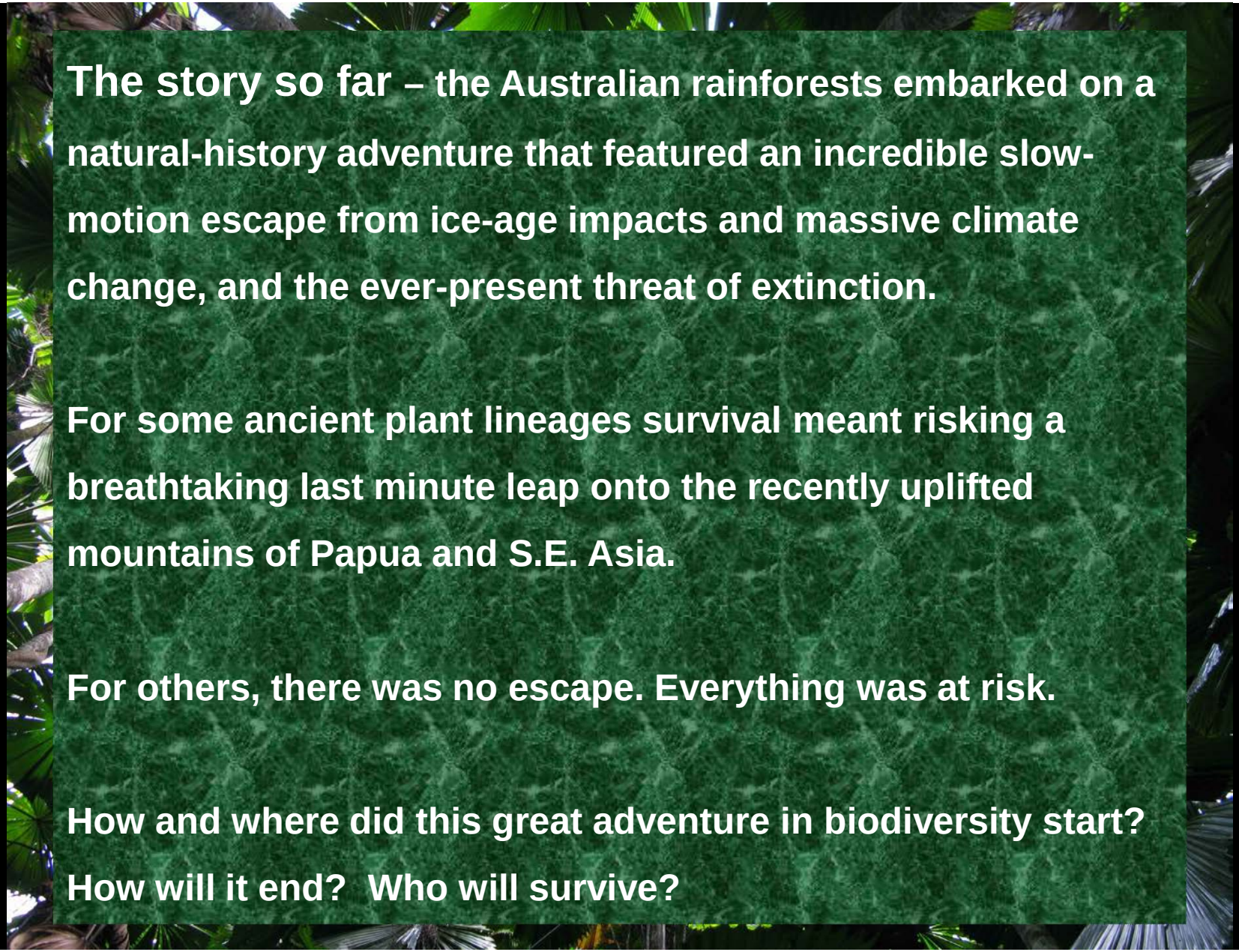
