Dendrobium Extension Project SSD 8194

Response of peatland ecosystems to longwall mining and fire

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Background

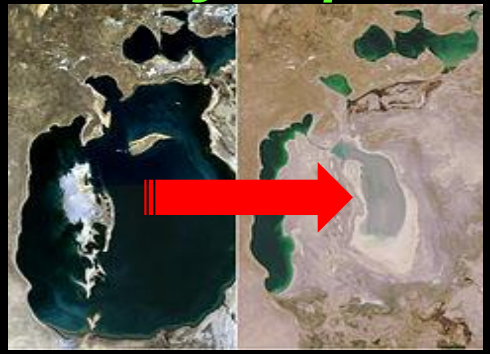
Research interests

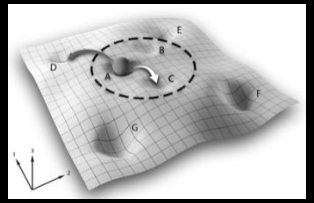
- Ecosystem dynamics & risk assessment
- Listing methods for threatened species and ecological communities (IUCN Red Lists)
- Long term ecological research in upland swamps (1980-present)

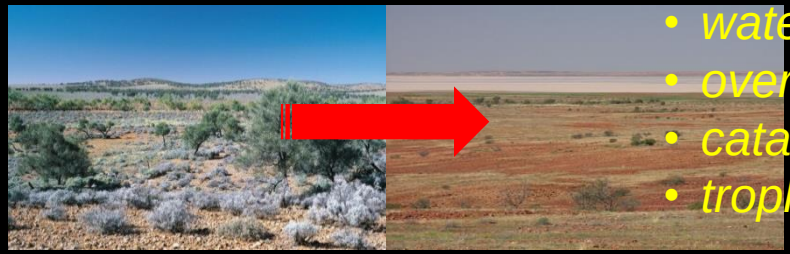
Research track record

- >200 peer-reviewed scientific publications
- 4 academic books on vegetation & ecosystems
- Multiple awards for scientific excellence
  - Aust Ecology Research Award 2014
  - Eureka Prize Env Science 2015
  - Clarke Medal Roy Soc NSW 2018
  - Premiers Prize Env Science 2019

Research program: *Mechanisms & symptoms of ecosystem collapse*







Varied drivers:

- *land clearing*
- *water extraction*
- *overfishing*
- *catastrophic events*
- *trophic disruption*

Ecosystem Collapse:

Understanding mechanisms is critical to ecosystem management & avoidance of collapse

Degradation
Fragmentation
Regime shift
Hysteresis
Extinction debt
Catastrophic disturbance
Trophic cascade
Landscape trap

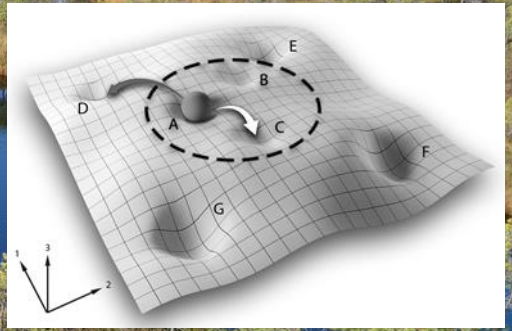
Ecosystem case study

Upland swamps

- *a **dynamic** peat-accumulating wetland ecosystem*

Why are they important?

- Unique biodiversity
- Ecosystem services
  - Sustained flow of high quality water
  - Carbon sequestration
- Endangered status
  - NSW & Cwth



<u>Ecosystem dynamics</u>

- Alternate states
- Mechanisms & conditions governing transitions
- State variables

Ecosystem case study – upland swamps

1 Wet climate
2 Flat terrain
3 Impermeable substrate

(Rainfall + Run-on) **>** (Evapotranspiration + Run-off + Percolation)

