

# **Wetland wildfire: seedbank response to different watering regimes**

Vincent, B<sup>1</sup>, Southwell, M<sup>2</sup>, Growns, I<sup>3</sup>, Lewis, Z<sup>4</sup>

1 University of New England, Armidale, NSW, Australia. Email: [ben.vincent@une.edu.au](mailto:ben.vincent@une.edu.au)

2. University of New England, Armidale, NSW, Australia. Email: [mark.southwell@une.edu.au](mailto:mark.southwell@une.edu.au)

3. University of New England, Armidale, NSW, Australia. Email: [ivor.growns@une.edu.au](mailto:ivor.growns@une.edu.au)

4. University of New England, Armidale, NSW, Australia. Email: [zac.lewis@une.edu.au](mailto:zac.lewis@une.edu.au)

## **Key Points**

- No fire effect on mean species richness or abundance
- Fire influenced community composition in typha and coolabah woodlands
- Inundation regime influenced community composition across all wetland vegetation communities
- Findings suggest that providing a range of inundation conditions post fire may enhance wetland vegetation seedbank response.

## **Abstract**

Floodplain wetlands are extremely productive ecosystems that often contain high vegetative cover which can be highly susceptible to wildfire. Inundation plays a central role in shaping wetland structure and can influence the recovery of wetland vegetation following fire. In systems where flows can be delivered to assist in wetland recovery post fire, knowledge of the effect of fire and inundation regimes on seedbank germination rates becomes important for their management. In September 2019 a wildfire burnt 1600ha of the Gwydir Wetlands in northern NSW. We collected burnt and unburnt wetland soil samples from three wetland vegetation communities: Typha rushland, water couch – spike rush – tussock rush meadow, and coolabah wetland woodland, and undertook a glasshouse experiment to assess the effect of fire and follow up inundation on seedbank germination. We found no effect of fire or inundation regime on mean species richness or abundance within mesocosms. However, community composition was influenced by fire in both typha and coolabah open woodlands and by inundation in all three vegetation communities studied. While species responses to fire and inundation were at times inconsistent between vegetation communities our study indicates that both fire and the inundation regime employed following fire can influence wetland vegetation community structure.

## **Keywords**

Wetland fire; wetland seedbank; wetland inundation following wildfire; vegetation recovery

## **Introduction**

Inland floodplain wetlands are extremely dynamic ecosystems where their hydrology or inundation regime plays a central role in shaping their structure and function (Colloff and Baldwin 2010). Other disturbances such as fire, grazing and land clearing place additional stressors to these ecosystems, in particular on the composition and structure of wetland vegetation communities (Wilson et al., 2009; Bixby et al., 2015). Following disturbance events, recovery of wetland vegetation communities is heavily influenced by the prevailing climatic conditions and the resultant inundation regime (Colloff and Baldwin 2010).

Floodplain wetlands are productive and as such often contain high to very high vegetative cover, which during dry periods can be highly susceptible to fire (Lugo 2015). Despite this, the effect of fire on wetland vegetation is not well understood (Kotze 2013; Bixby et al., 2015). Recovery of wetland vegetation following fire can be

## Full Paper

### Vincent et.al. – Wetland seedbank response to fire and inundation

influenced by many factors including; the amount of vegetative cover present, the type (wildfire or management burn) and severity of the fire, the antecedent moisture conditions of the wetland, and the inundation regime post fire (NSW DPI 2009). In systems where managed river flows can be used to provide inundation to assist in wetland recovery post fire, knowledge of the influence of different watering regimes becomes important for their management.

The Gwydir Wetlands are a biodiverse, highly fertile inland floodplain wetland complex located west of Moree in northern central NSW (Wilson et al., 2009). The wetlands are not only internationally recognised under the Ramsar Convention for their importance in supporting migratory and endangered wetland bird species, they also support substantial areas of floodplain and wetland vegetation communities that are poorly conserved in NSW (Wilson et al., 2009; Bowen and Simpson, 2010). In September 2019, a wildfire burnt around 1,600 ha of the wetlands, primarily within the Gwydir Wetlands State Conservation Area (SCA) (Figure 1). This included areas of 'core wetland' dominated by water couch (*Paspalum distichum*) meadows and vast stands of typha (*Typha orientalis*). Some fringing Coolabah woodland was also burnt. Fire severity ranged from high to low throughout the fire ground (DoPIE 2019) with available post-fire mapping too coarse to determine exact severity at the plot scale.



