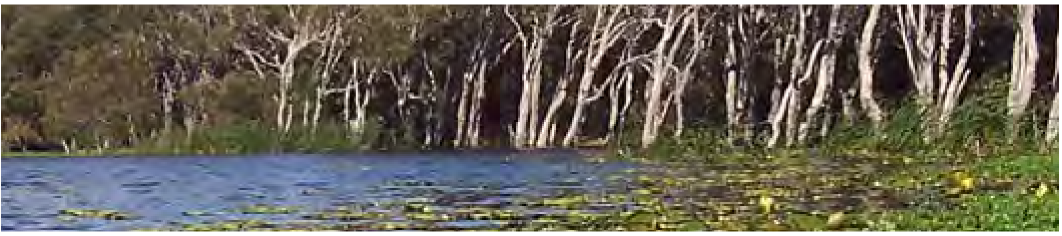
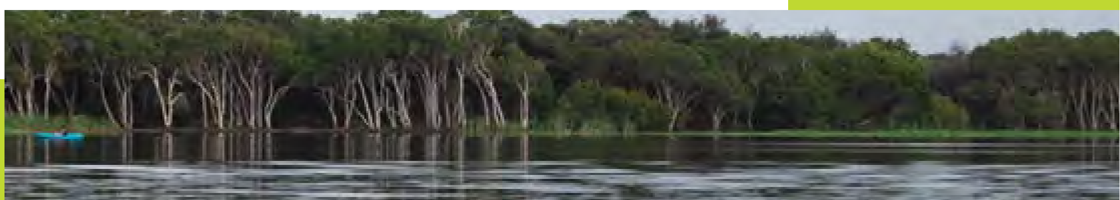
Wetland Assessment Techniques Manual for Australian Wetlands



Compiled by Cassie Price, Adam Gosling, Megan Westlake and Che Golus
WetlandCare Australia, November 2008

Version 3.6



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Acknowledgments

Wetland**Care** Australia's The Revised Wetland Assessment Technique, is adapted from;

Bolton, K.G.E. (2001) North Coast Wetland Assessment Guide Manual. Paperbark Wetlands. Department of Land and Water Conservation and Southern Cross University.

Bolton, K.G.E. (2001) North Coast Wetland Assessment Guide Manual. Freshwater Wetlands. Department of Land and Water Conservation and Southern Cross University.

Bolton, K.G.E. (2001) North Coast Wetland Assessment Field Manual. Paperbark Wetlands. Department of Land and Water Conservation and Southern Cross University.

Bolton, K.G.E. (2001) North Coast Wetland Assessment Field Manual. Freshwater Wetlands. Department of Land and Water Conservation and Southern Cross University.

Wetland Assessment, Prioritisation & Mapping Project May 2004

Smith, B., & Burns, C. (2004) WetlandCare Australia's Revised Wetland Assessment Technique (Freshwater and Paperbark Wetlands). WetlandCare Australia, Ballina, NSW.

Wetland**Care** Australia would like to thank the great number of people who have contributed so significantly to the development of these techniques over the years. The members of the Technical Reference Groups who have so kindly donated their time and expertise, the many landholders who have allowed us to assess their wetlands, the many individuals from local councils, state agencies and community groups who have helped us to identify wetlands in their areas and provided support, and the countless volunteers who have waded through the mud for the team.

Particular thanks needs to go to the Department for Environment and Heritage and Environmental Trust for their funding support and belief in the project.

This manual can be reference as:

Price, C., Gosling, A., Golus, C., & Weslake, M. (2007) Wetland Assessment Techniques Manual for Australian Wetlands. WetlandCare Australia, Ballina, NSW.

Disclaimer & Please Note:

This document is a work in progress. As more information becomes available and improved techniques are developed, this document will be revised and updated. Wetland**Care** Australia will also be developing further wetland health assessment indices for upland, inland and constructed wetlands in the future.

This Wetland Assessment Technique is designed to allow land managers, with little wetland experience, to assess the health of their wetland and make more informed decisions about management of the wetland. This technique has been tested on Swamp Forest, Open Freshwater and Estuarine Wetlands in northern NSW and south-eastern Qld. If you are using the technique in other areas, it can be adapted to suit, but please be aware that results may vary in other regions of Australia.

Any errors, omissions or suggestions for updates for future versions of the technique should also be forwarded to Wetland**Care** Australia's Ballina Office. Please contact Wetland**Care** Australia for the most up-to-date version of this document **PO Box 114, Ballina NSW 2478 or 02 66816169.**

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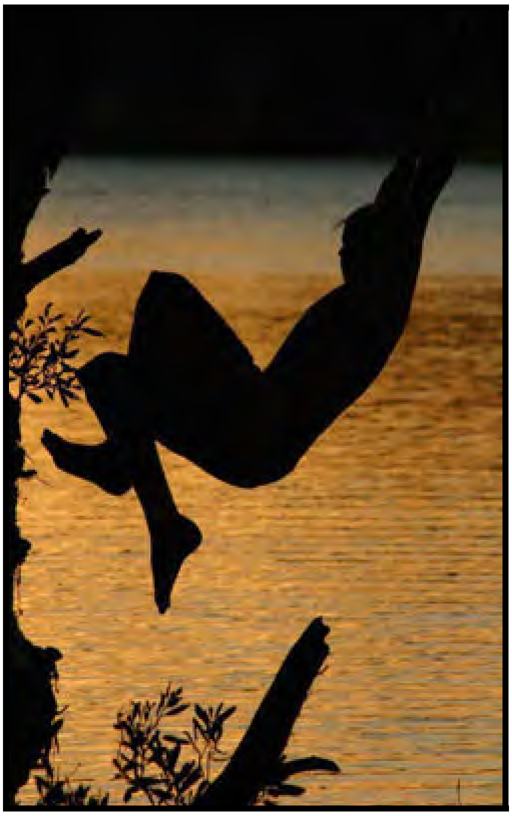
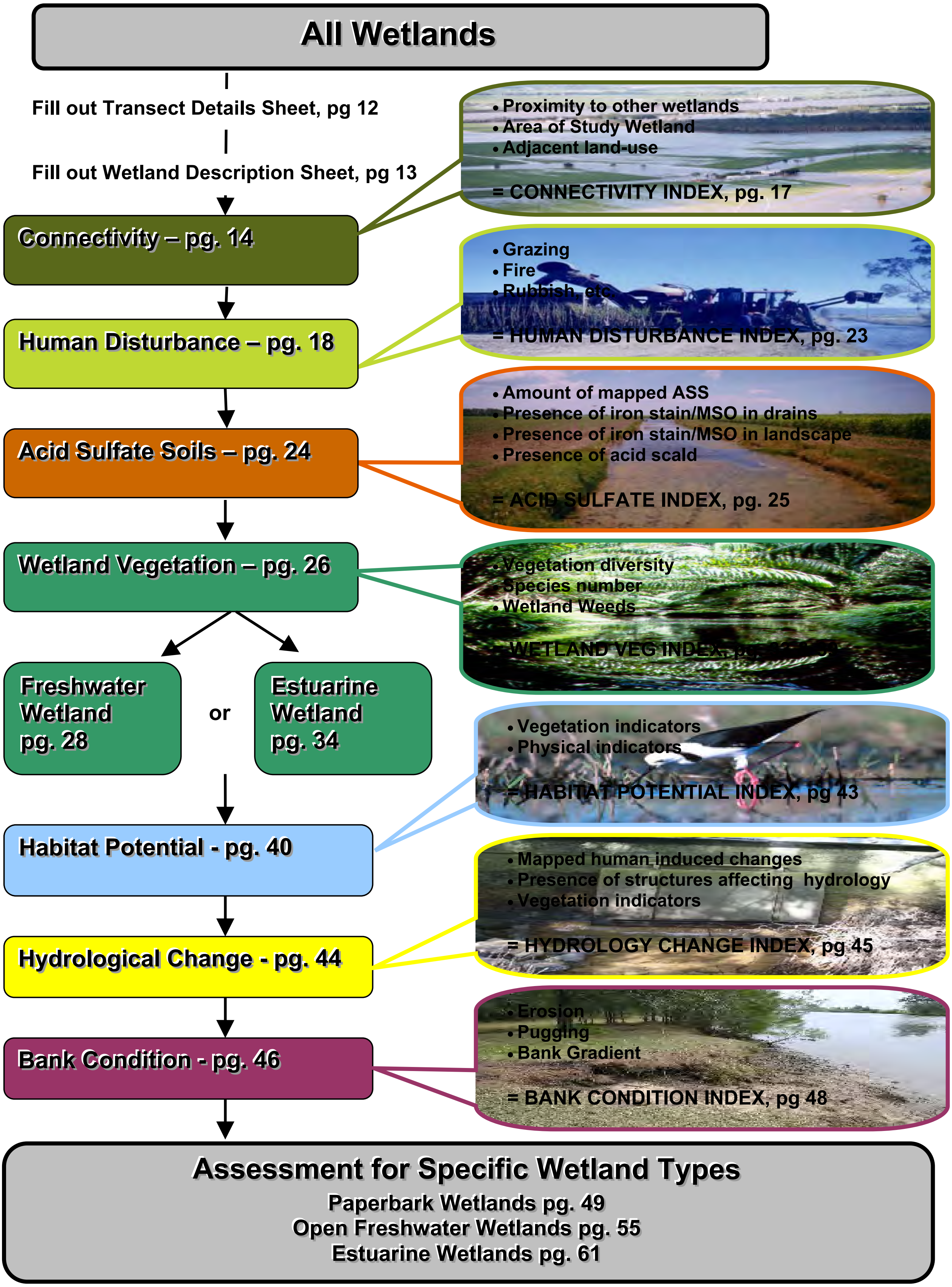


Photo: ***Adam Gosling, WetlandCare Australia***

Quick Reference Chart



Paperbark Wetlands

Paperbark Condition

- Vine growth
- Galls
- Standing dead & dying trees
- Clusters of fallen trees
- Necrotic spots

= PAPERBARK CONDITION INDEX *pg. 52*

Wetland Establishment

- Girth circumference
- Depth of peat layer

= WETLAND ESTABLISHMENT INDEX *pg. 54*

Open Freshwater Wetlands

Fringing Vegetation

- Width
- Diversity
- Species no.
- Weeds

= FRINGING VEGETATION INDEX *pg. 57*

Water Quality

- pH, turbidity, electrical conductivity, nitrate, ammonium, phosphate

= WATER QUALITY INDEX *pg. 60*

Estuarine Wetlands

Mangrove Condition

- Foliage cover
- Foliage health
- Community structure

= MANGROVE CONDITION INDEX *pg. 65*

Saltmarsh Condition

- Ground cover
- Crab burrows
- Snail density
- Necrosis
- Mangrove & terrestrial, freshwater weed encroachment

= SALTMARSH CONDITION INDEX *pg. 69*

Seagrass Condition

- Cover
- Depth
- Epiphyte cover

= SEAGRASS CONDITION INDEX *pg. 73*

SECTION 1

Why Use This Manual?

This Manual is an initiative of Wetland**Care** Australia and is designed to standardise and re-structure wetland assessment techniques. Standardised wetland assessment techniques will allow the formation of regional (and hopefully in the future, national) comparable databases that can be used for inclusion in a Decision Support Database to assist with prioritisation of wetlands for management through the Catchment Management Authorities and other sources of funds (this database has been developed under Wetland**Care** Australia, Hunter Rivers CMA and Northern Rivers CMA, and funded by the Environmental Trust).

The technique detailed in this document provides a comprehensive basis for natural resource managers to assess and monitor the overall health and general conditions of wetlands, achieving greater baseline and, where applicable, benchmark data and understanding. The technique allows rapid identification of changes in wetland health and condition, allowing impact monitoring and timely implementation of protection and / or restoration / rehabilitation measures.

How to Use This Manual

This Manual is intended to be used as a rapid and practical guide to paperbark, freshwater and estuarine wetland health and condition assessment. It is designed for a range of users with various levels of wetland knowledge and understanding. Although it is recommended that users possess a detailed knowledge of the local wetland and potential impacts upon it. The (Revised) Wetland Assessment Techniques Manual is a 'working draft'; it is up-to-date at the time of print. Although adjustments will be made as necessary and it is intended that additional indices (inland, upland and constructed wetlands) will be included over time.

Currently, this assessment technique is only suitable for use in swamp forests, reed & rush marshes, open freshwater wetlands, and estuarine wetlands. Further health assessment indices for upland, inland and constructed wetlands are likely to be developed by 2008. The information collected in this assessment can also be used in conjunction with GIS programs and databases to produce a range of useful tools, such as health maps and priority lists (for more information please phone your local Wetland**Care** Australia office or see **www.wetlandcare.com.au**).

Follow the steps in the 'Setting up a field assessment' section for a successful wetland health and condition assessment; it outlines the field gear required, how to plan the assessment and which health indices in this Manual to use. Follow the instructions under each health index, make the calculations provided and arrive at a health value (%) for that index. The health values can be converted into ratings, Very Poor, Poor, Fair, Good or Excellent, use the 'Results' section to do this, there is also space to make comments, if you like.

Use the 'Management Options Flowchart' section to make a 'wish list' of activities that will improve the wetlands health. These basic options can be used as the basis for a more detailed management plan for wetland rehabilitation. Use the 'Landholder Survey' section when consulting with the owner of the wetland, to get an idea of their thoughts on wetland management (Note: private landholders should only be approached by an extension staff).

Setting up a Field Assessment

To complete the wetland health assessments in the following pages, assessors should pack the equipment listed below, be sure that they are assessing the correct health indices for their wetland type and consider where and how they will complete their assessment (see below for further details).

Field Kit:

- 1 m^2 quadrat, with sub-quadrats
- 100m measuring tape
- Camera
- Compass
- Conductivity meter
- Drinking water
- EPIRB and/or mobile phone
- Esky & iceblocks for samples
- Eye protection goggles
- Field ID guides (plants, birds, reptiles, mammals etc)
- Field recording sheets (with clip board & pen / pencil)
- First Aid kit
- GPS
- Insect repellent
- pH meter
- Shovel
- Skin protection cream and gear
- Sturdy footwear
- Topographic map &/or aerial of the assessment site
- Turbidity tube
- Zip-lock sample bags & tags

Choosing Which Indices to Use

To decide which health assessment indices to use from this manual, assessors need to determine what type of wetland it is. Use the 'Wetland Type' guide below to determine which type relates best to the wetland concerned and the suitable health indices to assess.

There may be more than one wetland type in the area. In this case, multiple assessments are recommended, one for each wetland type. This is because the health indices to assess one wetland type might not be suitable to assess the other. Regardless of wetland type, there are seven health indices that relate to all wetlands, be sure to always assess these indices. These are provided below.

Indices for All Wetland Types:

- **Connectivity**
- **Human Disturbance**
- **Acid Sulfate Soils**
- **Vegetation (Freshwater or Estuarine)**
- **Habitat Potential**
- **Tidal Restriction or Hydrological Change**
- **Bank Condition (where applicable)**

Find the additional health indices below, for your wetland type, and then use the corresponding chapters in this manual to complete the criteria to assess your wetland's health.

