Rainforests continuing funding shortfalls will lead to their inevitable degradation and decline.

This study provides an overview of the challenges and threats facing conservation of biodiversity values in the Queensland portion of the Gondwana Rainforests WHA. It

[44] The degree of difference between the regional effects on Australia's east coast region of global warming (heating) at 1.5°C, 2.0°C and 3.0°C is apparent in the graphs above. Despite a late start, a substantial number of climate scientists consider it may be possible to limit average global heating to about 1.5°C.

was prepared about a year after the major fires of 2019-20 seriously affected many of the 41 National Parks in Queensland and NSW that together constitute the WHA.

In Queensland the WHA covers nearly 60,000 ha of rugged terrain. On the Queensland side some 21,000 ha was affected, but only about one third of this severely burnt. Two of the five National Parks in Queensland – Main Range and Mt Barney were severely damaged (~60% burnt), thankfully Lamington was left largely intact (~5% burnt).

Almost the whole extent of the Gondwana Rainforests WHA is included in Native Title claims by the *Danggan Balun* (Five Rivers) People and the *Yuggera Ugarapul* People, both claims awaiting adjudication since 2017. A Native Title application by *Githabul* People for the Queensland portion of their country is in preparation.

On completing this study it is difficult not to be pessimistic about future conservation of biodiversity values in Gondwana Rainforests in the coming decades. Three comprehensive IUCN assessments since 2014 have expressed increasing concern about conservation of the many relict species and ecosystems that make Gondwana special, most recently in December 2020. This led them to express 'Serious Concern' – a 'Yellow Card' warning to the Queensland and Australian governments.

The reason for IUCN's concern was not bushfires per se – although these *dramatically changed the conservation outlook* – rather IUCN re-emphasised pre-existing concerns stemming from chronic underfunding by the responsible governments. They identified the critical need for more funding to control invasive alien weeds and feral animals. In this study provide preliminary estimates of funding needed for post-fire weed control, spanning initial work and follow-up over a decade. A total of $15M to $42M is necessary for work in fire-affected areas, separate from and additional to annual budget allocations for park management.

One overriding challenge for maintaining biodiversity values in Gondwana, and all protected areas in Queensland, is the increasing probability of rising temperatures, lower and less reliable precipitation, more frequent and extended heat waves and prolonged droughts. Mounting stresses are already affecting higher altitude, cool temperate forest ecosystems and many riparian habitats. Lower rainfall in late winter and through spring, combined with higher temperatures, will markedly increase fire risks in spring and summer.

There is now credible ecological evidence for landscape scale conservation that incorporates a network of protected areas supported by buffer zones and corridors that link ecosystems and build connectivity and ecological resilience. UNESCO guidelines strongly recommend creating buffer zones and ensuring connectivity for WHAs. This has not yet been done for Gondwana Rainforests WHA in either Queensland or NSW, which are characterised by isolated and fragmented protected areas. Moreover, the great majority (88%) of land use adjacent to Gondwana WHA in Queensland is regarded as semi- or non-compatible in terms of various invasive risks. Improving connectivity with compatible adjacent ecosystems is necessary to build resilience in times of drought or bushfires, and to better accommodate the long term ecological shifts arising from climate change

Two studies in 2018 confirm that underfunding of National Parks in Queensland is a state-wide issue. These studies were used to make preliminary estimates of funding

needed to improve park management, especially biodiversity conservation, from Poor to Fair, from Fair to Good and Good to Very Good.

Preliminary estimates suggest that continuing annual operational allocations of about $278M are necessary to raise average park conditions from Poor to Fair, some $388M to move from Fair to Good, and $510M to improve from Good to Very Good. The current annual budget allocation is about $151M.

It was not possible to identify how much funding is allocated by the Queensland government for Gondwana WHA. The Commonwealth seems to contribute about $90,000 per annum. This study estimates the annual state budget allocation for Gondwana is less than $5M, as compared to a preliminary estimate of an allocation of $20M per annum needed to raise its status to Very Good. This is regarded as a credible standard to be maintained for a WHA in a wealthy state and nation.

