VEGETATION RESPONSE TO WATERING REGIME IN ASUTRALIAN DRYLAND WETLANDS: RESILIENCE AND THRESHOLDS

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1. What are the main drivers of vegetation succession in dryland wetlands?

In dryland wetlands of Australia, vegetation species have critical frequencies of inundation of several years and they are very persistent. Some species can maintain a seedbank for years and others can recover after many years without flooding due to rhizome banks in the soil. This means that vegetation successions can be delayed or not even occur even when watering requirements are not met.

Successions also depend on previous history and surrounding vegetation groups that are able to colonize. Forests and woodlands are more resilient to long periods without flooding, but they do require to be healthy in order to produce seeds which means that after a dry period a sequence of floods is required for regeneration.

These flow-vegetation interactions creates a grouped or mosaic-like vegetation distribution as mapped in real sites instead of a gradient like distribution of vegetation.

2. Study site

Our study site is the northern-most area of the Macquarie Marshes. This freshwater wetland system is located in the lowland floodplain of the Macquarie River in semiarid Australia.

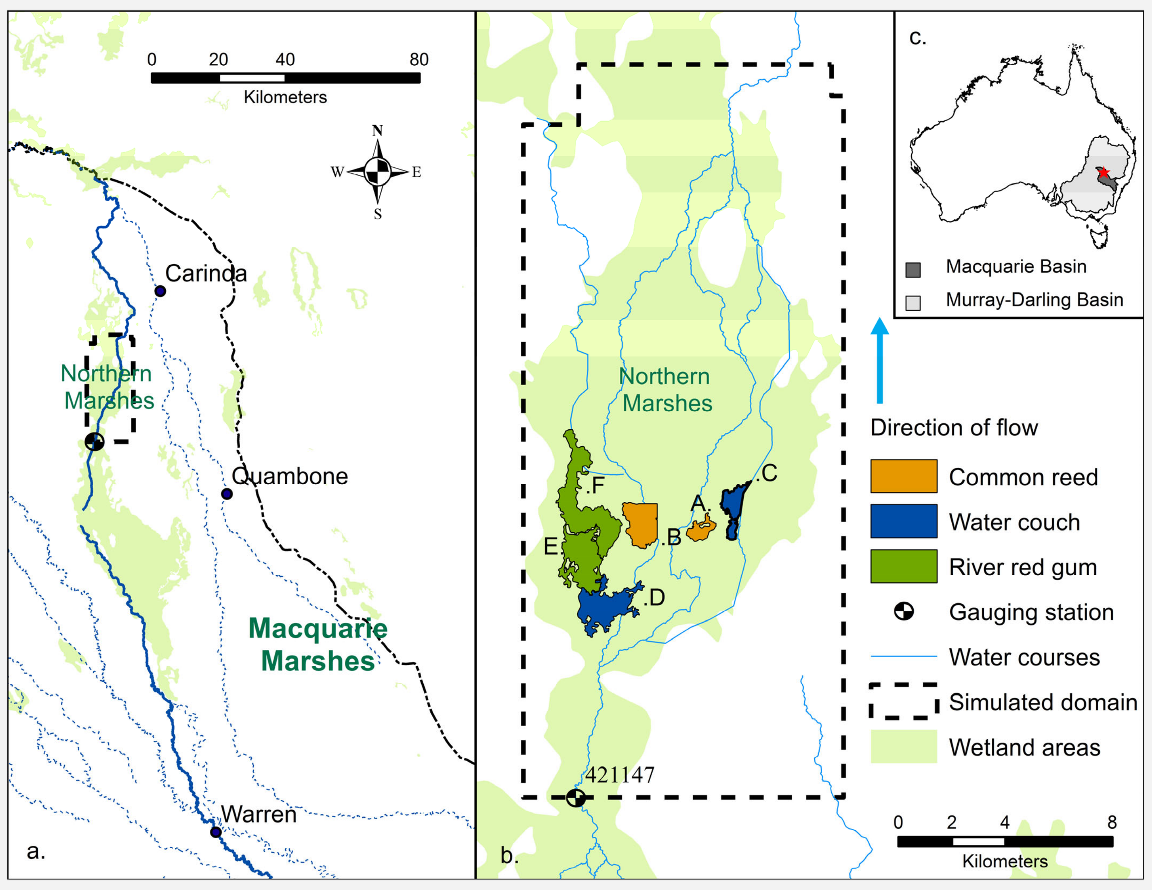

Figure 1. a.) Location of the northern Macquarie Marshes, b.) vegetation patches analysed, c.) general location of the study site.

3. Shifts in vegetation

Vegetation of the northern Macquarie Marshes is divided in 6 associations.

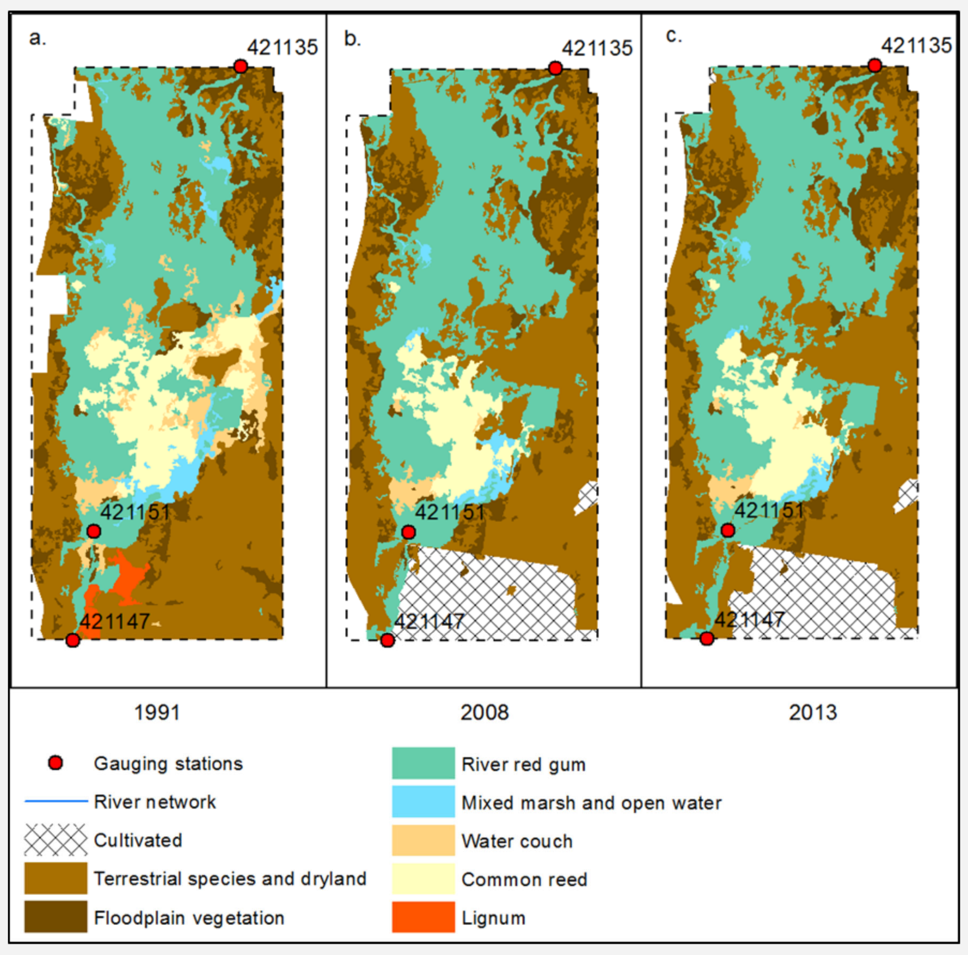

Figure 2. Wetland vegetation understory has suffered successions to terrestrial vegetation due to a severe drought period in the 1990's and 2000's.

