A framework for the characterisation of the hydrology and salinity regime of wetlands of the lower River Murray

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Introduction

The hydrological regime in the lower River Murray is highly regulated. In the 1920s a series of weirs and locks were installed to allow navigation and in the following 60 years a series of dams were constructed in the headwaters of the River Murray and its tributaries in Victoria and New South Wales to supply water for irrigation and hydro-electric schemes. The altered hydrology has had a significant impact upon the river; physical effects such as erosion, sedimentation and salinisation are easy to detect, however the ecological effects are more subtle (Walker and Thoms 1993). The changed hydrological regime has had a marked impact upon the wetlands. The majority of wetlands were once temporary and they are now permanently inundated (Pressey 1986).

In recent times, community groups have shown a greater interest in their wetlands and in returning them to a more natural state. In a survey of Australian wetland rehabilitation projects, Streever (1997) found that the two most common effects that have led to wetland rehabilitation are altered hydrology and salinity. However, there are few published scientific studies of lower River Murray wetlands on the effect (at an ecosystem level) of returning a more natural hydrological regime to wetlands in this altered state.

The objective of this study was to develop a characterisation scheme for the wetlands of the lower River Murray that can be used to aid in the decision making of wetland management, in particular to provide predictions of the hydrological and salinity regime of a given wetland. It is anticipated that knowing the hydrological and salinity regimes of a wetland will allow some inferences to be made of the wetland's ecological health.

Materials and methods

A comprehensive survey of a select number (~70) of wetlands has been conducted to provide a baseline condition of the health of wetlands along the lower River Murray (SKM 2004, 2006). These surveys are expensive and so it is not feasible to monitor all 2000 wetlands along this section of river. The data from the baseline surveys was used to classify the wetlands according to their hydrological (permanent or temporary) and salinity regimes (fresh < 1 dS m^{-1}, brackish < 5 dS m^{-1}, saline <50 dS m^{-1} or hypersaline > 50 dS m-1). The hydrological and salinity regimes were tested to see if they had a relationship with biodiversity. Biodiversity is the only measure that was available to assess the ecological health of the wetlands.

The physical properties of the wetlands were fitted into a system developed by the US Army Corps of Engineers: *A Hydrogeomorphic Classification for Wetlands* (Brinson 1993). It is a hierarchical model that was designed to be general enough to be used for all of the US. The three layers in the hierarchical structure are: geomorphic setting; water source; and, hydrodynamics (Figure 1). This characterisation scheme was tested against six measures of biodiversity from the baseline surveys (only native vegetation reported here) to see if ecological health could be inferred from simple physical properties of the wetlands. The characterisation scheme was then applied using GIS to all 2000 wetlands of the lower River Murray in South Australia.