**Figure 1. Top: The Gingham fire burning through wetland vegetation. Bottom: water couch – spike rush – tussock rush before (left) and after fire (right) (photos courtesy of Dave Preston, DoPIE).**

One post fire management consideration was whether to provide regulated water for the environment to the wetlands to promote vegetation recovery. These were not delivered due to concerns around the development of poor wetland water quality, though it was recognised that more site relevant data is needed to inform future management responses to fire within the wetlands. In addition, there is pressure for the wetland managers to undertake control burns within the Gwydir wetlands SCA to manage fuel loads. Improved understanding of the effects of fire timing, intensity and influence on the different vegetation communities can help inform this endeavor.

This paper presents the findings from a seedbank experiment investigating the influence of fire and inundation regime on vegetation recovery post fire. We asked two questions: (1) Was there a difference

between the seedbank response from sites that were burnt and not burnt, and (2) did this response vary with different inundation treatments.

## Study area and methods

Soil samples were collected from 17 locations within the Gwydir wetlands along the Gingham Watercourse. These were all located within the Gwydir Wetlands SCA (Figure 2). Three vegetation communities were sampled, nine sites within water couch marshlands (water couch), four sites within typha rushland (typha) and four sites within coolabah woodlands (coolibah). Within each vegetation community, paired burnt and unburnt sites were sampled. Each pair was located within similar inundation frequency zones to minimize the influence of inundation history on seedbank response. At each site, three replicate 20cm x20cm x 10cm sediment samples were collected giving a total of 51 samples. These replicates were separated by approximately 30m at each site. Soil was disaggregated and left to air dry for at least two weeks before the commencement of the glasshouse experiment (Figure 3). Each species identified in this seedbank study was assigned a pre-determined plant Functional Group (Cassanova 2011).