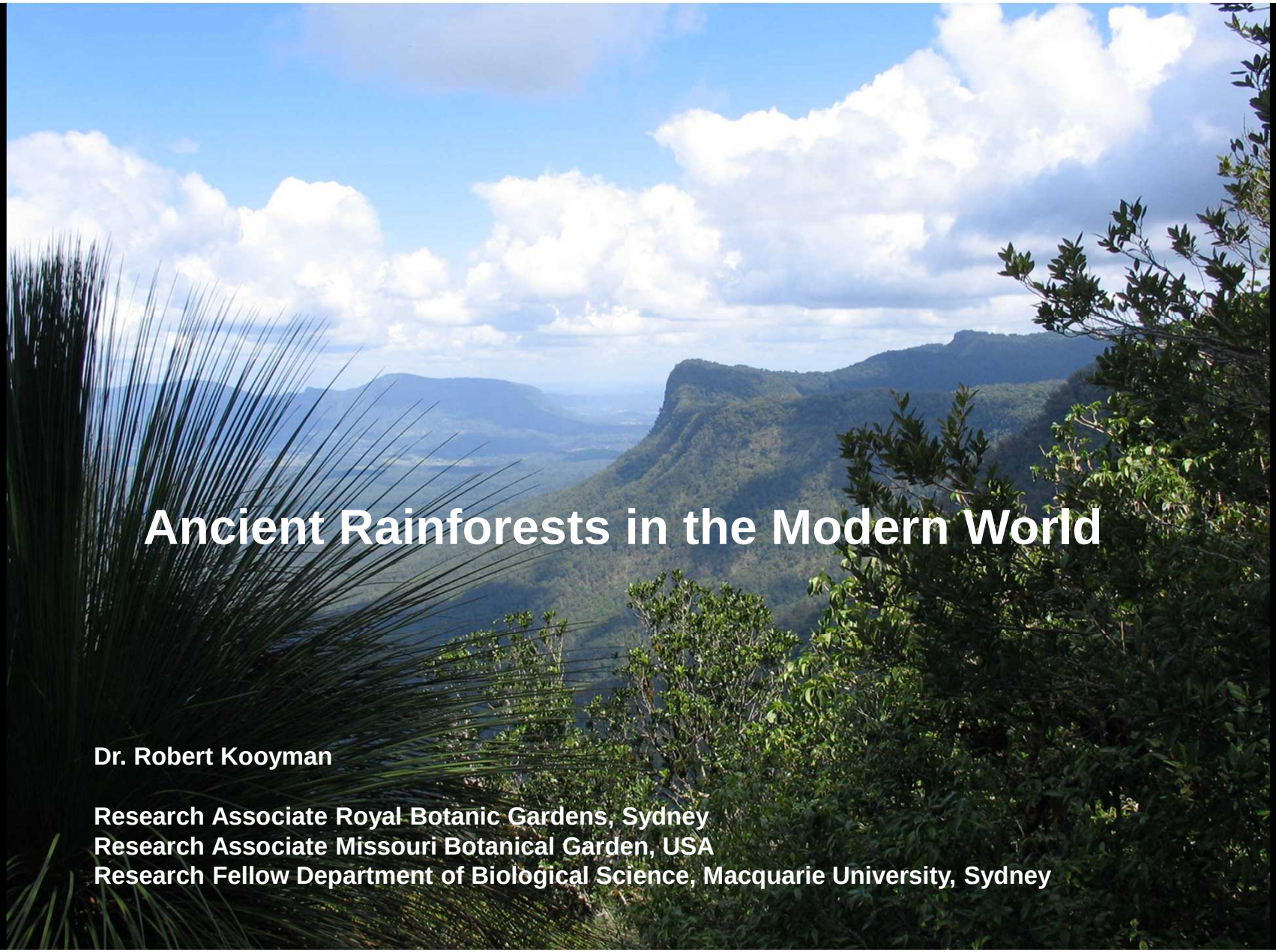

