# Integrating rehabilitation, restoration and conservation for a sustainable jarrah forest future during climate disruption

Grant Wardell-Johnson, Michael Calver, Neil Burrows & Giovanni Di Virgilio

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# Synopsis

- The Northern Jarrah forest: interactions between exploitation and climate disruption
  - History of exploitation
  - Climate change impacts
  - Changing rehabilitation for a sustainable future
  - Complex challenges require novel solutions

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*Pacific Conservation Biology*
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**Forum Essay**

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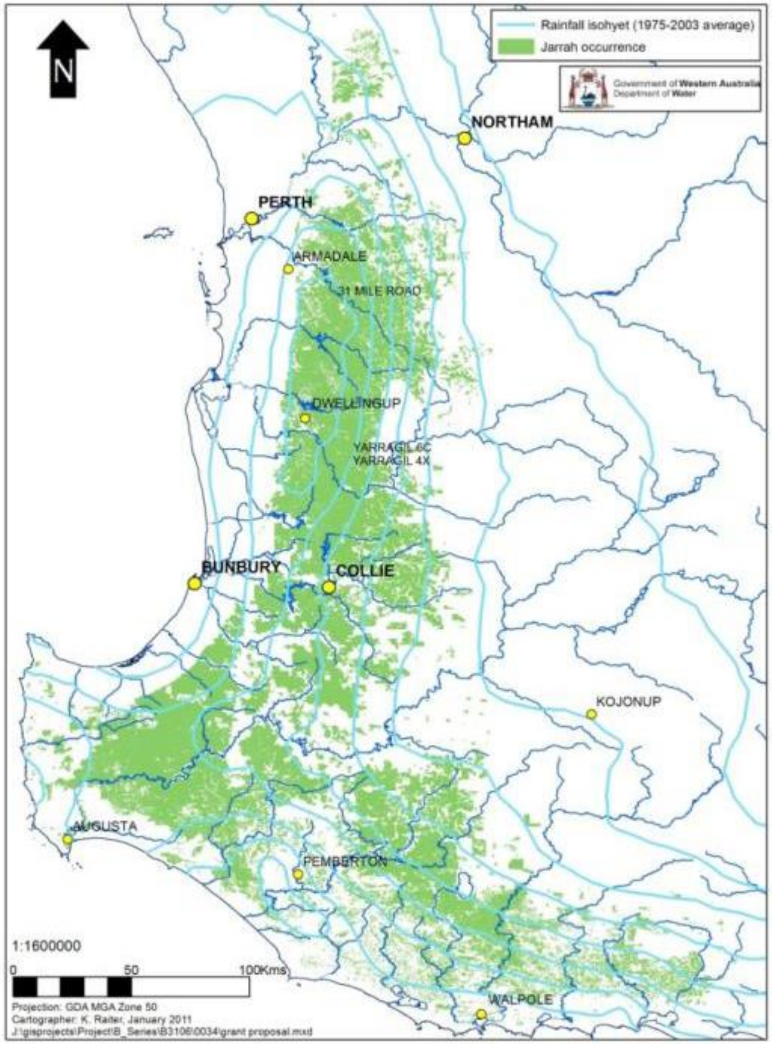
# The jarrah forest




- 4.25 milllion ha in the high rainfall south-west forest bioregions
- 2.5 million ha of publicly managed land
- Jarrah – historically the most important timber tree
  - Management history
  - Climate change impacts
  - Management responses

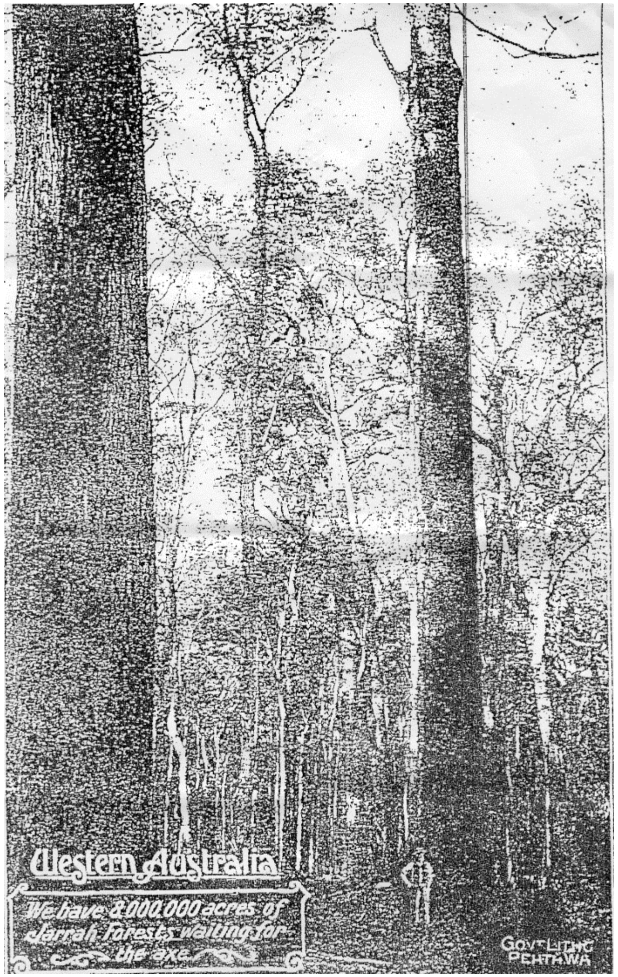
# Historical Jarrah Forest

*'… the splendid straight … jarrah trees, growing within three or six feet of each other, reaching to the height of 50 and 80 feet without a branch or blemish, and apparently quite sound.'*

Roe 1852

Roe JS (1852) Report of an expedition under the surveyor-general, Mr J S Roe, to the south-eastward of Perth, in Western Australia, between the months of September, 1848, and February, 1849, to the Hon. the colonial secretary. *Journal of the Royal Geographical Society of London* **22,** 1-57.

# Unimpeded exploitation & conflict between forestry, agriculture & conservation

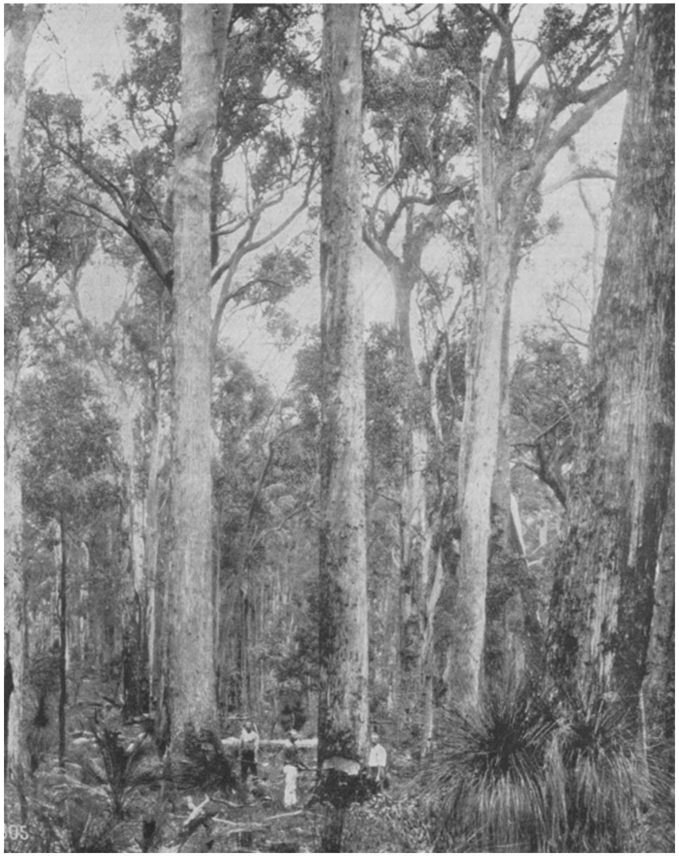



- Almost unimpeded exploitation so that by 1920:
- '...*nearly one million acres of the jarrah forest were cut over for the removal of 750 million cubic feet of logs, causing a reduction of almost 50% in the forest canopy*'
  - Wallace 1965, p. 35

Wallace WR (1965) Fire in the jarrah forest environment. *J. Roy. Soc. WA* **49**, 33-44.