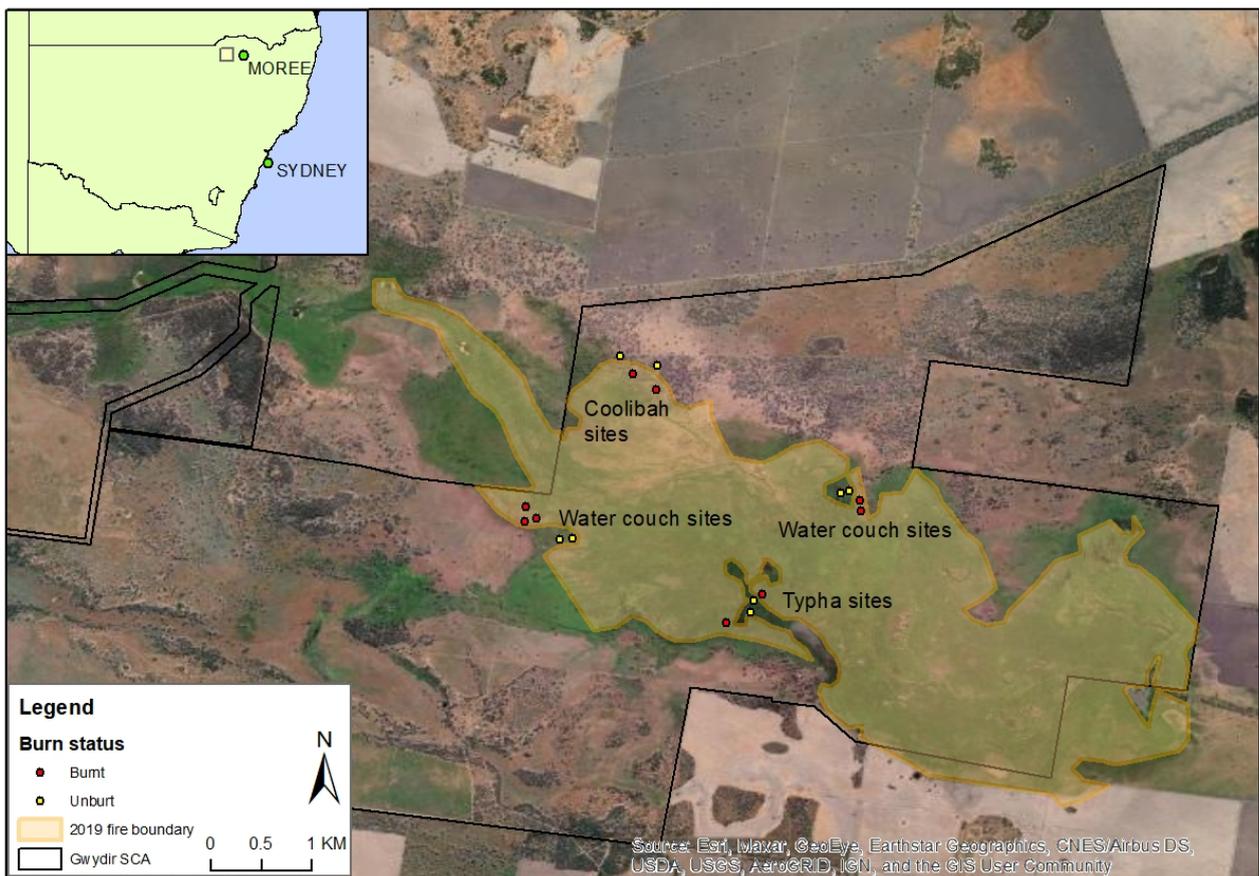


Figure 2. Location of field sites within and adjacent to the 2019 fire ground in the Gwydir Wetlands State Conservation Area (SCA)



**Figure 3. Soil collection at one of the Coolabah Woodland Wetland vegetation plots (left). Soil sample processing for glasshouse mesocosm experiment (right).**

In the glasshouse, 4L mesocosms containing 350 g of soil sample were randomly assigned bench space. In each mesocosm an absorbent fabric cloth was placed into the bottom to aid in water retention, then this was covered by 250g of sterilized sand and the 350g of soil sample (Figure 4). Each site replicate was exposed to one of three inundation treatments: Rainfall (estimated from long term spring rainfall data from Moree), wetted (soil substrate covered to 1cm depth) or inundated (soil substrate covered to 10cm depth). Water levels were topped up in tubs every two-three days to replace moisture lost by evaporation. Glasshouse temperatures were set to emulate average September/October conditions at Moree. The mesocosm experiment ran for eight weeks during summer 2020/21 (1<sup>st</sup> December 2020 – 27<sup>th</sup> January 2021), after which the tubs were harvested and individual plants were counted and identified to species (see Brock et al., 2003).



**Figure 4. Labelled and inundated mesocosms in glasshouse at the beginning of eight week trial (left). An example of a wetted mesocosm from the typha vegetation community at experiment end (right).**

Mesocosms subjected to the rainfall treatment did not produce any seedlings at the end of the eight week seedbank trial and were therefore removed from the analysis and study trial. This was likely due to the inability of the relatively small quantity of soil substrate used in each mesocosm to retain soil moisture under glasshouse conditions in between watering.

Species richness in each mesocosm and total count of individuals from each species were calculated. Permutational analysis of variance (PERMANOVA) (Anderson 2001) was used to test for differences in plant assemblages and univariate variables between vegetation communities (water couch v typha v coolabah), inundation treatment (rainfall v wetted v inundated) and burn status (burnt v unburnt) using 9999 randomisations. Bray Curtis distance was used to form the similarity matrices between samples for

community composition and functional group analyses and Euclidean distance was used for the univariate variables. Abundance data was log transformed prior to analyses. Patterns among samples in the multivariate data were presented diagrammatically, by using metric multidimensional scaling (MDS) using the bootstrap averaging routine (Clarke and Gorley 2015). The variables responsible for the separation of significantly different groups in multivariate data were tested using similarity percentages (SIMPER) (Clarke 1993). All statistical analyses were conducted using PERMANOVA+ for PRIMER software (Anderson et al. 2008).

