

# Barmah-Millewa Icon Site: Waterbird theme ground surveys refinement

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# Executive Summary

This report continues refinement recommendations for the Barmah-Millewa Forest (BMF) Icon Site (IS) waterbird condition (CM) monitoring project. This refinement produced a set of indices developed to address the TLM program objectives given the sampling, and their utility. Methods for generating a whole of icon site assessment was also reviewed. The data used, and the results presented here are indicative of wetlands within Millewa forest only.

A reference (or benchmark) condition approach was used, where the benchmark was not set using an ideal or subjective measure, but by using the actual data collected so far. The results should be interpreted for each individual wetland separately, however for the sake of icon site reporting to the MDBA, an average score for the six wetlands was calculated. Changes in the average can cautiously be interpreted as indicative of changes across wetlands within the Millewa forest.

Indices of condition for total waterbird abundance and diversity are sensitive to change and have potential use in Millewa Forest. We can report on individual wetlands in detail or make generalised and coarse statements at the whole of forest scale. On the other hand some potential indicators such as migratory waterbird species are so infrequent in Millewa forest that they are insensitive as an indicator of condition.

To complement the total abundance and richness indices, I recommend using abundance and richness indices for functional guilds of waterbirds. These allow insights into the types of waterbirds present in the forest. For example, whilst overall waterbird abundance and richness was higher in the period 2013 to 2016, there were actually fewer than normal piscivorous waterbirds in the forest in that period.

Reporting using the indices recommended above would only be descriptive in the interim as they have not been subjected to statistical rigour. If it was desired to use the indices to make more substantive statements about waterbird condition, a next step would be to evaluate the suggested indices statistical properties. This may determine; A) Confidence intervals in assessments/effect sizes for significant change in indices, and; B) Efficiency or need for surveying in all seasons.

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# Background

The Living Murray (TLM) Program is a large-scale river restoration program that aims to improve the ecological condition of key ecological assets along the River Murray. The assets, known as icon sites, each have a condition monitoring plan (CMP) that outlines relevant ecological components of each icon site that are monitored to enable assessments of condition and subsequently, provide feedback into the evaluation of the TLM Program as a whole.

The CMP's and the associated monitoring have evolved through time and have had periodic reviews evaluating their relevance, efficiency and outputs. Early internal reviews undertaken by MDBA (2007, 2009, and 2010) recommended achieving standardised monitoring practices, whilst two recent more reviews (Robinson 2012, 2013) advanced the plans towards standardised reporting of condition for each component at the scale of the whole icon site. This was identified as an original aim of the TLM Program in the TLM Outcomes Evaluation Framework (OEF) (2006). The Barmah-Millewa Forest CMP was partially refined in 2014 (Robinson 2014a) and there remains some components that require evaluating. The review and refinement process is hereafter referred to as the TLM refinement project. The fish, understorey and bush bird components have been successfully addressed in the TLM refinement project and the waterbirds component is scrutinised here.

The Millewa forest waterbird surveys were performed (quarterly) between 1999 and 2003, in 2008 and since 2010. This project aims to look at the data in detail and to investigate the utility of the potential indices identified by Robinson (2013). The report uses the entire data set (since 1999) in the development of the indices and their reference values, but reports only using the TLM data, collected since 2008.

This project aimed to develop, and trial, indices of condition that assess how the Millewa forest waterbird surveys can be used to track progress towards the TLM ecological objectives for waterbird and wetland health.

## TLM ecological Objective

The waterbirds theme is considered a TLM type “A” objective. This means that the overall objective is at a spatial scale larger than the icon site itself. These were generalised for the initial B-MF condition monitoring plan to state that the management objectives for waterbirds were to;

- Provide suitable feeding and breeding habitat for a range of waterbirds, including colonial nesting species.
- Promote and/or sustain successful breeding events for thousands of colonial and migratory waterbirds in at least 3 years in 10 by inundating selected floodplain and wetland areas to provide suitable nesting and feeding habitat.

These rather vague statements contain several undefined (e.g. ‘suitable’, ‘selected’) and unmeasurable terms (e.g. ‘provide’, ‘promote’, ‘sustain’) and were of little value when developing a monitoring program. A workshop was held in Melbourne in 2013 identified the following interim objective;

- ***“Healthy colonial water bird assemblages as defined by high species richness and relative abundance present in BMF each year”.***

There was also an identified requirement to develop a new objective to allow assessment of migratory species from the same data set and will include RoKAMBA, CAMBA JAMBA, and VRoT species that occur in BMF.

Recently, there have been further changes to the objectives in line with the basin plan (BP) and basin watering strategies (BWS), including;

### **BWS Waterbird Objectives:**

- The number and type of waterbird species present in the Basin will not fall below current observations
- A significant improvement in waterbird population breeding events (the opportunities to breed rather than the magnitude of breeding *per se*) of colonial nesting waterbirds to increase by up to 50% compared to the baseline scenario
- Breeding abundance (nests and broods) for all of the other functional groups to increase by 30–40% compared to the baseline scenario.

These objectives can be treated as targets that may be compared against at a scale much greater than B-MF icon site.

This report looks to see if the current data set can address assessment against suitable targets for waterbirds in Millewa forest in line with the 2013 workshop.