# The forest Act (1918) and beyond

- WA Forest Act (1918) demarcated State forest to provide timber in perpetuity
- Prospects daunting- in 1927 alone native hardwood logging exceeded estimated increment by over **1 050 400 m$^3$**



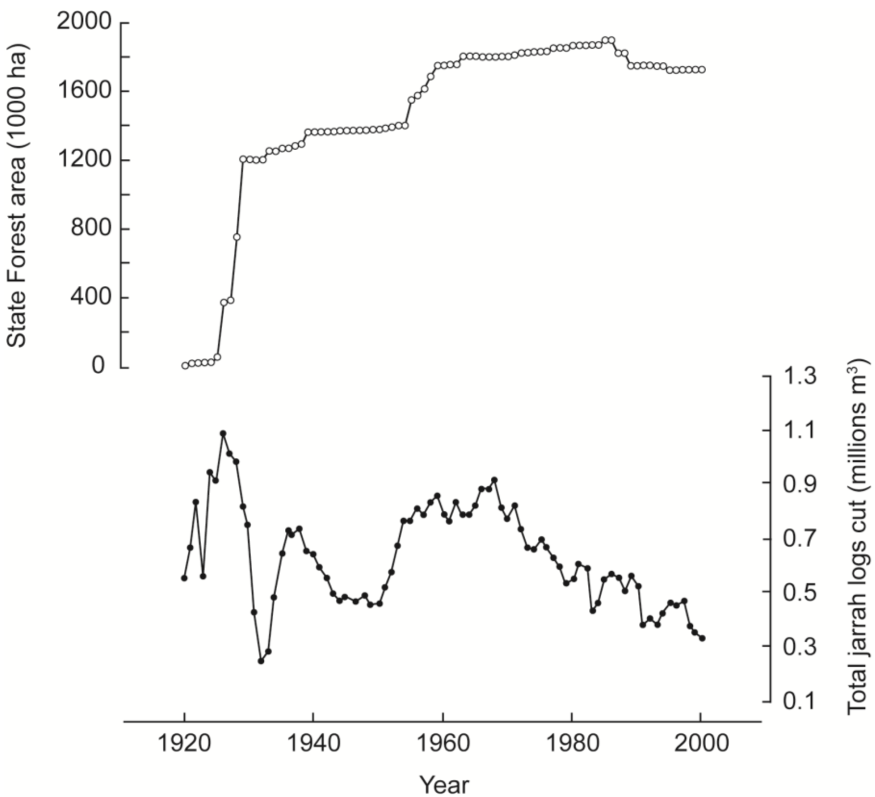
Calver M & Wardell-Johnson G (2004) Sustained unsustainability? An evaluation of evidence for a history of overcutting in the jarrah forests of Western Australia and its consequences for fauna conservation. In (Ed D Lunney) *Conservation of Australia's Forest Fauna*, Roy. Zoo. Soc. NSW, Mosman, pp 94-114.

# The future of the forest (1920 perspective)

- *'When what remains of the present over-mature crop of jarrah … has been cut down, it is unlikely that specimens equal in bulk to what the forests have already yielded or still possess will be seen by future generations. … Sentiment may dictate the preservation of a few …  as reminders … but whole forests of  giant trees will no longer be seen'*
  - Charles Lane Poole 1920, p 130

Lane Poole CE (1920) 'Notes on the forests and forest products and industries of Western Australia'. (Forests Department of Western Australia: Perth).

# Increase in area, decline in yield




- Yield forecasts for jarrah have declined post 1961 while area of State Forests has increased
- Volumes removed have responded markedly to international events

Calver, M. & Wardell-Johnson, G. (2004). Sustained unsustainability? An evaluation of evidence for a history of overcutting in the jarrah forests of Western Australia and its consequences for fauna conservation. In (Ed. D. Lunney) *Conservation of Australia's Forest Fauna*, Roy. Zoo. Soc. NSW, Mosman, pp 94-114.

# The situation pre 2004

- *'Current rates of cutting in the original forest cannot be sustained until a sufficient proportion of regrowth stands reach millable size. Cutting must, therefore, be progressively reduced for … 60 – 70 years'.*
  - McNamara (1984, p. 10).
- Declines in estimated annual increment between 1961 and 1974 not matched by declines in permissible cut.
- Awareness of overcutting in 1970s and 1980s
- Cutting reduced 20 years later (2004 management plan)

McNamara, P. J. (1984). 'Future timber supplies for Western Australia: a discussion paper prepared for the Hon. Premier and Minister for Forests' (Forests Department of Western Australia: Perth).

# A changed forest structure


- The Northern Jarrah Forest is now a degraded and regrowth forest of low stature and reduced capacity to provide timber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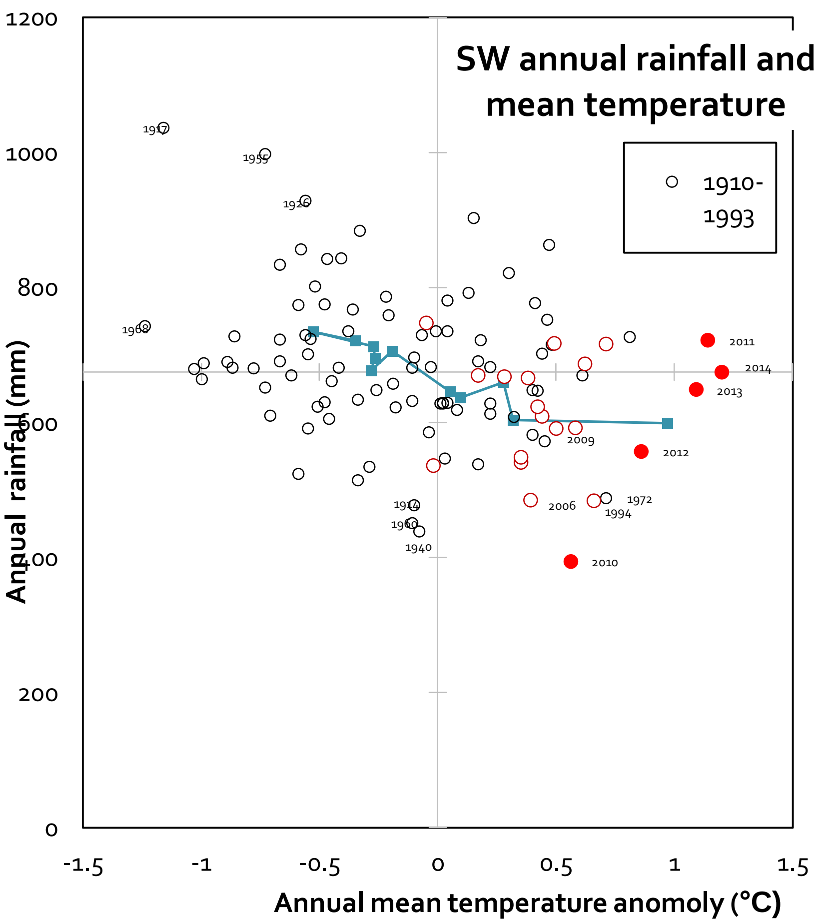
Australasian Plant Pathol.
DOI 10.1007/s13313-015-0356-5