Black-tailed Godwit, Red Rock NSW. Photo: ***Adam Gosling, WetlandCare Australia***

Wetland Types & Corresponding Health Indices:

- **Swamp Forest –** *generally* dominated by paperbark trees (*Melaleuca quinquenervia*) or swamp oak trees (*Casuarina glauca*), usually resembles a forest or swamp/forest with many other plant communities associated. Often has standing water, but can also be dry.

  Health Indices for Swamp Forests**:**
  - Paperbark Condition (where applicable)
  - Wetland Establishment (where applicable)

- **Freshwater Marsh -** dominated by reeds and/or rushes (e.g. Phragmites and/or Juncus), can have many different reed/rush species. Usually damp to very wet underneath the reeds & rushes.

  Health Indices for Reed/Rush Swamps:
  - Water Quality
  - Fringing Vegetation

- **Open Freshwater Bodies -** have at least a small area of open freshwater, often surrounded by varying vegetation. Can be of varying water depths. Can include lakes, lagoons, billabongs, oxbows and coastal freshwater dunal lakes, lagoons or swales.

  Health Indices for Open Freshwater Wetlands:
  - Water Quality
  - Fringing Vegetation

- **Mangrove -** are salt tolerant and dominated by mangrove trees or shrubs in areas that are periodically inundated by tides, in almost permanently waterlogged soils.

  Health Indices for Mangrove Forest Wetlands:
  - Mangrove Condition

- **Coastal Saltmarsh -** are communities of salt tolerant grasses, herbs, reeds, sedges, and shrubs that are found toward the upper limit of the tidal reach in estuarine environments. They are found at slightly higher elevations than mangrove forests.

  Health Indices for Saltmarsh Wetlands:
  - Saltmarsh Condition

- **Seagrass Meadows -** are found near-shore in brackish or marine environments, and consist of aquatic flowering plants.

  Health Indices for Seagrass Meadows:
  - Seagrass Condition

- **Coastal Lakes and Lagoons** - are bodies of saline or brackish water that has an intermittent opening to the sea. Usually separated from the sea by sand dunes or berms. Vegetation can be highly variable within this wetland type. Using the Fringing Vegetation Index may also provide useful data, particularly for highly modified systems or constructed wetlands.

  Health Indices for Coastal Lakes and Lagoons:
  - Mangrove Condition (where applicable)
  - Saltmarsh Condition (where applicable)
  - Seagrass condition (where applicable)
  - Water Quality

- **Freshwater Rivers / Creeks** – are flowing bodies of water which are not subject to tidal influences

  Health indices for Freshwater Creeks include:
  - Fringing Vegetation
  - Water Quality

Sampling Methodology

Sampling methodology describes the approach used to carry out the health assessment. Wetland health assessments are best completed so it can be easily repeated to show changes in wetland health over time. Maps and aerial photos are useful tools in planning sampling design and to get an overview of the area and type of wetland to be assessed.

Suggested sampling design includes walking a transect line from one side of the wetland to the other (or as far as possible) and using quadrats to quantify findings, following the steps below;

1. Use a GPS or marker pegs and a compass to record the transect starting point and compass bearing.
2. Describe your location on the 'Transect Details' sheet provided in this manual
3. Describe the wetland using the 'Wetland Description' sheet provided in this manual
4. Use the tape to measure and record the distance along the transect
5. As the wetland is traversed complete a full assessment of each health index at every significant vegetation change (i.e. New species begins to dominate in one or more stories or a number of additional species begin to appear). If your wetland has a fairly uniform distribution of species, it is recommended that you try to complete at least four quadrats if possible.
6. Follow the instructions carefully for each health index, note that some observations across the transect are pooled to arrive at the overall health of the wetland
7. Once the transect is completed be sure to have completed each of the health indices relevant to the wetland
8. Use the calculations provided to arrive at health ratings for each of the indices assessed.

Be prepared to get muddy! ***Photo: Sebastien Garcia-Cuenca***

SECTION 2: General Assessments for All Wetlands

Transect Details

Wetland Name:		
Transect Identifier:		
Assessors:		
Date assessed:		
Air Photo Ref.:		
Map Name:		
Map Scale:		
	Transect 1	Transect 2
Easting Start:		
Northing Start:		
Easting Finish:		
Northing Finish:		
Bearing:		
Landowner Name		
Landowner Address		
Landowner Phone No:		
Fax/email		
Written consent /date	Yes /	No /
Verbal consent/ date	Yes /	No /

Wetland Description

1. Assessed Management Unit (Individual Wetland) (= GIS polygon area)	**6. Brief Wetland Description**
2. Catchment Name	
3. Subcatchment Name	
4. CMA or NRM Region	
5. LGA Name and Zoning	

Site Characteristics

Water sources into the wetland - estimate the type of water sources entering the wetland and rank them in order of significance.

Floodplain waters		Ephemeral creek		Runoff – from rainfall (e.g. stormwater)	
Groundwater		Pumping		Runoff – from irrigation	
Estuary / Marine					

Other - specify

Current Weather (tick one below)		**Water Level** (tick one below)	
Dry Period		Lower than average / Low tide	
Average Period		Average / Mid tide	
Wet period		Higher than average / High tide	
Very wet period			

Land Situation

Who owns the wetland, and what is the land classification. The wetland is:

Located on private land		Located in a State forest		Located on Crown land	
Located in a National Park		Located within a flora or fauna nature reserve		Protected under JAMBA/CAMBA/ ROKAMBA	
Located in an area containing a site of aboriginal significance		Protected by SEPP14 or SEPP 26 Legislation (NSW)		Listed on a directory of wetlands of national or international significance	
Covered by Ramsar Treaties		Located within or adjacent to a key habitat corridor (regional or state)			

Sources of Information:

A wide range of information is contained through the Bureau of Meteorology website http://www.bom.gov.au/ including; Tides - http://www.bom.gov.au/oceanography/tides/ and

Weather - Rainfall maps to assist in determining current climate conditions compared to regional averages at http://www.bom.gov.au/cgi-bin/climate/rainmaps.cgi?page=indexa&area=aus

LGA Zoning – Information can be obtained through your local council including information regarding State Environmental Planning Policies (SEPP (NSW))

The Australian Wetlands Database contains information about Ramsar and important wetlands and is available at http://www.environment.gov.au/water/publications/environmental/wetlands/database/

The NSW National Parks website contains a mapping tool for identifying key habitat corridors and is available at http://maps.nationalparks.nsw.gov.au/keyhabs/default.htm

Connectivity

Wetlands once spanned thousands of square kilometres of the local landscape. Unfortunately the great majority of wetlands – more than 95% in some areas – have been destroyed. Most wetlands today are only fragments, becoming increasingly disconnected as agricultural and urban pressures intensify, and encroach upon their boundaries. This 'disconnection' compromises the ability of wetlands to perform their natural functions such as maintaining and providing biodiversity, treating water, trapping carbon from the atmosphere, and recycling nutrients. The connectivity index describes how well your study wetland is associated with surrounding wetlands and other ecosystems.

The connectivity index has four components:

1. proximity;
2. area;
3. roads; and
4. adjacent landuse.

As you assess each index, enter the score in the Wetland Connectivity Index table at the end of the section.

Proximity

How close is your study wetland to (i) other wetland fragments, and (ii) other natural ecosystems? Pristine wetlands are well-connected with other natural ecosystems due to their close proximity. However, clearing can disconnect wetlands, thereby reducing their ability to perform their ecological functions such as maintenance of biodiversity. The proximity table considers both of these questions.

A natural ecosystem is one that provides habitat for native fauna and flora. It must be at least ¼ ha (50 m x 50 m), be relatively undisturbed, and must not support rural, urban or industrial land use. Natural ecosystems can be terrestrial (on the land) or aquatic (in the water), and they are generally characterised by well-established stands of predominantly-native vegetation. Natural ecosystems can include other types of wetlands, natural waterways, eucalyptus or rainforest communities, or even a derelict paddock that now supports well-established regrowth.

Step 1: Estimate how far your study wetland is from the next nearest wetland that is at least 1 hectare in size, and circle the appropriate number. Maps and aerial photographs are very useful.

Distance to Nearest Wetland	Score
more than 10 km	0
5 to 10 km	1
1 to 5 km	2
200 m to 1 km	3
less than 200 m	4

Step 2: Estimate what portion of the wetland boundary merges with adjacent natural ecosystems, and circle the appropriate number.

Proximity to Adjacent Ecosystems	Score
No natural ecosystem merges with the wetland boundary	0
Adjacent natural ecosystem/s merges with up to 25% of the wetland boundary	1
Adjacent natural ecosystem/s merges with up to 50% of the wetland boundary	2
Adjacent natural ecosystem/s merges with up to 80% of the wetland boundary	3
Adjacent natural ecosystem/s merges with more than 80% of the wetland boundary	4

Step 3: Add up the two scores and enter the total here → **Proximity Score** [ ]

Step 4: Transfer proximity score to connectivity index table on page 17

Roads

Roads are a major cause of "disconnectivity" of wetlands. Approximately 3500 native animals are killed on Australian roads each day, and road kills are a major contributing factor to the loss of biodiversity. In addition, roads can cause erosion, pollution, and can modify the hydrology of a wetland. The road score is a measure of the road type and density within and around your study wetland.

Step 1: Estimate the area of your wetland (A (hectares)), and write the value in the road information table.

Step 2: Estimate the length of major roads (Lmajor (metres)) that are either within your study wetland, or within 50 metres from the wetland boundary. Major roads are defined as all bitumen roads and railway tracks, and all dirt roads that are used at least once per day on average.

Step 3: Estimate the length of minor roads (Lminor (metres)) within your study wetland, or within 50 metres from the wetland boundary. Minor roads are defined as dirt roads or grass roads that are used less than once per day on average, or a walking track.

Step 4: Calculate the road value using the equation:

$$\textbf{Road value} = \frac{(2 \times L_{major}) + L_{minor}}{A}$$

Step 5: Enter the relevant details in the table below.

Road Information	Value
Area of wetland (A) in hectares	ha.
Length of major roads (Lmajor) in metres	m.
Length of minor roads or walking tracks (Lminor) in metres	m.
Road value= $\frac{(2x\ L_{major}) + L_{minor}}{A}$	=

Step 6: Calculate the road score using the road conversion table.

Road Conversion Table					
Road Value	>200	>90 - 200	>30 - 90	>10 - 30	0 – 10
Road Score	0	1	2	3	4

Step 7: Enter your road score into the Connectivity Index table on pg 17.

Area

What is the area of your study wetland? Larger wetlands represent remnants of continuous wetland complexes that generally support more ecological values than smaller wetlands. There are 8 area ranges in the area table. Maps and aerial photographs are particularly useful when estimating the area of the wetland. Note that ¼ hectare is 50 m x 50 m, 1 hectare is 100 m x 100 m, 25 hectares is 500 m x 500 m and 100 hectares is 1,000 m x 1,000 m.

Step 1: Circle the number in the box that corresponds with the area of your study wetland

Area (ha)	< 2	2 - 5	> 5 - 20	> 20 – 50	>50– 200	>200–500	>500–1000	>1000– 2000	>2000
Score	0	1	2	3	4	5	6	7	8

Step 2: Write this number in the area score box in the Connectivity Index table on pg 17.

Important note: If you are doing more than one assessment for a single wetland, consider the total area of the wetland, not just the area of the assessment portion.

Adjacent Land Use

What land use/s does the surrounding land support? The land use activities in the adjacent land have a strong impact on the connectivity of a wetland.

Step 1: Tick each box in the adjacent land use table that describes the land use in the area surrounding your study wetland, tally up the ticks, and write this number in the adjacent land use value box.

Adjacent Land Use	Tick ✓
Within 200 metres from the wetland boundary :- there is an urban/agricultural structure (eg house, farm shed)	
there is more than one urban/agricultural structure	
some of the land supports high-density urban development (if so, also tick the option above).	
more than 10% of the land supports agriculture	
more than 50% of the land supports agriculture (if so, also tick the option above)	
some of the land supports intensive agriculture	
some of the land supports industrial activity	
Within 500 metres of the wetland boundary there is :- an effluent treatment works or similar	
a municipal waste disposal depot (dump)	
In the surrounding land within 1 km of the wetland:- more than 50% of the land supports intensive human activity. Type of intense human activity:	
there is an airport	
Within the wetland there are:-	
powerlines	
telephone cables	
natural drainage channels out of the wetland have been modified.	
natural drainage channels into the wetland have been modified	
a levee bank separates the wetland from the floodplain.	
Other (define)	
Adjacent Landuse Value (number of ticks)	

Step 2: Use the adjacent land use conversion table below to obtain the adjacent land use score and enter into the Connectivity Index table on pg 17.

Adjacent land use value	>12	10 - 12	8 - 9	6 - 7	5	4	3	2	1 or 0
Score	0	1	2	3	4	5	6	7	8

Step 3: Calculate the connectivity index. To do this calculate the proximity, area, road and adjacent land use scores, and write this number in the score value box.

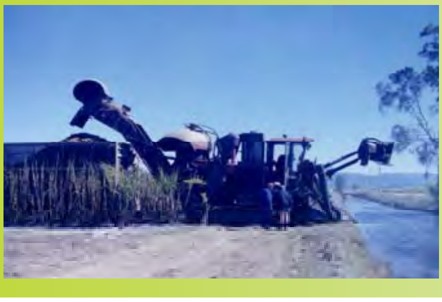
CONNECTIVITY INDEX TABLE						
Proximity Score +	**Roads Score +**	**Area Score +**	**Adjacent Landuse Score**	**Score Value**	**Calculation**	**Connectivity Index**
			=	**(**	**÷28) x 100**	**%**

Important Note: If for some reason you could not complete one of the scores, you can still get a rough idea of the connectivity index. To do this, you need to calculate a new potential value (the maximum score value you can achieve). If you have completed all four scores, then your potential value will be 28. For example, if you do not complete the adjacent landuse score, which has a maximum value of 8, then your potential value is 28 – 8 = 20.

Sources of Information:

A number of resources can be utilised to estimate the connectivity indices of your wetland including:
Topographic Maps (1:25 000 or 1:50 000)
Google Earth: http://earth.google.com/
NSW Department of Lands Spatial Information Exchange (SIX): http://www.maps.nsw.gov.au/

Wetlands are impacted by adjacent landuses including industrial and agricultural practices (Source: Department of Lands)



Human-Induced Disturbance

Has your study wetland been disturbed by human impacts? The human disturbance table considers the main disturbance factors that cause stresses to wetlands, and allows you to make an assessment of each of these factors. Each of these main disturbance factors is described in detail below. Once you have identified a disturbance factor in your wetland, you need to estimate its impact on the health of the wetland. You have the option of no impact, or low, medium and high impact.

Human-Induced Disturbance Factors

Grazing - Are grazing animals impacting on the health of your study wetland? Grazing animals can damage soil structure, vegetation, and can pollute the water. You may see cattle or other grazing animals in the wetland during your visit, or you may see signs that they have been present. Signs include pugging (hoof marks), cattle tracks, damage to the vegetation including rubbed bark off paperbark trees, and the presence of manure. Cattle have the potential to do major damage to vegetation, including stripping tree saplings of foliage, removing foliage from mature trees up to the level they can reach, and can ring-bark trees. Look for signs of these impacts, particularly in mangrove forests.

Not affected – no present or past evidence of cattle.