## Sampled Sites

The TLM Program desires a whole of icon site outcome, rather than assessments for individual study sites, however the (six) wetlands in this study were selected for *a-priori* reasons and not chosen to represent the entire icon site *per se*. Thus, the wetlands are not deemed to be replicates or easily comparable to each other in any way, and they all have unique waterbird habitats and inundation histories. This means that the recommended strategy for reporting these data is to report each wetland on its own and interpret results relative to the wetland's distinctive inundation and connectivity history. However given the number of themes and icon sites being monitored within the TLM Program, it is unmanageable to have a multitude of assessments made, and brevity in reporting is essential. Part of this report's aims are to attempt to find a way to summarise the results of the BMF icon site waterbird monitoring in an informative way for TLM Program reporting to the MDBA.

## Methods

I implement the recommendations in Robinson (2013) and investigate the utility and trialling of a

- **Species Richness Index,**
- **Guild type Index,**
- **Abundance Index.**

Data were combined across the colonial and migratory groups, plus another index just for the migratory species:

- **Important Species Index.**

## General approach

For every site and survey date in the data set (See Table 1 for the 6 sites in Millewa) I counted the total number of waterbirds and the total number of species present. I then partitioned these totals into the 6 guilds described by Kingsford *et al.* (2013) and whether not the species was listed as an internationally important migratory species. Species not listed by Kingsford were either allocated a guild or removed from the guild analyses. Guild descriptions are included in Table 2 and full guild allocations used are given in Appendix B. All species in the data set were searched for migratory status using the EPBC Migratory species list (Department of Environment, 2018). Species that were in the Millewa forest waterbird data set and listed are shown in Table 3.



**Table 1. Surveys seasons and years where each Millewa forest wetland was surveyed for waterbirds. St Helens swamp has been surveyed in earlier years, but the data has not yet been included in the database.**

Watering Season	Duck Lagoon				Horseshoe Lagoon				Moira Lake				Reed Bed (North)				Reed Bed (South)				St Helens swamp			
	Au	Sp	Su	Wi	Au	Sp	Su	Wi	Au	Sp	Su	Wi	Au	Sp	Su	Wi	Au	Sp	Su	Wi	Au	Sp	Su	Wi
1999-00		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓				
2000-01	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
2001-02	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
2002-03	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
2007-08	✓		✓		✓		✓				✓		✓		✓		✓		✓					
2008-09		✓		✓		✓		✓						✓		✓		✓		✓				
2009-10	✓		✓		✓		✓		✓		✓		✓		✓		✓		✓					
2010-11		✓		✓		✓		✓		✓		✓		✓		✓		✓		✓				
2011-12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
2012-13	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
2014-15		✓	✓						✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
2015-16	✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	
2016-17	✓				✓				✓				✓				✓				✓			

**Table 2. Description of guilds used in Millewa forest waterbird condition assessments.**

Functional group	Example species
Du-ducks,	Pink-eared duck
La-Large wading birds,	Egrets
Sh-shorebirds	Plovers
He-herbivores,	Purple swamp hen
Pi-piscivores,	Darters

**Table 3. Listed migratory species that have been present in Millewa forest waterbird surveys. Other listed species will be automatically included in the analysis methodology if they turn up in future surveys.**

Current Scientific Name	Common Name	Bonn	CAMBA	JAMBA	ROKAMBA
<i>Hydroprogne caspia</i>	Caspian Tern			Listed	
<i>Charadrius bicinctus</i>	Double-banded Plover	A2H			
<i>Plegadis falcinellus</i>	Glossy Ibis	A2S			
<i>Gallinago hardwickii</i>	Latham's Snipe, Japanese Snipe	A2H		Listed	Listed
<i>Calidris ruficollis</i>	Red-necked Stint	A2H	Listed	Listed	Listed

## Using a reference condition

To assess condition, the number of species or birds in each category (total, guild or migratory), it needed to be determined whether each wetland could be allocated a good/high/bad/low score for each survey date. Given that the first half or more of the survey years were held during a drought, the use of a baseline approach is not suitable for Millewa forest. Alternatively, a ‘best achievable’ approach and reference condition was used.

The resulting assessment of condition is achieved by converting each statistic into an index by comparing the raw data value to a best achievable benchmark or ‘reference’ value. When the data value, say number of individual waterbirds present in a wetland survey is close to the reference, the index scores a value close to 1. When there are only a few waterbirds present, the index score is close to zero.

## Setting the reference condition

A reference (or benchmark) condition approach was used, where the benchmark was not set using an ideal or subjective measure, but by using the actual data collected so far. This method is successfully used successfully by the USEPA Index of Biotic Integrity program since the late 1980’s (e.g. Karr & Chu, 1997) and is also used in the BMF bush bird condition index calculations. The principle is that when a large number of data already exists over a reasonable length of time and

conditions, the data themselves *probably* contain a range of good and bad scores. Therefore they probably contain scores that are indicative of the 'best achievable' scores if there is no change to the current management program. This differs from setting an idealistic or hypothesized target or objective using some form of modelling or management predictions which usually require a leap of faith for justification.