ORIGINAL PAPER

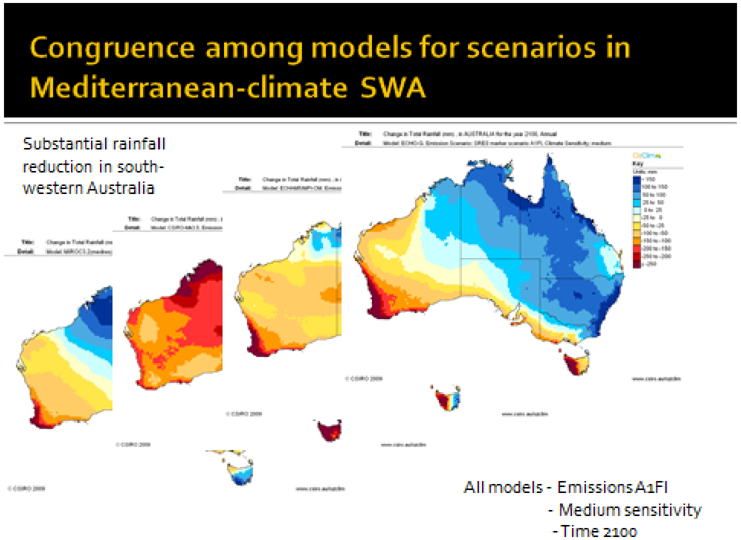
**How *Phytophthora cinnamomi* became associated with the death of *Eucalyptus marginata* – the early investigations into jarrah dieback**


E. M. Davison[1]

# Climate shift post 1970




- A climate shift since 1970
- Models project a further decrease in rainfall and increases in temperature

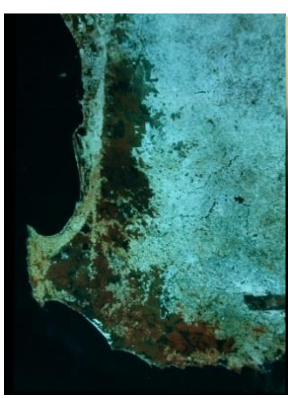



Thanks to Ben Miller, BGPA

# South-western Australia: impacts are high & landscapes are flat

2578 M. Byrne / Quaternary Science Reviews 27 (2008) 2576–2585

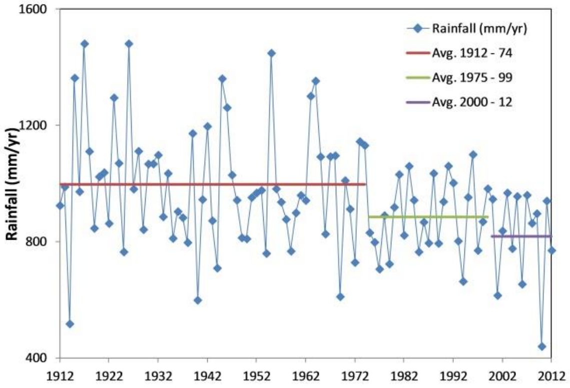

Fig. 1. Elevation map of Australia showing the extent of the arid (brown line) and semi-arid (black line) zone, the south-west and east/south-east mesic regions, and major geographical features mentioned in the text.

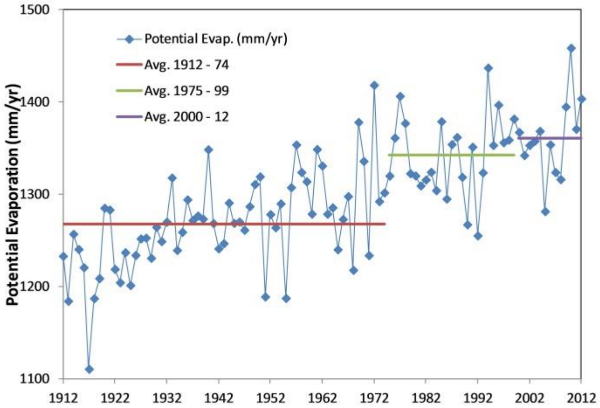


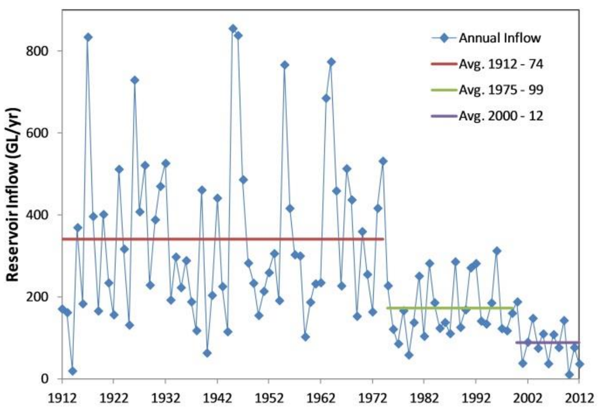
Thanks to Richard Woldendorp: 1999

# Reduced rainfall & stream flow

Historical inflows to the water-supply reservoirs in the NJF compared to average rainfall and potential evaporation across the catchments

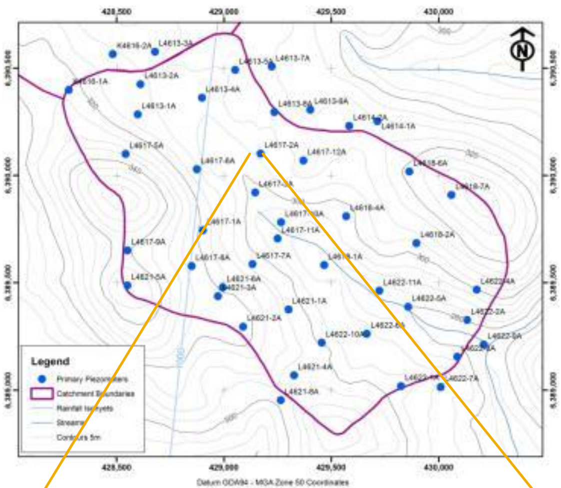


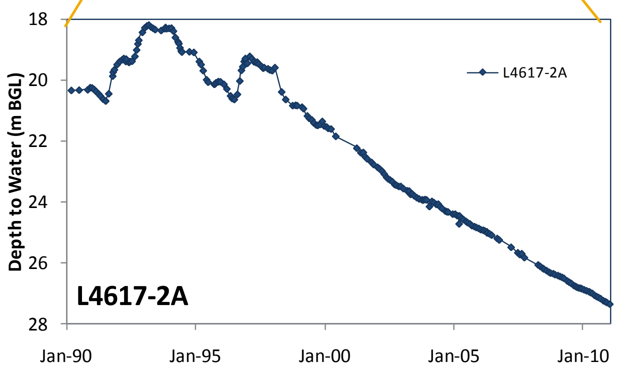



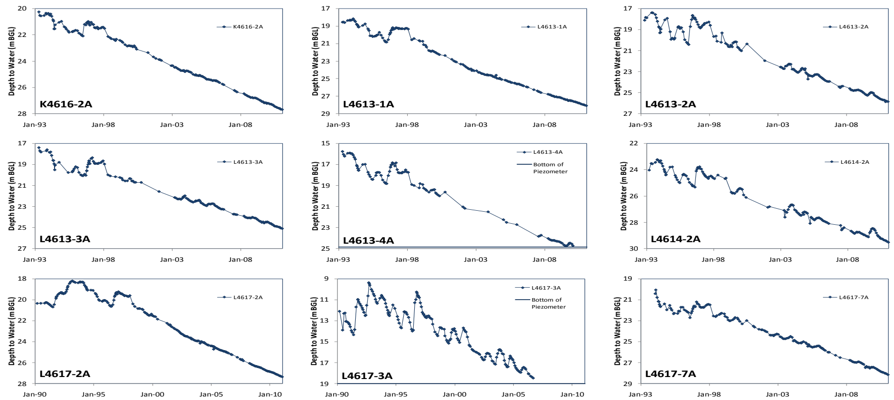

Croton JT *et al.* 2014, Forest and Ecosystem Management Division, Technical Report No. 9. DPaW, WA.

