4 Swamps, marshes and lakes in the Murray-Darling Basin

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Classification

National/State: Combines two vegetation classes in New South Wales - Inland Floodplain Swamps and Inland Floodplain Shrublands (Keith 2004).
IUCN Habitats Classification Scheme: 5. Wetlands / 5.5 Permanent Freshwater Lakes / 5.6 Seasonal/Intermittent Freshwater Lakes
Biogeographic realm: Australasia

Ecosystem description

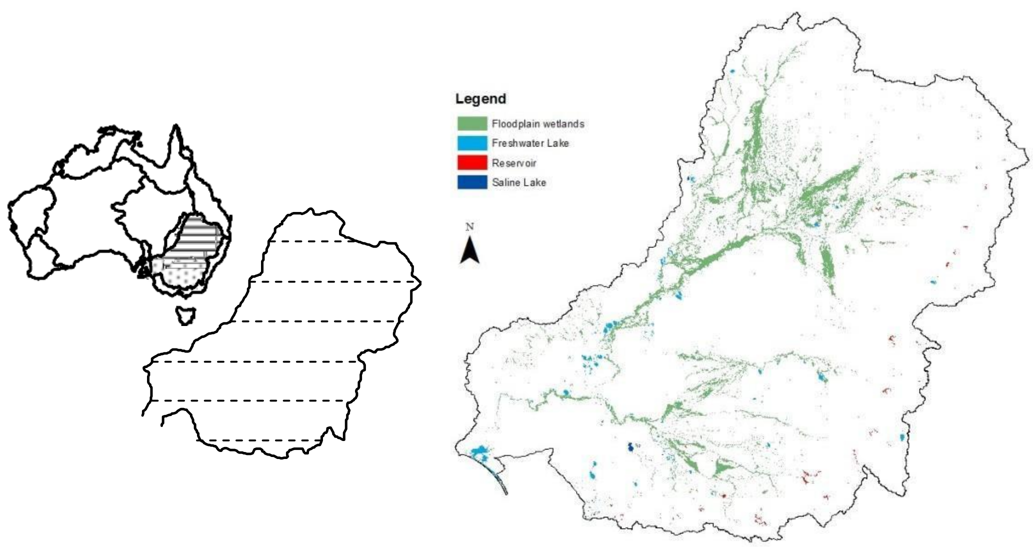
Characteristic native biota

Swamps, marshes and lakes in the Murray-Darling Basin comprise spatially complex and d ynamic mosaics of flood dependent vegetation communities. These include aquatic macrophyte assemblages, open water lakes, swamps, herbfields, reedbeds and shrublands, whose distribution is structured by inundation regimes, which are in turn driven by river flow behaviour (Brock et al. 2006). These wetlands are interspersed with floodplain eucalypt forests and woodlands (see case studies on River Red Gum forests, Coolibah - Black Box Woodlands).

Characteristic plant species in the wetlands include aquatic macrophytes, reeds, grasses and shrubs that are all flood dependent. For example, one of the large marshes, the Macquarie Marshes, consists of a mosaic of different vegetation types, including aquatic macrophytes (e.g. *Ruppia* spp., *Lepilaena* spp., *Lamprothamnium* spp., *Vallisneria australis*, *Myriophylium* spp. *Marsilea villosa*, extensive swards of water couch *Paspalum distichum*, common reed *Phragmites australis,* and lignum *Muelenbeckia florulenta*.

Such wetlands provide habitat for a wide range of other biota, including algae (Bunn et al. 2006), invertebrates (Boulton et al. 2006) and vertebrates (Kingsford et al. 2006). Waterbirds are a functionally important component of the biota, that characteristically depend on the wetland habitats. Waterbird assemblages often comprises more than thirty species for an individual wetland at any one time and can be usefully organised into functional groups of species based on diet and habitat use, including ducks, herbivores, large wading birds, piscivores and small waders (Kingsford and Porter 1994).

Figure S4. 1. Extensive marsh and swamp wetlands such as the Macquarie Marshes in the Murray-Darling Basin comprise complex and dynamic mosaics of vegetation (left) that support high concentrations of waterbirds such as large wading birds (e.g. straw-necked ibis Threskiornis spinicollis, right) which breed in colonies of tens of thousands of pairs, after widespread inundation.



a.

b

Figure S4. 2. a) Location of the Murray-Darling Basin, among 12 large river basins across Australia, showing the northern Darling basin (hatched) and the southern Murray basin (stippled) and six aerial survey bands (30 km wide) which form the basis of data collected for waterbirds. b) Distribution of four broad wetlands types in the Murray-Darling Basin, supplied by river flows from the 19 major river catchments.