4. Simulation approach

The final goal of our analysis is to achieve predictions of the vegetation evolution on dryland wetland systems. This is accomplished by combining hydrodynamic simulations and thresholds that describe vegetation succession. Feedbacks from vegetation change are looped in the hydraulic model.

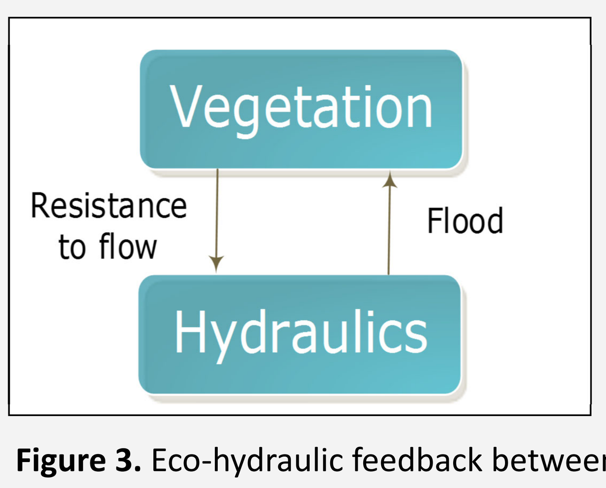

Figure 3. Eco-hydraulic feedback between vegetation, topography and water flow

6. Methods

6.1. Hydrodynamic simulations

We have calibrated a quasi-2D hydrodynamic model of the northern Macquarie Marshes. This model solves simplified versions of the Saint Venant shallow flow equations (Riccardi 2000). Model shows a very good performance as evidenced by performance indicators.

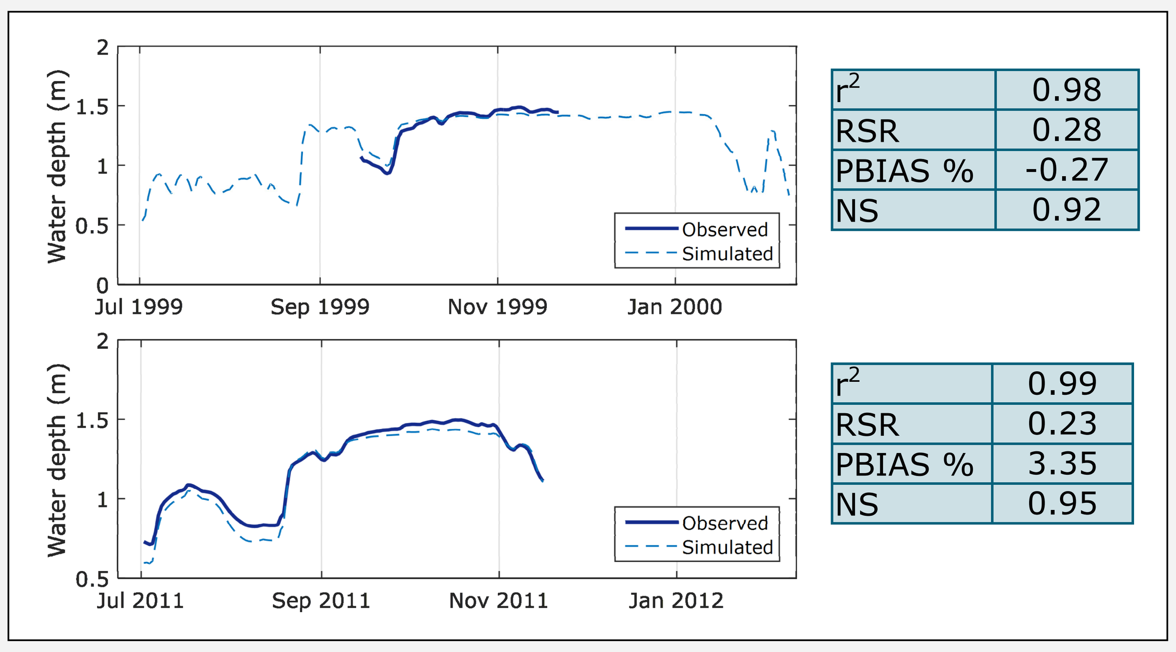

Figure 4. Simulated and observed water depth series for two events used in calibration.