The shortfall in funding to meet declared conservation policy and program commitments is not the sole responsibility of the QPWS but rather reflect ongoing decisions by the state government. It is clear the QPWS field and office staff are energetically committed to achieving as much as possible with the limited funds available.

Driml' s 2020 study estimated about half annual spending of some $3.7B by visitors to SE Queensland is attributable to National Parks. It estimated a benefit-cost ratio of $3.9-$6.3 for every dollar spent by the state government on park management, which would attract total spending of some $5.8-8.4B over a 30-50 year time frame. A government analysis suggest that some $80M per annum might be raised by increasing entrance and other fees for park visitors and allowing establishment of private resorts within National Parks. However, higher visitor numbers will require greater spending on both facilities and management so the net financial benefit is not clear. Furthermore the increased pressure on the environment will need to be carefully assessed.

The value of ecosystem services provided by Queensland National Parks have not been studied. A preliminary estimate of the value of just one major ecosystem service – clean water from upper- and mid-level catchments of Five Rivers (*Danggan Balun*) flowing from Gondwana – suggests this is worth over $300M annually to SEQ Water, and to communities in Logan and Gold Coast cities and the Scenic Rim region. Their annual reports highlight demand is growing rapidly and there is mounting concern about maintaining adequate supplies, especially in the event of droughts like that of 2017-19.

Sustaining ecosystem services brings together the issues of conserving biodiversity values within the Gondwana WHA, where upper- and mid-level catchments store large volumes of clean water that ensure adequate clean water supplies for adjacent and growing urban centres. Gondwana's natural water supply and storage benefits will become more critical in times of reduced precipitation and droughts. Continuing decline in biodiversity health will almost certainly reduce availability of these natural benefits, and prospects for long term engineering solutions, e.g. more dams, desalination plants are problematic. This suggests using some of the revenues from selling water be invested in long-term biodiversity conservation to ensure the resilience of the critical ecosystem values in Gondwana for ongoing water supply to growing population centres.

Suggestions

In the current context it is considered more appropriate to make suggestions rather than recommendations, for two reasons. First, the limited amount of detailed and verifiable information available on the conservation status of relict and endangered species in the WHA, beyond what can be gleaned from the series of IUCN assessments and location and ecosystem specific studies. Very limited detailed technical information is available from QPWS, possibly due to limited funds for staff and research. Possibly also because the Queensland government is 'closed and opaque' rather than 'open and transparent' regarding a very wide range of information about government activities that should be publicly available in a democratic society. This lack of transparency is a major inhibition on effective conservation decision making and management.

Second, QCC needs to review the report and discuss it internally and with the author to determine the nature and priority of recommendations it may decide to make to the government.

1. Naturally, it is suggested that substantial and continuing increases in near-term funding for Gondwana is critical. This funding needs to be directed primarily to engaging additional field staff and providing resources for improved biodiversity conservation, and secondly to research directed to preparing sustained action for climate change adaptation.
2. Attention needs to be given to identifying additional/complementary sources of funding for increasing resources available for current and future conservation management and climate change adaptation.
3. Begin progressively identifying critical locations/areas where WHA buffer zones need to be established, followed by initiating discussions with local councils, regional and community organisations and land owners to identify pathways for establishing and managing these cost-effectively.
4. Revise earlier proposals for extending already identified and new areas to be included in Gondwana to improve connectivity to provide better access to refugia during bushfires and from impacts of climate change. Link this closely with identifying and establishing buffer zones.
5. QPWS is currently preparing a strategic plan for Gondwana, this will be followed by developing a plan focused on climate change adaption. Given the multi-sectoral effects of climate change it would be wise to adopt an inclusive regional strategic planning approach similar to that developed by the National Climate Change Adaptation Research Facility (NCCARF) and trialed by the Wet Tropical Management Authority (WTMA).

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