Low – grazing animals currently have access to the wetland, however there are no well-established tracks, manure present but uncommon, and little damage to the vegetation OR no current signs of grazing, but evidence of grazing in the past, however the remaining damage is mild;

Medium – grazing animals currently have access to the wetland, some established tracks, manure common in some places, some damage to vegetation OR no current signs of grazing, but evidence of grazing in the past, and the remaining damage has a moderate impact on the health of the wetland.

High – grazing animals currently have access to the wetland, established tracks throughout the wetland, manure widespread, major damage to vegetation OR grazing animals have recently been removed from the wetland, however the wetland remains severely disturbed.

Fire - Is there evidence of fire damage in the wetland? Some wetlands, such as paperbark wetlands are adapted to fires, which occasionally occur naturally. However, intensive human pressures in the last two centuries have greatly accelerated the occurrence and damage caused by fires. Fires can destroy vegetation, fallen trees and plant litter, reducing the habitat value of paperbark wetlands. A high incidence of fires can also change the composition of the vegetation, which will reduce the vegetation diversity. Dense stands of bracken fern and blady grass are good indicators of a higher-than-natural incidence of fires. In extreme cases, fires can burn out extensive deposits of peat, which accumulates over millennia in established paperbark wetlands. These peat fires can sometimes burn for months, releasing thousands of tons of carbon into the atmosphere and contributing to the accumulation of Greenhouse gases. Since peat fires cause such a disturbance to paperbark wetlands, the high category achieves a 5 instead of a 3.

Not affected – No evidence of recent fire, however there may be char marks on the bark of paperbark trees, up to about head height, which indicates the incidence of a minor fire in the past. No signs of “burnt out” tree stumps or major fire damage to existing trees; litter and peat layers well established with no evidence of fire damage; no dense stands of blady grass or bracken fern.

Low – Evidence of recent fire, however no major damage was sustained to the vegetation, and there is healthy regrowth occurring. The majority of the litter layer remains intact, there is no significant burning of fallen trees, and there is no damage to the peat later. OR Evidence of a moderate fire in the past, which may be indicated by a few “burnt out” tree stumps (less than 5% of living tree numbers), or char marks above head-height on the bark of the paperbark trees. However the native vegetation remains relatively intact with no current fire damage to vegetation. No significant stands of blady grass and/or bracken fern.

Medium – Evidence of a recent major fire, which has burnt the majority of the litter layer and understorey vegetation. Some saplings may be killed but there is no death of well-established trees. Some of the fallen trees are significantly damaged. There may be some minor scorching of the peat layer, however no significant peat deposits have been lost. OR There are some dense stands of blady grass and/or bracken fern in more than 20% of the wetland area, indicating the presence of a major fire in the past.

High – A peat fire has destroyed some of the peat layer.

Siltation - Does your study wetland have signs of siltation (deposits of soil eroded from the surrounding land). Siltation is common when surrounding land has been cleared, especially in areas with a steep gradient. Survey the wetland for silt deposits, especially around the water / land interface. Minor silt deposits occupy a small area (a few square metres), and do not significantly alter the depth of the water column. Major silt deposits occupy several or more square metres, and significantly reduce the depth of the water column. Note that sometimes wetland vegetation grows over silt deposits, so look carefully.

Not affected – no sign of silt deposits;
Low – a minor silt deposit in a small portion of the wetland
Medium – minor silt deposits in several portions of the wetland causing a localised reduction of wetland depth
High – Major silt deposit in the wetland causing a general reduction of the wetland depth.

Polluted water - Is the water in the wetland polluted? Many sources of pollution affect wetlands including runoff from nearby agricultural systems, stormwater runoff from roads and urban areas, septic tank seepage, cattle and direct dumping of pollutants into or adjacent to wetlands. Signs of polluted water include floating algal scums, attached algae on underwater surfaces (eg stems and fallen branches), floating bacteria (can look like an oil-slick), excessive growth (>70% coverage) of acquatic plants (such as water hyacinth, azolla and duckweed) and unhealthy aquatic vegetation. The water may have an unpleasant smell.

Not affected – No signs of water pollution.
Low – minor occurrence of algal scums and/or attached algae and/or floating bacteria, but aquatic vegetation appears healthy. Acquatic vegetation not excessive, and water odour not unpleasant.
Medium – moderate occurrence of algal scums and/or attached algae and/or floating bacteria. Aquatic vegetation appears moderately healthy, and floating plants not excessive. Water odour may be slightly unpleasant
High - Major occurrence of algal scums and/or attached algae and/or floating bacteria. There may be excessive growth of acquatic plants, and / or aquatic vegetation is not healthy. The water odour may be unpleasant.

Dead trees - Are there dead or dying trees in the wetland? A single dead tree is sometimes a natural phenomenon; however a group of standing dead trees can indicate long-term changes in water level, increases in salinity or nutrients or disturbance of acid sulphate soils. In some cases, wetland managers may choose to poison weed trees (such as camphor laurel). If this is the case, do not consider these trees, as their riddance provides a net benefit to the health of the wetland.

Not affected – No stands of dead or dying trees. If there are only a small number of isolated standing dead trees, also tick this box,
Low – the wetland contains a small stand of dead or dying trees, and less than 5% of trees in the wetland are dead
Medium - the wetland contains one or more stands of dead or dying trees, and between 5% and 20% of the trees are dead.
High – more than 20% of the trees in the wetland are dead.

Weeds - Are there weeds in the wetland? In general, a weed is defined as an exotic plant, namely one that does not naturally exist in the area. The plant can be from overseas, or from another part of Australia. Weeds generally invade from the cleared edges of wetlands, or from roads within the wetland. Some weeds, like camphor laurel, can also be dispersed by birds and therefore may become established in disturbed parts of the wetland interior. Weeds can seriously disrupt the ecosystem of wetlands by displacing native plant species, reducing habitat values, and by causing the wetland to be a source of weed dissemination. Note that weeds are considered in the fringing vegetation index as well as the human disturbance index. This is because weeds affect several different aspects of wetland health.

Not affected – No weeds present in the wetland interior, and less than 5% of the wetland boundary is affected by weeds. No major or noxious weeds present.
Low – Weeds present only on the edges of wetlands, and no weed incursion into the wetland interior due to roads. There may be occasional bird-dispersed weeds such as camphor laurel in the wetland interior, but these are not common. No noxious weeds present.
Medium – Some weed incursion into the wetland interior resulting from edge colonisation and/or incursion from roads and tracks, however at least half of the wetland remains free of weeds. There may be occasional bird-dispersed weeds present. Noxious weeds are either not present, or they are found only in a minor part of a wetland, such as a small part of the wetland boundary.
High – More than half of the wetland is colonised by weeds OR there are noxious weeds present throughout the wetland.

Rubbish - Is there rubbish in the wetland? Wetlands are surrounded by urban development and rubbish may accumulate around the wetland edges. If the wetlands are frequented by people, rubbish may accumulate in the wetland interior. Sometimes wetlands are used as dumps by unscrupulous people, or may even be part of a landfill site. Estuarine wetlands are affected by rubbish that has been washed into the estuary from urban areas in stormwater and rubbish discarded by people on boats and the coastline.

Not affected – No rubbish present;

Low – Rubbish uncommon and mainly restricted to the outer boundaries;
Medium – Rubbish common around the outer boundaries of the wetland OR wetland interior affected by rubbish in less than 20% of its area.
High – More than 20% of the wetland interior is affected by rubbish, and rubbish may be common around the outer boundaries of the wetland. OR The wetland has been used as a dump. OR The wetland is part of a landfill site.

Recent clearing - Has your study wetland been cleared in the last five years? Most wetlands have been subjected to extensive clearing over the last 150 years, and the remaining wetlands are but fragments of a once-extensive wetland network. However, this disturbance factor considers recent clearing – undertaken in the past five years. Wetlands are often cleared for agricultural development, urban development, construction of roads or installation of powerlines and telephone cables. Signs to look for can include a monoculture appearance (vegetation all the same size), domination by pioneer species and limited class structure.
Not affected – the wetland has not been recently cleared.
Low – Some, but less than 10% of the wetland area has been cleared during the last 5 years
Medium – Between 10% - 25% of the wetland area has been cleared during the last 5 years
High – More than 25% of the wetland area has been cleared during the last 5 years.

Drains from wetland - Have drains been constructed which remove water from your wetland? Many wetlands have been drained, which changes the plant composition and reduces the ability of wetlands to perform their hydrological functions.
Not affected – There are no drains from the wetland.
Low – Presence of drainage infrastructure, however it has little effect on the wetland hydrology. This may include shallow spoon drains affecting a minor portion of the wetland.
Medium – Presence of a drainage infrastructure that has a moderate effect on the wetland hydrology.
High – Presence of a well-established drainage infrastructure that considerably reduces the water holding capability of the wetland.

Drains into wetland - Have drains been constructed to direct water into the wetland? Drains into wetlands can change the natural flow path, and may increase the water volume into the wetland. In addition, drains into wetlands may bring pollutants to the wetland. Drains include agricultural drains, diverted flow paths, stormwater drains from roads and urban areas, overflows from dams, overflows from sewerage treatment works and septic tanks.
Not affected – No drains direct water into the wetland.
Low – One or more drains direct water into the wetland, however the water is not polluted, and there is little impact on wetland hydrology.
Medium – One or more drains direct water into the wetland, sometimes causing a noticeable increase in water volumes or having a moderate effect on natural flow paths.
High – Drains direct water into the wetland, sometimes causing hydrological overloading of the wetland. OR one or more drains allow the entry of polluted water into the wetland.

Domestic animals - Do domestic animals frequent your study wetland? Domestic animals, particularly dogs and cats, can cause disruption to the ecology of wetlands. Dogs are prone to disturbing wildlife and may form packs, which can kill and distress native animals. Cats can kill several small native animals per day, sometimes leaving a pile of feathers as a calling card. In general, the more urbanization in areas surrounding the wetland, the more likely domestic animals will cause disturbance to the wetland. When accompanying responsible humans, domestic animals generally cause fewer disturbances, but when left to their own devices, they can cause major disturbance.
Not affected – No domestic animals have access to the wetland.
Low – Domestic animals rarely frequent the wetland, and are mostly accompanied by responsible humans. No dog packs in the area, no piles of feathers.
Medium – Domestic animals regularly access the wetland, but generally are accompanied by responsible humans. No dog packs known in the area. There may occasionally be a pile of feathers where a cat has killed a bird.
High – Domestic animals often access the wetland, and are not always accompanied by responsible humans. Packs of dogs known to frequent the wetland OR piles of feathers are common.

Feral Animals - Do feral animals use the wetland for habitat? Feral animals can kill and displace native animals and some may cause damage to the vegetation and soil structure. Feral animals in the North Coast include cane toads, cats, pigs, foxes, rabbits, and goats. Buffaloes and horses are a particular problem in wetlands in other parts of Australia. Local landholders are the best source of information about feral animals. Opportunistic sighting of feral animal tracks is another method for identification of their presence.
Not affected – No evidence of feral animals in the wetland.
Low – Feral animals are a minor problem in the wetland.
Medium – Feral animals are a moderate problem in the wetland.
High – Feral animals are a major problem in the wetland.

Dead, diseased or wounded native animals - Are there dead, diseased or wounded native animals in your study wetland? When ecosystems become severely disturbed, animals can die. Sometimes animals naturally die, so the occurrence of an occasional dead animal in wetlands is not necessarily a cause of concern. However, several dead animals, especially if they are concentrated in a particular part of the wetland, can be an indicator of a major human disturbance.

Many disturbance factors can cause death of native animals. A common cause of death in wetlands is overcrowding. As large pieces of wetlands are destroyed, native animals that used that ecosystem for habitat must use nearby wetland fragments. This can cause severe competition, and ultimately the death of weaker animals. Birds, such as egrets, are particularly prone to death through competition, and sometimes hundreds of birds and chicks can die during breeding seasons. Other causes of native animal death can include road kills, killings by dogs, cats, foxes or humans, poisons in or around the wetland or polluted water. Ingestion of plastics and entanglement in fishing line is a common cause of death for fish, birds and other wildlife. Wounded and diseased animals can also be indicators of human disturbance. Domestic, feral animals and humans can wound native animals. High numbers of diseased native animals are often an indicator of human disturbance, particularly disturbance that increases the competition for habitat.

Not affected – No dead, diseased or wounded native animals in the wetland due to human disturbance. An occasional dead animal may occur naturally.

Low – Occasional dead native animals due to road kills or domestic animals or feral animals or humans. No evidence of wounded or diseased animals, and the majority of sighted animals are healthy.

Medium – Some areas of the wetland have several dead animals but the majority of the wetland contains healthy native animals OR some wounded native animals, but the majority of the native animals are not afflicted OR some diseased animals, but the majority of each affected species are healthy

High – High numbers of dead native animals within the wetland OR the majority of members of at least one species are diseased (e.g. the majority of koalas may have Chlamydia) OR the majority of members of at least one species are wounded.

Plant & bark removal - Some people remove plants from wetlands, although regulations generally prohibit the unauthorized removal of plants from wetlands. Evidence of plant removal can include depressions where people have dug the plants out of the ground, or saw cuts on trees where people have removed epiphytes (plants that grow on other plants, such as tree ferns and tree orchids) from trees. In addition, trees and shrubs may be cut and removed from the wetland to be used for firewood or timber.

Has bark been removed from the paperbark trees in your wetland? The paperbark from Melaleuca trees is used for a variety of purposes including lining for pots in the nursery industry, filling in "baby safe" pillows and mattresses, and bark art. Bark removal reduces the habitat value of the wetland, and may make the paperbark trees more susceptible to diseases, and less able to tolerate waterlogging. Generally the bark is removed by cutting a ring through the bark in two places - about 1 – 2 metres apart - then peeling the bark off. This leaves the tree with a "ringbarked" appearance, which is quite easy to identify. If the trees have been recently "ringbarked", there may be some bark regrowth, however when the regrown bark is pushed with the finger, it does not have a spongy feel like normal bark. If the trees have been ringbarked several years ago, the regrown bark has a spongy feel similar to uncut bark.

Not affected – No evidence of plant removal from your study wetland.

Low – Evidence of some plant removal from the wetland, however affected areas comprise less than 10% of the wetland area

Medium – Evidence of plant removal affecting between 10% - 50% of the wetland area, however less than half of the members of each species have been removed. No evidence of removal of rare, endangered or threatened plant species.

High – Evidence of plant removal throughout the majority of the wetland OR the removal of the majority of members of one or more species OR evidence of removal of rare, endangered or threatened plant species.

Boat Wash - Boat wash or wake is caused by the movement of the boat through the water, the faster the speed, the larger and more damaging the effect of the wash on river banks and shorelines. Boat wash has the potential to erode and undercut banks, causing severe damage to the riparian zone

Not Affected – No powered vessels are permitted or found on the waterway. No erosion or undercutting of the bank is evident at any location in the study site.

Low – Very few small powered vessels are found on the waterway, travelling only at 'no wash' speeds of below 4 knots. Some erosion of the bank may be evident within the study site

Medium – Small powered vessels are frequent on waterways, and some larger craft may be present. Craft are found travelling above 'no wash' speeds. Erosion and undercutting of the bank is present within the study site.

High – Powered vessels frequent the waterway, and are found travelling above 'no wash' speeds. Erosion and undercutting of banks is severe in places within the study site.