A fully worked example of an index calculation is given in appendix C. All abundances were square root transformed to make the response scale less sensitive to extreme values that sometimes occurs in waterbird abundances. For each wetland, I calculated the 90<sup>th</sup> percentile of all data collected so far and used that to set the reference. A lay interpretation of this is *'of all the data collected so far, the highest 10% of scores are indicative of the best achievable condition (or 'reference point') for the wetland'*. It should be remembered that the reference is somewhat arbitrary and can be refined or adjusted in the future. Further, whether one agrees that the value used for the reference value is ideal, the change through time of the condition score is always relative. In other words, with the absolute value of the score on a 0 to 1 scale, a higher score in year x than year y indicates a better condition in year x than year y. In the case of the 90<sup>th</sup> percentile being 0 (for example a wetland may have only had a migratory species present once or twice in 48 surveys), the index is left in the analysis but is obviously of little utility for that wetland. The reference value is not always an integer as weighted averaging was used when the percentile fell between two values of the raw data. However, as indices are ceiled at 1 (see next section) the reference values are effectively rounded up to the nearest integer.

The seasons were not separated in setting the reference as there are not enough data to set separate seasonal references. This means that if there are seasonal effects in the data, then some seasons will probably score low on a regular basis. St Helens swamp has a far shorter data series than the other sites and so its reference values (hence assessments) are likely to be more unreliable in the short-term.

## **The indices**

Waterbird species richness and abundance was calculated for indices for all waterbirds and for each of the functional guilds and for migratory species. I also generated a composite functional guild score which was the number of functional guilds present in the wetland (0 to 5). To convert the scores into indices of condition, I compared the raw score for each wetland on each survey date to

the reference value and ceiled the maximum score at a value of 1. Thus, every survey date and wetland have a condition score between 0 and 1 for each of the measures identified in table 4.

**Table 4. Potential indices of condition generated for each wetland and survey date in the Millewa forest waterbird data set.**

Index Label	Index Name
I <sub>totalbirds</sub>	Index of total waterbird abundance
I <sub>numsp</sub>	Index of total waterbird species richness
I <sub>nummigbirds</sub>	Index of migratory waterbird abundance
I <sub>nummigspecies</sub>	Index of migratory waterbird richness
I <sub>abund_Du</sub>	Index of total duck abundance
I <sub>numsp_Du</sub>	Index of total duck richness
I <sub>abund_He</sub>	Index of total Herbivore abundance
I <sub>numsp_He</sub>	Index of total Herbivore richness
I <sub>t numFGpres</sub>	Index of Number of Functional Guilds present

Naturally, not all indices are expected to be suitable for every wetland (for example, some may not be expected to contain all types of functional guilds or migratory species).

## Reporting of results

Because the wetlands are not selected in a way to represent the entire forest accurately, the indices should be interpreted for each individual wetland separately. This will also allow local interpretation relative to local management and antecedent conditions. However, for the sake of icon site reporting to the MDBA, a simple whole of icon site assessment is all that is required. To that end, I report individual wetland scores firstly, followed by an average score for the six wetlands. The latter should not be interpreted as the true average for the icon site, however changes in the average can cautiously be interpreted as indicative of changes in wetland waterbird communities in general across the icon site.

Whilst all data from 1999 onwards are used in calculations as they add value to the setting of reference conditions, only data from TLM relevant monitoring (2008 onwards) are used for reporting.

# Results

## Reference values

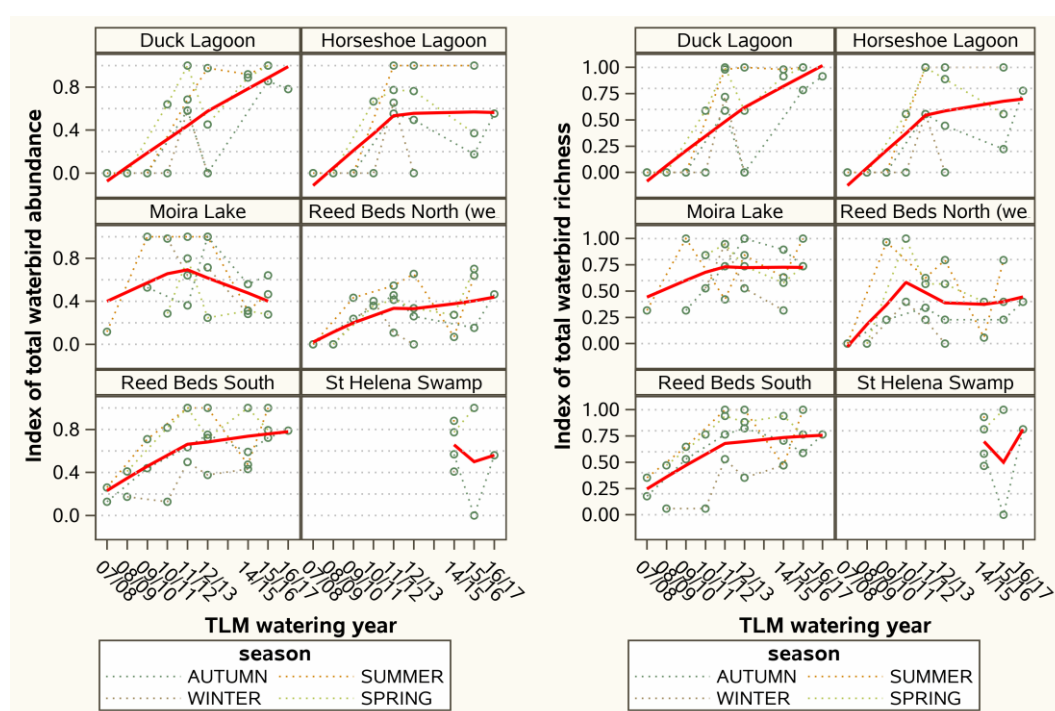
Table 5. Reference values used in setting indices of condition for Millewa forest Waterbird data set. Values may fall between two data points as indicated by a decimal place, however, all values are effectively rounded up in calculations. A reference value of 0 indicates that index is probably not useful for that wetland.