Waterlogging & sediment accumulation

Dense swamp vegetation & peat

Obstruction of water flow

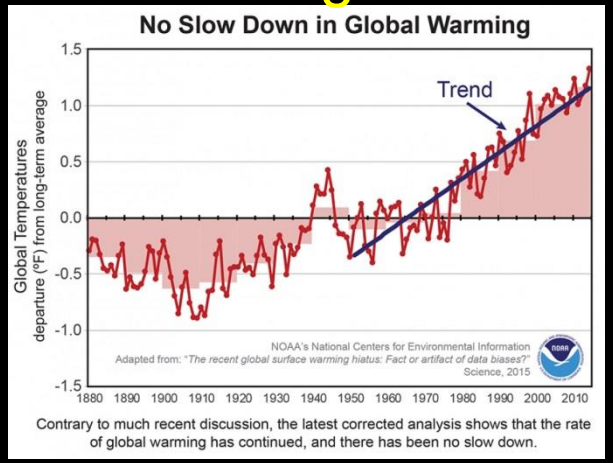
Positive feedback loop

Low permeability substrate

Other processes influencing ecosystem dynamics in upland swamps

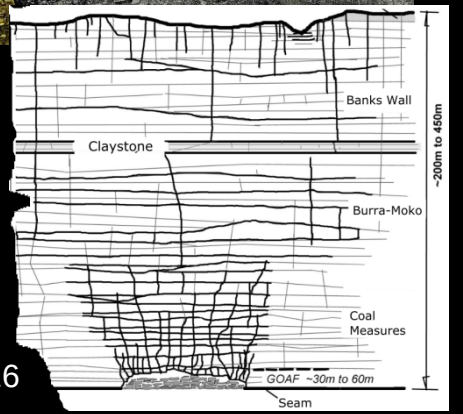
Fire regimes

Global climate change



Local hydrological change

Longwall mining



Pell Consulting 2016

How does longwall mining affect fire response of upland swamps?

Factorial experimental design:

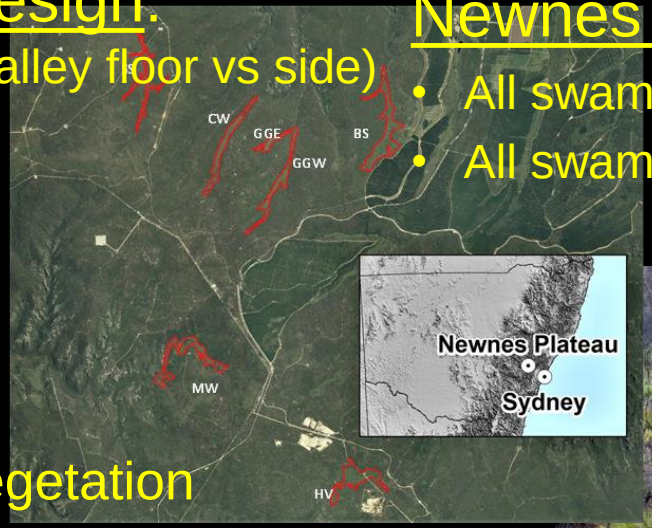
Mining treatment X Landform (valley floor vs side)

n = 4

Field measurements

(10 weeks after fire, Mar 2020)

- Fire severity (twig diam.)
- Peat consumption
- Structure of regenerating vegetation
- Biomass of regeneration
- Plant species richness
- Plant species composition*



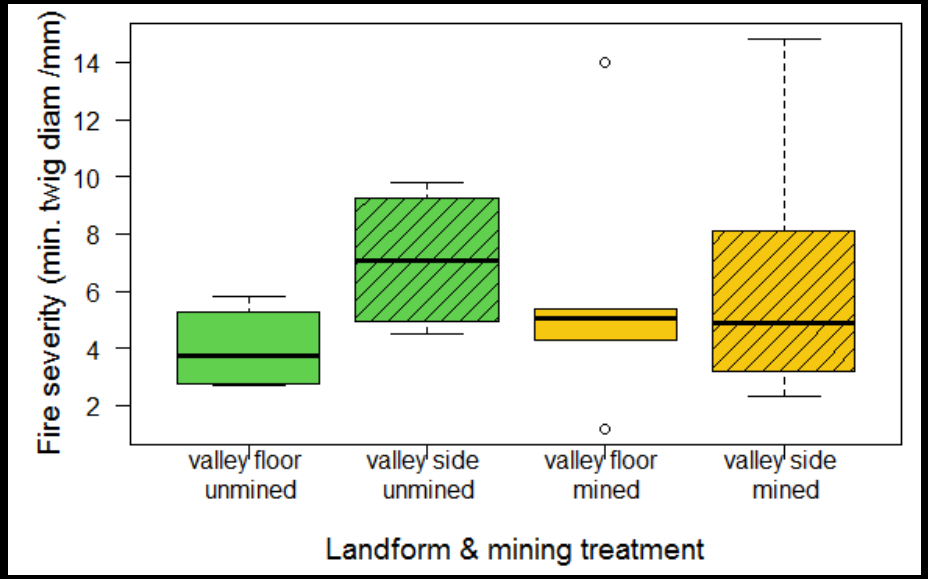
Newnes (Blue Mtns)