Abiotic environment

The Murray-Darling Basin is dominated by semi-arid and arid climates (rainfall <500mm per year) with more mesic climates in the eastern regions (rainfall 800-1,000 mm per year). Of the 500,000 GL of rainfall which falls each year, only about 6% (31,800 GL) naturally flows into the rivers of the basin each year on average, although this is highly variable (range 6,740 GL (2006)-117,907 GL 1956); the rest evaporates or flows into groundwater ecosystems (MDBA 2010). Diversions from the Snowy and Glenelg Rivers have boosted inflow by 997 GL per year (MDBA 2010).

Within the Basin, there are 19 major rivers (MDBA 2010) which flow into large marshes, swamps and lakes (Kingsford et al. 2004). The rivers separate into those that mainly flow from east to west in the Murray catchment and those that flow east to west or north to south in the Darling catchment (Figure 2b). Most of the water flows down the rivers of the Murray catchment with many of the rivers of the Darling catchment flooding large wetland ecosystems. The two catchments also differ in flow seasonality. The southern Murray catchment primarily has a spring-dominated flow regime generated as rainfall and snow on the Great Dividing Range, which forms its eastern watershed. Snow falling in winter (June-August) melts in the subsequent spring months and begins to flow down the rivers. In contrast, the rivers of the Darling catchment in the northeast, are influenced by northern tropical weather patterns, with maximum flows typically during the summer months (December-February), coinciding with the wet season in northern Australia. The southern rivers in the Darling River catchment are also influenced by winter spring rainfall that dominates climatic patterns of southeastern Australia.

Generally, marshes, swamps and lakes in the Murray-Darling Basin can be distinguished by having reasonably frequent extensive flooding regimes, with inundation occurring in at least about one in every five years, and water retained for up to six months in swamps and years for open water lakes. This generally produces more complex and more extensive communities of flood dependent vegetation, with higher primary productivity, than those found elsewhere in Australia. Flows can take weeks to months to reach the dependent wetlands, which often lie at the ends of rivers, depending on the distance of the wetlands from the rainfall. Flows feeding the wetlands are characterised by high temporal and spatial variability (Maheshwari et al. 1995; Thoms and Sheldon 2000; Young and Kingsford 2006). Although the majority of the system is freshwater wetlands, some lakes are naturally saline and this influences the composition of the biotic community.

Distribution

The Murray-Darling Basin is one of 12 major river drainage basins in Australia (Figure 2a), covering about one seventh of the continent in the southeast (1.04×10^6 km^2). Within the Basin, there are about 28,000 wetlands mapped on the basis of flood extent (Figure 2b), covering about 5.68 million ha and most (>90%) of this area comprises floodplain wetlands, including swamps and marshes as well as forests and woodlands (Kingsford et al. 2004). Of the 28,000 mapped wetlands, relatively few (~20) are large wetland complexes associated with a single river and extend over hundreds of thousands of hectares for a single river (Kingsford 2004). Many of these large complexes lie at the ends of the 19 river systems within the Murray-Darling Basin, including 16 wetlands of international significance, listed under the Ramsar Convention (MDBA 2010, Pittock and Finlayson 2011), although a few of these belong to other ecosystem types.

Key processes and interactions

Ecological processes in floodplain wetlands are primarily driven by the boom and bust ecology of floodplain rivers (Boulton et al. 2006; Bunn et al. 2006; Brock et al. 2006; Kingsford et al. 2006; Young and Kingsford 2006). Natural river flow regimes are primarily responsive to rainfall in more mesic regions in the east. Natural flows drive hydrology, including the frequency and extent of inundation (Figure 3). They also control flow paths of small meandering channels in large wetlands, which shift over decadal and century periods, as a result of altered erosion and sedimentation processes (Yonge and Hesse 2010). Geomorphological and hydrological processes within the wetland are driven by upstream flows. These interact with local climate to produce different habitat types that drive primary and secondary productivity by creating the physico-chemical environment for different organisms and ecological processes (Figure 3). Floods trigger the release of nutrients, carbon and nitrogen cycling which stimulate key characteristic food web and life cycle processes including seed germination, egg hatching and movement between wetland areas. During boom flood periods, aquatic invertebrate food webs become highly productive as microcrustaceans either hatch out of sediments or are transported by floods and proliferate in wetland systems (Jenkins and Boulton 2007).