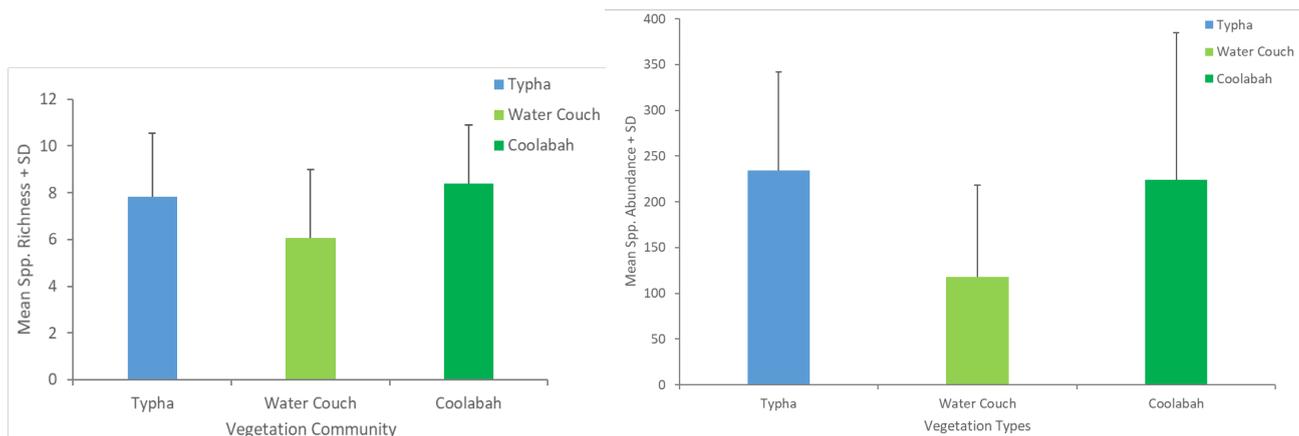
## Results and Discussion

### Vegetation species richness and abundance

A total of 36 species (31 native, 5 exotic) from 22 families were recorded across the three flood dependent vegetation communities studied. Water couch communities supported greater total species richness (28 species) than typha (25 species) and coolibah (23 species) communities. Total abundance of seedlings was similar for each vegetation community; water couch (5,319), coolibah (5,271) and typha (5,193). *Cyperus difformis* was the most common species found and occurred in 93% of seedbank tubs, followed by *Eleocharis plana* (64%), *Ludwigia octovalvis* (59%) and *Echinochloa colona* (54%).

Mean species richness and abundance did not differ between fire or inundation treatments. However significant differences were detected between vegetation communities, with both typha and coolibah communities having higher mean species richness (8 species) than water couch (6 species) (Pseudo F=20.1 p<0.001; Figure 5). Similarly, mean species abundance was also greater in typha (234 seedlings) and coolibah (224 seedlings) than in water couch (118 seedlings) (Pseudo F=11.9 p<0.001; Figure 5).

Similar patterns in mean species richness and abundance between vegetation communities have been noted in long term field data collected in the Gwydir Wetlands (Commonwealth of Australia 2020). However, species richness recorded in the seedbank trial was around half that of the long term data. Many floodplain species have specific germination requirements (Capon 2003) and the reduced mean species richness values observed in our glasshouse seedbank trial suggests that specific germination requirements for many species may not have been met in the trial.



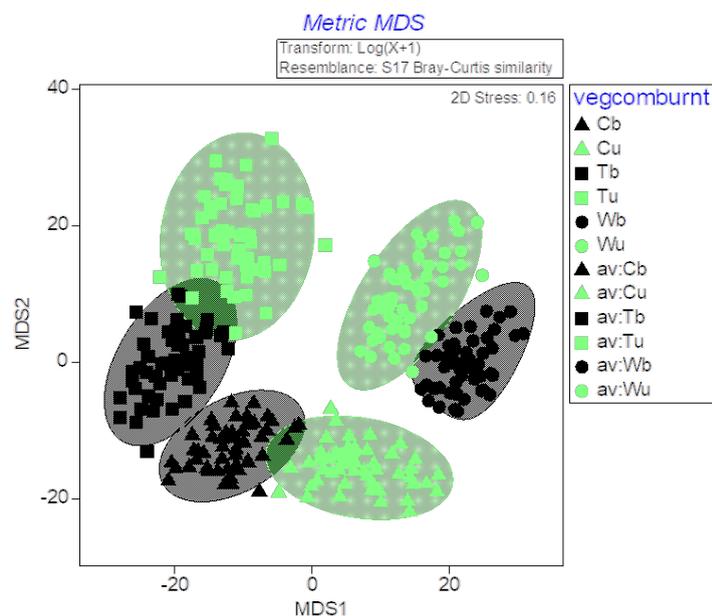
Figures 5. Mean species richness (left) and abundance (right) recorded at each of the three vegetation communities throughout the seedbank experiment.

### Vegetation community structure

Statistical differences in community composition were detected between vegetation communities (Pseudo F=9.2 p<0.001), fire (Pseudo F=2.5 p<0.05) and inundation treatments (Pseudo F=25.3 p<0.001). Additionally,

significant interactions were observed between fire and vegetation community, and inundation treatment and vegetation community, but not between fire and inundation.