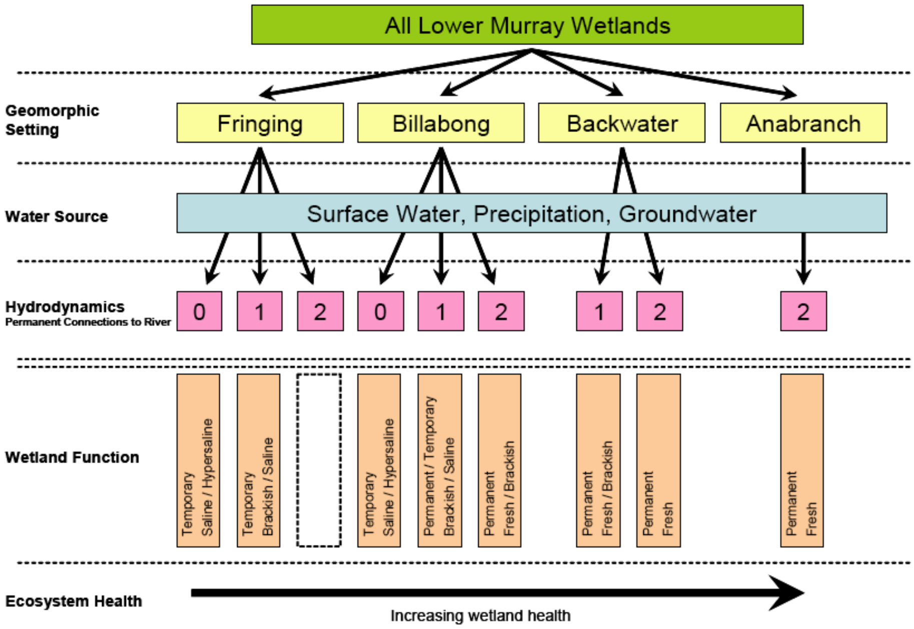

Figure 1 **Adopted charactisation scheme**

Results and discussion

When the existing native vegetation data (SKM 2004, 2006) was analysed it was found that there was a weak relationship between salinity and the diversity of native vegetation species and a much stronger relationship between the number of native vegetation species and the permanence of the wetlands (Figure 2). The relationship between species diversity and salinity was expected as many studies have shown that increasing salinity has a negative effect upon biota (McEwan et al. 2006). The hypersaline and saline wetlands had the same mean number of native vegetation species (19) while the brackish had more (25) and the fresh wetlands had the greatest diversity of native vegetation species (30). It was only between the categories of fresh and saline / hypersaline wetlands where the differences were statistically significant ($P<0.01$). The permanent wetlands had significantly more ($P<0.01$) species of native vegetation identified, probably as a result of the permanent wetlands having significantly ($P<0.01$) lower salinity (EC 1.5 dS m^{-1}) on average than the temporary wetlands (EC 30 dS m^{-1}).

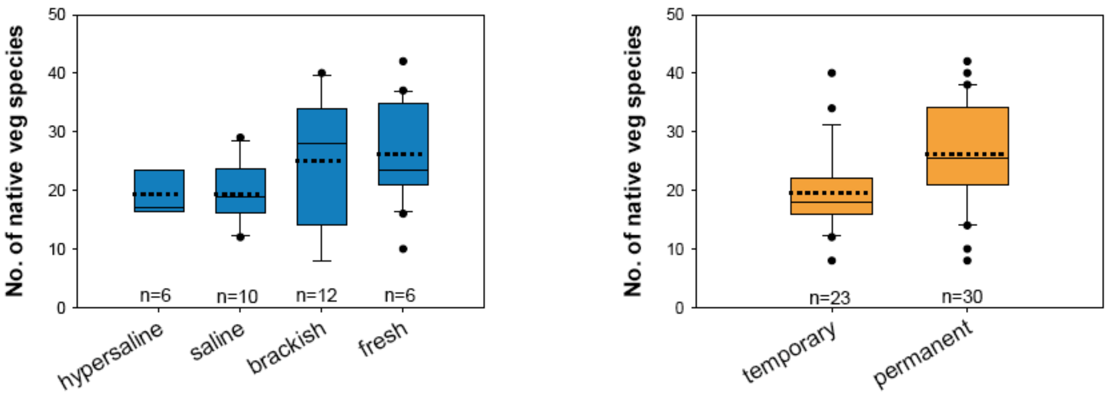

Figure 2 **Boxplots of number of native vegetation species identified at each of the wetlands studied in the baseline studies in categories of salinity and hydrological regime. The box is the interquartile range, the solid line is the median and the dashed line is the mean of the data.**

In the wetland characterisation scheme the geomorphic setting of the wetlands is the position of the wetland in the landscape and the form that the wetland takes. The classes of geomorphic setting used are: fringing wetlands; billabongs; backwaters; and, anabranches. Fringing wetlands are wetlands on the edge of a lake where the supply of water is due to water motion in the lake (waves, sieches etc.). Billabongs are depressions in the floodplain usually caused by river channel changes. Backwaters are small stagnant branches of a river not affected by its current. Anabranches are streams that leave the river and then return to the main river channel.

The water source can not be determined easily without detailed field measurements and so only one category was used at this level comprised of three sources of water: surface water from the river, precipitation and groundwater.