Vehicular Damage – Access to wetlands by vehicles such as 4 wheel drives and motorbikes can cause significant destruction to wetlands. Impacts can include soil compaction, flora damage, increased sedimentation, and disturbance of native fauna. Vehicular damage frequently occurs in ephemeral wetlands or saltmarsh. Areas impacted by vehicles usually take decades to rehabilitate.

Not Affected – No tyre tracks or evidence of vehicular access noted.

Low – Very few tyre tracks evident within the study site and limited to small area.
Medium – A number of tyre tracks within the wetland. These tracks may not be limited to one or two routes, but may cover considerable portions of the wetland.
High – Numerous tracks covering significant areas of the study site. Serious damage is noticeable and tracks dissect a majority or the wetland.

Other. If you see evidence of other disturbances that are not listed in the table, you can list them and allocate them a low, medium or high score in this section. Use the area under the table to further describe the disturbance. Other disturbances could include fishing, swimming, bait collecting or bushwalking.

Step 1: Circle the appropriate level of impact of each disturbance using the above explanations as a guide, and add the total value in the below table.

Human-Induced Disturbance Data Table				
	Level of Impact on Wetland			
Disturbance	Not Affected	Low	Medium	High
Grazing	0	1	3	5
Fire	0	1	2	5
Weeds	0	1	2	5
Rubbish	0	1	2	3
Recent clearing	0	1	2	3
Siltation	0	1	2	3
Polluted Water	0	1	2	3
Dead Trees	0	1	2	3
Drains from wetland	0	1	2	3
Drains into wetland	0	1	2	3
Domestic animals	0	1	2	3
Evidence of Feral animals	0	1	2	3
Dead, wounded or diseased native animals	0	1	2	3
Plant or bark removal	0	1	2	3
Boat Wash	0	1	2	3
Vehicular Damage	0	1	2	3
Other define	0	1	2	3
Human Disturbance Value (Add scores to find value – to be used in next table)				

Step 2: Use the Human Disturbance Value figure and convert it into a score using the below table.

Human Disturbance Value	>=20	18-19	16-17	14-15	12-13	10-11	8-9	6-7	4-5	2-3	0-1
Score	0	1	2	3	4	5	6	7	8	9	10

Step 3: Complete the below calculation to arrive at your Human Disturbance Index which is entered into the Results table in Section 4.

HUMAN DISTURBANCE INDEX TABLE		
Score Value	**Calculation**	**Human Disturbance Index**
	x10	**%**

Stormwater drains into wetlands represent a major source of human disturbance. They input pollution, rubbish, excess nutrients, sediments, garden weeds and alter the natural hydrology of the wetland. Photo: *Adam Gosling, WetlandCare Australia*

Sources of Information:

There are a number of sources of information that can be potentially utilised to attain information regarding the impacts that humans can have on a wetland. The owner of the land will normally have a good idea of the impacts that are occurring, and how they affect the wetland. Other useful resources may include:

Local councils

Local Landcare groups

Catchment Management Authorities (or regional Natural Resource Management Authority which can be found at http://www.nrm.gov.au/)

Acid Sulfate Soils

Is your study wetland affected by acid sulfate soils? Acid sulfate soils were formed by sulphur-reducing bacteria several thousands of years ago when the sea levels were about one metre higher than present levels. Disturbance of acid sulfate soils, such as digging drains, can cause these soils to oxidise and produce sulphuric acid. Active acid sulfate soils can cause serious degradation of water quality, and kill vegetation.

Field / Desktop Observations	Score	Comment
Mapped PASS (Potential Acid Sulfate Soil) Score: 2-High 1-Low 0-None		
Drainage intensity (Score value) Score: 0 = 0 m3 /ha 1 = 0 < 100 m3 /ha 2 = 100 < 500 m3 /ha 3 = > 500 m3 /ha **NB: drainage intensity is the approximate length x width x depth of drains per hectare**		
Presence of iron stain/ MSO in bottom of constructed drains (Use shovel to bring up bottom sediment) Score: 0 = Not present 1 = Slight < 1% 2 = Moderate 1 < 5% 3 = Heavy 5 < 20% 4 = Very Heavy > 20% **NB: MSO = black monosulfidic ooze, which has a distinctive sulfidic odour**		
Presence of iron stain / MSO across the low lying parts of the landscape (Use shovel to examine top 100 mm of surface soil profile. Look for MSO and/or iron deposits Score: 0 = Not present 1 = Slight < 1% 2 = Moderate 1 < 5% 3 = Heavy 5 < 20% 4 = Very Heavy > 20%		
Presence of scald (% transect polygon) Score: 0 = Not present 1 = Slight < 1% 2 = Moderate 1 < 5% 3 = Heavy 5 < 20% 4 = Very Heavy >20%		
ASS Total Value: **(add all scores above)**		

Step 1: Complete the Field / Desktop Observations table above. Sources of information to assist you to calculate Mapped Potential Acid Sulfate Soils are suggested below.

Step 2: Use the table below to convert the acid sulfate soil value to a score out of four.

Acid Sulfate Value	>10	6-10	4-5	1-3	0
Score	0	1	2	3	4

Step 3: Calculate your Acid Sulfate Index by using the formula below.

ACID SULFATE INDEX		
Score	Calculation	Acid Sulfate Index
(	**÷ 4) x 100 =**	**%**

Iron flocs are a good indication of the presence of acid sulfate soils.
Photo: ***Adam Gosling, WetlandCare Australia***

Sources of Information:

For further advice on acid sulfate soils contact the following organisations: your local council, NSW Department of Primary Industries, NSW Department of Environment and Climate Change, Landcare or Wetland**Care** Australia.

The entire NSW coastline has had its acid sulfate soil risk mapped. Maps (1:25,000) are available from the Department of Environment and Climate Change.

http://naturalresources.nsw.gov.au/soils/as_maps.shtml
To determine whether acid sulfate soils are present in your wetland refer to the NSW Department of Primary Industries publication "Keys to Success". To obtain a copy please phone (**02) 6626 1355**.

For general inquiries about acid sulfate soils contact the National Acid Sulfate Soil Information Officer on **(02) 6626 1355** or christina.clay@dpi.nsw.gov.au

Vegetation

How healthy is the vegetation associated with your wetland? The associated vegetation is defined as the native plant community of the wetland. Three separate indicators are used to quantify the health of the vegetation. This section is divided into two parts. The first part is for freshwater wetlands, and the second part for estuarine wetlands.

Vegetation Types: How many different plant types are present in the associated vegetation of your wetland? The number of vegetation types (e.g. tall trees, medium trees, small trees, vines and climbers, shrubs, ferns and orchids, grasses, herbs, and water plants etc.) plays a key role in shaping and community structure play an important role in maintaining habitat and plant biodiversity. In general, less disturbed and larger wetlands have a higher vegetation type score. However, it must be noted that some paperbark, mangrove, saltmarsh, and seagrass wetlands naturally have fewer vegetation types and species number than others. In particular, paperbark wetlands that have standing water for prolonged periods often have lower vegetation diversity. Generally, estuarine wetlands are expected to have less vegetation types and species diversity than freshwater wetlands.

Native Species: How many different native plant species are in the associated vegetation? The species number is a direct measure of the plant biodiversity, and an indirect measure of the habitat functions of the wetland. The species number score is the most variable score of all because it takes a high degree of field experience to count every one of the plant species. Wetland assessors with more field and plant identification experience will invariably find more species than assessors with less experience. This should be taken into account when drawing conclusions from the data. However, the species number score does not require you to identify plant species, which makes it easier for us novices! If you are not sure which category a plant goes in, then give it your best guess. The important thing is not to count the same plant in more than one category. For example, you can call a tree fern either a tree or a fern, but don't count it in both categories. When you have finished counting the number of native plant species, add up all the strokes, and write this total in the box provided.

Weeds: What weeds are in your study wetland, and how much have they infiltrated into the wetland interior?
For each quadrat record any new weed species and weed type (Sheet D) down the left hand side of the field sheets. Using the DAFOR scale (description below) record a rating for each weed species in every quadrat. This will help to describe vegetation changes within the wetland. Once the quadrats are completed you will be able to determine the extent of infiltration into your study wetland.

DAFOR Scale:

Dominant – the plant dominates the whole quadrat
Abundant – the plant occurs frequently over the whole quadrat, but is not dominant
Frequent – the plant occurs frequently over part of the quadrat
Occasional – the plant occurs in <3 quarters of the quadrat
Rare – there is only 1-2 specimens of the plant in the quadrat

At completion of the transect, count the number of vegetation types and the number of vegetation species and record the totals in the boxes provided at the bottom of the data sheets. On the weed data sheet record whether each weed was, minor, moderate or major AND if they had a low (L), medium (M) or high (H) infiltration into the wetland.

Weed Type:
Minor – the weed has low potential of spreading (non-invasive), it is not a noxious weed and it can be easily managed and/or removed.
Moderate – the weed has a moderate potential of spreading, is not a noxious weed and is more difficult to manage and/or remove.
Major – the weed has a high potential of spreading rapidly, it can be a noxious weed, it is extremely difficult to manage and/or remove.

Infiltration:
Low – Weed restricted to less than half of the wetland boundary, and there is no incursion of the weed into the wetland interior.
Medium – Weed is present in more than half of the wetland boundary and/or some incursion into the wetland interior resulting from edge colonisation and/or incursion from roads and tracks, however less than 25% of the wetland interior remains free of the weed.

High – More than 25% of the wetland interior is colonised by the weeds.
Use the quadrat sampling system to assess associated vegetation. Suggested quadrat size is 10m x 10m, within that area assess each parameter and record a representative letter for the DAFOR scale (detailed above in notes and below in summary).

Step 1: At each quadrat of your transect, complete Sheets A through to D to record number of vegetation types and number of species, and any weeds that may be present. Once your transect is completed, proceed to pg 32 to complete the necessary calculations for freshwater associated vegetation and pg. 38 for estuarine associated vegetation.

NB Photo point monitoring - Four photos are to be taken at every quadrat looking in the direction of the transect first then in a clockwise direction, to the right, back and left. Photo numbers to be recorded at the bottom of Weeds data sheet.

Aegiceras corniculatum. **Photo: *Adam Gosling, WetlandCare Australia***

Sources of Information:

Vegetation: Department of the Environment and Water Resources - http://www.anbg.gov.au/ or
http://www.environment.gov.au/biodiversity/abrs/online-resources/flora/main/
These websites are a great online starting point for information on Australian natives. Additionally they contain a number of links to other online resource material.

Also see:
PlantNET at http://plantnet.rbgsyd.nsw.gov.au/

Weeds: Classes of weeds vary considerably between regions and it is important to check weed categories for your area. Useful starting points to obtain information include:

Weeds Australia - http://www.weeds.org.au/
NSW Department of Primary Industries - http://www.dpi.nsw.gov.au/agriculture/noxweed (noxious weeds by LGA (NSW)
National Parks and Wildlife Service - http://www.nationalparks.nsw.gov.au/npws.nsf/content/weeds
Far North Coast Weeds - http://www.fncw.nsw.gov.au/cmst/fncw002/nova.asp

Freshwater Wetlands

SHEET A: Freshwater Associated Vegetation List all species within appropriate vegetation types eg. tall trees, medium trees etc	D= dominant A= abundant F= frequent O= occasional R= rare X= absent Quadrat No.																			
Tall Trees	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Eucalypt or Swamp Box trees																				
Figs																				
Medium Trees	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Paperbarks																				
Casuarinas																				
Acacia *sp.*																				
Small Trees (<3m)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Vines & Climbers (native species)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Twining Guinea Flower																				
Scrambling Lily																				
Common Silkpod																				
Five Leaved Water Vine																				
Climbing Fern, *Lygodium microphyllum*																				

SHEET B: Freshwater Associated Vegetation List all species within appropriate vegetation types eg. tall trees, medium trees etc	D= dominant A= abundant F= frequent O= occasional R= rare X= absent Quadrat No.																			
Shrubs (< 3 m)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Bearded Heath																				
Duboisia – *Duboisia myoporoides*																				
Palm Trees	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ferns & Orchids in Trees (eg staghorns)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Elkhorns																				
Birdsnest Ferns																				
Ferns & Orchids on Ground	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Bracken Fern																				
Blechnum sp.																				
Fishbone Fern																				
Grasses	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Blady Grass																				
Couch																				

SHEET C: Freshwater Associated Vegetation List all species within appropriate vegetation types eg. tall trees, medium trees etc	D= dominant A= abundant F= frequent O= occasional R= rare X= absent Quadrat No.																			
Herbs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Moss/ Lichen	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Cunjevoi (Elephant Ears)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Water Plants	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Reeds, rushes & sedges																				
Gahnia sp.																				
Restio sp.																				
Juncus sp.																				

TOTAL NUMBER OF DIFFERENT VEGETATION TYPES (Vegetation Type Value) Veg Types eg tall trees=1, shrubs=1 etc Tally from sheets A, B & C (to be used in the 'vegetation type conversion table' on pg. 32)	**TOTAL NUMBER OF SPECIES =** **(Species Number Value)** Tally from sheets A, B & C (excluding Weeds) (to be used in the 'species number conversion table' on pg. 32)

Record weed species found in quadrats in the table below. Also enter their weed type and infiltration rate, as described in the notes above.

SHEET D: Weeds

Immediately after field work include Weed Type (ie minor, moderate, major) and Weed Infiltration = L,M,H (ie low-med-high)

Quadrats 1 to 20

NB mark every box D-A-F-O-R or X

D= dominant A= abundant F= frequent

O= occasional R= rare X= absent

Weed Species Name	**Type** Min, Mod, Maj	**Weed Infiltration** Low Med High	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Lantana																						
Cassia																						
Morning Glory																						
Dutchman's Pipe																						
Passionfruit Vine																						
Crofton Weed																						
Mist Flower																						
Carpet Grass																						
Photo			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Record with a tick when 4 photos taken for quadrat.																						

Step 2: On completion of the transect, count the number of different **vegetation types** (Vegetation Type Value) using the headings provided in Sheets A – D (ie. Tall Trees, Small Trees, Water Plants etc). Also count the number of different **species** recorded (Species Number Value). Record these totals at the bottom of Sheet C. If you do not know a species, enter it as unknown, but be sure to count it as a different species.

Step 3: Enter the Values into the tables and calculations provided below. DO NOT enter WEED data until Step 6.

Step 4: Use the table below to convert the Vegetation Type Value (from Sheet C) to a score out of five.

VEGETATION TYPE CONVERSION TABLE						
Vegetation Type Value	0-1	2-3	4-5	6-7	8-9	>=10
Vegetation Type Score	0	1	2	3	4	5

Step 5: Use the table below to convert the Species Number Value (from Sheet C) to a score out of five.

SPECIES NUMBER CONVERSION TABLE						
Species Number Value	< 8	8 - 15	15 - 25	25 - 35	35 - 50	>50
Species Number Score	0	1	2	3	4	5

Step 6: Use the table below to calculate the weed value, taking into account the number of weeds, their type and infiltration into the wetland.

WETLAND WEED TABLE	Sub Total
No. of Minor Weeds x 1 =	
No. of Moderate Weeds x 2 =	
No. of Major Weeds x 3 =	
No. of Low Infiltration Weeds x 1=	
No. of Medium Infiltration Weeds x 2 =	
No. of High Infiltration Weeds x 3 =	
Total Weed Value:	

Step 7: Use the table below to convert the Total Weed Value (from Step 6) to a score out of five. Use the score below, along with the Vegetation Type and Species Scores to calculate the Wetland Vegetation Index.