Site	Duck Lagoon	Horseshoe Lagoon	Moira Lake	Reed Beds North	Reed Beds South	St Helens Swamp
<b>Number of data points used to set reference value</b>	37	36	35	38	40	7
<b>Total abundance</b>	16.5	8.1	36.5	20.7	20.7	10.1
<b>Total species richness</b>	15.3	9.0	19.0	17.6	17.0	8.6
<b>Abundance of migratory species</b>	0.0	0.0	0.5	0.0	0.0	0.0
<b>Richness of migratory species</b>	0.0	0.0	0.5	0.0	0.0	0.0
<b>Number of duck species</b>	4.0	4.0	6.0	5.0	4.0	2.6
<b>Number of herbivore species</b>	2.0	0.0	2.5	3.0	3.0	1.0
<b>Number of large wader species</b>	5.3	2.0	6.0	4.2	6.0	4.0
<b>Number of piscivore species</b>	4.0	4.0	6.5	3.0	5.0	3.3
<b>Number of shorebird species</b>	1.0	0.0	3.0	1.0	1.0	0.0
<b>Abundance of ducks</b>	11.3	7.8	21.9	12.6	12.8	5.4
<b>Abundance of herbivores</b>	6.4	0.0	7.0	7.9	7.2	1.4
<b>Abundance of large waders</b>	7.5	2.3	16.2	11.5	15.7	5.9
<b>Abundance of piscivores</b>	5.8	3.2	21.2	4.4	9.4	6.2
<b>Abundance of shorebirds</b>	1.1	0.0	11.4	1.4	1.4	0.0
<b>Number of functional guilds present</b>	4.3	3.0	5.0	4.0	4.0	3.3

# Potential of Indices of condition

## Total abundance and richness

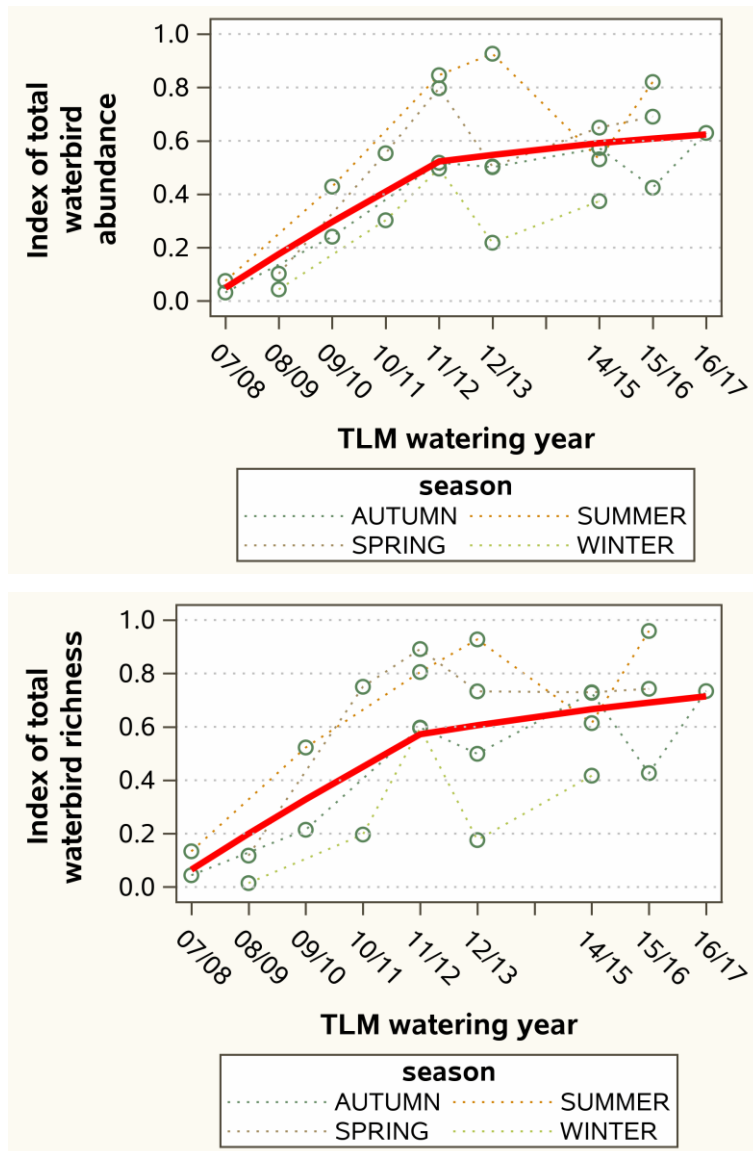
Individual wetlands showed highly variable response using the simple indices of total abundance and richness (Figure 1). Duck lagoon in particular, has experienced index scores of 0 and 1 at various times throughout the study, whilst Moira Lake was at the other extreme, only varying by about 0.2 during the study (Figure 1). The site averages were consistent in showing a general increase in condition from 2008 to 2012 and a general condition score of about 0.7 since then (Figure 2).