6.2. Water requirements of vegetation species

The site managers recommend a minimum of 3 month for vegetation maintenance.

Plant Association	Percent exceedance time	Depth of water
Water couch association	33% < E < 67%	0.02 < D < 0.6
Common reeds association	67% < E < 67%	0.02 < D < 0.5
River red gum	25% < E < 50%	0.02 < D < 0.5

Table 1. Theoretical requirements for different vegetation associations.

6.3. Vegetation patch selection

Six vegetation patches were selected to analyse the hydraulic thresholds that lead to vegetation succession under drought conditions.

Table 2. Selected vegetation patches.

Patch	Vegetation on 1991	Vegetation on 2008	Vegetation on 2013	Changes	Conditions
A	Common reed	Terrestrial	Common reed	Transitional	- Transition back to wetland understory by 2013
B	Common reed	Common reed	Common reed	Non-transitional	- Good condition in 2008 and 2013
C	Water couch	Terrestrial	Terrestrial	Transitional	- Complete transition
D	Water couch	Water couch	Water couch	Non transitional	- Some chenopod invasion in 2008 and 2013
E	River red gum	River red gum	River red gum	Non-transitional	- 80% dead trees - Chenopod shrubland invasion in 2008
F	River red gum	River red gum	River red gum	Non-transitional	- <10% dead trees - Healthy mixed marsh understory during the whole period

6.4. Fractional seasonal coverage

Seasonal vegetation cover maps suggest the time of vegetation succession as the wetland vegetation responds quickly to flood.

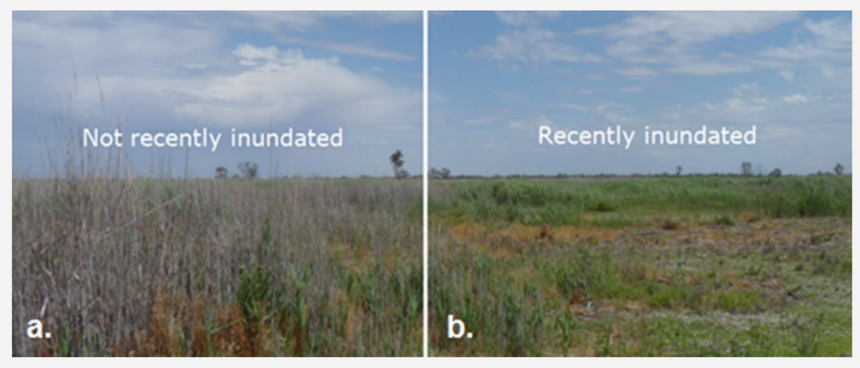

Figure 5. Comparison of recently and non-recently inundated reed bed in 2015.

7. Results

7.1. Thresholds determining vegetation changes

Fractional green vegetation coverage provides indication of when the wetland vegetation undergoes succession. Succession most likely occurred during the peak of the drought (2001-2009) Similar results were observed for Water Couch and River Red Gum.