Wetland weed conversion table						
Weed Value	>42	31 - 42	21 - 30	13 - 20	6 - 12	<6
Weed Score	0	1	2	3	4	5

Step 8: Use the calculation below to add the scores above and determine the Wetland Vegetation Index.

WETLAND VEGETATION INDEX					
Vegetation Type Score +	Species Number Score +	Weed Score	Score Value	Calculation	Wetland Vegetation Index
		=	**(**	**÷ 15) x 100**	**%**

Ground Asparagus is a garden escapee which has become a major threat to biodiversity in coastal wetlands. Photo: *Adam Gosling, WetlandCare Australia*

Estuarine Wetlands

SHEET A: Estuarine Associated Vegetation List all species within appropriate vegetation types eg. tall trees, medium trees etc	D= dominant A= abundant F= frequent O= occasional R= rare X= absent																			
Trees	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Grey Mangrove (*Avicennia marina*)																				
Orange Mangrove (*Brugiera gymnorhiza*)																				
Stilted Mangrove (*Rhizophora stylosa*)																				
River Mangrove (*Aegiceras corniculatum*)																				
Milky Mangrove (*Excoecaria agallocha*)																				
Yellow Mangrove (*Ceriops australis*)																				
Hibiscus (*Hibiscus tiliaceus*)																				
Swamp Oak (*Casuarina glauca*)																				
Paperbarks																				
Tuckeroo																				
Small Trees & Shrubs (< 3m)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**

SHEET B: Estuarine Associated Vegetation List all species within appropriate vegetation types eg. tall trees, medium trees etc	D= dominant A= abundant F= frequent O= occasional R= rare X= absent Quadrat No.																			
Reeds & Rushes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Spiny Rush (*Juncus krausii*)																				
Bare Twig Rush (*Baumea juncea*)																				
Fringe Rush (*Fimbristylis dichotoma*)																				
Common Reed (*Phragmites australis*)																				
Vines & Climbers (native species)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Mangrove wax flower vine																				
Ferns	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Mangrove fern (*Acrostichum speciosum*)																				
Grasses	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Salt Couch (*Sporobolus virginicus*)																				
Prickly/Dune Couch (*Zoysia macrantha*)																				
Streaked Arrowgrass (*Triglochin striatum*)																				
Blady Grass (*Imperata cylindrica*)																				

SHEET C: Estuarine Associated Vegetation

List all species within appropriate vegetation types eg. tall trees, medium trees etc

D= dominant A= abundant F= frequent O= occasional R= rare X= absent

Quadrat No.

Herbs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Samphire/Glasswort (*Sarcocornia quinqueflora*)																				
Seablite (*Sueda australis*)																				
Creeping Brookweed (*Samolus repens*)																				
Berry Saltbush (*Einadia hastate*)																				
Other (fungi, lichens, mistletoe, orchids etc)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Fungi species																				
Lichen species																				
Water Plants	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Eelgrass or Ribbonweed (*Zostera capricorni*)																				
Eelgrass (*Zostera Muelleri*)																				
Eelgrass (*Heterozostera tasmanica*)																				
Paddleweed (*Halophila ovalis*)																				
Paddleweed (*Halophila decipiens*)																				
Sea Tassel (Ruppia spp.).																				

TOTAL NUMBER OF DIFFERENT VEGETATION TYPES =

Veg Types eg tall trees=1, shrubs=1 etc

Tally from sheets A, B & C (Number to be used in the 'vegetation type table' on pg. 38) =

TOTAL NUMBER OF SPECIES =

(ie. species diversity)

Tally from sheets A, B & C (excluding all Weeds) =

(Number to be used in the 'species number table' on pg. 38)

Record weed species found in quadrats in the table below. Also enter their weed type and infiltration rate, as described in the notes above.

SHEET D: WEEDS

Immediately after Field Work– include Weed Type (ie minor, moderate or major) and Weed Infiltration = L,M,H (ie low-med-high) by referring to the weed list attached, Addendum Section 5 and the Addendum's weed table

Quadrats 1 to 20

NB mark every box D-A-F-O-R or X

D= dominant A= abundant F= frequent

O= occasional R= rare X= absent

Weed Species Name	**Type** Min, Mod, Maj	**Weed Infiltration** Low Med High	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Bitou Bush / Boneseed																						
Groundsel																						
Five-Leaved Morning Glory																						
Coral Tree																						
Siratro																						
Winter Senna																						
Broad-leafed Paspalum																						
Singapore Daisy																						
Brazilian Pepper Tree																						
Marram Grass																						
Rice Grass																						

Step 2: On completion of the transect, count the number of different **vegetation types** (Vegetation Type Value) using the headings provided in Sheets A – D (ie. Tall Trees, Small Trees, Water Plants etc). Also count the number of different **species** recorded (Species Number Value). Record these totals at the bottom of Sheet C. If you do not know a species, enter it as unknown, but be sure to count it as a different species.

Step 3: Enter the Values into the tables and calculations provided below. DO NOT enter WEED species recorded until Step 6.

Step 4: Use the table below to convert the Vegetation Type Value (from Sheet C) to a score out of five.

VEGETATION TYPE CONVERSION TABLE						
Vegetation Type Value	0-2	3	4	5	6-7	8+
Vegetation Type Score	0	1	2	3	4	5

Step 5: Use the table below to convert the Species Number Value (from Sheet C) to a score out of five.

SPECIES NUMBER CONVERSION TABLE						
Species number value	0 – 4	5 – 9	10 - 14	15 – 19	20 – 24	25+
Species number score	0	1	2	3	4	5

Step 6: Use the table below to calculate the weed value, taking into account the number of weeds, their type and infiltration into the wetland.

WETLAND WEED TABLE	**Sub Total**
No. of Minor Weeds x 1 =	
No. of Moderate Weeds x 2 =	
No. of Major Weeds x 3 =	
No. of Low Infiltration Weeds x 1=	
No. of Medium Infiltration Weeds x 2 =	
No. of High Infiltration Weeds x 3 =	
Total Weed Value:	

Step 7: Use the table below to convert the weed value (from Step 6) to a score out of five. Use the score below, along with the vegetation type and species number scores to calculate the Wetland Vegetation Index.

WETLAND WEED CONVERSION TABLE						
Weed Value	>42	31 - 42	21 - 30	13 - 20	6 - 12	<6
Weed score	0	1	2	3	4	5

Step 8: Use the calculation below to add the scores above and determine the Wetland Vegetation Index.

WETLAND VEGETATION INDEX					
Diversity Score +	Species Number Score +	Weed Score =	Score Value	Calculation	Wetland Veg Index
			(	**÷ 15) x 100**	**%**

Brugiera gymnorrhiza **Photo:** ***Cassie Burns, WetlandCare Australia***

Habitat Potential

How effective is your study wetland at providing habitat for native animals? The provision of habitat is a very important ecological role of wetlands, which can be great buffers and maintainers of biodiversity. The habitat tables contain 24 habitat indicators. Use the tables to record the frequency of each habitat indicator in your study wetland. Only consider native animals in your assessment. It takes quite a bit of field experience to get "tuned-in" to some of the habitat indicators, so less experienced assessors may get lower scores than those more experienced. This should be taken into account when drawing conclusions from the data. You need to be a bit of a detective to spot some of the habitat indicators. Look in the leaf litter for insects and other wetland animals.
Have a good look at the stems and bark of the trees. Small animals make their homes in crevices in the bark, and older wetlands can have many habitat holes in them. Look for animal paths and animal claw marks on the bark of paperbark trees – some branches get rubbed almost raw from all the little feet that climb on them. Look for animal scats. Footprints are easy to spot in muddy areas. To make things easier, you can draw on the experience of landholders and other locals who may be able to tell you what types of native animals are present in the wetland.

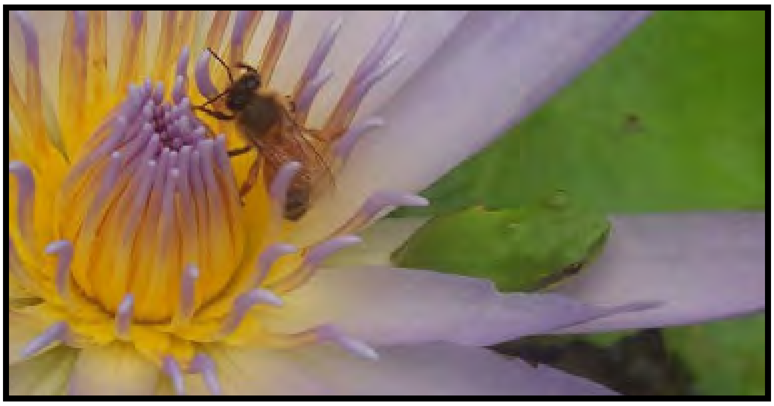


Photo: *Cassie Burns, WetlandCare Australia*

There are four scoring options for each of your quadrats:

0 - means that there was no evidence of the indicator
1 - means that the indicator is present 1-2 times within your quadrat.
2 - means that the indicator is present 2-5 times within your quadrat.
3 - means that the indicator is present >5 times within your quadrat.

When assessing the frequency of occurrence, consider the diversity of the indicator. For example, you may assess a degraded wetland that has a lot of mosquitoes, but few signs of other insects. In this case, the insect indicator would be allocated a low frequency despite the numerous amounts of this annoying pest.

All estuarine vegetation including mangroves, saltmarsh and seagrass meadows can be considered as aquatic vegetation.

Sources of Information:

The potential habitat for your wetland will be assessed on site inspection. It can however be beneficial if you have knowledge of the fauna species which are found in your region, and the types of habitat which these species are dependant. A great deal of information is available online through the Department of Environment and Climate Change NSW website http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/index.aspx where you can search for endangered or vulnerable species found in your region.
For Qld species see http://www.epa.qld.gov.au/nature_conservation/wildlife/wildlife_online/

Habitat

Step 1: Complete the table below during field work/transects

Step 2: Score occurrence for each indicator for each quadrat as 0 = Absent, 1 = Low (indicator present 1-2 times), 2 = Medium (2-5 times), 3 = High (>5 times).
** For Forest Structure/Layers score occurrence as 0 = Absent, 1 = one layer, 2 = two layers present, 3 = three to four layers present.

Step 3: On completion of transect, add total of all scores for each indicator in the 'Overall' and divide by number of quadrats for the average. Then add up your averages to determine your total averages score (α).

Table A	Quadrat number																					
Habitat indicator	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Overall**	**Av.**
Physical Indicators																						
Forest Structure/layers**																						
Fallen branches/ trees																						
Standing dead trees																						
Large Hollows (trunk)																						
Small Hollows (branches)																						
Decorticating Bark																						
Snags/ Rocks (aquatic habitat)																						
Estuarine vegetation parameters below should be recorded using % cover– Low (<5%) = 1, Medium (>5% or <75%) = 2, High (>75%) = 3 (record species in vegetation section)																						
Est. Veg. (aquatic habitat)																						
Est. Veg. (aquatic shade)																						
Nectar Bearing Plants																						
Use a 1m^2 quadrat when recording for leaf litter, numbers of burrows and shells present.																						
Leaf Litter or debris																						
Shells																						
Burrows																						
Freshwater Wetland parameters below should be scored using % cover– Absent =1, Low (<5%) = 2, Medium (>5% or <75%) = 3, High (>75%) = 0																						
Floating Aquatic Plants																						
Submergent Aquatic Plants																						
Emergent Aquatic Plants																						
																					Total of Averages(α) =	

Step 4: For the following habitat indicators, determine if the wetland has any of the following core habitat types or bonus indicators.

Scoring options are: assign a score of 3 if the indicator is present and covers an area of at least a 10m x 10m ($100m^2$) quadrat in one complete parcel;
assign a score of 2 if the indicator is present and small patches add up to a total of at least approx. $100m^2$;
assign a score of 1 if the indicator is present, but only in very isolated patches of less than approx. $100m^2$.

Table B **Core Habitat Types**	✓ when present	Score
Open Water		
Forest		
Sedge or Saltmarsh		
Sand or MudFlats		
Island		
Standing Water		
Bonus Indicators		
Fauna Activity – burrows, scats, insects, tracks etc **		
Tidal Influence or evidence		
	TOTAL (β) =	

** For fauna activity – Score occurrence for your wetland as 0 = Absent, 1 = Low (indicator present 1-2 times), 2 = Medium (2-5 times), 3 = High (>5 times)

Step 5: Add your total average score from table A (**α**) and the total score from Table B (**β**) together to determine your habitat score.

HABITAT SCORE **Total Average from Table A (α)**	**Total Score from Table B (β)**	**Habitat Score**
	+	**=**

Step 6: Convert the Habitat Score to a Value using the Habitat Conversion Table below, then complete the Habitat Index equation to find your Habitat Potential Index.

HABITAT CONVERSION TABLE	
Habitat Score	Value
0-1	0
2-3	1
4-5	2
6-7	3
8-9	4
10-11	5
12-13	6
14-15	7
16-17	8
18-19	9
20-21	10
22-23	11
24-25	12
26-27	13
28-29	14
30-31	15
32-33	16
34-35	17
36-37	18
38-39	19
40-41	20
42-43	21
44-45	22
46-47	23
48-49	24
50+	25

HABITAT POTENTIAL INDEX		
Value	Calculation	Habitat Potential Index
(	**÷ 25) x 100**	**%**

Hydrological Change or Tidal Restriction

"Hydrology is probably the single most important determinant of the establishment and maintenance of specific types of wetlands and wetland processes." -Mitsch and Grosselink (1993)

Changes to the hydrological function of a wetland can have serious deleterious impacts on the health of the ecosystem. These impacts can include altering the maximum or minimum water levels, reducing the amount of flow through the wetland, changes to the natural wetting and drying cycles, or completely disconnecting the wetland from its hydrological source. These actions can significantly alter ecosystem balance, vegetation community structure and distribution, animal habitat potential, or to the complete destruction of the wetland.

Tidal restriction to estuarine wetlands lowers the salinity and increases the intrusion of terrestrial and freshwater species into the area (Scheltinga et al. 2004). Tidal restriction can be caused by structures such as breakwalls, pipes, barrages, locks, and weirs. Land reclamation and sedimentation can also result in major changes to the hydrological function of wetlands. Each of these elements has a unique effect on the tidal regime of an estuary, and should be scored according to the impact on the natural tidal regime.

There are 3 important steps involved in assessment of hydrological regime:

Step 1: Study maps, aerial photographs and if at all possible use GIS to observe any large scale structures that may have been put in place. Vegetation structure can also be easily identified by comparing older photographs with newer ones. Things to look out for include the construction of roads, bridges, and urban areas, change in the vegetation community of an area,

Step 2: Field observation of structures and assessment of the impact they have on the wetland. Sometimes roads and other urban features are built on reclaimed wetlands. This effectively cuts off any areas on higher ground, and drastically changes the hydrological regime.

Step 3: Vegetation indicators are the final method. Are there signs that the distribution, health or mixture of species has been altered or stressed by changes in hydrological function? In estuarine wetlands, freshwater or terrestrial species present may indicate a lack of tidal flushing, or encroachment of native or exotic species which may indicate changes to the natural hydrological regime? Assessing the level of impact may be subjective, particularly for a one-off survey. If you have access to historical information like maps, photos or personal communications with local landholders may provide invaluable information in establishing the degree of change for that site.