**Figure 1. Simple indices of total waterbird abundance and species richness in 6 Millewa forest wetlands surveyed in TLM condition monitoring program since 2008. The red line is a smoothed average of the individual season lines.**

## Migratory Species

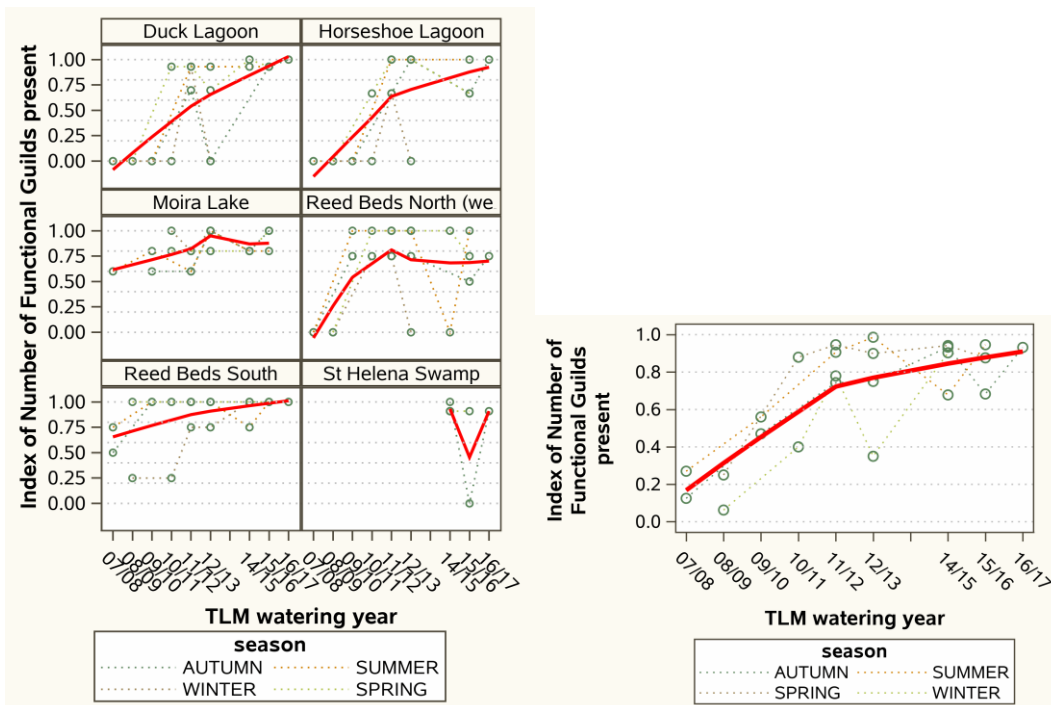
The migratory species indices were of little value. Moira Lake is the only wetland that has had migratory species occur consistently enough to set a reference condition (Table 5). And the reference value was only 1 bird present, hence the wetland scored only 0 (most years) or 1, which only occurred in spring in 2010 and 2012. In lay-terms, migratory species are so infrequent in the BMF wetlands that are sampled as to be an insensitive indicator of condition. Another way of saying this is “it is not unusual that there are no migratory birds present during a survey”.



**Figure 2. Average indices of total waterbird abundance and species richness across 6 Millewa forest wetlands surveyed in TLM condition monitoring program since 2008. The red line is a smoothed average of the individual season lines.**

***Number of functional guilds present***

The response of this index was similar to the total abundance and richness graphs (Figure 3), which intuitively implies that more birds and more species corresponds to more functional groups being present. The anomaly was Reed Beds South which always scored above 0.6 in functional diversity (Figure 3), but scored much lower for total richness and abundance (Figure 1). Overall, the Millewa wetlands were in relatively good condition (score above 0.7) from 2011 onwards after being in poor condition from 2007 to 2009 (Figure 3).



**Figure 3. Index of waterbird functional group diversity across 6 Millewa forest wetlands surveyed in TLM condition monitoring program since 2008. The right hand graph is the average of the left hand graphs. The red line is a smoothed average of the individual season lines.**

### ***Individual functional guild abundance and richness***

Individual wetland responses are included in Appendix D. The duck, piscivore and large wader abundance indices performed similarly throughout TLM monitoring, rising from zero in 2008 to above 0.5 since 2011 (Figure 4). Shorebird and herbivore abundance indices also showed improved conditions from 2008 to 2011, but both also showed a dip in condition in the 2014/15 watering year (Figure 4).

The trends in the functional group richness indices mimicked the trends in the abundance indices (Figure 5). The richness indices were generally more variable however, achieving scores up to 0.9 for herbivores and overall appear as if they could be a slightly more sensitive option for reporting in guilds than using guild abundance.