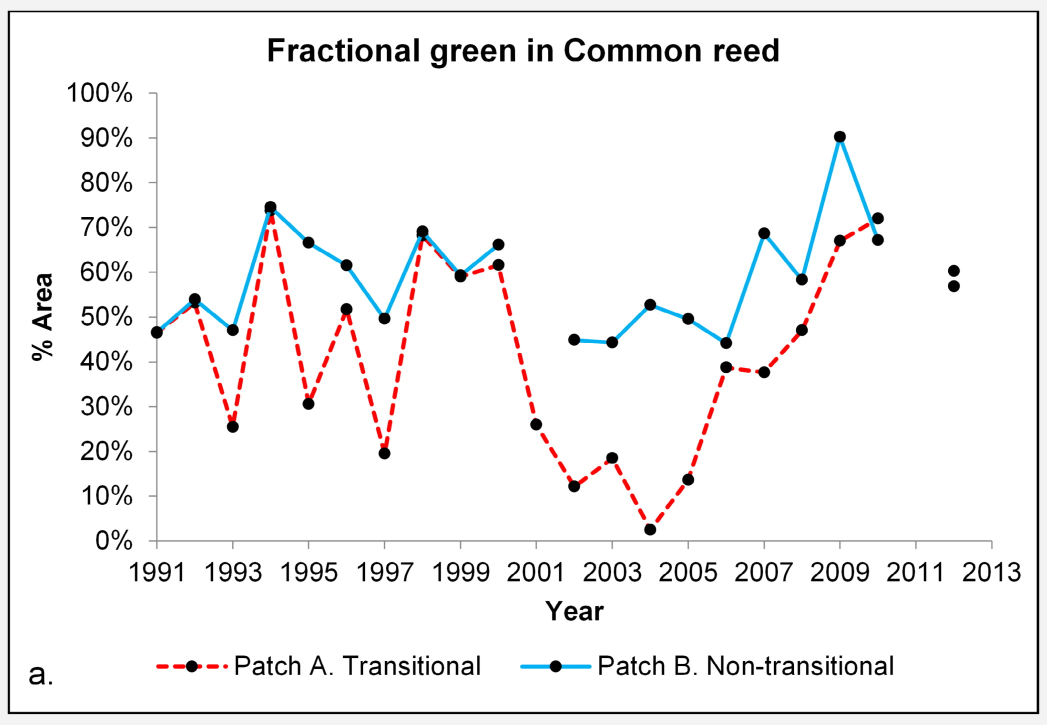

Figure 6. Green vegetation coverage for transitional and non-transitional Common Reed patches.

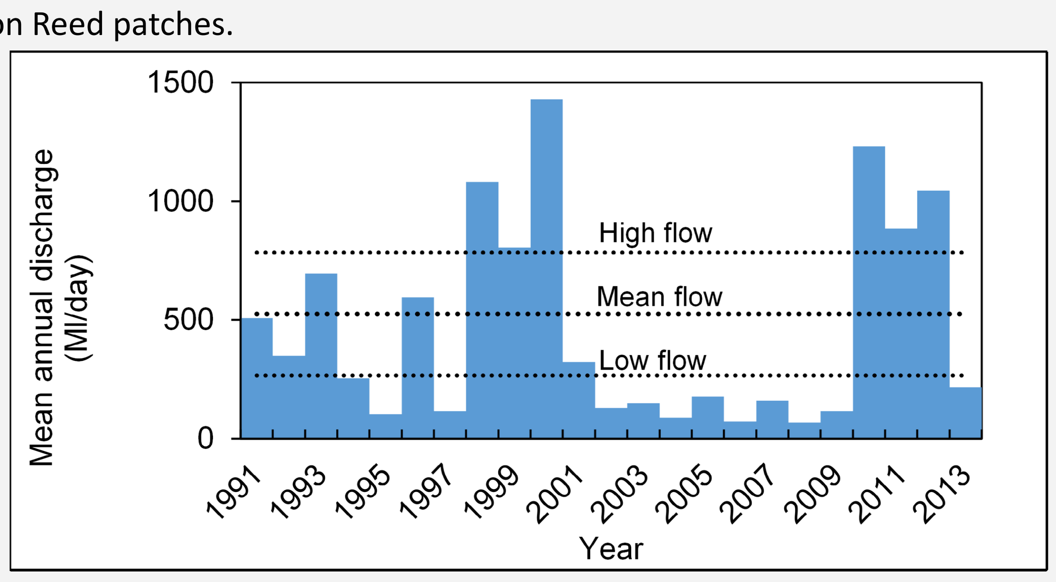

Figure 7. Average annual discharge entering the northern Macquarie Marshes between 1991-2013

Thresholds of possible vegetation changes can be found by combining the percentage of the patch with adequate watering conditions and seasonal coverage.