Key to assessing tidal restriction and hydrological modification:

Not Present – The ecosystem is in a natural or near-natural state with none, or no measurable hydrological change.

Small – Some hydrological modification has taken place, either by placing small artificial structures for drainage (small, shallow drains), or barriers to prevent tidal influx or water flow. These structures will only affect the ecosystem at low tide, with mid – high tides inundating the wetland, or prevent low water flows in freshwater systems.

Mod – Larger structures or degree of hydrological modification of the landscape. Structures such as levee banks cutting off the wetland from the estuary or water source, with pipes, drains or culverts connecting the two, that restrict water inflow (increasing lag time) or only allow mid – high tides (or higher level flows) to inundate the wetland. Structures to look for include: Drains in and out of the wetland, bridges, pipes, culverts, roads, walkways, levee banks, or landfill.

High – As above, but with an even greater degree of tidal restriction and/or hydrological modification. Very large structures may be present with the wetland experiencing a highly modified flow regime. Only high or king tides or extreme weather events will inundate the wetland, or lag times are extreme.

Complete – The hydrological regime has been totally modified, with no tidal inundation or water flow on a regular basis. For tidal areas, water flow may be restricted to freshwater only which will result in the eventual loss of the natural ecosystem. Constructed levees without any water passage structures are a major cause of complete hydrological modification.

OBSERVATION	SCORE	COMMENT	
Mapped Human Induced Changes & Structures **Score** **2** – None visible **1** – Moderate **0** – High			
Presence of Structures Affecting Hydrological Regime **Score** **5** – Not Present **4** – Small structures with little hydrological or tidal restriction **3** – Structures with low degree of hydrological or tidal restriction **2** – Structures with moderate degree of hydrological or tidal restriction **1** – Structures with high degree of hydrological or tidal restriction **0** – Complete hydrological or tidal restriction			
Vegetation Indicators **Score** **3** – No obvious changes to vegetation community health, type or structure as a result of hydrological change or tidal restriction **2** – Some indications of changes to vegetation community health, type or structure as a result of hydrological change or tidal restriction **1** – Significant indications of changes to vegetation community health, type or structure as a result of hydrological change or tidal restriction **0** – Complete vegetation community change or very high mortality of original vegetation species due to hydrological change or tidal restriction			
HYDROLOGICAL CHANGE INDEX = TOTAL (add all scores from above)		**X 10**	**=**

Sources of Information:

Topographic Maps and Aerials / Satellite Imagery

Local Management Plans and / or local landholder personal communication

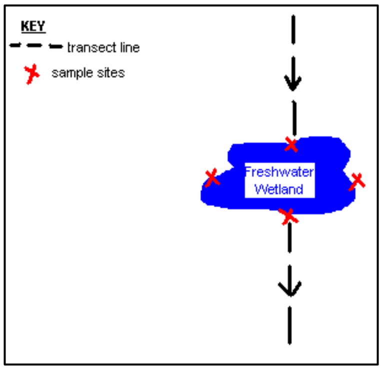
Department of Primary Industries (NSW) – Floodgates, fish barrier structures

Bank Condition

The condition and stability of the terrestrial / aquatic boundary of a wetland plays an integral role in the overall health of the wetland, and connected aquatic environs. Human induced factors can lead to significant degradation of bank condition including pedestrian or stock access, feral animals, riparian vegetation destruction and drainage.

Erosion

Is your study wetland affected by erosion? A number of stresses can promote erosion including clearing, grazing, roads and burst pipes. At each of the four sampling sites for open freshwater wetlands (see diagram on right), and at least three (preferably four) sampling sites for other freshwater or estuarine wetland systems, assess the erosion of the bank using the erosion classification table to help you make your choices.



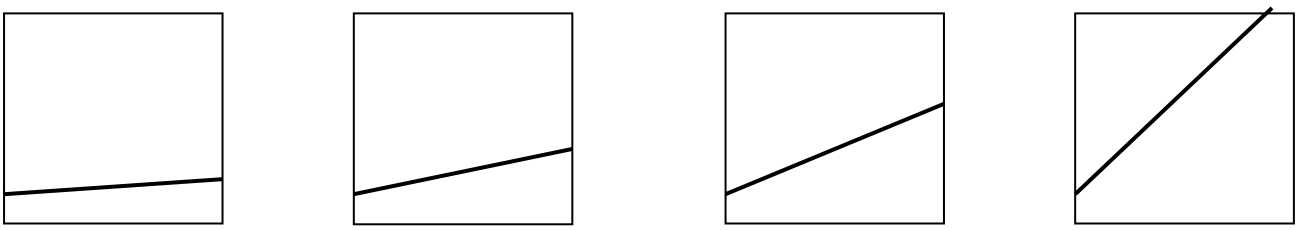
Erosion classification table	
Stable	No signs of erosion, and the bank is protected by healthy ground cover plants and/or a well-developed litter layer (fallen leaves, twigs, bark etc).
Good	Minor spot erosion occurring in some places, however most of the bank is protected by healthy ground cover plants and/or a well-developed litter layer.
Moderate	Spot erosion linked causing damage to vegetation and bare spots. There may be rill erosion causing some scouring, and there is damage to the ground cover vegetation and / or the litter layer.
Unstable	Extensive erosion with bare spots, rills and scouring common. There may also be gully erosion. There is considerable damage to the ground cover vegetation and / or the litter layer.

Pugging

Do grazing animals have access to your study wetland? Pugging is the term used to describe hoofprints of cattle and other stock or feral animals such as pigs or goats. To measure pugging, you need a 1 m^2 quadrat. Place the quadrat close to the waters edge, and record the number of pugs within the quadrat. Be careful to count every one – sometimes two or more overlapping pugmarks are easy to mistake as a single pugmark, and old pugmarks can be disguised by vegetation and siltation. If at least half of a pugmark is within the area of the quadrat, count it, but if less than half of a pugmark is within the quadrat, then do not count it.

Bank Gradient

How steep are the banks in your wetland? In general, the steeper the bank, the more prone it is to erosion, and the fewer zones of vegetation that the bank can support. Farm dams often have steep banks, although eco-conscious land managers are starting to build dams with shallower bank gradients. Bank gradient must be assessed at each of the four sites.



Shallow   Moderate   Steep   Very Steep

Step 1: At each of your quadrats, circle the number which best represents the degree of erosion at that site. Use the ‘erosion classification table’ on page 46 as a guide. After you have completed this assessment at your quadrat sites, take an average of your circled numbers and record in the space provided.

Erosion Table – circle one number per site				
	Stable	Good	Moderate	Unstable
Site 1	3	2	1	0
Site 2	3	2	1	0
Site 3	3	2	1	0
Site 4	3	2	1	0
Erosion Value(avg of circled numbers):				**=**

Step 2: Convert the Erosion Value to a ‘Score’ using the table below. This score will be used to calculate the Bank Condition Index on pg. 48.

Erosion Value	<1	>=1 & <2	>=2 & <3	3
Score	0	1	2	3

Step 3: At each of your selected bank condition sites, randomly select three 1m^2 quadrats and count the pug marks within. Calculate and record the pugging average

Pugging	**Site 1**			**Site 2**			**Site 3**			**Site 4**			**Total Average**
Quadrat	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	
Value													

Step 4: Use your pugging average to determine your ‘score’ which is to be used in the Bank Condition Index on pg. 48.

Pugging Average	**>18**	**>16- 18**	**>14 -16**	**>11-14**	**>8 -11**	**>5 - 8**	**>2 - 5**	**>0 - 2**	**0**
Score	0	1	2	3	4	5	6	7	8

Step 5: At each site, compare the gradient of the bank to the gradient diagrams on pg. 46, and circle the number in the box that best describes the bank gradient. Once you have completed your assessment, calculate the bank gradient score by taking the average of circled values.

Bank Gradient				
	shallow	moderate	steep	very steep
Site 1	1	2	3	4
Site 2	1	2	3	4
Site 3	1	2	3	4
Site 4	1	2	3	4
Bank Gradient Value (avg of circled numbers):				**=**

Step 6: Use the gradient conversion table to calculate the gradient score for your study wetland. Use the example below for guidance.

Gradient Conversion Table				
Gradient value	4	>=3 & <4	>=2 & <3	>=1 & <2
Gradient score	1	2	3	4

Step 7: Calculate the Bank Condition Index by adding your erosion, pugging and gradient scores, and then perform the necessary formula.

BANK CONDITION INDEX					
Erosion Score +	Pugging Score +	Gradient Score =	Score Value	Calculation	Bank Condition Index
			(	**÷ 15) x 100**	**%**

SECTION 3: Assessments for Specific Wetland Types

Paperbark Wetlands

How healthy are the paperbark trees in your study wetland? The paperbark trees themselves can be a good indicator of the health of paperbark wetlands. When paperbark wetlands are disturbed or polluted, they become more susceptible to disease and damage. Use the notes and examples below to assist you to identify and assess the health of the paperbark trees in your study wetland.

Paperbark Condition Indicators

Standing dead or dying trees. Are there dead or dying trees in the wetland? Occasional isolated dead trees are a natural phenomenon, however a stand of dead or dying trees can indicate a severe disturbance. Disturbances that can cause tree death include: disturbance of acid sulfate soils, severe fire, increases in salinity, pollutants, sudden changes in water level, severe cattle damage, or even tree poisoning.

Not affected – No stands of dead or dying trees, however there may be occasional isolated standing dead trees.

Low – The wetland contains one or more stands of dead or dying trees, the combined area of which occupies less than 5% of the total wetland area.

Medium – The wetland contains one or more stand of dead or dying trees, the combined area of which is between 5% - 10% of the total wetland area.

High – The wetland contains one or more stands of dead or dying trees, the combined area of which exceeds 10% of the total wetland area.

Clusters of fallen trees. Are there clusters of fallen trees in your study wetland? When wetlands and surrounding ecosystems are cleared, trees become susceptible to wind toppling, particularly at the exposed edges. Trees do occasionally fall in undisturbed wetlands, especially in sandy soils, but the presence of clusters of fallen trees is often an indicator of human disturbance.

Fallen trees do not necessarily die in paperbark wetlands, however toppling reduces their vigour, damages epiphytes, and allows the incursion of opportunistic weeds. In addition, clusters of fallen trees can make the newly exposed trees susceptible to wind toppling. Another cause of fallen trees is clearing, which continually eats into the remaining fragments of paperbark wetlands.

Not affected – No clusters of fallen trees.

Low – Some clusters of fallen trees on exposed wetland edges, however less than 10% of the wetland perimeter is affected.

Medium – Between 10% - 25% of the exposed wetland edges are affected by clusters of fallen trees.

High – More than 25% of the exposed edges of the wetland are affected by clusters of fallen trees OR some clusters of fallen trees exist within the wetland.

Excessive vine growth. Is excessive vine growth reducing the vigour of the paperbark trees in your study wetland? When wetlands are disturbed, the paperbark trees may become susceptible to excessive colonization by vines, particularly common silkpod vine.

Although several species of vines are native to paperbark wetlands, disturbance of paperbark wetlands can break the delicate balance and allow the vines to dominate the canopy of the trees. This in turn reduces the vigour of the paperbark trees, making them more susceptible to other stressors, which may ultimately cause tree death. Clearing and wind toppling are common causes of excessive vine growth. The vine colonization process generally starts near cleared edges of the wetland, and moves into the wetland interior. Severe disturbance can result in widespread colonisation throughout the wetland.

Not affected – No signs of excessive vine growth, although vines may be present.

Low – Some excessive vine growth near the cleared edges of the wetland, however there is little or no excessive vine growth within the interior of the wetland.

Medium – Excessive vine growth common near the cleared edges of the wetland. Some excessive vine growth within the interior of the wetland, however the majority of the wetland interior remains free.

High - Excessive vine growth throughout the wetland.

Necrotic spots on leaves caused by sap sucking insects. Do the leaves on the paperbark trees have necrotic spots caused by sap sucking insects? Many leaves have slight blemishes resulting from the death of small sections of the leaf tissue. However this assessment method considers only necrotic spots caused by sap sucking insects. Sap sucking insects are part of the natural ecosystem of wetlands, however when trees receive water polluted with nutrients, sap sucking insects can cause considerable leaf damage. This is because the leaves of these paperbark trees accumulate higher concentrations of nutrients, and are therefore more desirable to the sap sucking insects.

Necrotic spots caused by sap sucking insects are quite distinctive once you get your eye attuned. They are generally quite round and are between 1 - 3 mm diameter. The margins of the spots sometimes, but not often, overlap, and in such cases, generally occur only in severely affected leaves. Sap sucking insects feed on young leaves that have not hardened, leaving a circular “bruised” appearance on the wound. When the leaves mature, the spots become slightly indented, and if you rub your finger over the spots, you can feel the indentation. During severe infestations, a high proportion of young leaves can be lost. Infestations tend to be cyclical, so make sure you check young and old leaves.

A bronchus of leaves is a diary of the past attacks by sap sucking insects, and you may find clusters of leaves that have necrotic spots, while other clusters have no necrotic spots at all. If you cannot reach growing leaves, examine the fallen leaves in the litter layer as the necrotic spots are still evident.

Not affected – Most leaves don’t have necrotic spots.

Low – Clusters of young or mature leaves have an average of 1-2 spots per leaf

Medium – Clusters of young or mature leaves have an average of >2 – 4 spots per leaf

High – Clusters of young or mature leaves have an average of > 4 spots per leaf OR death of young leaves occurring because of damage from sap sucking insects.

Galls on small branches. Do the branches of the paperbark have galls? Some types of wasps lay their eggs in the small branches, which cause them to form spherical galls as big as 2 cm in diameter. Although these wasps are a natural part of wetland communities, disturbances such as clearing and polluted water trigger outbreaks of these gall-producing wasps. The galls are not smooth – rather they look like lots of small new shoots clumped together. Indeed, occasionally these galls do produce established shoots with leaves on them. This is because the wasps cause a hormone imbalance in the branches, which makes them produce shoot-forming tissues where they don’t normally form them. Fresh galls are green and are slightly bristly, and old galls are brown, and may have a spiky feel. During severe outbreaks, the trees can acquire a slightly “fluffy” appearance from the galls. If you can’t reach branches, examine the litter layer for evidence of fallen galls.

Not affected – None, or very few galls evident.

Low – Less than 5% of the small branches have galls.

Medium – 5 – 10% of the small branches have galls.

High – More than 10% of small branches have galls.

Step 1: Use a quadrat sampling system to quantitatively assess paperbark condition. Suggested quadrat size is 10m x 10m.

Step 2: Assess each parameter within that area and record whether it is absent (X), low (L), medium (M), or high (H).

Step 3: At the completion of the transect summarise the measures recorded for each quadrat into an 'Overall' measure (X, L, M or H) for the wetland.

PAPERBARK CONDITION	Quadrats 1 to 20 NB mark every box in the shaded rows as either X - L - M or H X = ABSENT/ Not affected L = LOW M = MEDIUM H = HIGH																				
PAPER BARK CONDITION INDICATORS NB record data for every quadrat:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Overall**
Standing dead or dying trees																					
Clusters of fallen trees																					
Vine Growth (incl. native & non native)																					
Necrotic Spots on Paperbark leaves																					
Galls on small branches																					
Other:																					

Step 4: Use the 'Overall' value (X, L, M, H) for each of the criteria above and circle the corresponding numbers in the table below, add these to find the 'paperbark condition value'.