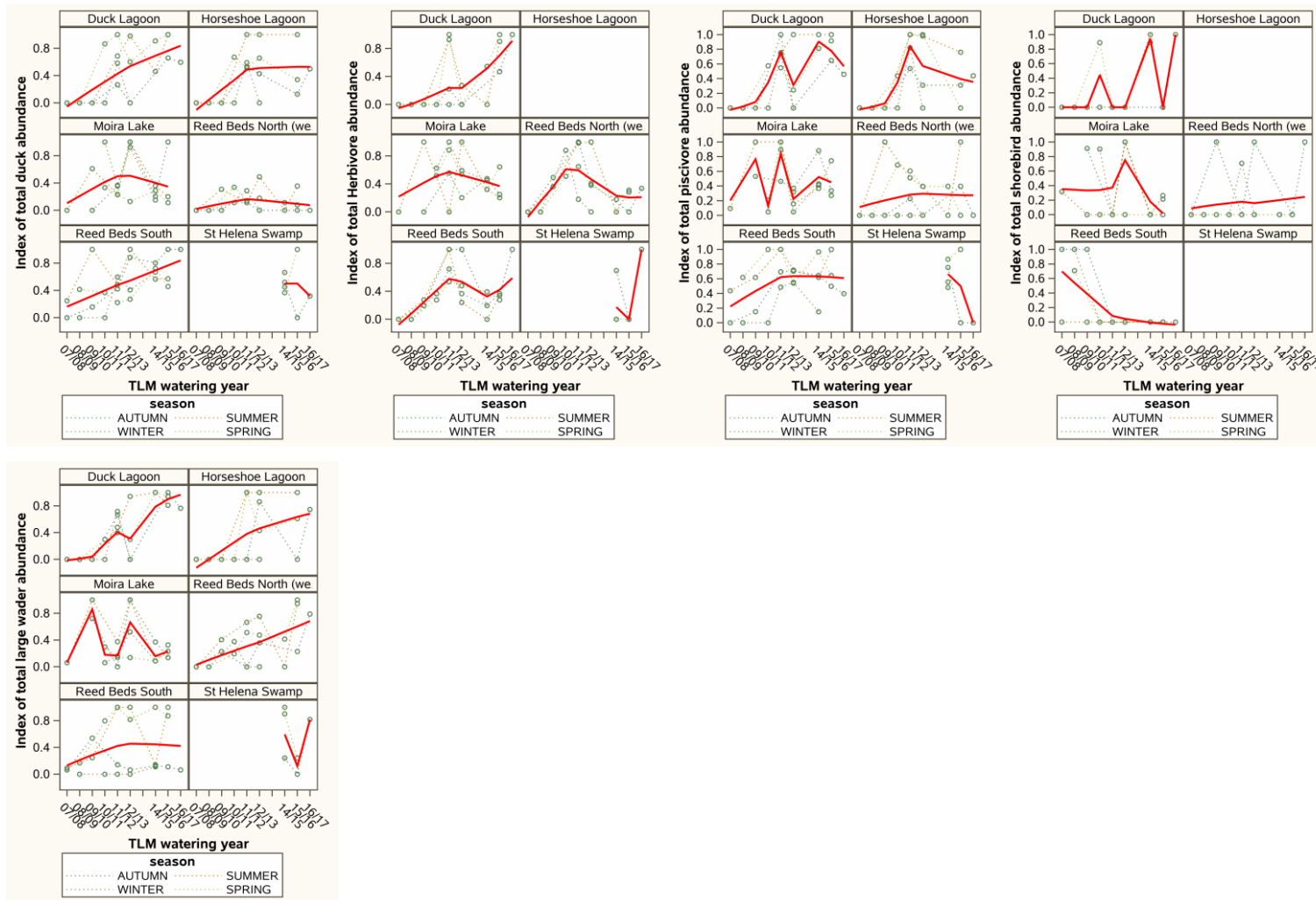


Figure 4. Abundance indices for each of the functional groups in the Millewa forest waterbird data set. The red line is smoothed average across the four seasons.