# Monitoring of the groundwater system in the northern jarrah forest



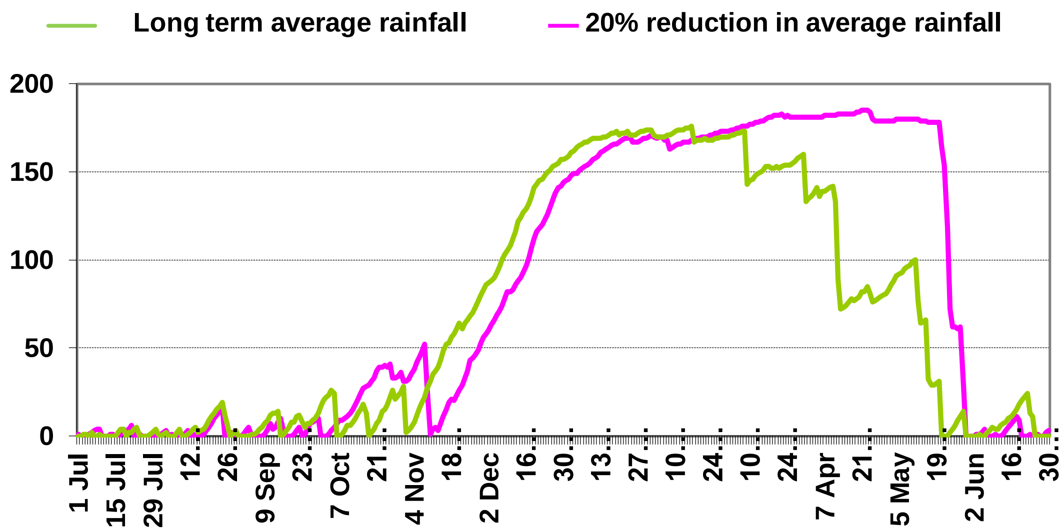




Borehole monitoring in a catchment not-mined or logged during monitoring (the Gordon Groundwater Piezometer Network)

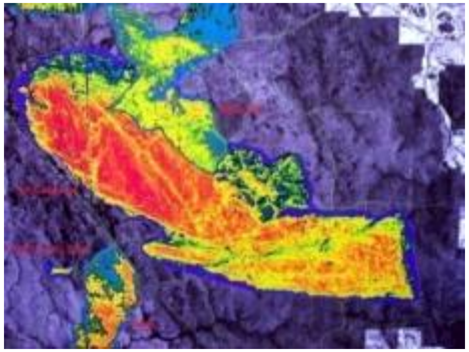



- Groundwater of Gordon reducing at **0.5 m/yr since mid-1990s.**
- Groundwater in stream zone at **least 10 metres** below ground.
- Regolith system will **disappear** by **2026** under current projections.

# Hydrological change & fire in south-western Australia




**Soil Dryness Index** under changed climate (20% rainfall reduction) for Dwellingup, south-western Australia



Mt Cook fire (Jan 2003 Photo Kristian Pollock) burnt virtually all sites within its boundary

Wardell-Johnson GW, Calver M, Burrows N and Di Virgilio G. (2015). Integrating rehabilitation, restoration and conservation for a sustainable jarrah forest future during climate disruption. *Pacific Conservation Biology* **21**: 1-11

# Adaptive management in the northern jarrah forest

Adaptive management trials attempted in the northern jarrah forest

Their impact on the biota may depend on the extent of decoupling of the overstorey (chiefly jarrah) from the understorey & riparian biota

Impact of declining water tables on jarrah

Experimental thinning in Wungong catchment

Croton JT *et al.* 2014, Forest and Ecosystem Management Division, Technical Report No. 9. DPaW, WA.

# Thinning to improve water yields

- May be some ecological advantages to thinning
  - May increase growth rates of retained trees – fast track old-growth characteristics
  - Correcting mistakes of the past
  - Prioritise areas low in landscape
  - Potential to remove ‘fuel loads’
  - Integrate with other land uses (e.g. bauxite rehabilitation).
- But the disadvantages may outweigh the positives

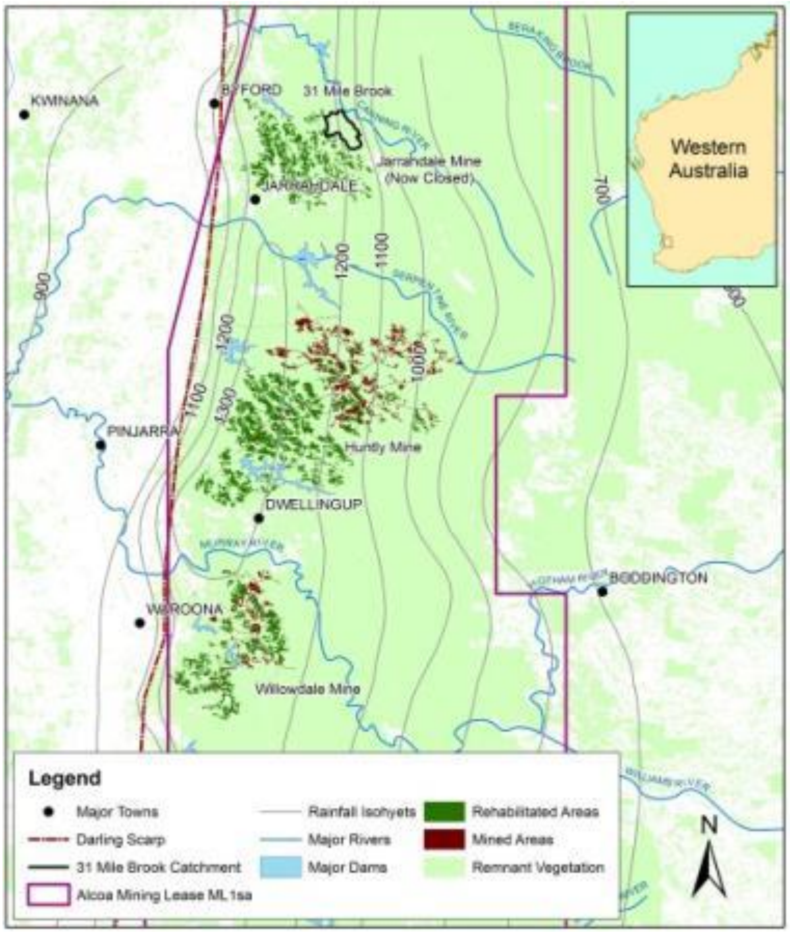



# Should we thin the forest to slow water table declines?

- Can lead to perverse outcomes
  - Produces increased emissions
  - Can exacerbate warming & drying by increasing thermodynamic amplitudes
  - Requires constant follow-up and is expensive
  - Low likelihood of positive outcomes for water tables in drying climate
  - Uncertain impacts on biota
- But – the Importance of hydrological balance widely recognised