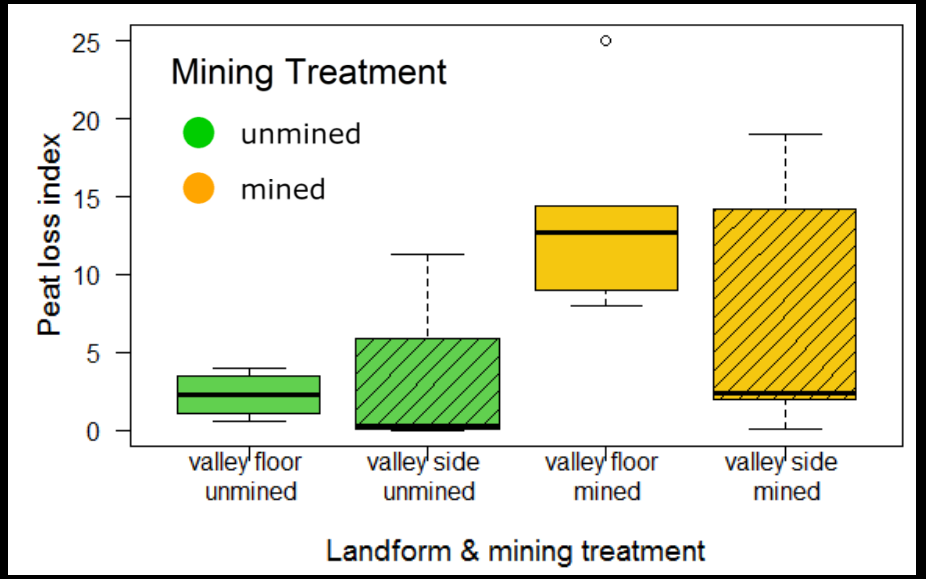
- All swamps burnt Dec 2019
- All swamps with similar climate