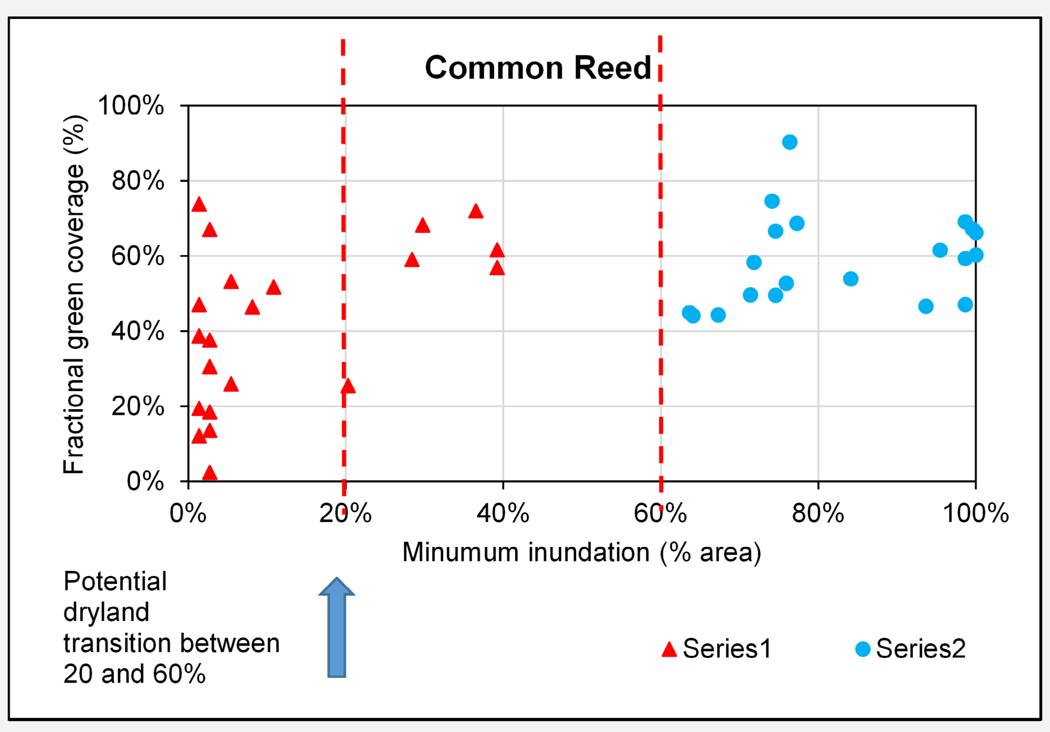

Figure 8. Threshold for potential transition of Common Reed beds.