The frequency of flooding is critical for diversity and abundance of invertebrates (Boulton et al. 2006; Jenkins et al. 2009). Flow regimes govern dynamic zonation of flood dependent vegetation which responds to the frequency of flooding. For example, many aquatic macrophyte communities require frequent flooding regimes (Brock et al. 2006; Roberts and Marston 2011). The abundance of waterbirds in each functional group can correlate with food availability (Kingsford and Porter 1994). Waterbirds are also highly dependent on widespread flooding and rainfall to provide sufficient resources for breeding. Characteristically, many colonial waterbird species breed only when there is widespread flooding (Kingsford and Johnson 1998; Leslie 2001; Kingsford and Auld 2005; Brandis et al. 2011), with the extent of breeding often positively related to the number of nesting birds and even species richness (Kingsford and Johnson 1998). River flooding and floodplain inundation also stimulate responses from fish species, reptiles and frogs (Kingsford et al. 2006; Balcombe et al. 2007; King et al.2009; Wassens et al. 2010).

After flooding, large complex marshes and swamps generally remain inundated for up to about six months, but refugia (e.g. waterholes and lagoons) can retain water for much longer periods, along with lake systems, sometimes perennially (Kingsford et al. 2010). During dry periods organisms either leave the wetland (e.g. waterbirds), enter a resting phase (e.g. plants) or remain only as dormant eggs (e.g. invertebrates). Fires can occur during dry periods when floodplain vegetation is desiccated.

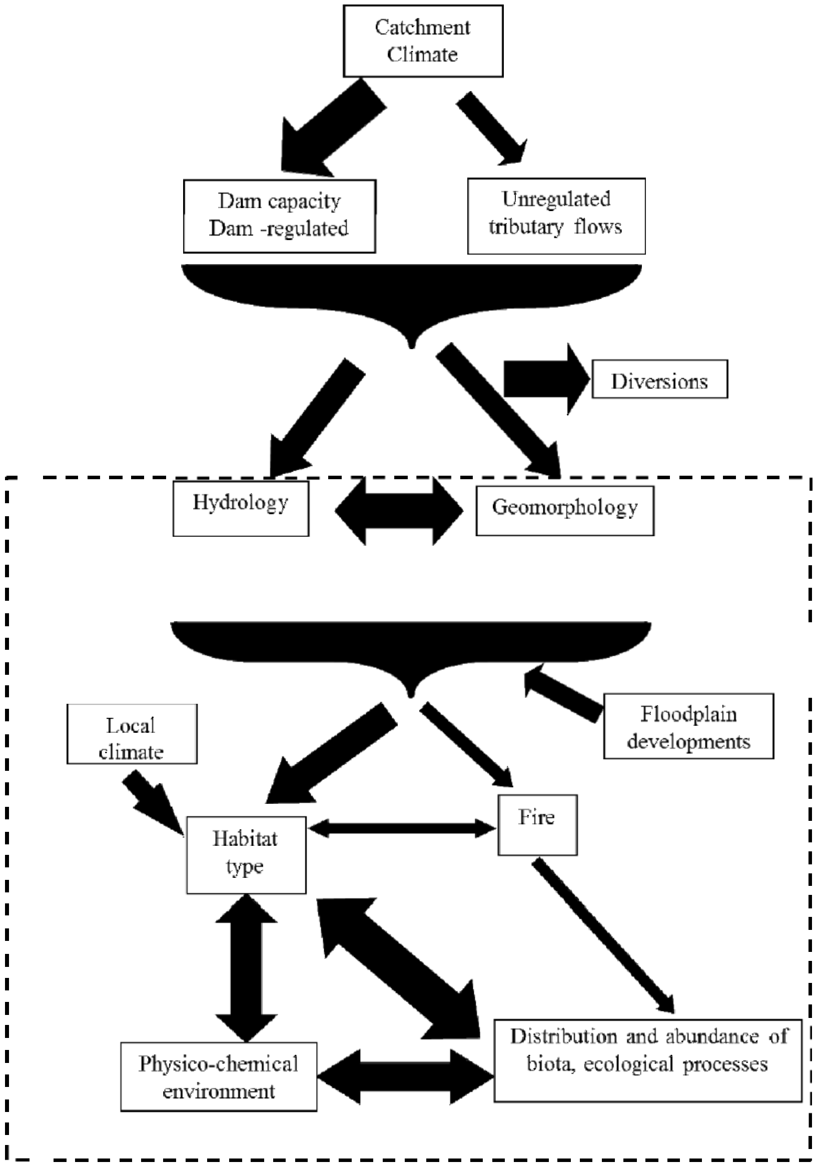


Figure S4. 3. Generalised cause and effect model summarising drivers of key characteristic biota and processes in floodplain wetlands (dashed rectangle) where the river system is regulated by dams in the upper catchment and floodplain developments within the floodplain wetland.