Data analyses

- Linear models
- Multivariate GLM & Global Non-metric multidimensional scaling*

Fire severity & peat consumption

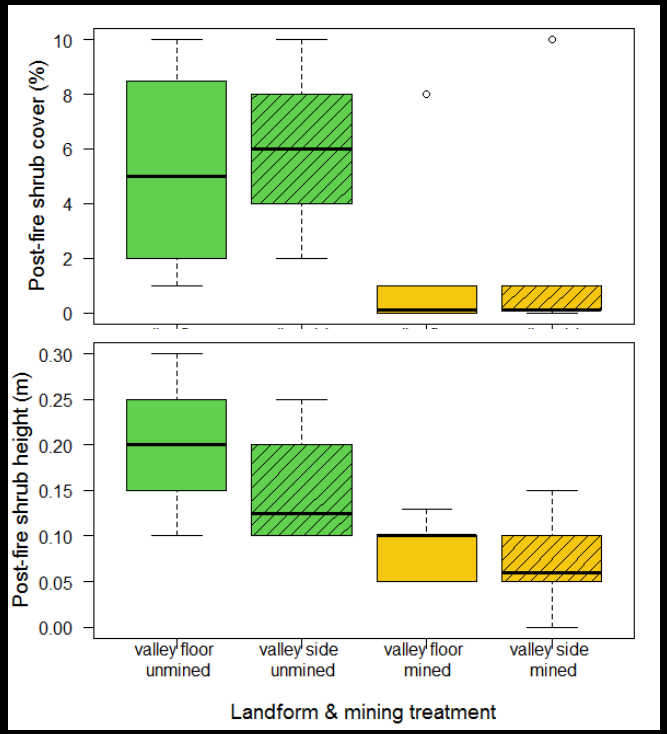


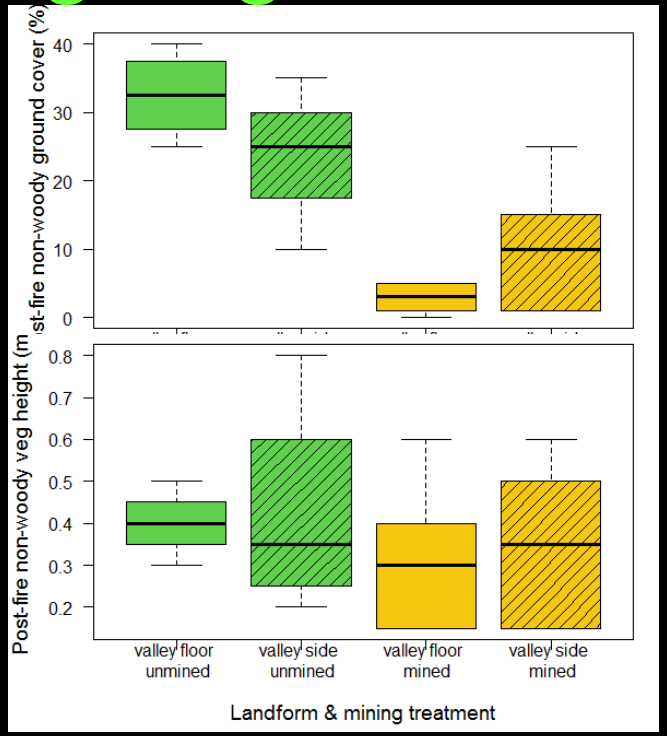


No difference in fire severity

Peat loss greater in mined swamps than unmined swamps

Structure of regenerating vegetation