The story so far – the Australian rainforests embarked on a natural-history adventure that featured an incredible slow-motion escape from ice-age impacts and massive climate change, and the ever-present threat of extinction.
For some ancient plant lineages survival meant risking a breathtaking last minute leap onto the recently uplifted mountains of Papua and S.E. Asia.
For others, there was no escape. Everything was at risk.
How and where did this great adventure in biodiversity start? How will it end? Who will survive?



Ancient Rainforests in the Modern World

Dr. Robert Kooyman

Research Associate Royal Botanic Gardens, Sydney
Research Associate Missouri Botanical Garden, USA
Research Fellow Department of Biological Science, Macquarie University, Sydney

In a voyage of 40 million years the Australian plate (Sahul) ground its way free of Antarctica and travelled north carrying the green vestiges of Gondwana with it.

The Australian Plate ‘Sahul’ eventually smashed into the Asian Plate ‘Sunda’ lifting the northern highlands (New Guinea) into a volcanic splendour.

Paleo-Antarctic Rainforest Lineages
The Gondwanan ‘Survivors’

Riding on Australia (Sahul), the survival and movement of ‘woody’ Gondwanan lineages from Patagonia-Antarctica to S.E. Asia (70 Mya to Present) is one of the great biological survival stories.

This natural-history adventure features an incredible slow-motion escape from ice-age impacts, massive climate change and extinction, and for some ancient lineages ends in a breathtaking last minute leap onto the recently uplifted mountains of Papua and S.E. Asia.

Will they survive the combination of human impacts and climate change?

Kooyman, R.M., Wilf, P., Barreda, V.D., Carpenter, R.J., Jordan, G.J., Sniderman, J.M.K., Allen, A., Brodribb, T.J., Crayn, D., Feild, T.S., Laffan, S.W., Lusk, C.H., Rossetto, M., Weston, P.H. (2014**) Paleo-Antarctic Rainforest into the Modern Old World Tropics: the Rich Past and Threatened Future of the ‘Southern Wet Forest Survivors’** ***American Journal of Botany*** 101:2121-2135.

Eidothea hardeniana – Proteaceae – Sch. 1

Uromyrtus australis – Myrtaceae – Sch. 1

Corokia whiteana – Argophyllaceae - Sch. 2

Hicksbeachia pinnatifolia – Proteaceae - Sch. 2

Intact World Heritage Gondwana Rainforest canopy Mt. Nardi, Nightcap NP

World Heritage
Gondwana Rainforest Burning

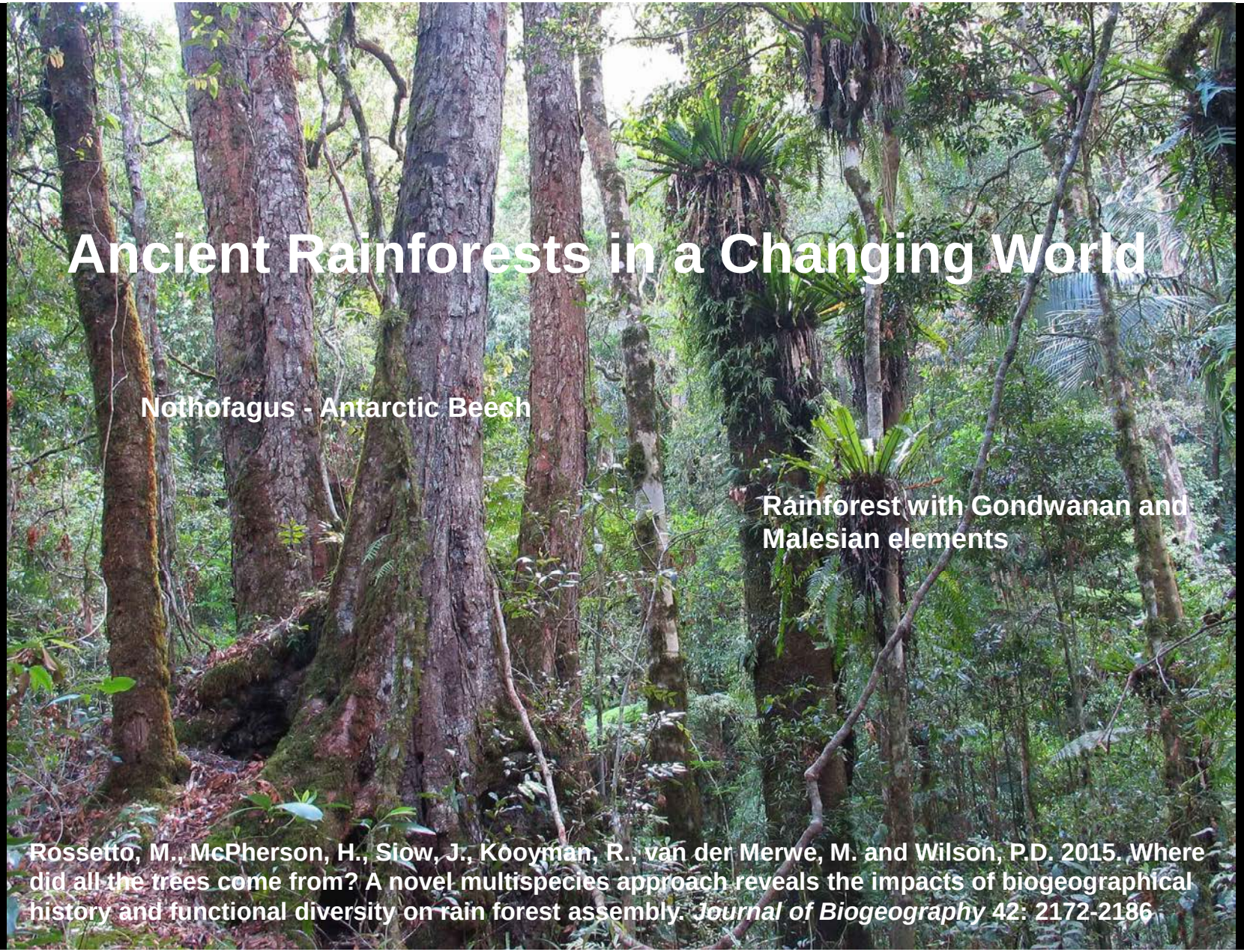
Photo courtesy Heidi de Silva_ABC North Coast