Typha and coolibah vegetation communities supported significantly different species composition in burnt vs unburnt treatments, while water couch showed no statistical difference between the fire treatments (Pseudo  $F=2.3$   $p<0.01$ ; Figure 6). These differences in species composition were driven by different species responses to fire. For instance, in typha and coolibah vegetation communities two dominant understory species, *Eleocharis plana* and *Juncus usitatus*, showed a consistent reduction in average abundance in burnt plots. These findings were in contrast to a third dominant species *Ludwigia octovalvis* which showed higher means in burnt plots. There were mixed responses to fire between vegetation communities for two additional dominant understory species, *Echinochloa colona* and *Myriophyllum crispatum*, which suggests that either fire severity differed between vegetation types or that there may be additional factors aside from fire driving species composition. While it is recognised that when soil moisture levels are low in wetland soils fire can consume and reduce seed viability which can result in changes in community composition and structure (NSW DPI 2009), our findings indicated an inconsistent mixed response to wetland fire.



**Figure 6. Vegetation community composition before and after fire in typha, water couch and coolibah vegetation communities.**

All three vegetation communities, typha, water couch and coolibah, supported significantly different species composition between wetted and inundated treatments (Pseudo  $F=2.5$   $p<0.01$ ; Figure 7). These differences in species composition were driven by different species responses to wetted and inundated watering regimes. We observed consistently greater abundances in the wetted treatment for *Juncus usitatus*, *Echinochloa colona*, *Ludwigia octovalvis*, *Persicaria decipiens* and *Paspalum distichum* irrespective of vegetation community. However, for some dominant species such as *Cyperus difformis*, *Eleocharis plana*, *Myriophyllum crispatum*, *Ludwigia peploides* the response to watering regimes was inconsistent between inundated and wetted treatments.

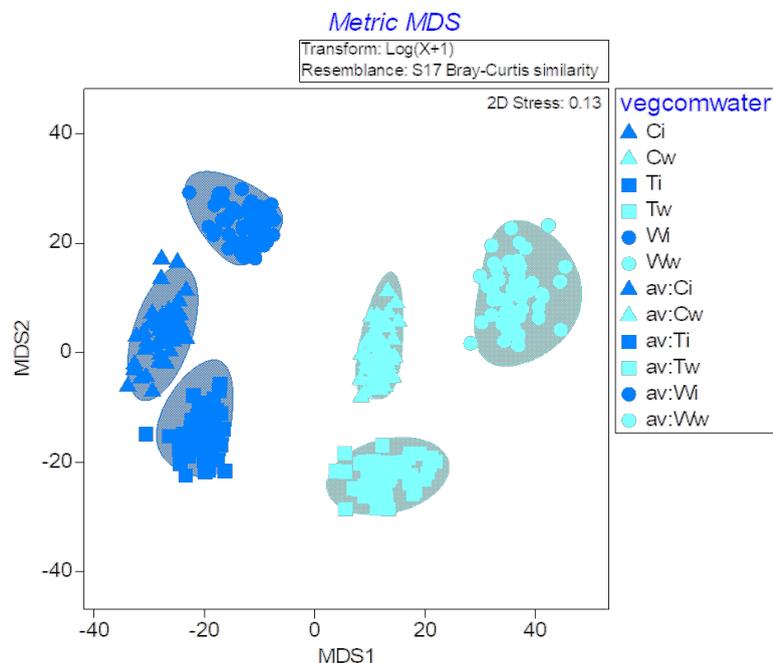
Species responses of particular interest are *Paspalum distichum*, *Eleocharis plana* and *Juncus usitatus*. All three species are dominant understory vegetation elements in each of the three vegetation communities and are key species in determining the water couch – spike rush – tussock rush grassy meadows vegetation community within the Gwydir wetlands. *Paspalum distichum*, and *Juncus usitatus* showed a higher abundance

## Full Paper

Vincent et.al. – Wetland seedbank response to fire and inundation

in wetted treatments, while *Eleocharis plana* showed a greater abundance in inundated treatments. These differing responses are likely related to each species functional preferences, with *Eleocharis plana* and *Juncus usitatus* being recognised as amphibious fluctuation tolerators and *Paspalum distichum* an amphibious fluctuation responder (Casanova 2011). In a practical sense, these results suggest that no one inundation treatment appeared to favor all key wetland vegetation species during this study, so a 'one size fits all' approach to watering after fire may not promote all species equally. This suggests that providing a range of inundation conditions post fire may enhance wetland vegetation seedbank response.