Wungong catchment trial

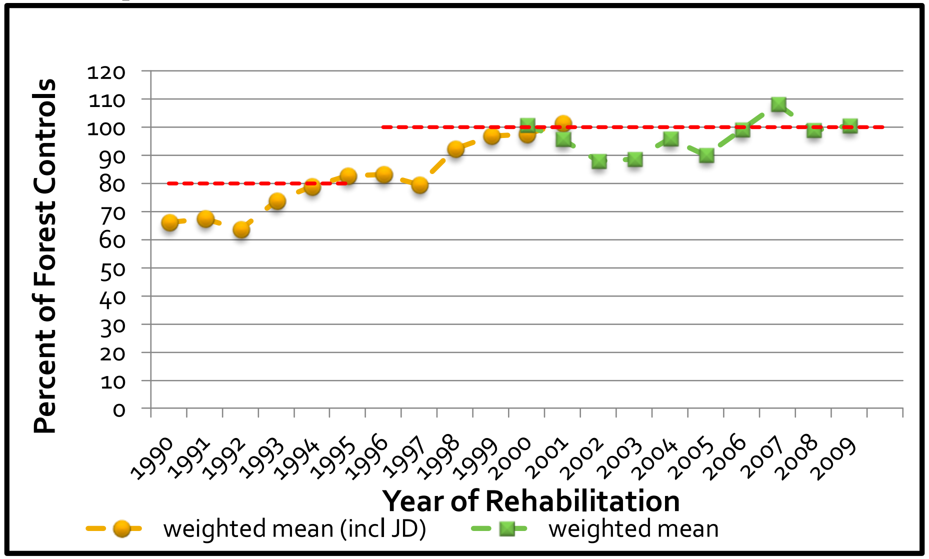
# The mining industry & rehabilitation



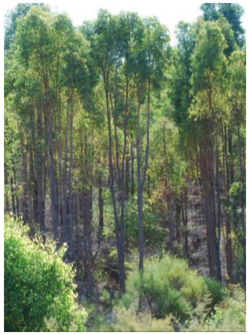

- Bauxite, coal, tin & gold mined in the jarrah forest
- Now over 28 000 ha of rehabilitation - rudimentary in the 1960s to advanced approaches today
- 45% of State forest in approved mining leases or State agreements – so mine rehabilitation important to the future of the surrounding forest

# Developments in jarrah forest bauxite mine rehabilitation

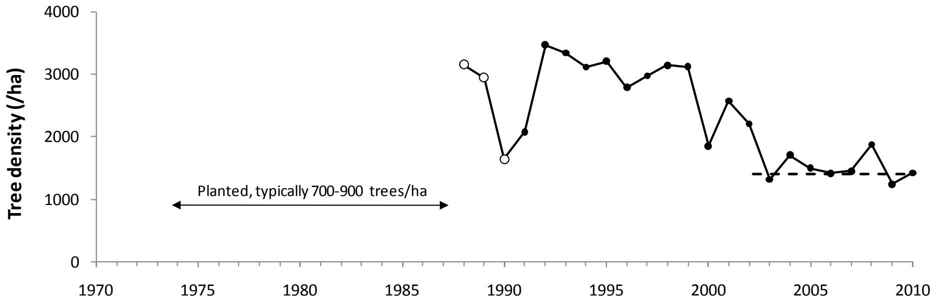
## Species richness




Changes in species richness of bauxite mining rehabilitation



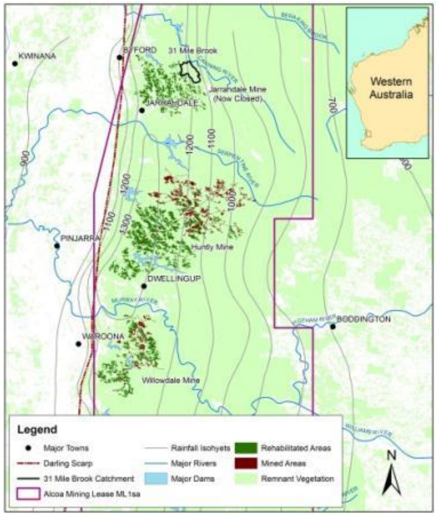
## Tree density




Density of eucalypts 9 months after establishment, showing current target density commenced in 2003 (dotted line).

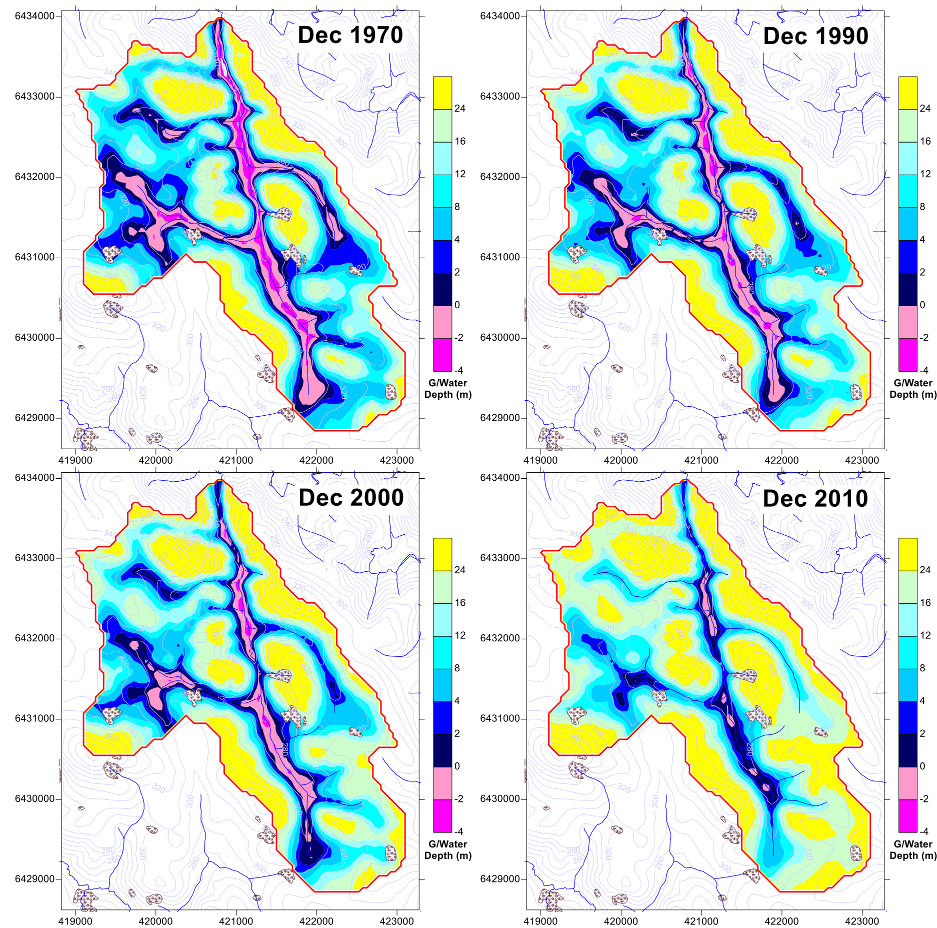
- Logging and bauxite mining with rehabilitation has changed the jarrah forest from old-growth to dense regrowth
    - High water use
    - Mandated requirement of bauxite rehabilitation to return a 'jarrah forest'

