Vulnerable wetland ecosystem seeks sustainable relationship with plantation forestry

(Or...)

Hydro-ecological modelling of a perched wetland system in search of a sustainable forest planting fraction.

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Today covering the following:

• Introduce Fleurieu Peninsula wetlands
• Define the problem and questions
• Modelling approach
• Findings
Fleurieu swamps and wetlands

• Major ecological assets - critical remnant habitat:
  30% of 742 plant species of conservation significance
  Fleurieu Peninsula Swamp is an EPBC Listed TEC

• Three functional categories based on hydrogeology:
  Perched (local scale processes ~75% of all)
  Fractured rock (intermediate scale processes)
  Permian Sands (regional scale processes)
Hydro - ecological character

• Intact swamps typically present a structural mosaic with 3 vegetation strata

• Seasonal hydrology – winter spring dominated rainfall and streamflow

• Perched swamps feature only very shallow, seasonal inundation
Perched Fleurieu wetland
a priori conceptual model

Clay (weathered basement)

Fractured rock aquifer (fresh basement)
Questions

• How sensitive are perched wetlands to afforestation?

• How would ecological expression change with increasing planting fraction?

• Are major shifts in character predictable?

• Are state water allocation policies around the mark to protect perched systems?
Study approach

• Three small (~100 ha) low order perched wetland catchments under different landuse:
  pine forest; pasture; and native woodland

• Install hydrometric network at each (RF, SW, GW) plus vegetation and soil survey

• Built models of runoff response and predictive vegetation models
Modelling approach

• Construct rainfall runoff model, calibrating each land cover to observed data

• Incorporate a residual wetland storage (analogous to a farm dam)

• Lumped model, semi-distributed to create hypothetical catchment/wetland system

• Model wetland dynamics as a piecewise linear function of storage – based on two layer soil profile
Rainfall – runoff model construction

- Plantation fraction
- Pasture fraction
- Buffer (pasture)
- Wetland storage
- Catchment runoff
- Hydrological statistics

Transform to a depth to water using piecewise linear function

PFG probabilities

Post processing

Model node

Model output

Model domain
Modelling – vegetation

• Model wetland vegetation community at plant functional group level (Casanova and Brock 2000)

• Categorise species based on water availability preference

• Logistic regression used to match PFG probability to a given phreatic surface duration from observed data

• Probabilities or each PFG used as an objective community state variable for each water regime
Plant functional groups

Increasing depth ➔

Increasing duration ➔

Tdamp ➔ Tdry

Se ➔ Sk

Aftl ➔ Afrp, Afrf, Sr

Afte ➔ Aftw
Scenarios – based on state policy

• Varied planting fraction of pine
  12%, 30%, 50% 70% 100% of catchment, remainder pasture

• Varied buffer widths:
  10, 20, 50, 100 metres width (0.2 – 2.5 x wetland area)
Analysis

• Statistical summaries of runoff response and phreatic surface dynamics

• Estimates of plant functional group (PFG) probabilities of presence

• Community analysis of the resulting (arcsine transformed) PFG probabilities
Results - reviewed conceptual model

• Original model more or less supported

• Hydrology strongly influenced by the texture contrast soils

  1). Interstitial seepage through surface loams over the control layer

  2). Via preferential flow through cracks and macropores in sub-soils
Revised conceptual model
Results – catchment yield

- Most statistical measures exhibit inverse linear relationship with planting fraction

![Data Chart] (180, 160, 12, 10, Pasture, 12% pine, 30% pine, 50% pine, 70% pine, 100% pine, Native woodland)
Results – catchment yield continued

• Linear response often observed in forest vs grassland runoff comparative studies

• Reduction low compared with published values: (13mm/10% forest; lit: ~15 – >40 mm/10%)

• Absence of a clear threshold response raises the question of what is a sustainable yield reduction?

• What about wetland storage impacts?
Results – phreatic surface dynamics

![Graph showing the relationship between forest planting fraction and depth to water. The graph indicates a negative linear trend.]
Results – phreatic surface dynamics

Mean depth to water for month (m)

Month

Pasture
20B30
20B12
20B100
Native
Results – phreatic surface dynamics (continued)

• As with runoff, changes in wetland storage were inverse linear to planting fraction

• Again the question arises of ‘how much is too much’?

• What about buffers?
Results – Buffers

• Tended to have limited value for low planting fractions

• For fully planted catchments, major affects on catchment yield and wetland storage

• Runoff and phreatic surface durations were increased, with effects on PFG communities
For 100% forest 0 to 100 metre buffer:

- Median annual runoff + ~50%
- Mean depth to water + 0.1m

For 30% forest 20 to 100 metre buffer:

- Median annual runoff + ~5%
- Mean depth to water + 0.01m
Results – predicted vegetation communities

• All PFG models were monotonically increasing functions of duration

• Differences between planting fractions, but not for buffers (except 100% planted)

• Major split between pasture $\geq$ 30% and 100% forest (Tdry – terrestrial plants)

• Minor split between intermediate plantings and low plantings ($\leq$30%; Afrp, SE)
Plant functional group ‘communities’

Partially cleared scenarios

Fully forested scenarios

Height

pasture 20B12 20B30 20B50 20B70 0B100 20B100 Native 50B100 100B100
Answers to questions posed

*How sensitive are perched wetlands to afforestation?*

- Below 30% planting, reasonably robust with some caveats
  - Functional groups contain variability – some risk
  - Minimise shared boundary to avoid local effects
Answers to questions posed

*How would ecological expression change with increasing planting fraction?*

- Low suitability for high water requirement functional groups
  
  Afrp (and SE) high risk at > 30% planting fraction
  
  At 30% high water requirement *species* may be at risk
  
  12% planting fraction unlikely to make a detectable difference

- Increments in planting fraction would express as shifts in relative abundance of PFG
Answers to questions posed

Are shifts in ecological character predictable?

• Some thresholds suggested but generality of the findings need caution

• Terrestrial species likely able to colonise wetland at 100% planting – manage with buffers
Answers to questions posed

*Are state policies adequate to protect perched systems?*

- Probably - 30% planting fraction seems OK, and a 20m buffer appears adequate – local effects need further investigation

- Results are not guaranteed to be applicable where catchment:wetland ratios differ
Conclusions

• Forest and perched wetlands can coexist sustainably

• Probability of changes to vegetation community increase with planting fractions greater than ~ 12%

• A 30% planting with buffer unlikely to change ecological character, but some cautions

• Plant functional group modelling provides a clearer picture of a suitable development threshold