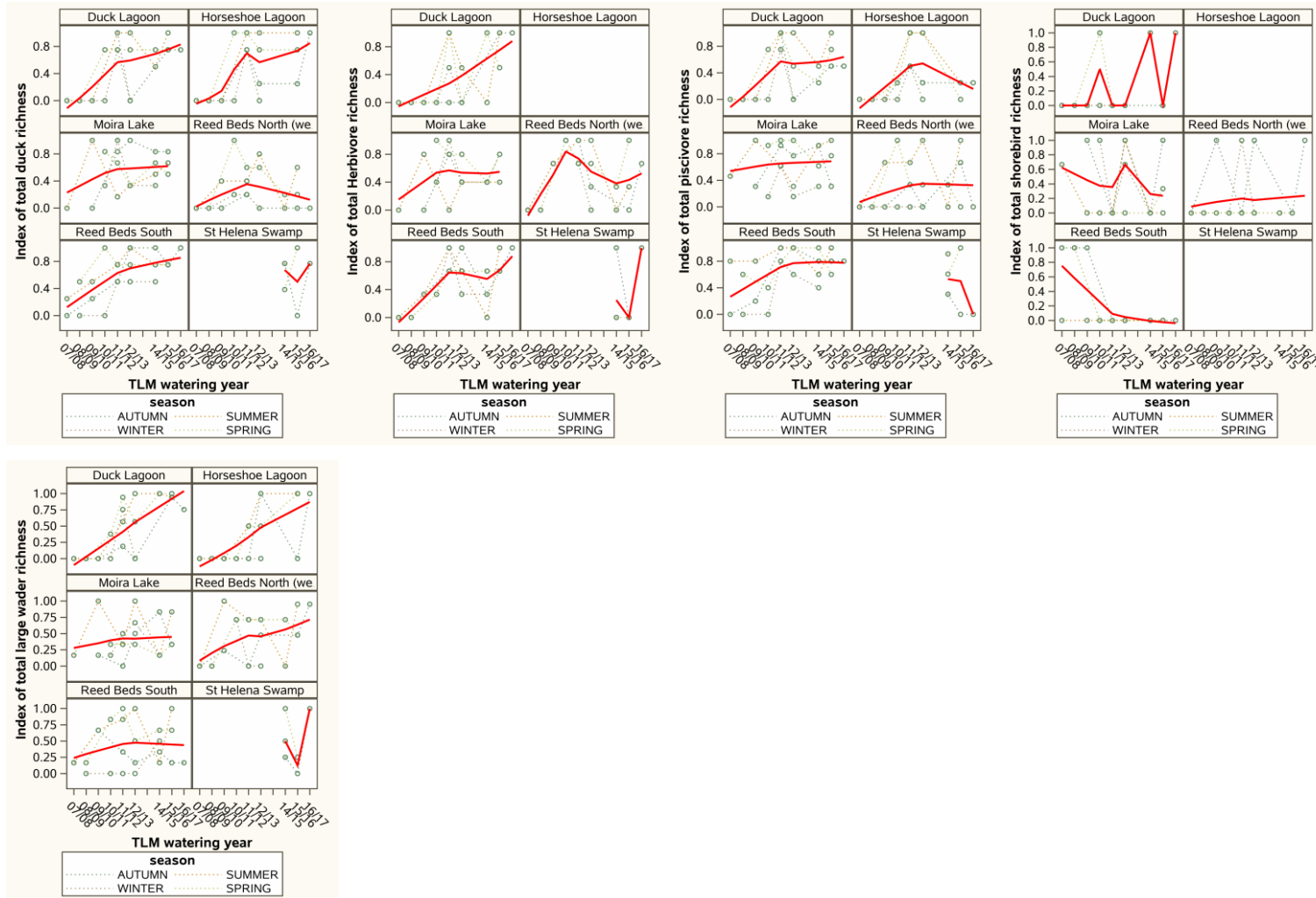


Figure 5. Species richness indices for each of the functional groups in the Millewa forest waterbird data set. The red line is smoothed average across the four seasons.

## Summary and Discussion

The variability in results between years and wetlands are an indication that the total abundance and diversity indices are sensitive to change and have potential use in Millewa Forest. The indices are not stable, so this means that we can say there are years where wetland condition were better or worse. Further, as there was apparent consistency across wetlands in some of the years with high and low scores, it appears the changes in the indices is not random, and thus they reflect changes in Millewa forest wetland waterbird community condition well.

A full sensitivity analysis in the future may help determine if there are specific species or environmental conditions that are more or less related to the observed variability in the indices. For now, if we assume more species and more birds are a good thing, we can say that all 6 wetlands were in better condition after 2012 than before 2012 and that Moira lake has consistently better waterbird communities than any other wetland.

On the other hand, migratory species are so infrequent in the BMF wetlands that are sampled that the proposed indicator is totally insensitive as an indicator of condition. There is little variability in the index of condition through time with all wetlands scoring poorly in every survey. It is not recommended that the migratory species index be used for TLM reporting on Millewa waterbird communities.

The response of the number of functional guilds index showed that it too was sensitive to changes in condition between years and wetlands. However, in general, any changes in this index were the same as the changes indicated by the total abundance and richness indices, thus it adds little extra value to reporting.

Alternatively, the individual abundance and richness indices for the functional guilds may be of value to TLM reporting. They will tend to mimic the overall abundance and richness indices, but they will also allow interpretation of the changes as well. For example, the abundance and richness of piscivores was actually lower or decreasing in many wetlands in the period since 2012. This feature is not noticed when overall abundance and richness are considered alone and this may add value to interpretation of the condition of the wetlands.

# Recommendations

- *Indices generated from Millewa Forest waterbird surveys can be included in TLM annual reporting*
- *Total abundance and diversity indices are sensitive to change and can be used to determine relative condition of wetlands for TLM reporting*
- *The abundance and diversity indices could be complemented by including abundance and richness indices for individual functional guilds to aid in interpretation of changes*
- *Reporting using the indices recommended above would only be descriptive in the interim as they have not been subjected to statistical rigour*
- *A next step to refinement and evaluation of the suggested indices could be to determine;*
  - *Confidence intervals in assessments/effect sizes for significant change*
  - *Efficiency or need for surveying in all seasons.*

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## Appendix A: Data Handling notes

- Incidental observations are removed
- Heard only data are removed (there are not many of these)
- Flyovers are included in all analyses.
- Reed Beds North (west) has 2 survey points in one year. These are just included and treated as a normal sample (the two samples are combined).

# Appendix B: Feeding guilds

Guilds are described in Table 2.