The hydrodynamics of the wetland is the movement of water and consequently the ability of the wetland to exchange water, salt and nutrients with the river. The strength of the connection to the river was assumed to be an important characteristic of a wetland in determining the hydrological and salinity regime. The number of permanent connections to the river was used as a surrogate for the strength of connection to the river. The classes used for this characterisation were: 0 – no connection to the river at pool level; 1 – one connection to the river at pool level; and, 2+ – two or more connections to the river at pool level.

The number of wetlands with suitable biodiversity data was not great enough to analyse each of the categories individually and so the characterisation scheme was tested at the geomorphic setting and hydrodynamics levels individually. Both the median and mean number of native vegetation species identified increased in the order: fringing wetlands < billabongs < backwaters < anabranches. It was only the case of billabongs and backwaters that were not statistically significantly ($P<0.05$) different from each other (Figure 3). The mean and median of the diversity of native vegetation species increased with the number of connections to the river, although only no permanent connection and two or more permanent connections to the river were significantly ($P<0.05$) different from each other. At both levels of the characterisation scheme the diversity of native vegetation species identified increased to the right in Figure 1. This shows that the characterisation scheme can be used to infer the ecological health of the wetlands from simple physical observations.

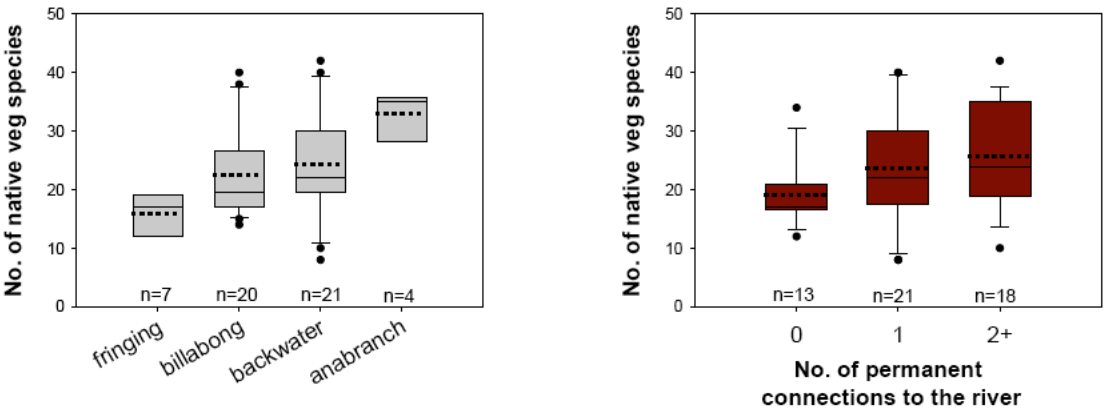

Figure 3 Boxplots of number of native species identified at each wetland investigated by the baseline studies in categories of wetland type and number of permanent connections to the river. The box is the interquartile range, the solid line is the median and the dashed line is the mean of the data.

The wetland characterisation scheme has been applied to all 2000 wetlands in the lower River Murray through a desktop survey using existing data (Table 1). This shows that fringing wetlands with no connection to the river have the greatest area and billabongs with no connection to the river have the greatest number of wetlands.

Table 1 Matrix of number of wetlands in each category from Figure 1, figure in brackets refers to area of wetlands in hectares

	Fringing Wetlands	Billabongs	Backwaters	Anabranches	Total
0 Permanent Connections	213 (8,719)	915 (5,270)			1,128 (13,989)
1 Permanent Connection	404 (7,392)	259 (5,270)	126 (6,859)		789 (19,521)
2+ Permanent Connections	0 (0)	9 (397)	2 (79)	66 (1,294)	77 (1,770)
Total	617 (16,111)	1,183 (10,937)	128 (6,938)	66 (1,294)	1,994 (35,280)

This characterisation scheme could potentially be used in a management sense when looking at modifying a wetland for ecological benefits. It is a shift to the right in Figure 1 that is likely to lead to healthier wetland; which can be achieved by increasing the number of permanent connections to the river.

Conclusions

This study found that returning a more natural hydrological regime to these wetlands is not likely to increase their ecological health. By converting the now permanently inundated wetlands to temporary wetlands it is likely that the result will be an increase in salinity and a decrease in biodiversity.

Acknowledgments

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