Paperbark Condition Data Table				
Condition indicator	Overall Impact on Wetland			
	Not affected	Low	Medium	High
Standing dead or dying trees	0	2	4	6
Clusters of fallen trees	0	1	2	3
Vine growth reducing paperbark vigour	0	1	2	3
Necrotic spots on leaves caused by sap sucking insects	0	1	2	3
Galls on branches	0	1	2	3
Other (define):	0	1	2	3
Other (define):	0	1	2	3
			Paperbark Condition Value (total of circled scores)	

Step 5: Use the table below to convert the paperbark condition value to a score out of ten. Use the score in the calculation below to determine the Paperbark Condition Index.

Paperbark condition value	>9	9	8	7	6	5	4	3	2	1	0
Score	0	1	2	3	4	5	6	7	8	9	10

PAPERBARK CONDITION INDEX		
Score	Calculation	Paperbark Condition Index
	x10	**%**

Wetland Establishment

How well established is your study wetland? Some wetlands can be predominantly paperbark regrowth; these wetlands are ones that have re-established on areas once occupied by older paperbark wetlands that were cleared. Colonisation paperbark wetlands are ones that have taken advantage of clearing, and have established on areas that were previously occupied by another type of ecosystem (such as eucalypt forest or freshwater wetlands). Because peat takes thousands of years to build up, only areas that have been occupied by paperbark wetlands for long periods of time have a well-established peat layer. Tree growth, however, takes decades and centuries. This wetland assessment technique considers two age indicators: girth diameter of paperbark trees, and the depth of the peat layer.

Girth circumference

The girth circumference score is an indicator of the age of the paperbark trees. Trees in regrowth and colonization wetlands generally have smaller girth circumferences than trees in wetlands that have never been cleared.

Step 1: In an area away from the wetland boundary, walk in a straight line towards the wetland interior.

Step 2: Use a cloth tape measure to determine the girth circumference at chest height of the first thirty trees you come across above head height. If your wetland has trees with multiple stems, only measure the largest stem per tree. Do not measure dead or fallen trees.

Step 3: Once you have finished measuring girth circumferences of each tree, calculate the average girth circumference and write this number in the average girth circumference column.

Step 4: Circle the corresponding girth circumference score in the girth circumference conversion table.

Depth of peat layer

The depth of the peat layer is a measure of wetland establishment over a longer time scale than the brief European history in the North Coast. Over the centuries and millennia, peat forms from fallen leaves, bark and woody tissues. In older wetlands, the peat layer can be several metres deep. Peat is a dark brown to black soil layer consisting of decomposed organic material. If it is dry it is considerably lighter than most soil types, but it can hold more than five times its own weight in water. Sometimes you may even find buried preserved trees in deeper peat layers. These trees may be several thousand of years old! Peat is extremely important for the ecological functions of paperbark wetlands. Peat acts like a sponge, soaking up water, which then supplies the wetland during dry periods. This saturated peat layer also locks up acid sulfate soils, rendering them harmless to downstream ecosystems. In addition, one hectare of paperbark wetlands can store several thousands of tonnes of carbon in the peat layer, acting as a buffer for atmospheric carbon and the Greenhouse Effect.

Step 5: At four sampling stations throughout the wetland, use an auger to examine soil samples from your study wetland, and to measure the depth of the peat layer.

Step 6: Record this data in the peat depth table, and calculate the average peat depth.

Step 7: Use the peat depth conversion table to calculate the peat depth score.

Photo: Adam Gosling*, *WetlandCare Australia

Along the transect, measure tree girths and dig to discover peat depths as outlined above. Record the measurements in the field sheet below. On completion of the transect, average both measures and use them in the tables and calculation below to determine the wetland's establishment **(Step 1 – 3 & Step 5 - 6)**.

WETLAND ESTABLISHMENT INDICATORS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Avg**
Girth Circumference (cms) NB measure one average Paperbark per quadrat at chest height																					
Peat Depth (in cms) NB check & record at least 4 per transect																					

Use the tables below to convert the average tree girth circumference and peat depth to scores out of five **(Step 4 & 7)**.

Girth Circumference Conversion Table						
Average Girth Circumference (cm)	<20	20 – 40	40 – 80	80 – 140	140 –180	>180
Girth circumference score	0	1	2	3	4	5

Peat Depth Conversion Table						
Average Peat Depth (cm)	0 – 5	6 – 15	15 – 50	51– 100	101 –200	> 200
Peat depth score	0	1	2	3	4	5

Step 8: Add these scores and complete the calculation below to determine the Wetland Establishment Index.

WETLAND ESTABLISHMENT INDEX				
Girth Score +	Peat Depth Score =	Total Score	Calculation	Wetland Establishment Index
			x10	**%**

Open Freshwater Wetlands

When an open freshwater wetland is encountered along a transect, such as a lagoon, billabong or oxbow, the following indexes should be completed - fringing vegetation, bank condition and water quality. If an open freshwater wetland is not encountered along a transect then these indexes become not applicable (N/A).

Fringing Vegetation

The vegetation surrounding fresh water wetlands plays a very important role. It hosts many species of native plants and animals, and it is an important part of bank and soil stability. The fringing vegetation is also a critical filter for wetlands, sieving out sediment, nutrients and even anthropogenic pollutants before they enter the water column. Without the fringing vegetation, a fresh water wetland cannot perform many of its important functions. This wetland assessment technique examines four aspects of the health of fresh water wetlands and farm dams: width of the fringing vegetation, vegetation diversity, species number and fringing weeds.

Width of fringing vegetation

How intact is the fringing vegetation of your study wetland? This wetland assessment technique considers fringing vegetation to extend up to 50 metres from the high water mark. To qualify as fringing vegetation, the plant community must consist predominantly of native species, must not have been cleared, or is at an advanced stage of regeneration. Vegetation that does not qualify includes plant communities that are predominantly weeds, pasture, agricultural crops, urban plant communities and highly disturbed vegetation communities.

Step 1: At the four sampling sites, use a 50-metre tape to measure the width of the fringing vegetation (or pace it out if you're confident), and record these values (in metres) in the width table. Measure from the water's edge to the outer edge of the fringing vegetation. The boundary is defined when the fringing vegetation stops, or when it extends beyond 50 m from the high water mark. If the fringing vegetation continues beyond 50 metres in width (generally the case with undisturbed wetlands), then the wetland is considered to merge with an adjacent ecosystem.

Step 2: When you have measured the width of fringing vegetation at each of the four sample sites, calculate the average width, and write this value in the mean width box.

Note. The fringing vegetation stops when:

- It meets cleared land
- The plant community is predominantly exotic or cultivated crops
- The plant community extends 50 m beyond the high-water mark

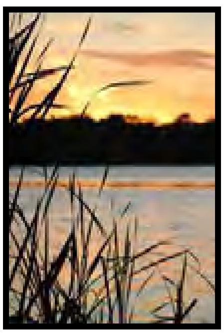


Photo: ***Adam Gosling, WetlandCare Australia***

Step 1: At the four sampling sites, use a 50-metre tape to measure the width of the fringing vegetation, and record these values (m) in the width table. Measure from the water's edge to the outer edge of the fringing vegetation. The boundary is defined when the fringing vegetation stops, or when it extends beyond 50 m from the high water mark. If the fringing vegetation continues beyond 50 metres in width (generally the case with undisturbed wetlands), then the wetland is considered to merge with an adjacent ecosystem.

Fringing Vegetation	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4
Width of Fringing Vegetation (m)				

Step 2: When you have measured the width of fringing vegetation at each of the four sample sites, calculate the average width, and record below.

Average Width =	

Step 3: Use the width conversion table below to determine your Width Score.

Width Conversion Table	
Average Width	Width Score
0-2 m	0
>2-5 m	1
>5-15 m	2
>15-30 m	3
>30-48 m	4
>48 m	5

Step 4: Copy the scores for these tables from the **Wetland Vegetation** section pg 32.
NB: These scores are for freshwater wetlands only. For estuarine wetlands use corresponding tables in the Estuarine Vegetation Section on pg 38

Vegetation Type Conversion Table						
Vegetation Type Value	0-1	2-3	4-5	6-7	8-9	>=10
Vegetation Type Score	0	1	2	3	4	5

Species Number Conversion Table						
Species Number value	**< 8**	**8 - 15**	**15 - 25**	**25 - 35**	**35 - 50**	**>50**
Species Number score	**0**	**1**	**2**	**3**	**4**	**5**

Wetland Weed Conversion Table						
Weed Value	>42	31 - 42	21 - 30	13 - 20	6 - 12	<6
Weed score	0	1	2	3	4	5

Step 5: Use the calculation table below to determine your Fringing Vegetation Index.

FRINGING VEGETATION INDEX						
Width Score +	Vegetation Type Score +	Species Number Score +	Weed Score =	Total Score	Calculation	Fringing Veg Index
				(	÷ 20) x 100	%

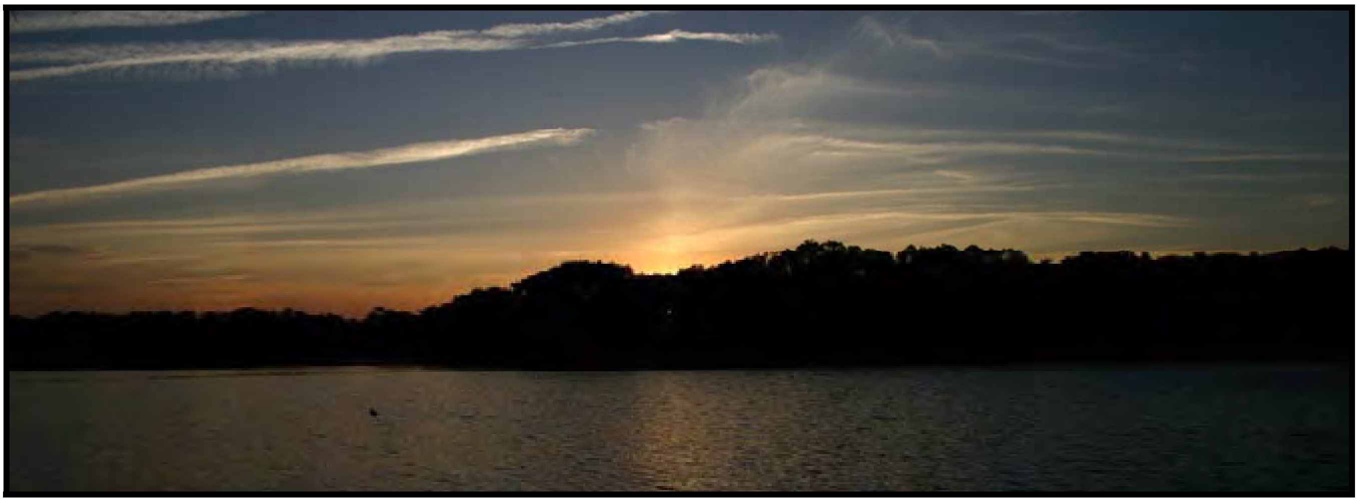


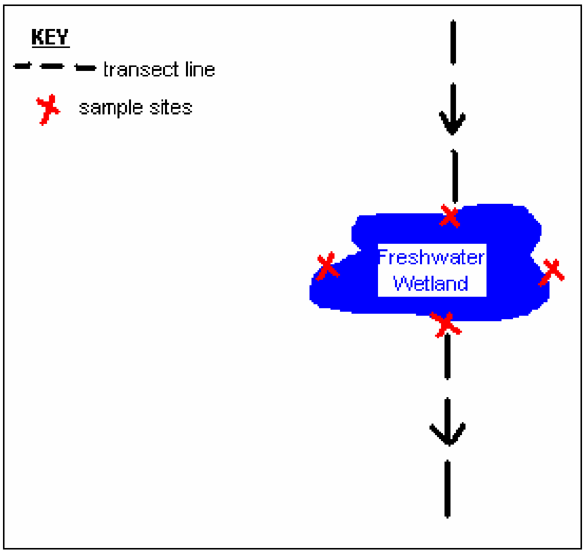
Photo: ***Adam Gosling, WetlandCare Australia***

Water Quality

What is the quality of the water in your study wetland? Measurement of water quality parameters can yield useful information about the health of fresh water wetlands. Parameters such as pH, electrical conductivity and turbidity can be measured with relatively inexpensive equipment. For measurements of ammonium, nitrate and phosphate, a water sample will be required and may need to be sent to a laboratory.

** At each sample site, collect a quarter of a sample bottle to make one single sample. This water sample will be used to test for Nitrate, Ammonium and Phosphate where possible. If you do not have access to the necessary equipment or a lab to test your water sample, it is not necessary to collect one.

Site Selection Diagram



pH

pH is a measure of the acidity or alkalinity of the water in your wetland. Wetlands affected by acid sulphate soils often have a low pH (are acidic).

Step 1: Measure pH at each of the four sampling sites using a pH meter or broad-spectrum litmus paper. The water in which you undertake your measurements should ideally be 50 cm deep or more. Position the probe midway between the water surface and the wetland floor – make sure the probe does not contact the sediment! Record the pH values in the 'water quality table'.

Electrical Conductivity

Electrical conductivity (EC) is a measure of the concentration of dissolved salts in your wetland water column. The units of electrical conductivity are milli Siemens per centimetre or deci Siemens per centimetre (mS / cm or dS / cm). Generally, the higher the salt concentration, the poorer the water quality.

Step 2: Measure electrical conductivity at each of the four sampling sites using an electrical conductivity meter. The water in which you undertake your measurements should ideally be 50 cm deep or more. Position the probe midway between the water surface and the wetland floor – make sure the probe does not contact the sediment! Record the values in the 'water quality table'.

Turbidity

Turbidity is caused by the light-blocking properties of suspended particles in the water. Cattle walking in the water, siltation after a storm event and blue-green algae are all common causes of high turbidity in North Coast wetlands.

Step 3: Use a turbidity tube, a secci disk or an electronic turbidity meter to measure turbidity at your four sampling sites. Be very careful not to stir up sediment when you are collecting your sample, or you may obtain a higher-than-actual value. Record the values in the 'water quality table'.

Water Quality	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4
pH				
Electrical Conductivity				
Turbidity				
Water Quality Sample taken (tick) **				

Step 4: Use the 'pH conversion table' to convert the pH to the pH score.

pH Conversion Table				
Average pH	**< 4**	**<5 – 4**	**5 – 6or > 8**	**6 – 8**
pH score	0	1	**2**	**3**

Step 5: Use the 'EC conversion table' to convert the electrical conductivity to the EC score.

EC Conversion Table				
Average EC	> 3 000 µS / cm	1000 –2999 µS / cm	200 – 999 µS / cm	**<200 µS / cm**
EC score	0	1	2	3

Step 6:, then use the 'turbidity conversion table' to obtain the turbidity score for your wetland.

Turbidity Conversion Table				
Average Turbidity	>100 NTU	50 - 100	20 - 50	<20
Turbidity Score	**0**	**1**	**2**	**3**

Water Sample:

To be sure that you have taken a water sample, make sure you have ticked the water sample taken box on the data sheet.