Common Name	Guild
Australasian Bittern	Lw
Australasian Darter	Pi
Australasian Grebe	Du
Australasian Shoveler	Du
Australian Little Bittern	Lw
Australian Pelican	Pi
Australian Reed-Warbler	.
Australian Shelduck	Du
Australian White Ibis	La
Australian Wood Duck	Du
Azure Kingfisher	Pi
Black Swan	He
Black-fronted Dotterel	Sh
Black-tailed Native-hen	He
Black-winged Stilt	Sh
Blue-billed Duck	Du
Brolga	Lw
Brown Falcon	T
Caspian Tern	Pi
Chestnut Teal	Du
Double-banded Plover	Sh
Dusky Moorhen	Du
Eastern Great Egret	La
Eurasian Coot	He
Freckled Duck	Du
Glossy Ibis	La
Golden-headed Cisticola	T
Great Cormorant	Pi
Great Crested Grebe	Du
Grey Teal	Du
Hardhead	Du
Hoary-headed Grebe	Du
Intermediate Egret	La
Latham's Snipe	Sh
Little Black Cormorant	Pi
Little Grassbird	T
Little Pied Cormorant	Pi

Common Name	Guild
Marsh Sandpiper	Sh
Masked Lapwing	Sh
Musk Duck	Du
Nankeen Night-Heron	La
Pacific Black Duck	Du
Pied Cormorant	Pi
Pink-eared Duck	Du
Plumed Whistling-Duck	Du
Purple Swamphen	He
Red-capped Plover	Sh
Red-kneed Dotterel	Sh
Red-necked Avocet	Sh
Red-necked Stint	Sh
Royal Spoonbill	La
Sacred Kingfisher	T
Silver Gull	Pi
Spotless Crake	He
Straw-necked Ibis	La
Swamp Harrier	T
Unidentified Cormorant	Pi
Unidentified Duck	Du
Unidentified Egret	La
Unidentified Small Grebe	Du
Unidentified Spoonbill	La
Unidentified spoonbill	La
Whiskered Tern	Pi
Whistling Kite	T
White-bellied Sea-Eagle	Pi
White-faced Heron	La
White-necked Heron	La
Yellow-billed Spoonbill	La

## Appendix C: Worked example of calculations

Here are the data from Duck Lagoon in autumn 2016;

Site Code	Visit Date	Common Name	Total Count	Guild	UNSW Common Name
DUC	15/04/2016	Australasian Darter	2	Pi	Darter
DUC	15/04/2016	Australian Pelican	12	Pi	Pelican
DUC	15/04/2016	Australian White Ibis	8	La	White (Sacred) Ibis
DUC	15/04/2016	Black Swan	6	He	Black Swan
DUC	15/04/2016	Eastern Great Egret	2	La	Great egret
DUC	15/04/2016	Grey Teal	53	Du	Grey teal
DUC	15/04/2016	Hardhead	1	Du	Hardhead
DUC	15/04/2016	Pacific Black Duck	1	Du	Pacific black Duck
DUC	15/04/2016	Purple Swamphen	3	He	Purple swamphen
DUC	15/04/2016	Royal Spoonbill	75	La	Royal Spoonbill
DUC	15/04/2016	White-faced Heron	1	La	White-faced Heron
DUC	15/04/2016	Yellow-billed Spoonbill	36	La	Yellow-billed Spoonbill

Which can in turn be summarised as;

<b>Total birds</b>	<b>200</b>
<b>Number of species</b>	12
<b>Number of migratory birds</b>	0
<b>Number of migratory species</b>	0
<b>Number of species of Du</b>	3
<b>Number of species of He</b>	2
<b>Number of species of La</b>	5
<b>Number of species of Pi</b>	2
<b>Number of species of Sh</b>	0
<b>Number (abundance) of Du</b>	55
<b>Number (abundance) of He</b>	9
<b>Number (abundance) of La</b>	122
<b>Number (abundance) of Pi</b>	14
<b>Number (abundance) of Sh</b>	0
<b>Are Du present?</b>	1
<b>Are He present?</b>	1
<b>Are La present?</b>	1
<b>Are Pi present?</b>	1
<b>Are Sh present?</b>	0
<b>Number of functional guilds present</b>	4

And then converted to an index by comparing the raw scores to the reference values from Table 5 above. Scores greater than 1 are capped at 1.

E.g. Total abundance index =  $200 \div 16.5 = 12.12 = 1.00$

Site	Autumn 2016 raw score	Duck Lagoon Reference	Index
<b>Total abundance</b>	<b>200</b>	16.5	1.00
<b>Total species richness</b>	12	15.3	0.78
<b>Abundance of migratory species</b>	0	0	.
<b>Richness of migratory species</b>	0	0	.
<b>Number of duck species</b>	3	4	0.75
<b>Number of herbivore species</b>	2	2	1.00
<b>Number of large wader species</b>	5	5.3	0.94
<b>Number of piscivore species</b>	2	4	0.50
<b>Number of shorebird species</b>	0	1	0.00
<b>Abundance of ducks</b>	55	11.3	1.00
<b>Abundance of herbivores</b>	9	6.4	1.00
<b>Abundance of large waders</b>	122	7.5	1.00
<b>Abundance of piscivores</b>	14	5.8	1.00
<b>Abundance of shorebirds</b>	0	1.1	0.00
<b>Number of functional guilds present</b>	4	4.3	0.93