# 'Hydroscape' - Historical simulation 1970 to 2010




Hydrological monitoring in *31 Mile Brook* catchment

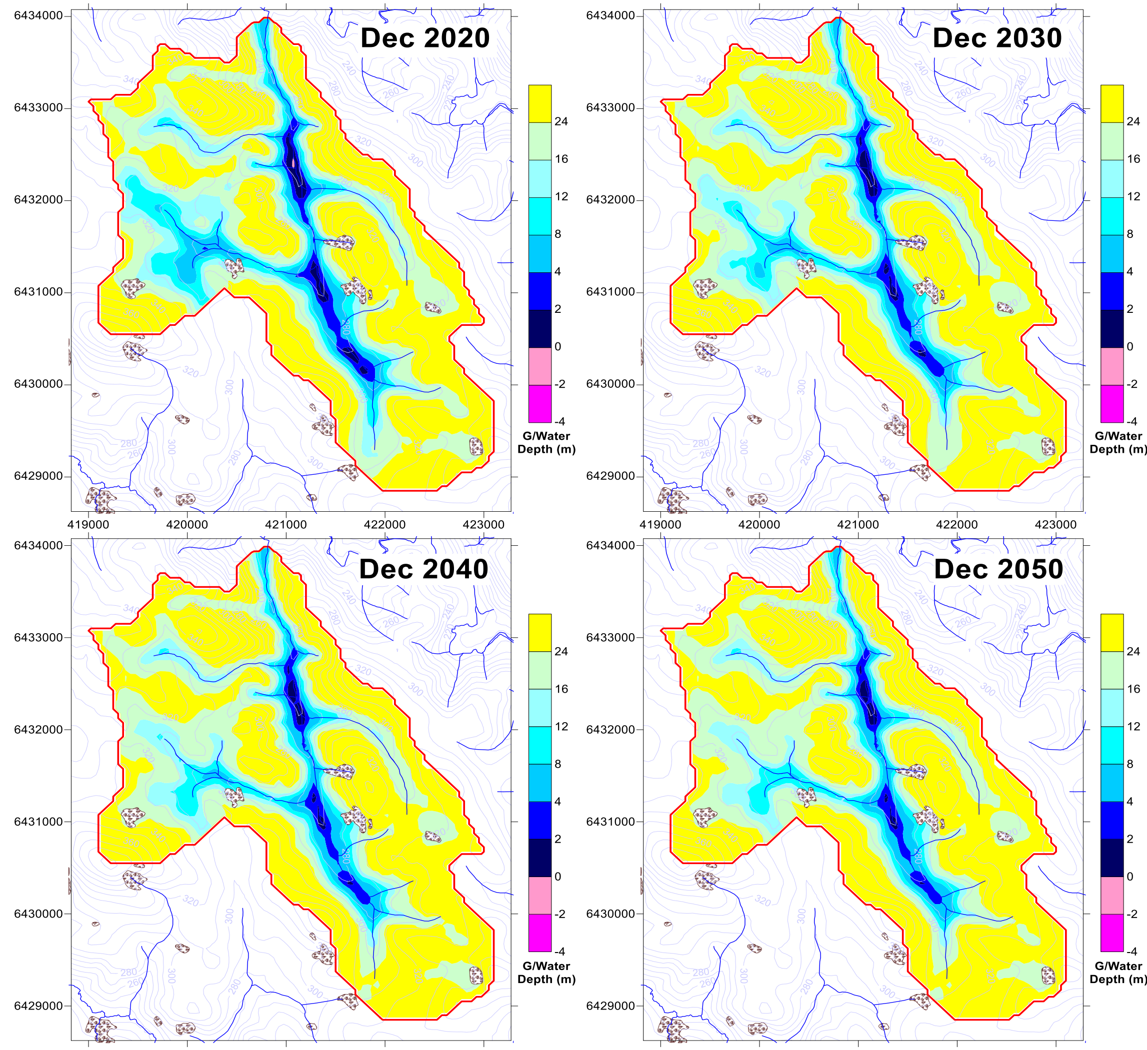
Groundwater modelling (WEC-C) shows predicted future for ground water storage and stream flow, if 2001-2010 rainfall regime persists (Croton & Dalton 2010).




Croton JT *et al.* 2014, Forest and Ecosystem Management Division, Technical Report No. 9. DPaW, WA.

# ‘Hydroscape’ - Future unmined simulation

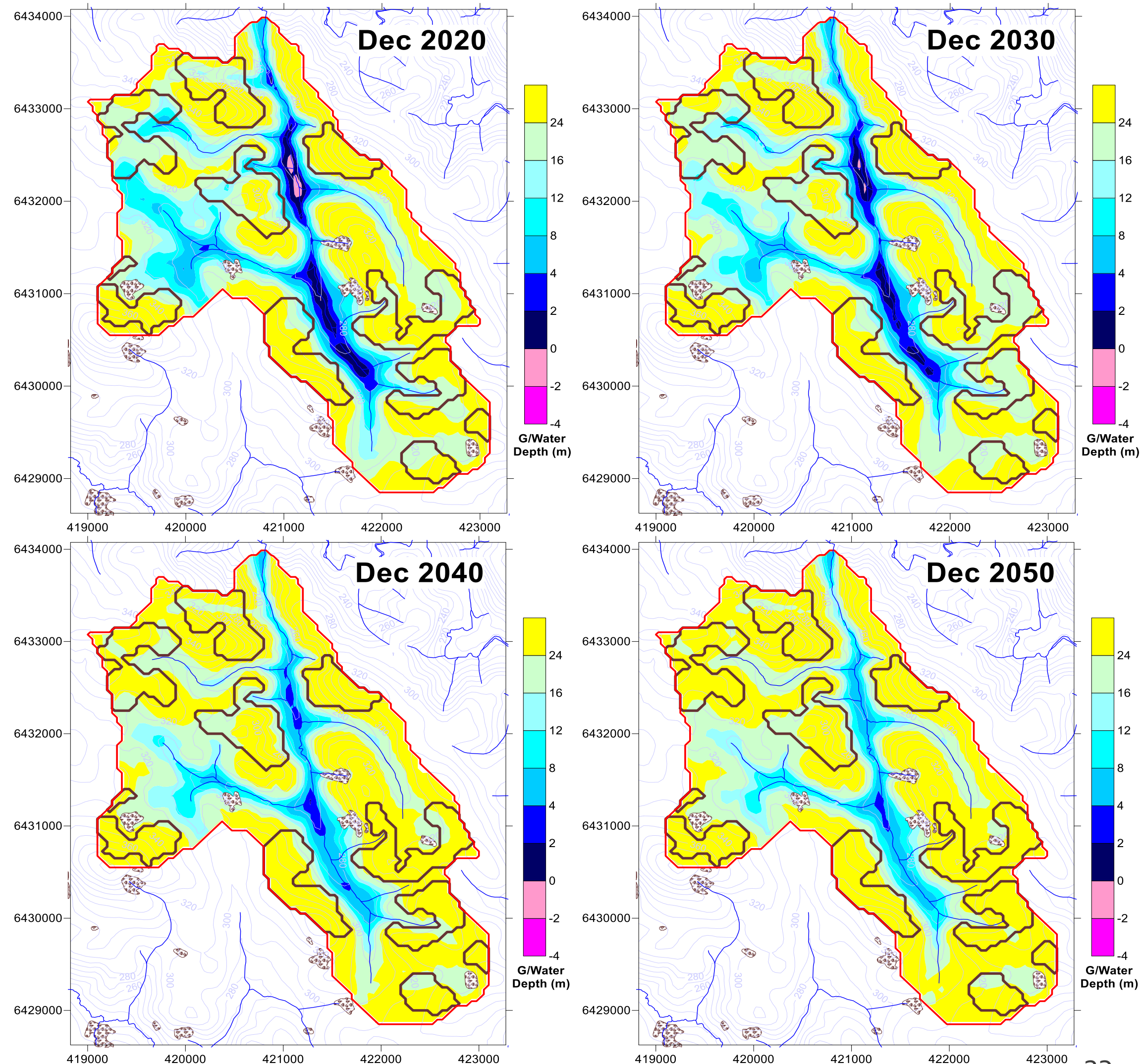
Groundwater modelling (WEC-C) of 31 Mile Brook showing predicted future for ground water storage and streamflow, if 2001-2010 rainfall regime persists (Croton & Dalton 2010).