Lophostemon confertus – Brush Box, and rainforest. Terania Creek Nightcap NP

Burned Rainforest, Terania Creek Nightcap NP

Burned rainforest trees,
Terania Creek, Nightcap NP.

Thin-barked and slowly dying.


Ancient Rainforests in a Changing World
Nothofagus - Antarctic Beech
Rainforest with Gondwanan and Malesian elements
Rossetto, M., McPherson, H., Siow, J., Kooyman, R., van der Merwe, M. and Wilson, P.D. 2015. Where did all the trees come from? A novel multispecies approach reveals the impacts of biogeographical history and functional diversity on rain forest assembly. *Journal of Biogeography* 42: 2172-2186

Paleo-Antarctic Rainforest Lineages

Community Assembly through time:

Ceratopetalum, Ackama / Caldcluvia, Austrobuxus, Araucaria, Akania, Ripogonum, diverse Laurales, Orites, Wilkiea, Todea, Dicksonia, Sticherus … and many more…

Ancient Forests in the Modern World


Post-fire research and monitoring
What have we been doing?

World Heritage Gondwana Rainforest +

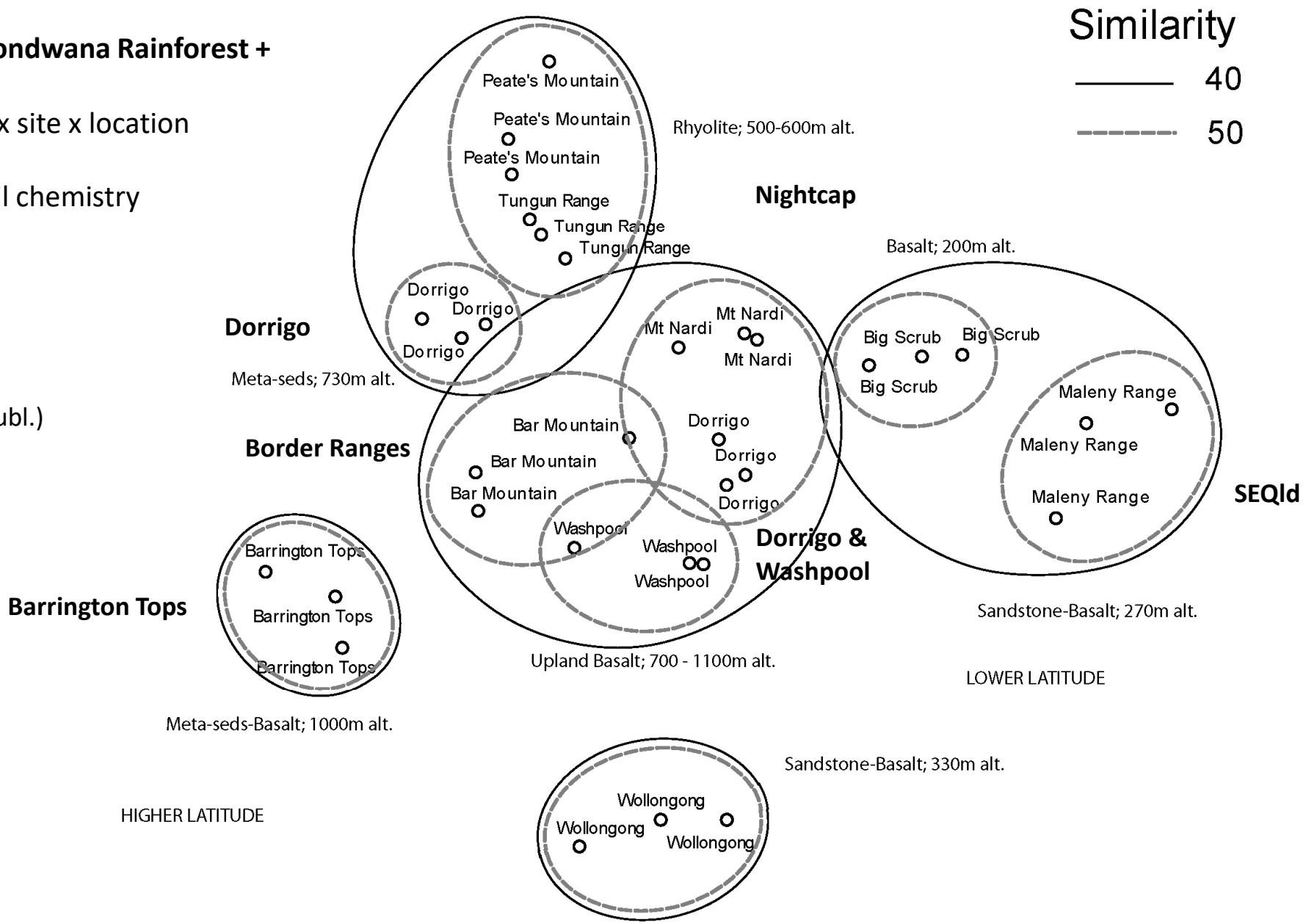
Floristic similarity x site x location

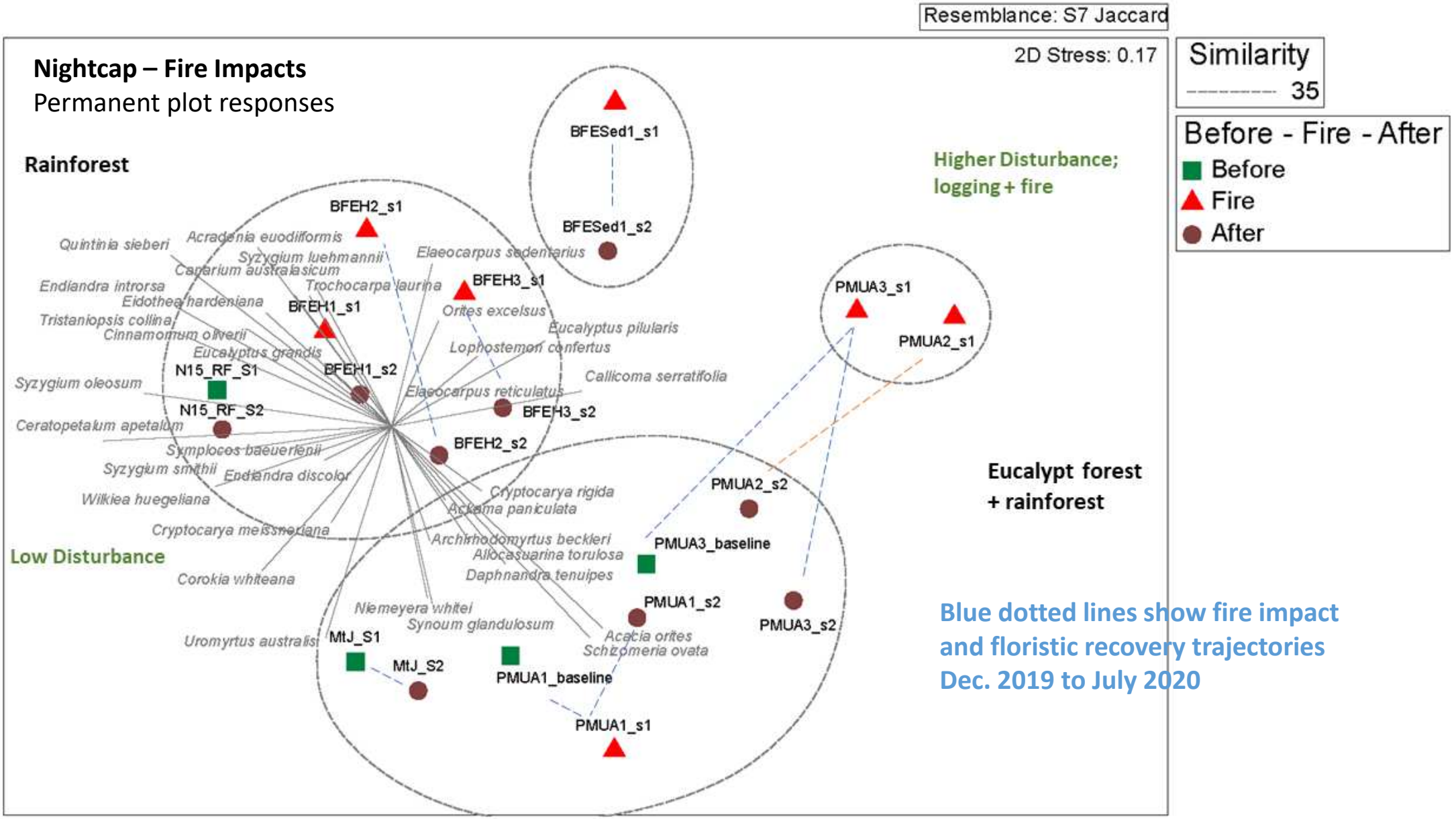
Soil types – full soil chemistry

Altitude

Latitude

Kooyman et al. (unpubl.)




Nightcap – Fire Impacts
Permanent plot responses
Resemblance: S7 Jaccard
2D Stress: 0.17
Similarity
35
Before - Fire - After
Before
Fire
After
Rainforest
Higher Disturbance;
logging + fire
Eucalypt forest
+ rainforest
Low Disturbance
BFESed1_s1
BFESed1_s2
BFEH2_s1
BFEH3_s1
BFEH1_s1
BFEH1_s2
BFEH3_s2
BFEH2_s2
N15_RF_S1
N15_RF_S2
PMUA3_s1
PMUA2_s1
PMUA2_s2
PMUA3_baseline
PMUA3_s2
PMUA1_s2
PMUA1_baseline
PMUA1_s1
MtJ_S1
MtJ_S2
Quintinia sieberi
Acradenia euodiiformis
Syzygium luehmannii
Elaeocarpus sedentarius
Caldcluvia australasicum
Endiandra introrsa
Trochocarpa laurina
Eidothea hardeniana
Orites excelsus
Tristaniopsis collina
Cinnamomum oliveri
Eucalyptus pilularis
Eucalyptus grandis
Lophostemon confertus
Syzygium oleosum
Callicoma serratifolia
Elaeocarpus reticulatus
Ceratopetalum apetalum
Symplocos baeuerlenii
Syzygium smithii
Endiandra discolor
Cryptocarya rigida
Wilkiea huegeliana
Acmena paniculata
Cryptocarya meissneriana
Archirhodomyrtus beckleri
Allocasuarina torulosa
Corokia whiteana
Daphnandra tenuipes
Niemeyera whitei
Synoum glandulosum
Uromyrtus australis
Acacia orites
Schizomeria ovata
Blue dotted lines show fire impact
and floristic recovery trajectories
Dec. 2019 to July 2020

> 12 months after fire

Up to 70% mortality of rainforest canopy trees

Continuing decline and increasing mortalities

>100 species resprouting

Some seed based regeneration

Significant risk of competition by *Acacia* and disruption of Initial Floristic Regeneration

Proximity of rainforest to historic logging increased fire impacts

Major impacts on high conservation value Gondwana lineages (PARLs) and RF habitats

Shortlist of current and continuing research relevant to assessing impacts of fire on WH Gondwana Rainforest
Kooyman R.M. et al.