Threatening processes

The main threatening process is water resource development upstream which reduces frequency and extent of inundation of floodplain wetlands (Kingsford 2000a; Arthington and Pusey 2003). Flood regimes are significantly altered with the building of dams upstream of wetlands (Figures 2 and 3). These regulate flows which can then be controlled and diverted away from wetlands, mostly for irrigation (Figure 3; Kingsford et al. 2011). Hence, much of the diverted water no longer inundates marshes, swamps and lakes or replenishes groundwater systems. In addition to these major diversions upstream, floodplain developments including small dams, levees, channels and off-river storages (Steinfeld and Kingsford 2011), which often occur within the main wetland system, affect floodplain inundation, connectivity and health of flood dependent vegetation (Figure 3).

Changes in water quality, particularly increased salinity (Boon et al. 2006) and altered sedimentation are also key threats to floodplain ecosystems (Thoms et al. 2006). Other threats include introduced species (e.g. European carp *Cyprinus carpio*, water hyacinth *Eichhornia crassipes*), which may be exacerbated by river regulation (Gehrke et al. 1995). In addition, cereal crops are grown on some wetland systems, often after flood dependent vegetation is cleared (Jenkins and Briggs 1995). Finally, there is also increasing concern that reductions in rainfall and increases in temperatures will reduce duration of inundation of wetlands as a result of climate change (Kingsford 2011).

Ecosystem collapse

For assessment of criterion A and B, the ecosystem was assumed to collapse when its mapped distribution declines to zero, either as a consequence of conversion to agriculture or transition to dryland ecosystem types. Because the ecosystem is flood-dependent, the spatial extent of flooding was identified as an appropriate variable for assessing environmental degradation under criterion C. As collapse is likely to occur before flooding completely ceases, it was conservatively assumed that the ecosystem would collapse when flood extent is reduced to 90-100% of the mapped floodplain. Waterbird abundance was identified as an appropriate variable for assessing disruption of biotic processes and interactions under criterion D, as waterbirds plays a key role in flows of genes, matter and energy and also have important trophic roles within this ecosystem, and the disappearance of waterbirds would indicate a significant loss of key characterstic biota. Therefore we assumed that populations of all five functional groups of waterbirds must remain extant to avoid ecosystem collapse, with the threshold of collapse being the complete loss of any of the five functional groups.

ASSESSMENT

Summary

Criterion	A	B	C	D	E	overall
subcriterion 1	VU(VU-EN)	LC	VU(LC-EN)	EN(EN-CR)	DD	EN(EN-CR)
subcriterion 2	DD	LC	LC	DD		
subcriterion 3	LC(LC-VU)	LC	VU(LC-EN)	EN(VU-EN)		

Criterion A

<u>Current decline</u>: A decline in distribution of large swamps, marshes and lakes within the Murray-Darling Basin has occurred over the past 50 years in response to clearing and cropping as well as drying related to river regulation and accompanying water extraction. Some data are available on clearing and cropping, but only for recent years in part of the distribution. Based on total current area of wetlands (Kingsford et al. 2004), likely impacts on three major wetland areas (Keyte 1994; Kingsford and Thomas 1995; 2004) and linear effects of water resource development, at least 42% of wetlands have been lost in the Murray-Darling Basin since 1960. Declines in river flows are assessed further under criterion C. The status of the ecosystem is conservatively Vulnerable (plausible range Vulnerable - Endangered) under criterion A1.

<u>Future decline</u>: There are no projections on future trends in distribution available for large swamps, marshes and lakes, within the Murray-Darling Basin. The status of the ecosystem is Data Deficient under criterion A2.