Croton JT *et al.* 2014, Forest and Ecosystem Management Division, Technical Report No. 9. DPaW, WA.

# ‘Hydroscape’- Rehabilitation following bauxite mining with understory and trees at 1300 spha

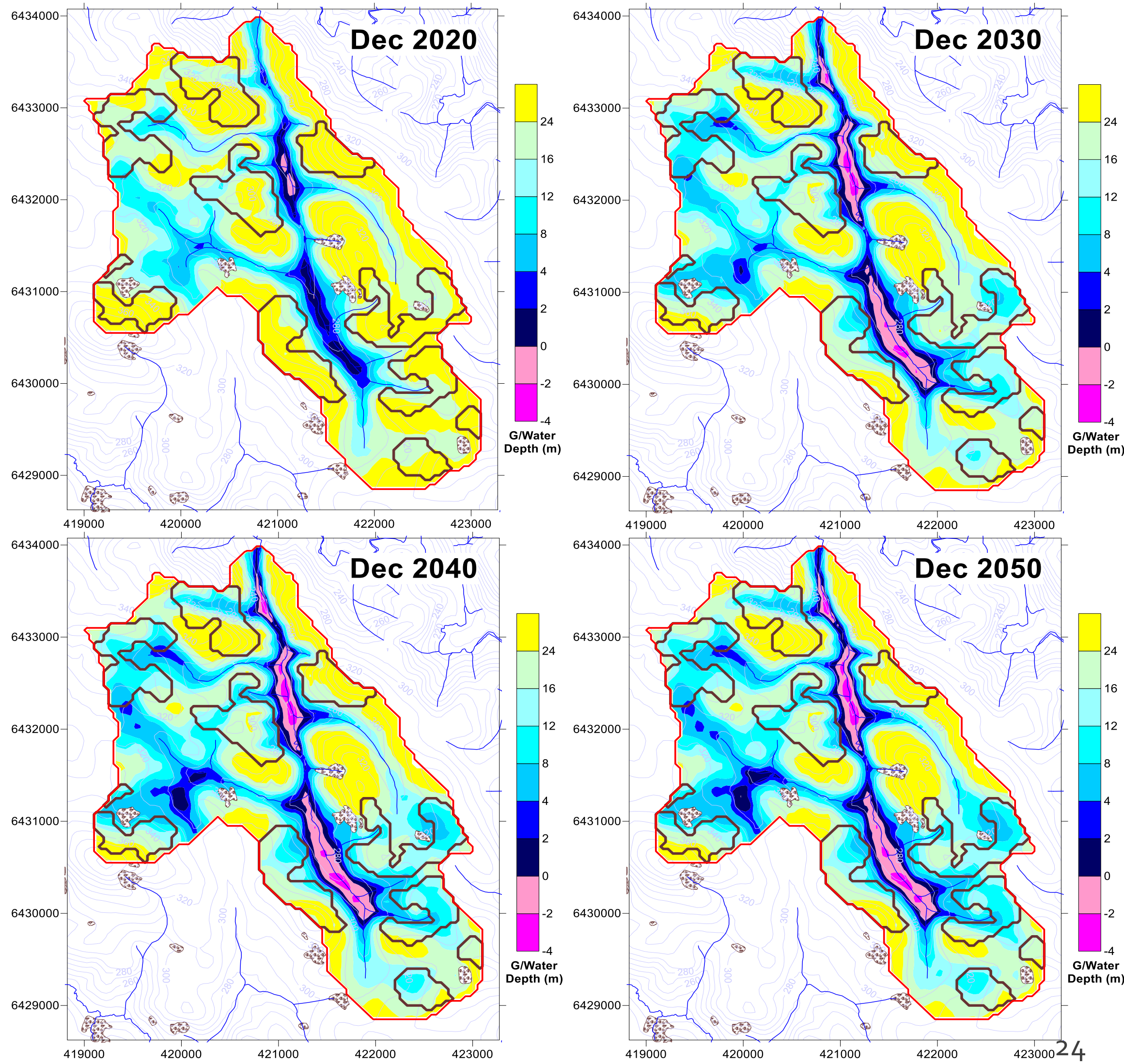
Groundwater modelling (WEC-C) of 31 Mile Brook showing predicted future for ground water storage and streamflow, if 2001-2010 rainfall regime persists (Croton & Dalton 2010).




Croton JT *et al.* 2014, Forest and Ecosystem Management Division, Technical Report No. 9. DPaW, WA.

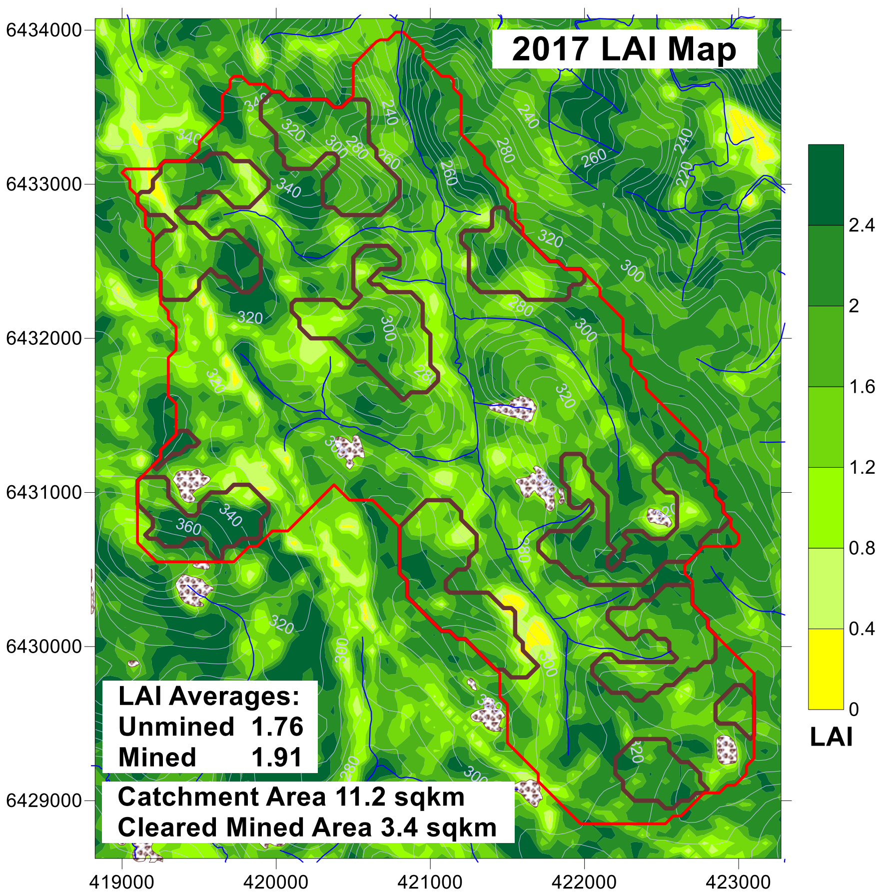
# ‘Hydroscape’- Rehabilitation following bauxite mining with understory only at LAI of 0.5