Continue monitoring permanent plots to track recovery trajectories through time (**SoS, UNSW**);

Expand plot sampling geographically across soil types (e.g., basalt, rhyolite – high and low nutrient scenarios) (**UNSW**);

Include Complex Notophyll versus Simple Notophyll-Microphyll vine forest types and transitions (**NPWS and UNSW**);

Focus on EPBC listed Endangered Communities (**UNSW**);

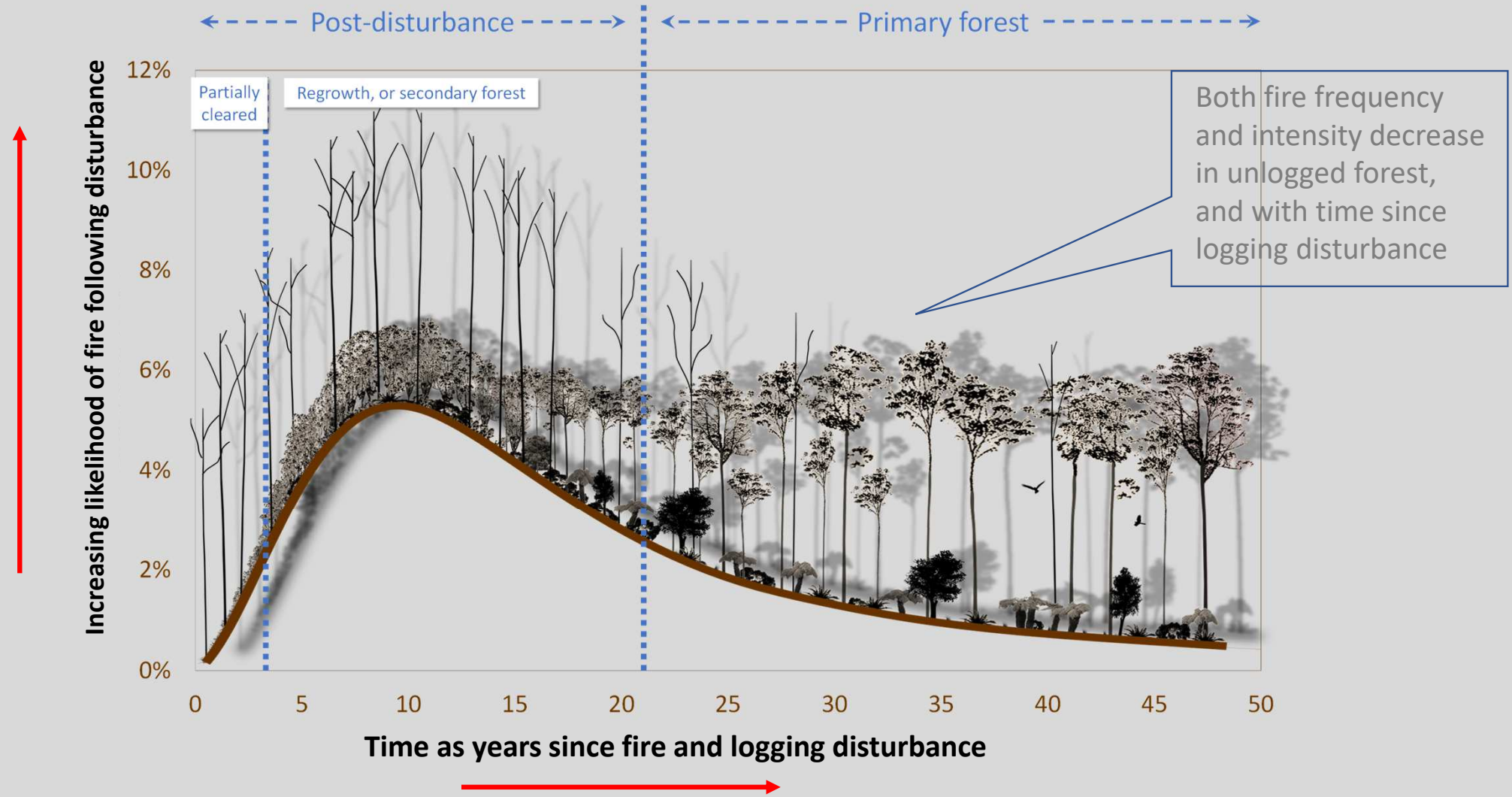
Continue monitoring Threatened Plant Species – impacts and recovery to inform potential recovery actions (**SoS, RBGSyd**);