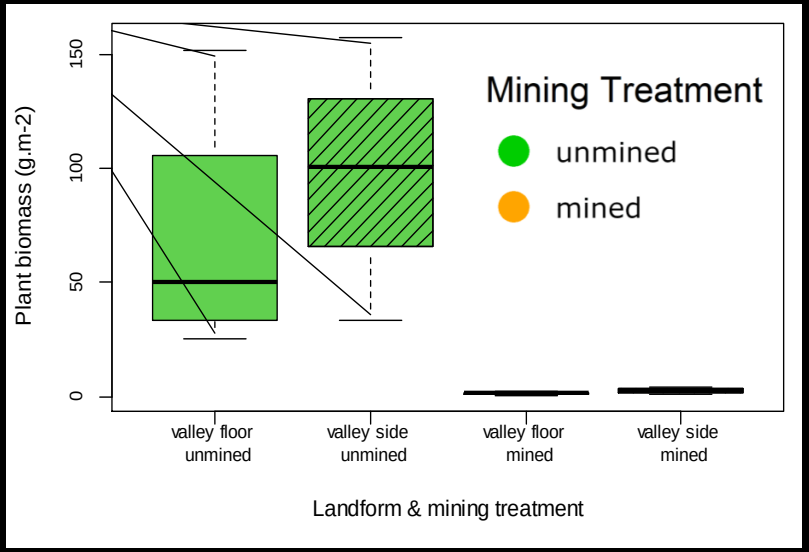




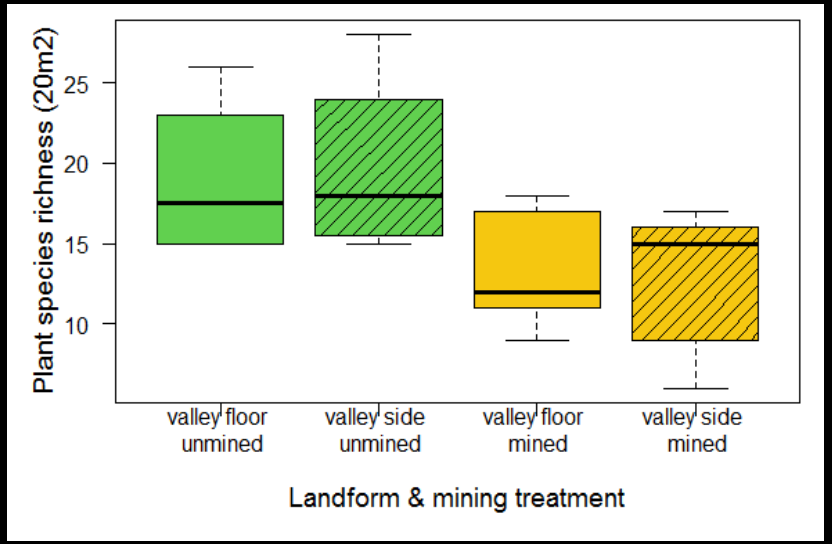
Shrubs shorter & sparser in mined than unmined swamps

Non-woody veg sparser in mined swamps than unmined

Plant species richness & biomass



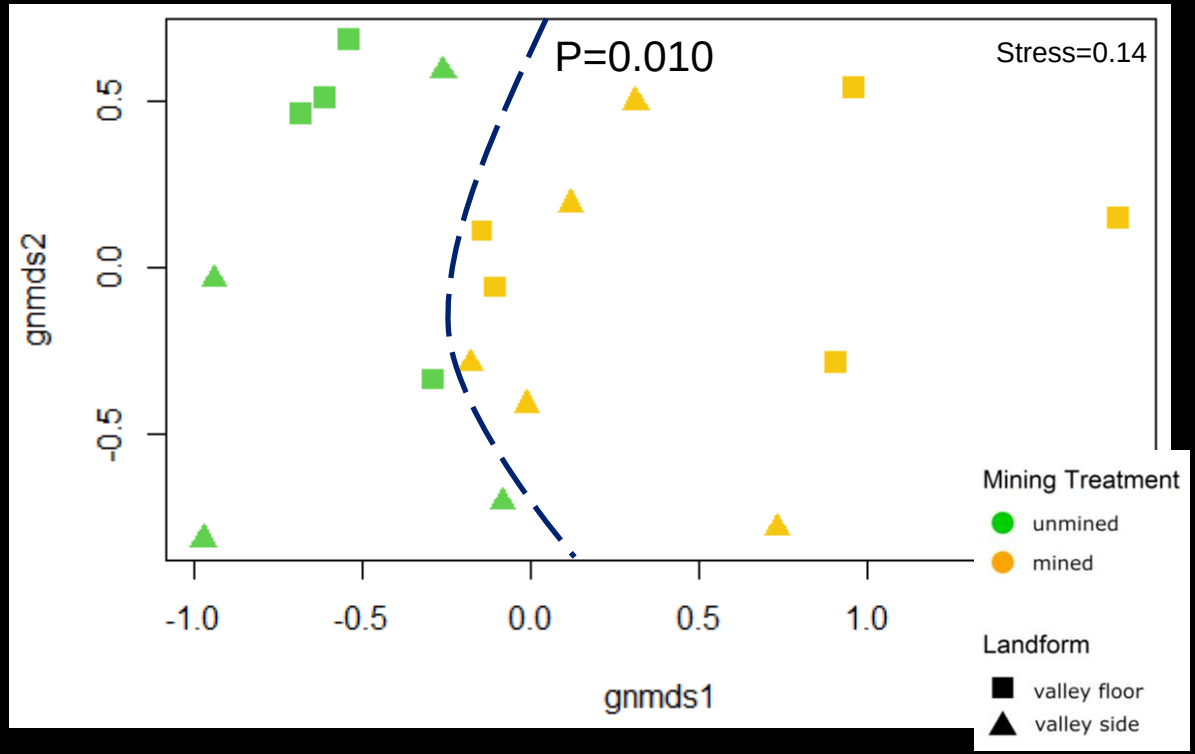
Less biomass regenerating in mined swamps than unmined swamps