<u>Historic decline</u>: Historic declines in ecosystem distribution to be estimated from available maps of expected native vegetation that were constructed from subjective models relating

remnant vegetation to landform, substrate and climate (Keith 2004). The estimates only account for declines attributable to land clearing and cropping, and do not take into account losses that may be attributable to water extraction or climate change. In the New South Wales portion of the Murray Darling Basin, the combined distribution of Inland Floodplain Wetlands and Inland Floodplain Shrublands was estimated to have declined by approximately 15% due to clearing and cropping since 1750 (based on updated map data from Keith 2004). While New South Wales accounts for the majority of the ecosystem distribution, declines in other states are likely to be similar or greater. The additional decline attributable to wetland drying is unknown but could be as much as 5-10%, based on draining of wetlands (Norman and Corrick 1988), prior to 1960 and a further 42%, after 1960. Based on these components, the overall historic decline is likely to be 47%-52% and so the status of the ecosystem is Least Concern (plausible range Least Concern - Vulnerable), under criterion A3.

Criterion B

About 5.68 million ha of wetland were mapped using recent satellite imagery (Kingsford et al. 2004). The current distribution of wetlands primarily reflects the elevation of different catchments within the Murray-Darling Basin, as well as the impacts of river regulation (Fig. 1b).

Extent of occurrence: A minimum convex polygon enclosing all mapped extant occurrences of open floodplain wetlands in the Murray Darling Basin includes at least 750,000 km^2. This is much larger than the threshold values of Extent of Occurrence for threatened categories and so the status of the ecosystem is Least Concern, under criterion B1.

Area of occupancy: Based on updated mapping of Inland floodplain swamps and Inland floodplain shrublands (updated v3.02 from Keith 2004), open floodplain wetlands in in the Murray Darling Basin occupy about 1500 10 × 10 km grid cells in New South Wales alone. Of these, the wetlands occupy more than 1% of the cell area in 997 cells. This greatly exceeds the threshold values of Area of occupancy for threatened categories and so the status of the ecosystem in Least Concern under criterion B2.

Locations: Wetlands occur within 19 different river systems within the Murray Darling Basin. As the most severe plausible threats are hydrologically based, these were assumed to represent 19 independent locations. Therefore, the status of the ecosystem is Least Concern under criterion B3.

Criterion C

Current decline: This process model (Fig. 3) and available research suggest that flood extent and river flow data are suitable for assessing rates of environmental degradation under criterion C. Time series of inundation maps are available for marshes and swamps in two of the major floodplain wetlands of the Murray-Darling Basin: the Lowbidgee floodplain on the Murrumbidgee River and the Macquarie Marshes on the Macquarie River (Kingsford and Thomas 1995; 2004). By hindcasting flow regimes and using historical maps, these latter studies showed 40 and 75% reductions in area of inundation for the Macquarie Marshes and Lowbidgee wetlands, respectively. These reductions occurred over approximately the last 50 years, a period when all irrigation areas were developed and water licences were fully activated for both the Macquarie Marshes and Lowbidgee wetlands. Some clearing of flood dependent vegetation also occurred during this time.

Although flood extent data are currently unavailable for other catchments within the Murray-Darling Basin, river flow data (from generic studies of hydrology across the Basin, CSIRO 2008) can be used to estimate changes in flood regimes in those catchments, relative to the observed changes in the Macquarie and Lowbidgee. For example, the Macquarie-Castlereagh and Lachlan catchments are currently subject to similar levels of 20-30% water extraction (Table 1). As the Macquarie Marshes underwent a 40% reduction in flood extent in response to this level of water use (Table 1), a similar reduction in flood extent may be assumed for wetlands of the Lachlan. This assumed relationship between changes in river flows and changes in flood extent is justified because: i) most large swamps, marshes and lakes occur at the ends of other rivers in Murray-Darling Basin; ii) most catchments, with the exception of the Warrego and Paroo, had similar water resource development trajectories and similar declines in river flows (Kingsford 2000a; CSIRO 2008);and iii) end of system flows are correlated with loss of wetland area (Kingsford and Thomas 1995; 2004) and function (Kingsford et al. 2004). Thus by summing the initial wetland extent for the last four rows of Table 1, it was estimated that 71% of ecosystem extent underwent similar levels of reduction in flood extent to that observed for the Macquarie Marshes and Lowbidgee wetlands (i.e. 40-75% reduction). In addition, the major lake systems of the Murray-Darling Basin, the Coorong and Lower Lakes, may have had significant reductions in functionalit y, as only about 28% of median flows still reach the system (72% reduction), resulting in a likely change in ecological character (Kingsford et al. 2011).