Assist regional fire planning by providing ecological research and highlighting highest conservation priorities for protection of World Heritage Gondwana Rainforest, Paleo-Antractic Rainforest Lineages (PARLs), and World Heritage values (**NPWS**);

Continue working on the Biogeographic History, Origins, and Assembly of the Gondwana Rainforests using paleo-historical data (fossils) (**Penn. State U. and Cornell with Conicet in Argentina**), genomic research on selected lineages and threatened species across full distributional extents (**RBGSydney**), species level physiological responses to climate change to inform distribution modelling under climate variation (**UWS**), comparisons of lineages from Sunda and Sahul (**RBGSyd**), modelling of Paleo-Antractic lineage distributions in Australia and Southeast Asia relative to climate variables (**NSF with Penn. State**), evaluate role of pyrophillic fungi in recovery trajectories (**RBGSyd**), continue detailed studies of soil types across WH Gondwana Rainforest distribution in relation to mycorrhiza and plant strategy types (**MQU**), continue trait-based research into plant strategy types and distributions relative to environmental gradients and disturbance responses (including fire) (**MQU**).

Unburned Gondwana rainforest next to New England Blackbutt, eastern side Nightcap NP


Burned New England Blackbutt, eastern side Nightcap NP
Note historic logging debris and residues



Flammability dynamics in eucalypt forest. The brown curved line shows the empirically measured annual likelihood of fire per ha, and the changes in regenerating forest are shown with years since fire. Zylstra 2014

Old-Growth Flooded Gum with Rainforest, Nightcap NP.

Many large trees with hollows lost.

> 90% lost previously to logging


Flooded Gum
+ rainforest
Brush Box
+ rainforest
Tea-tree Rocky Heath
Brush
Box
Brush Box
+ rainforest
Rainforest – Coachwood type
with Hoop Pine
New England Blackbutt

***Eidothea hardeniana* – Nightcap Oak. Ancient basal lineage in Proteaceae**
LEST WE EVER FORGET >40 My of Australian evolutionary history

What will recovery look like/how long will it take in rainforests like this - will they recover or turn into other types of forest?

The data collected to date in the Nightcap suggests that historic logging played a major role in fire behaviour across the forest because of rainforest clearing, woody material left post-logging, and the spatial and size class rearrangement of tree and shrub species adjacent to rainforest refugia areas.

Rainforest recovery in some cases will be slow with the loss of large trees of sometimes enormous ages (>500 to 1000 years in some cases) making full recovery something well beyond human lifespans. However, seedling based regeneration and some resprouting (of some species) will occur. These are mostly natural forest areas with a strong natural regenerative capacity and a low incidence of weeds (at least on the lower nutrient soils).

The issue is the assault on more than 40 My of evolutionary history and the loss of ecological function (e.g., large fruit producing habitat trees, canopy decline and loss of forest structure) that will impact on the forest for many decades and in some cases hundreds of years. For some threatened species, the fire has pushed them yet closer to extinction.

Will we need to intervene to help these natural areas recover?
How? - by planting trees or seeds..?

Seeding and tree planting in such scenarios is generally not necessary and may actually be a threatening process in itself unless guided by approved Recovery Plans and informed by both genetic and demographic work to develop the best strategy.

However, some translocation work is being done for Threatened Rainforest Species.

In general the best contribution we can make is to protect the natural systems and the natural ecological processes and intervene only after careful evaluation, and then only to assist the natural processes by (as an example) removing competing weed (or aggressive post-fire) species that might displace the rainforest or particular native species.

Were the lowland sub-tropical rainforests affected by these fires?

Mostly not, and certainly not to the same extent as the upland rainforests. However, in parts of SE Qld (Lamington and Main Range NP foothills) and Terania Creek they were affected.

Should we plant more rainforest in the landscape to buffer against fire?

Expanding the area of rainforest on previously cleared privately owned lands to buffer against future fires in the landscape is a good strategy, and one that collectively we can, and should support. In some cases rainforest may be destroyed by fire but it is also resistant to fire, and modifies fire behaviour.

Groups like ENVITE and Big Scrub Landcare have been doing rainforest plantings for many years and understand the role of rainforest in the landscape.