Fewer plant species regenerating in mined than unmined swamps

Plant species composition

Different plant assemblages regenerating in mined & unmined swamps

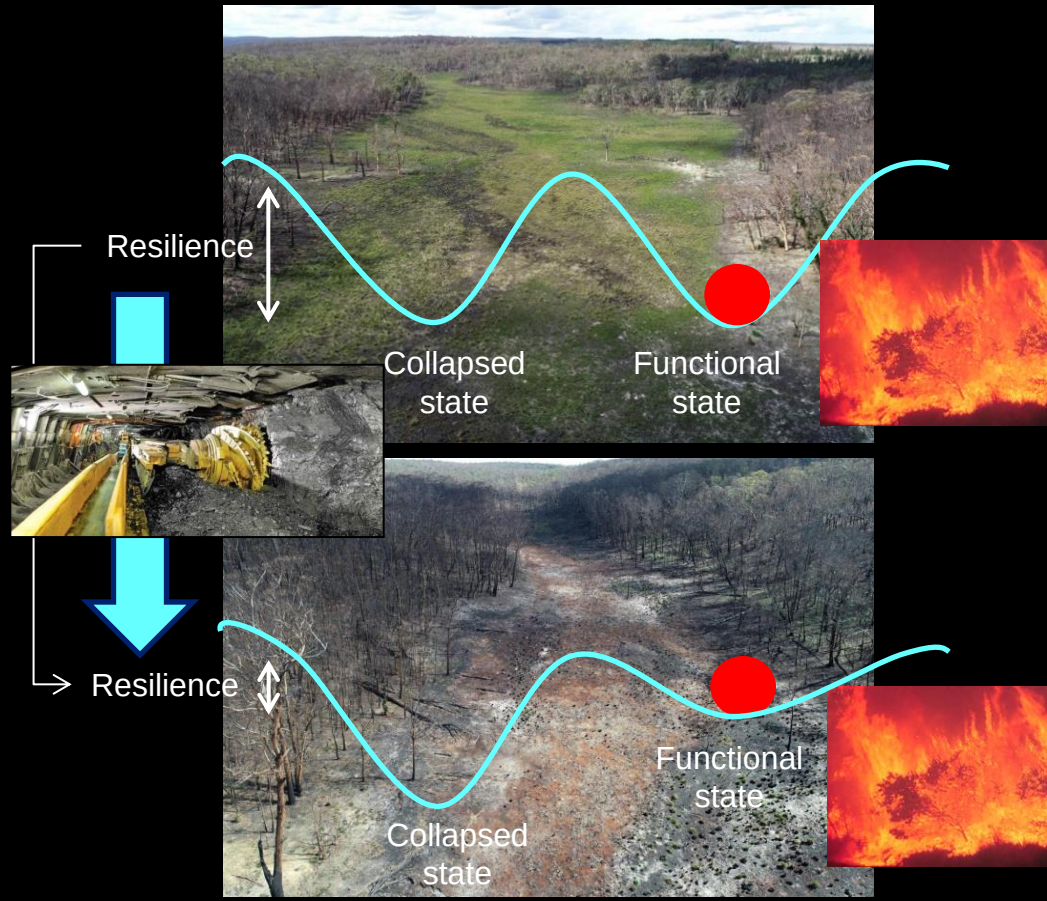


For all response variables:

No consistent differences between landforms

What happened?

- Unmined swamps resilient to fire - recovery underway
- Mined swamps collapsed
- Longwall mining weakened ecosystem resilience through hydrological change
- Combination of longwall mining & fire caused ecosystem collapse