A standardised estimate of relative severity of environmental degradation may be calculated by assuming that the ecosystem collapses when flood extent is reduced to a critical threshold. For example, at one extreme the cessation of all floods (100% reduction) would inevitably cause collapse of the ecosystem. As the ecosystem is flood-dependent (Fig. 3), collapse is likely to occur before complete cessation of flooding occurs, For the purpose of assessment, it was conservatively assumed that the ecosystem would collapse when flood extent is reduction by 90-100%. The relative severity of environmental degradation is therefore between 40/1.0 = 40% and 75/0.9 = 83% across 71% of the extent of the ecosystem, and is status is thus Vulnerable (plausible range Least Concern - Endangered) under criterion C1.

Table S4. 1. Relative level of water use, relative to natural, for 18 catchments in the Murray-Darling Basin (data from CSIRO 2008). Proportional extent is based on mapping of wetlands in 1984-1993 (Kingsford et al. 2004) and assessment of likely wetland extent in 1750, based on alteration of hydrology.

Current level of water use	Initial extent of wetlands(%)[a]	Catchments	Reductions in flood extent
Low (<10%)	11.7	Paroo, Ovens[b]	
Moderate (10-20%)	15.7	Barwon-Darling, Warrego	
Moderately high (20-30%)	21.1	Macquarie-Castlereagh, Lachlan	40% (Macquarie)
High (30-40%)	9.9	Border Rivers, Campaspe[c], Loddon-Avoca[c], Moonie, Murray[c], Namoi	
Very high (40-50%)	2.3	Goulburn-Broken, Gwydir	
Extremely high (>50%)	37.7	Condamine-Balonne, Murray-Darling Basin[d], Murrumbidgee, Wimmera	75% (Lowbidgee)

[a]Estimated % of ecosystem extent by assessing area of wetlands likely in 1960 on the basis of impacts of water resource developments in each catchment since then (Kingsford et al. 2004)
[b]Includes Upper Murray catchment (Victoria) (Kingsford et al. 2004)
[c]Includes Upper Murray catchment (NSW); Murray-Riverina, Benanee (Kingsford et al. 2004)
[d]Includes Lower Murray catchment (NSW, SA) (Kingsford et al. 2004)

Future decline: In addition to current decline, primarily as a result of water resource development, increased temperatures from climate change will reduce the duration of flooding and rainfall. This and the revegetation of catchments are likely to reduce flows to floodplain wetlands by an additional 15% by 2030 (Herron et al. 2002). Besides these sources of degradation, future government policy is aiming to return some water currently diverted for irrigation (2,750 GL yr^{-1}) to the environment, improving environmental flows to wetlands (MDBA 2011). If it occurs, the return of water to the rivers will improve the status of swamps and marshes but negative impacts of climate change will reduce effectiveness of increased flows to marshes, swamps and lakes. The net outcome of these compensatory changes is likely to be either restoration of some previously lost hydrological function or at least a slower future rate of environmental degradation with relative severity less than 30%. The status of the ecosystem would therefore be Least Concern under criterion C2.

Historic decline: There are insufficient data to estimate changes to flood extent prior to 1960, but the majority of water resource development occurred during the past 50 years. The historic reduction in flood extent is therefore likely to be similar to that estimated for the past 50 years, or perhaps 5-10% greater because there is evidence for widespread draining of swamps in the Murray-Darling Basin primarily for agriculture, but largely unrelated to, and preceding water resource development (Norman and Carrick 1988; Kingsford and Thomas 2004). This occurred within the same catchments that were later exposed to water resource development. The extent of historic environmental degradation due to reduced flooding was therefore estimated to cover 71% of the ecosystem distribution (same as current) with a relative severity of 45-93% (5-10% greater than current). The status of the ecosystem spans Least Concern, Vulnerable and Endangered, under criterion C3.

Criterion D

As waterbirds are central to several biotic interactions within the ecosystem and highly dependent on ecosystem function and water regimes (Fig. 3), the abundance of various waterbird functional groups is a suitable response variable for assessing criterion D. Long- term data sets on waterbirds are available for about 10% of wetlands in the Murray-Darling Basin which have been surveyed as part of an aerial survey each October between 1983-2011 (Figure 1). This long-term survey covers some of the major wetland systems in the Murray- Darling Basin, including Paroo overflow lakes, Menindee Lakes, Macquarie Marshes, Lowbidgee wetlands, Wallenjoe wetland system and the southern part of the Coorong wetlands. It also covers many small wetlands and rivers. Fixed 30 km wide survey bands, 200 km apart, extend across the Murray-Darling Basin (Kingsford and Porter 2009; Figure 2a). All waterbirds (>50 taxa) are identified and counted in each wetland within the survey bands to provide estimates of abundance and diversity.