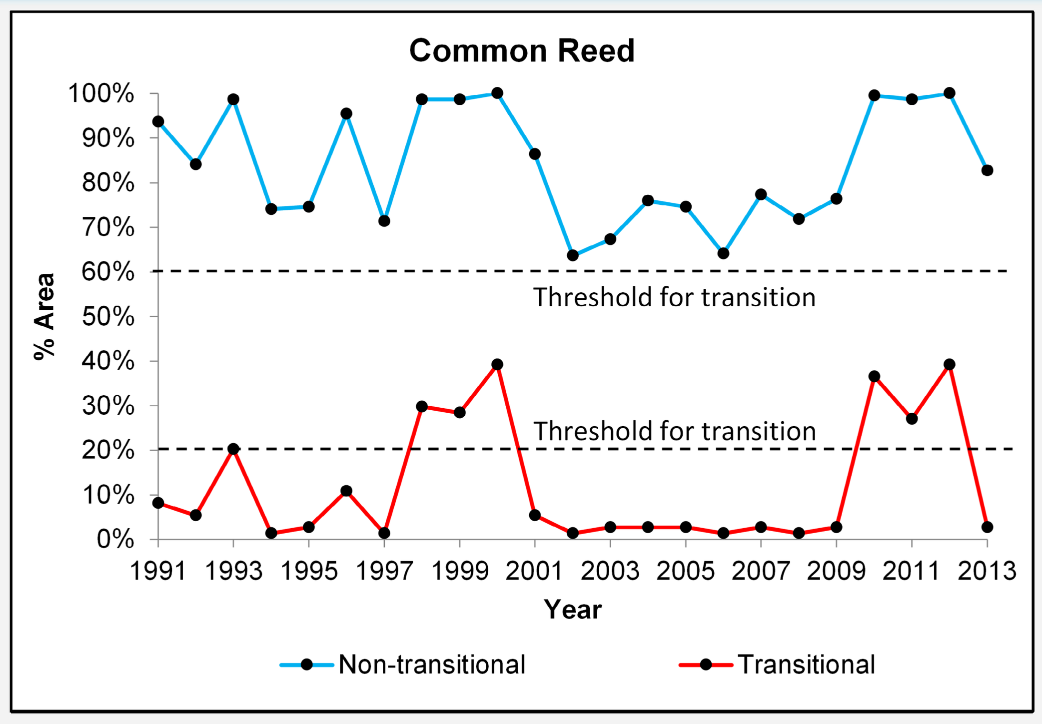

Figure 9. Percent areas with adequate water conditions in Common Patches.

8. Applications and future work

Recent work has extended the analysis to other areas of the wetland. We have combined continuous hydrodynamic modelling to recreate the distribution of Common Reeds and Water Couch during the period from 1991 to 2015. Figure 9 shows a comparison of the vegetation extent observed in 1991, 2008 and 2013 the simulation. Further improvements can lead to the analysis and evaluation of water sharing plans or applications in other dryland wetland systems.

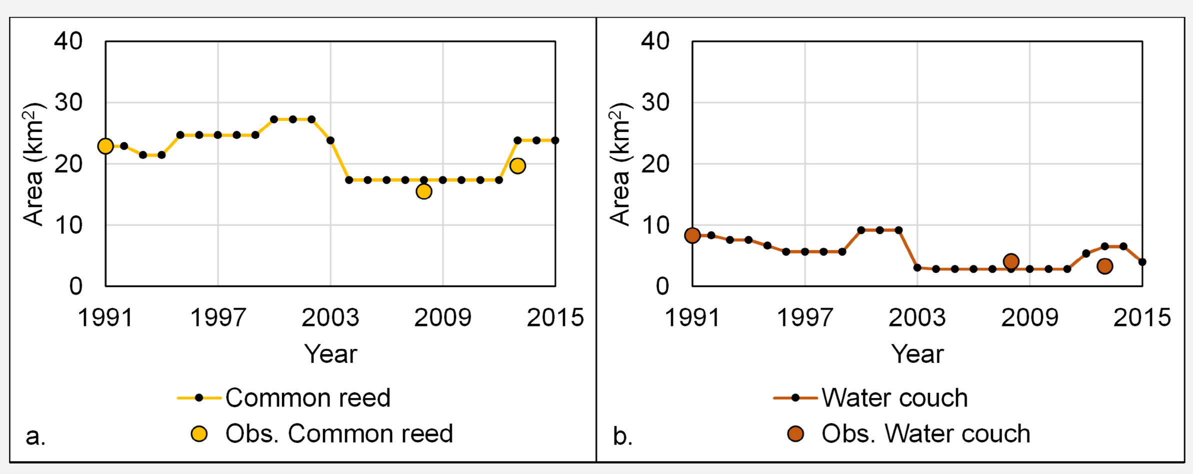

Figure 10. Vegetation extent series of a.) Common Reed and b.) Water Couch.

9. References

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