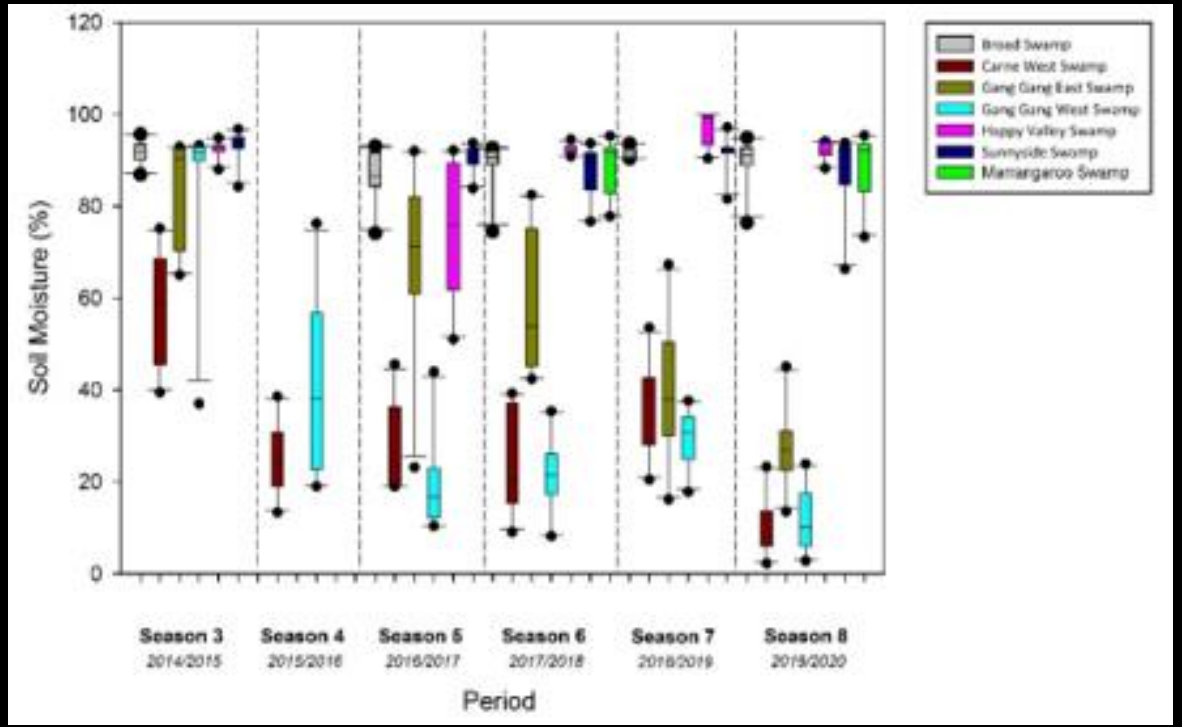


Evidence of cause-effect

Longwall mining ⟶ Hydrological change ⟶ Ecosystem collapse

Soil moisture declined to 20-30% of reference values in swamps within mining footprint 1-4 years before fire

- Initial symptoms (soil & vegetation drying)
- Increased risk of peat combustion



Unpubl. data: Gorissen & Krogh

Interactive effects of mining and fire

Undermined by longwall

Impacts of drying (cf. unmined reference swamps) appear to become larger as post-fire regeneration proceeds

11 months post-fire

Reference swamp (unmined)

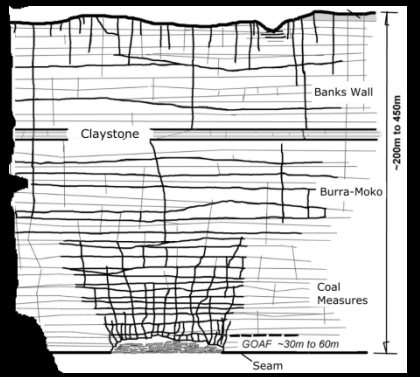
Consequences of ecosystem collapse

- Loss of biodiversity
  - Endangered Ecological Community
  - Loss of hydrological niche
  - Postfire shelter & food
- Loss of hydrological function
  - Regulation of stream flow
  - Regulation of water quality
- Loss of carbon storage
  - 805 $t.ha^{-1}$ (Cowley & Fryirs 2020)
- Loss of soil stability

What can be done about it?

Interactive mechanisms: *mitigate one threat by managing the other*

- Exclude fire from mined swamps, especially during drought
  - May delay collapse but cannot prevent it
- Stabilise swamp sediments (various methods)
  - May protect downstream aquatic systems but cannot restore swamp hydrology & biota
- Preventative planning
  - Implement mine designs that protect swamps
  - Options: exclusion zones, bord-pillar



Are similar responses to Newnes likely on Woronora plateau & Dendrobium?

Yes

- Similar drivers of ecosystem dynamics and function
  - Hydrology (climate, terrain, substrate)
  - Fire-prone
  - Similar vegetation but greater diversity
- Similar longwall extraction methods
  - wide panels