These data were used to assess the severity and extent of changes to biotic interactions within the ecosystem. All waterbird species were assigned to one of five functional groups: ducks, herbivores, large wading birds, piscivores and small wading birds (Kingsford and Porter 1994). Long-term changes in abundance were modelled, estimating the effect of inundated area and time on total counts, using generalized additive models with a LOESS (locally weighted regression) smoother for Poisson distribution with log link function. Fitted data were compared to actual count data using the goodness of fit and a Mann-Kendall trend test (Mann 1945) was used to show the direction of trends in annual counts.

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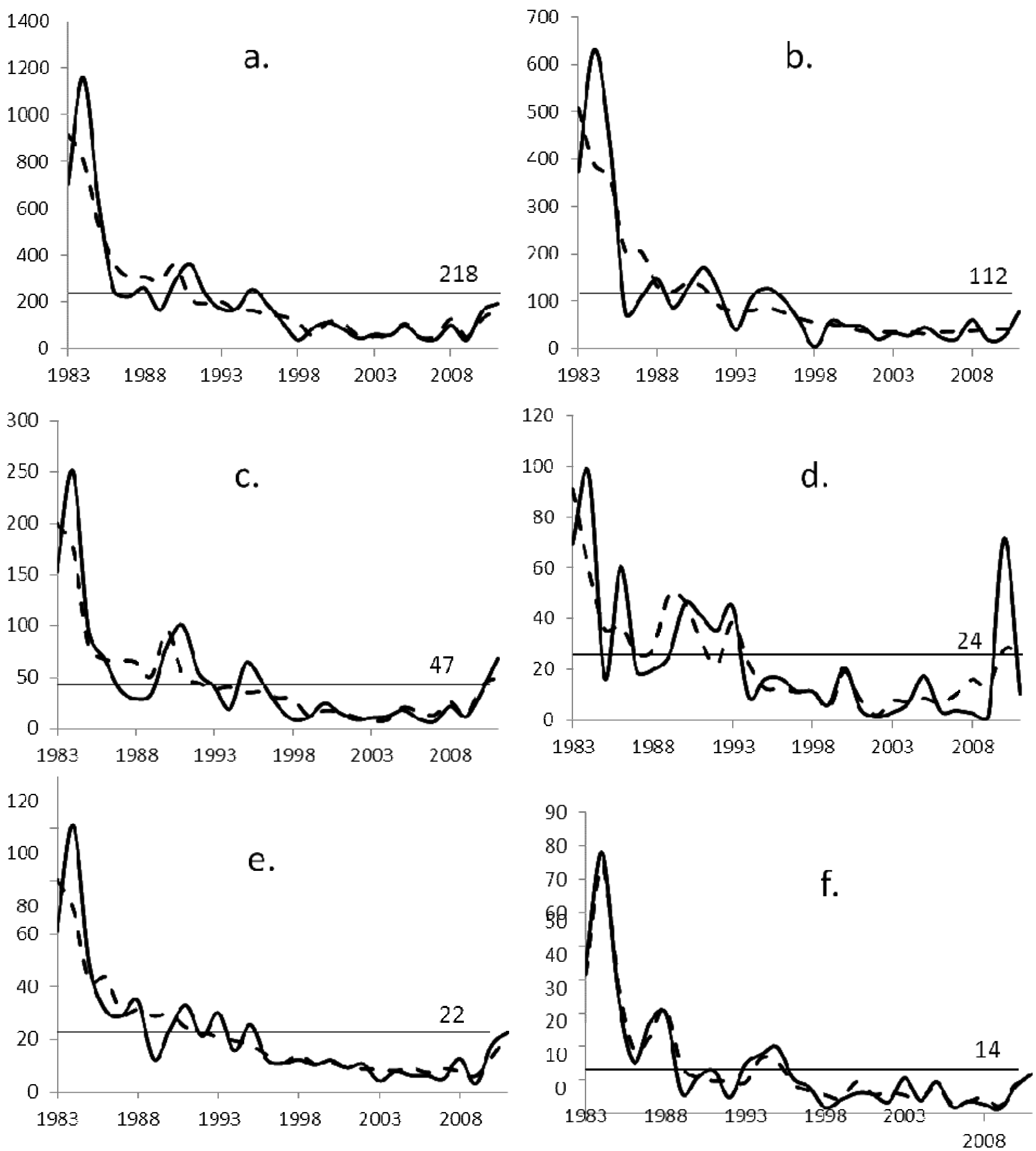

Figure S4. 4. Total numbers of all waterbirds (x 1000) (a), ducks (b), herbivorous waterbirds (c), large wading birds (d), piscivores (e) and small wading birds (f), showing long-term declines in the Murray-Darling Basin. Data were collected during annual aerial surveys of eastern Australia (1983-2011). Actual data linked by continuous line and dotted line shows modelled data, using year and wetland area. Long-term averages given as horizontal lines, with actual mean abundance for each category.