The exotic herb, *Phylla canescens* (Lippia), was a fourth species of interest in our seedbank study as it is listed as a key threatening process in coolabah wetland woodland. McCosker and Earl (1999; 2003) reported that Lippia is depressed under semi-regular flooding regimes of >20cm water depth. While we observed a significant reduction in the presence of Lippia in coolabah woodland mesocosms at 10cm inundation, the species remained present in low numbers.



**Figure 7.** Vegetation community composition in response to both wetted (w) and inundated (i) treatments in typha, water couch and coolabah vegetation communities.

## Conclusions

Fire and inundation did not influence species richness or species abundance, however, community composition was influenced by fire in both Typha Rushlands and Coolabah Wetland Woodlands and by inundation in all three vegetation communities studied. While species responses to fire and inundation were at times inconsistent between vegetation communities our study indicates that both fire and the inundation regime employed following fire can influence wetland vegetation community structure. Providing a range of inundation conditions post fire, may enhance the wetland vegetation seedbank response. It is recommended that further research on the effects of fire on wetland vegetation consider frequency and timing.

## Full Paper

Vincent et.al. – Wetland seedbank response to fire and inundation

## Acknowledgments

We would like to acknowledge the Commonwealth Environmental Water Office for their funding of the Gwydir Monitoring, Evaluation and Research (MER) project, through which this work was undertaken. We also thank the NSW National Parks and Wildlife Service for allowing access to the Gwydir Wetlands SCA. We also acknowledge the Kamilaroi-Gamilaraay traditional owners of the country on which we work.

## References

- Bixby, R.J., Cooper, S.D., Gresswell, R.E., Brown, L.E., Dahm, C.N. and Dwire, K.A. 2015. Fire effects on aquatic ecosystems: an assessment of the current state of the science. *Freshwater Science* 34, 1340-1350.
- Bowen S. and Simpson, S.L., 2010. Changes in Extent and Condition of the Vegetation Communities of the Gwydir Wetlands and Floodplain 1996-2008: Final Report NSW Wetland Recovery Program. NSW Department of Environment Climate Change and Water: Sydney
- Brock M.A., Nielsen D.L., Shiel R.J., Green J.D. & Langley J.D. 2003. Drought and aquatic community resilience: the role of eggs and seeds in sediments of temporary wetlands. *Freshwater Biology*, 48, 1207–1218.
- Capon, S.J., 2003. Plant community responses to wetting and drying in a large arid floodplain. *River Research and Applications* 19, 509-520.
- Casanova, M., 2011. Using water plant functional groups to investigate environmental water requirements. *Freshwater Biology* 56, 2637-2652.
- Clarke, K.R. and Gorley, R.N. (2015). PRIMER v7: User Manual/Tutorial. PRIMER-E, United Kingdom.
- Colloff, M.J. and Baldwin, D.S. 2010. Resilience of floodplain ecosystems in a semi-arid environment. *The Rangeland Journal* 32, 305-314.
- Commonwealth of Australia. 2020. Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Gwydir River system Selected Area – 2019-20 Evaluation Report. Commonwealth of Australia 2020.
- Department of Planning and Environment, ‘DoPIE’. 2019. Gwydir Wetlands SCA fire mapping, September 2019.
- Earl, J., 2003. The distribution and impacts of *Lippia* (*Phyla canescens*) in the Murray Darling System. Report to the *Lippia* Working Group. Australian Cotton Cooperative Research Centre
- Kotze, D. C., 2013. The effects of fire on wetland structure and functioning. *African Journal of Aquatic Science*, 38, 237–247.
- McCosker, R.O., 1999. Gwydir Wetlands: Ecological Response to Flooding. Landmax Pty Ltd, Kangaroo Point, Queensland.
- New South Wales Department of Primary Industries ‘NSW DPI’, 2009. Guidelines for grazing in the Gwydir Wetlands & Macquarie Marshes ISBN 978 0 7347 1985 0
- NPWS. 2013. Gwydir Wetlands State Conservation Area Fire Management Strategy. 2012-17. Office of Environment and Heritage, Sydney.
- Wilson, G.G., Bickel, T.O., Berney, P.J. and Sisson, J.L. 2009. Managing environmental flows in an agricultural landscape: the Lower Gwydir floodplain. Final Report to the Australian Government Department of the Environment, Water, Heritage and the Arts. University of New England and Cotton Catchment Communities Cooperative Research Centre, Armidale, New South Wales. 173pp