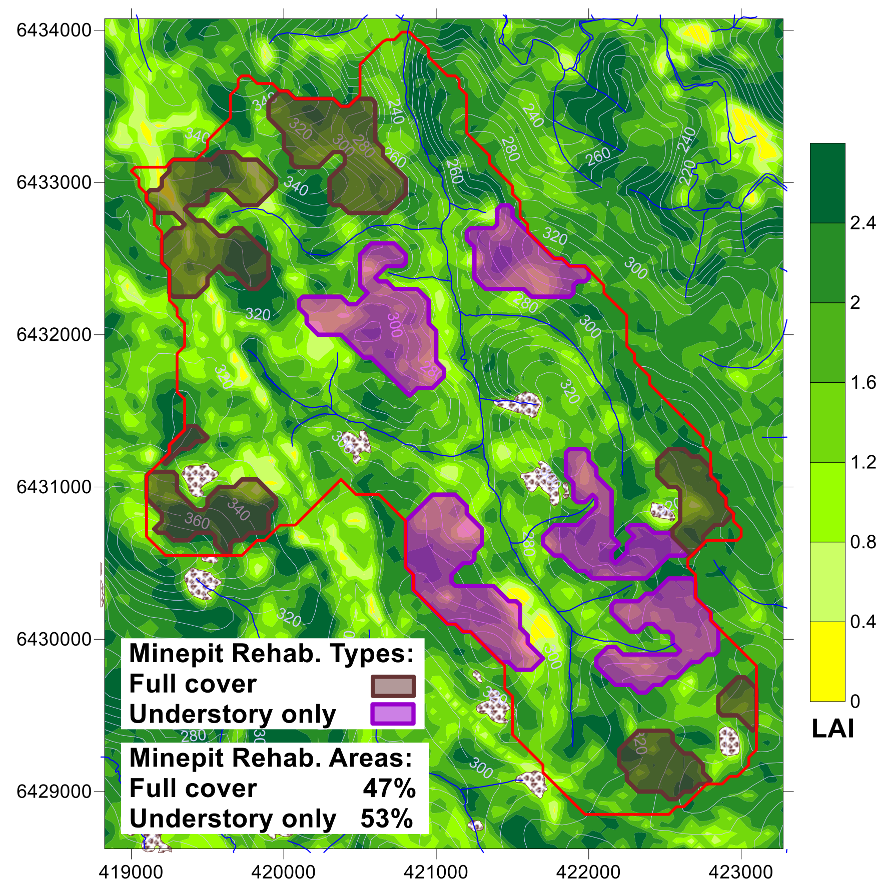
Groundwater modelling (WEC-C) of 31 Mile Brook showing predicted future for ground water storage and streamflow, if 2001-2010 rainfall regime persists (Croton & Dalton 2010).




Croton JT *et al.* 2014, Forest and Ecosystem Management Division, Technical Report No. 9. DPaW, WA.

# Combining Two Mine Revegetation Treatments



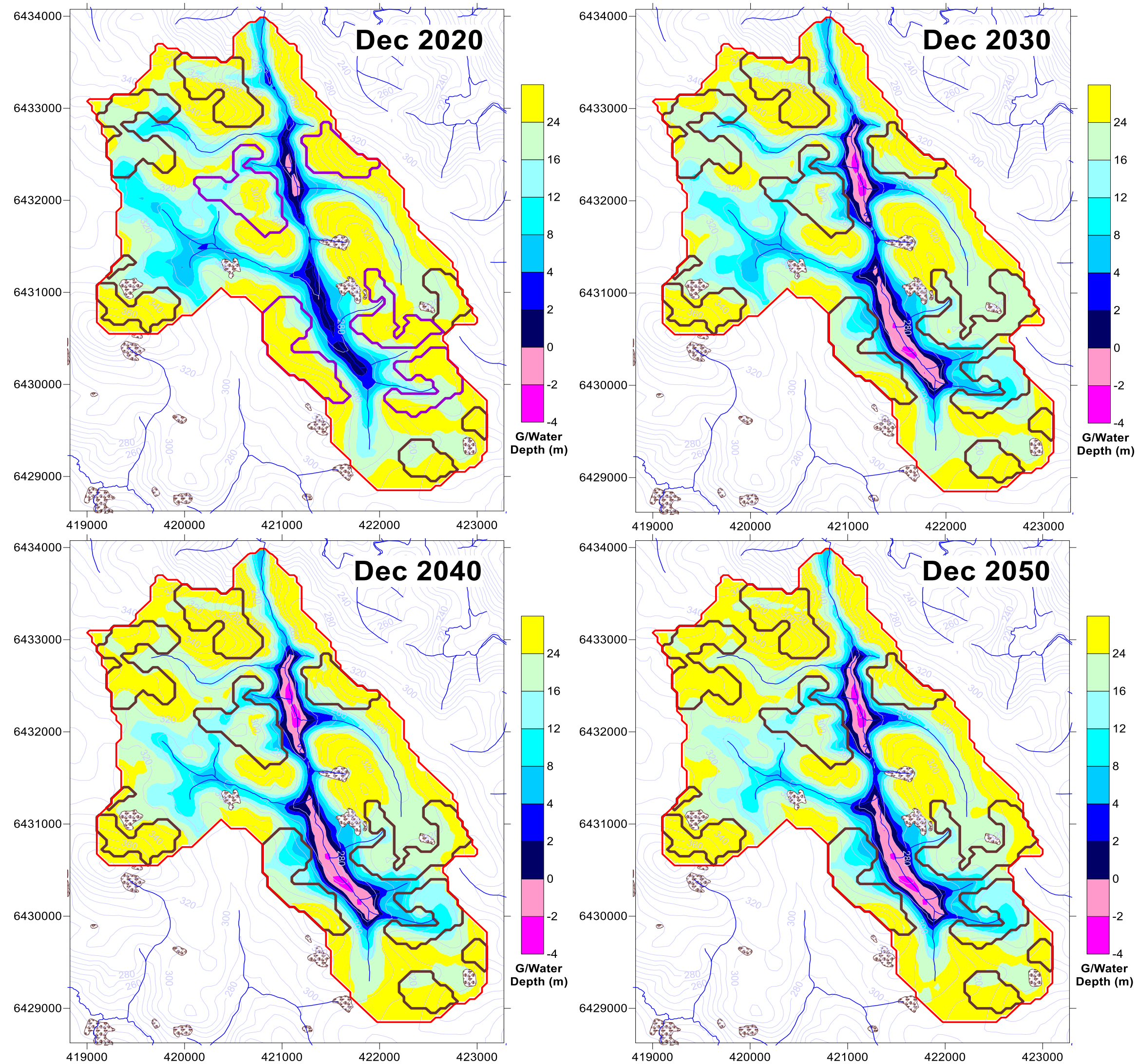




Croton JT *et al.* 2014, Forest and Ecosystem Management Division, Technical Report No. 9. DPaW, WA.

# Mixed rehabilitation following bauxite mining (hydroscape)

Revegetation to understory maintained at an LAI of 0.5 combined with trees at 1300 spha

Outcome similar to situation where all mine rehabilitation to an LAI of 0.5




Croton JT *et al.* 2014, Forest and Ecosystem Management Division, Technical Report No. 9. DPaW, WA.

# Integration of rehabilitation, restoration & veneration

- Reverence of increasingly non-renewable forest structure, and retained components of biodiversity
- Restoration of  degraded native forest
- Rehabilitation with climate-ready rehabilitation following bauxite mining.
- Treatment of previous overstocked rehabilitation
- Complex challenges under climate disruptive require novel solutions