Current decline: There is strong evidence that most functional groups of waterbirds have experienced declines of >50% in abundance in the Murray-Darling Basin wetlands over a period of 29 years, since the early 1980s (Figure 4). Only piscivores have exhibited some recovery above the long-term mean in more recent years (Figure 4d), despite significant flooding in 2010 that broke a long period of drought. Assuming that hydrological condit ions were similar in the early 1980s to previously, it is plausible that the high numbers of the early 1980s (Figure 4), occurred in the previous 21 years. There may have been some decline in waterbird numbers prior to survey commencement, although construction of dams and irrigation infrastructure was significant in the 1950-1970 period, full diversion of water from rivers occurred later as irrigation areas were developed (Kingsford et al. 2011). Full development of all rivers probably occurred in the period of 1985-1995 when the last major river, the Condamine-Balonne was developed (Kingsford 200b). It was also assumed that populations of all five functional groups of waterbirds must remain extant to avoid ecosystem collapse. The severity of declines in waterbird numbers varied between 56 and 79% for five of the six functional groups, with the other group declingin by 85% (Table 2) over the past 50 years, assuming their populations were stable prior to start of the aerial survey in 1983. As the surveys sampled the full extent of the Murray-Darling Basin, these observed declines were assumed to have occurred over 100% of the extent of the ecosystem. Therefore, the status of the ecosystem is Endangered (plausible range Endangered - Critically Endangered), under Criterion D1.

It is noteworthy that these general population trends are reflected in data on waterbird breeding. Breeding of colonial waterbirds is also a key process that forms the basis of some flow management decision-making in floodplain wetlands. The frequency and size of breeding events is highly dependent on the size and frequency of floods with threshold effects (Kingsford and Johnson 1998; Arthur et al. in press). Large scale breeding of colonial waterbirds occurs with large floods in relatively few sites (~10), reflecting availability of resources. Declining flows have reduced the frequency and extent of breeding on wetland ecosystems (Kingsford and Johnson 1998; Leslie 2001). Given the relatively few areas where such significant breeding occurs, mostly on the regulated Murray-Darling Basin Rivers (Marchant and Higgins 1990) and the effects of the declining flows on inundation patterns (Thomas et al. 2011), breeding has declined.

Table S4. 2. Summary of statistical analyses of trends (all significant declines, p<0.001) in total waterbird numbers on wetlands of the Murray-Darling Basin, 1983-2011 and five functional groups of waterbirds.

Waterbird group	Decline[a] (%)	tau	Goodness of fit
All waterbirds	73	-0.586	83.7
Ducks	79	-0.581	77.4
Herbivores	56	-0.478	79.8
Large wading birds	85	-0.512	61
Piscivores	63	-0.635	80.9
Shorebirds	74	-0.542	96

[a]2011 estimate relative to 1983 estimate

Future decline: Future trends in waterbird numbers depend on climate change and government water policy and regulations, which are currently under review. The models required to make a robust projection of waterbird numbers into the future are yet to be developed. Consequently, the status of the ecosystem is Data Deficient under Criterion D2.

Historic decline: Few data exist for long-term changes beyond those in the last 50-100 years, but it is likely that water resource development prior to 1960 had a relatively minor effect on waterbird populations. The historical declines were therefore assumed to be of a similar severit y and extent to those observed in the past 50 years. The status of the ecosystem is therefore Endangered (plausible range Vulnerable - Endangered- under Criterion D3.

Criterion E

There are no data to estimate risk of ecosystem collapse but the recent dry period was close to forcing collapse of the major wetland at the mouth of the River Murray – the Lower Lakes and the Coorong. Decreasing water levels, increased salinity and acidification of large areas of the major lake systems, considerably altered the ecology of the wetland (Kingsford et al. 2011). Under criterion E, the status of the ecosystem is Data Deficient.

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