Nitrate (NO_3^-) and ammonium (NH_4^+) are two forms of nitrogen that are common in aquatic ecosystems. Some nitrogen is required to maintain ecosystems, however excessive concentrations can cause many problems such as algal blooms, excessive growth of aquatic vegetation, and loss of biodiversity of benthic organisms. Runoff from fertilised agricultural land and cattle excreting into the water are two major causes of excessive nitrogen concentrations in fresh water wetlands.

Step 1: Use the water sample taken at your sites to determine the levels of nitrate, ammonium and phosphate at your wetland.

Step 2: Use the conversion tables to work out nitrate and ammonium scores.

Nitrate

Nitrate Conversion Table				
Average Nitrate	> 4 mgN/L	1 - 4 mgN/L	0.4 - 1 mgN/L	<0.4 mgN/L
Nitrate score	0	1	2	3

Ammonium

Ammonium Conversion Table				
Average Ammonium	> 4 mgN/L	1 - 4 mgN/L	0.4 – 1 mgN/L	<0.4 – 1 mgN/L
Ammonium score	0	1	2	3

Phosphate

Orthophosphate (H_3PO_4, H_2PO^{4-}, HPO_4^{2-} and PO_4^{3-}) is a soluble form of phosphorus. Sometimes people just refer to it as phosphate. Excess phosphate concentrations can degrade aquatic ecosystems, and can be responsible for toxic blue-green algae blooms. Runoff from fertilised agricultural land and cattle excreting into the water are two major causes of excessive phosphorus concentrations in fresh water wetlands.

Step 3: Use the 'phosphorus conversion table' to work out the phosphate score.

Average phosphate	> 2 mgP/L	0.5 - 2 mgP/L	0.2 – 0.5 mgP/L	<0.2 mgP/L
Phosphate score	0	1	2	3

Step 4: Use your 'scores' to calculate your Water Quality Index. If you have only tested for pH, EC and turbidity, divide your score value by 9 instead of 18.

WATER QUALITY INDEX								
pH Score	EC Score	Turbidity Score	Nitrate Score +	Ammonium Score +	Phosphate Score =	Total Score	Calculation	Water Quality Index
						(	÷ 18) x 100	%

Estuarine Wetlands

To determine the health of mangrove forest at the study site, trees are a good indicator. Are the canopies of the trees abundant with green, healthy foliage, or do they show signs of discolouration and foliage loss? Healthy systems should display a dense canopy cover, good colour of the foliage, and a large amount of seedlings becoming established. Dieback occurs in mangrove systems when they become stressed either by human induced or natural influences. Signs of dieback in mangroves include reduced canopy cover and loss of pigmentation of the leaves. Human factors impacting the health of mangroves include water pollution, pollution of groundwater, dredging, land reclamation, and modification of the natural tidal regime.

Mangrove communities may also be affected by natural events such as cyclones and other large storms, tidal waves, and coastal erosion. Community structure, foliage cover and foliage health are good indicators of the general health of the mangroves in the study estuary. Follow the steps below to calculate the mangrove condition index.

Community Structure

Are all the trees in the mangrove forest the same height and general structure? Are there distinct layers in the forest, an overstorey and an understorey? A healthy undisturbed mangrove forest should have a mix of older established trees, with smaller seedlings under 1m tall underneath, or wherever they can access enough light and room. The complexity of a mangrove community can give a good indication of how established, sustainable, or disturbed the mangrove community is. Mangroves are opportunistic and will establish where sedimentation is occurring. While these younger mangrove stands may appear healthy, they may not be as well established and functional as a fully established mangrove forest. Younger stands may also consist purely of more opportunistic species, and form a monoculture, which generally supports a less diverse array of fauna and flora. *Avicennia marina* is a robust species and is often first to colonise an area. It becomes more common towards the south where it may be the only species.

Gauging the community structure of mangroves can be performed using a method adapted from Holdridge (1967) that determines the complexity index of forest structure. The method takes into account the number of species, tree density, basal area, and mean tree height.

Foliage Cover

Foliage percentage cover is determined by estimating the area of a 1m^2 quadrat in shade (at mid-day sun) when placed on the ground beneath the tree, this should be done at each sample site, along a transect. Alternatively a viewing tube with cross-hairs provides accurate estimates of foliage cover. Mangroves naturally have an open canopy, so 100 % cover would not be expected. Data should be recorded as a percentage at each sampling interval, which can then be averaged out for the entire transect and converted to a score.

The following percentages are a guide to measuring percentage cover for mangroves:

High – Greater than 60 % canopy cover

Med – Between 30 – 60 % canopy cover

Low – Between 10 – 30 % canopy cover

Very Low – Less than 10 % canopy cover

Foliage Health

The health of foliage can be determined by the amount of photosynthetic chlorophyll in the canopy, which gives leaves their green colour. It is natural for mangroves to have some degree of discolouration in their leaves, so no trees should be expected to be found with 100 % healthy green leaves. If trees become stressed they may lose colour in many of their leaves, and some branches may die altogether.

The health of the foliage is gauged by looking at the condition of the whole canopy, and giving an overall indication. This should be done with at each sample site assessed above for foliage cover.

Healthy trees should display the following foliage characteristics (Saenger, 2002):

- A large number of leaves per branch
- Foliage along the entire length of the branch
- Normal leaf size, with little deformation (twisting or curling)
- Consistent foliage colour
- Good foliage cover

Unhealthy trees will display the following characteristics (Saenger, 2002):

- Reduced numbers of leaves per branch
- Ends of the upper and outer most branches dying
- Reduced leaf size
- Deformation of leaves (twisting and curling)
- Chlorosis (Yellowing), and necrosis (dying) of leaves
- Lowered foliage cover

The health of the trees should be scored using the following scale:

High - Greater than 75 % healthy foliage, a small amount of unhealthy foliage may be present showing very few of the symptoms described previously.

Med – Between 25-75 % healthy foliage, some unhealthy branches and foliage present, showing a few symptoms of unhealthy foliage

Low – Less than 25 % healthy foliage, large proportion of the tree dying or dead, shows many symptoms of unhealthy foliage.

Step 1: Collect the following data, using 10 x 10 m quadrats, sampling up to 10 quadrats (minimum of 4) and record in the table below.

Step 2: Measure and record the diameter of each tree over 2.5cm within the quadrat at chest height. This is referred to as Diameter at Breast Height (DBH). This height is approximately 1.3 meters from ground level.

Step 3: Calculate mean tree height by measuring a number of trees within the plot and calculating the mean, in metres.

Step 4: Count the number of trees within each quadrat to calculate your tree density. Only count those mangroves with a DBH>2.5cm

Photo: *Adam Gosling, WetlandCare Australia*

	Community Structure Data Quadrats 1 - 10									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Diameter at Breast Height (DBH) (cm)										
Mean Height (m)										
Tree Density										

Step 5: Calculate the Basal Area by applying the **Basal Area formula** - to do this, square (multiply by itself) all the individual tree diameters (DBH) and then sum (add) these figures.

$$\textbf{a (Basal Area)} = 0.000785 \times \sum(DBH^2)$$

Where: $\sum$ = Sum

DBH^2 = Diameter Breast Height in cm squared (dbh x dbh)

Total of all DBH^2 collected in above table =		BASAL AREA
Sum of (DBH^2) =	**X 0.000785**	**=** **m^2**

Step 6: Calculate the area assessed

AREA ASSESSED
No. Quadrats x 100 m^2 = m^2

Step 7: These parameters are then used to calculate the complexity in the following equation:

$$C \text{ (Complexity)} = \frac{(a \times d \times n \times h)}{A}$$

Where:
C = Complexity index
a = basal Area in m^2
d = average tree density per quadrat (with DBH >2.5cm)
n = number of different mangrove species along transect (from Sheet A on Page 34)
h = mean tree height in m
A = Area assessed in m^2 (no. of quadrats x 100)

Apply the Complexity formula by transferring the totals and averages from the data collection tables above, to the calculation table below to give the Complexity Index**.** Use this number in Step 8 to convert to a 'score'.

Basal Area (a)		Mean Tree Density (d)		No. of mangrove species (from veg section) (n)		Mean tree height (h)		Area Assessed (A)	Complexity Index
m^2	X		X		X	m	/	m^2	=

Step 8: Circle the corresponding score in the table below, this will be used to calculate the Mangrove Condition Index below.

Complexity Score Conversion Table					
Complexity Index	0-3	4 -9	10-19	20 - 39	40 +
Score	0	1	2	3	4

Step 9: Use a quadrat sampling system to quantitatively assess mangrove foliage condition, quadrats should be located at the same locations where data is recorded for the complexity index. Suggested quadrat size is 1x1 m for foliage cover. Within the area assess each parameter and record the appropriate figure. At the completion of the transect calculate the average (SUM quadrats ÷ no. quadrats) measure for the wetland.

Mangrove Condition	Quadrats 1 - 10 Record each as a percentage for each quadrat										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Avg**
Foliage Cover (%)											
Foliage Health (%)											

Step 10: Circle the corresponding scores in the table below.

Mangrove Condition Conversion Table				
Avg Foliage Cover	<10%	10 – 30 %	31-60 %	> 60 %
Score	0	1	2	3
Avg Foliage Health	<10%	10 – 25 %	26-75 %	> 75 %
Score	0	1	2	3

Step 11: Add your Avg Foliage Cover Score and Avg Foliage Health Score to give you a 'Mangrove Condition Score' and record in the table in Step 12.

Step 12: Add up the scores from the Complexity and Mangrove Condition conversion tables to give the total score.

Complexity Score	+ Mangrove Condition Score	= TOTAL

Step 13: Use the formula below to calculate the Mangrove Condition Index

MANGROVE CONDITION INDEX		
TOTAL Score	Calculation	Mangrove Condition Index
	/10 x 100	= %

Royal Spoonbill roosting amongst *Rhizophora stylosa.* Photo: *Adam Gosling*

Saltmarsh Condition

Saltmarshes are found towards the upper extent of the tidal range, between mangrove and terrestrial vegetation. Due to this position they experience a large amount of variability in the salinity of the soil. The soils found in saltmarsh areas are generally drier than the anoxic waterlogged soils found in mangrove ecosystems. Tidal restrictions can cause the salinity of the soil to drop and encourage invasion by weeds, terrestrial, and freshwater plant species. The soils found in saltmarsh areas are sometimes high in iron sulphides, making them a potential source of acid sulfate soils, if they are disturbed. Saltmarsh vegetation consists of mostly low grasses, herbs, reeds, sedges, and shrubs that are adapted to the soil. Saltmarshes contain a high degree of vegetation diversity, with some common saltmarsh species including: *Sarcocornia quinqueflora*, Halosarcia spp*., Sporobolus virginicus, Zoysia macrantha, Distichlis distichophylla, Samolus repens*, Sclerostegia spp., Tecticornia spp., and *Triglochin striatum*.

Percentage Ground Cover

The percentage of vegetation covering the ground is measured by estimating cover over a 10 x 10 m quadrat. This estimate is done by working out the ratio of vegetation compared to bare soil. A higher vegetative cover indicates better condition of the saltmarsh vegetation. Saltmarsh is slow to recover, so any bare areas may take a long time to become re-established with a good vegetative cover, increasing erosion and the threat of weed establishment.

Crab Burrows

Crab burrows give a good indication of the infauna supported by the saltmarsh, and the general health of the ecosystem. Crab burrows transport seawater underground, assisting in subsurface soil metabolism. By counting the number of active crab burrows we can determine how healthy the saltmarsh system is. The grapsid crab (*Helograpsus haswellianus*) is commonly found in mangrove and saltmarsh areas, and creates burrows in the soft sediment (Breitfuss, 2003). Only new or active burrows must be counted in order to gain a true indication of the health. Crab burrows should be counted in a 1m x 1m quadrat placed randomly in each 10m x 10m quadrat. A description of visual clues includes:

New and used burrows display:

- Presence of fresh, lighter coloured clay sediments
- Sharp edges of the burrow

Disused burrows display:

- Distinct lack of fresh, lighter coloured sediments
- Degraded burrow edges
- Worn appearance

Mangrove Crab. Photo: Adam Gosling, WetlandCare Australia

Snail Density

Snails are another creature that are found in saltmarsh areas. Snails feed on the algae and detrital matter in estuaries and form a vital part of the cycle. Fish commonly feed on snails during high tide when saltmarshes are inundated, making them an important food resource (Roach 1998). Some snails have adapted to tolerate the highly saline conditions found in saltmarshes, two such species are *Salinator solida* and *Ophicardelus ornatus*. *Salinator solida* can be identified by the zig-zag stripes on its coiled shell, whilst *Ophicardelus ornatus* is identified by its elongate shell with straight stripes. The best sampling time for snails is 1-3 hours after high tide. Quadrat size for determining snail is 30 x 30 cm which is placed randomly within the 10 x 10 m quadrat at each sampling interval.

Snail density in saltmarsh wetlands can be a good indicator of health.
Photo: ***Adam Gosling, WetlandCare Australia***

Necrosis

Percentage of dead vegetative cover in the quadrat. A higher percentage of necrosis of saltmarsh vegetation indicates a system that is unhealthy or stressed. Some plants such as samphire and seablite naturally vary in colour from red to green colour during natural cycles. Necrosis of large areas or a large percentage of plants, can give important information about the disturbance or modification of the hydrological regime.

Necrosis Rating:

High = >50% quadrat dead
Med = 25 – 50% quadrat dead
Low = 5 – 25 % quadrat dead
Very Low = < 5 % quadrat dead

Step 1: Usinq a quadrat sampling system with 10 x 10 m quadrats, sample up to 20 locations along the transect to assess saltmarsh condition. Quadrats should be placed every 100 m or at every change in vegetation type. In each quadrat the percentage covered by vegetation should be recorded, along with the number of species present.

GROUND COVER	1	2	3	4	5	6	7	8	9	10	Avg.
Area of 10 m quadrat covered by veg (%)											
Area of 10m quadrat with signs of necrosis (%)											
Number of crab burrows in 1 x 1 m quadrat											
Snail density (30 cm quadrat)											

Step 2: Use the average determined in the ground cover table to convert the percentage to a score. Circle the appropriate score

Cover Percentage Conversion Table				
% Cover	< 25	25– 50	50 – 75	> 75
Score	1	2	4	5

Step 3: Use the average necrosis level to convert to a score which is used to calculate the Saltmarsh Condition Index.

Necrosis Conversion Table				
Average Necrosis	>50%	>25 – 50%	5 - 25	<5%
Score	0	1	3	4

Step 4: Use the average crab burrow count from above to convert the number to a score. Circle the appropriate score.

Crab Burrow Conversion Table				
Average Crab Burrows	0	0 - 2	2 – 4	> 4
Score	0	1	2	3

Step 5: Use the average snail count from above to convert the number to a score. Circle the appropriate score.

Snail Density Conversion Table				
Average Snail Density	0	0 - 5	>5 – 20	> 20
Score	0	1	2	3

Mangrove and Terrestrial Plant Encroachment

Has the ecotone between the mangrove or terrestrial vegetation areas and saltmarsh moved over time? Is it different to the boundary on historical aerial photographs of the area? A number of factors contribute to encroachment. Sea level rise and lower salinity of saltmarsh areas are thought to be responsible for mangrove encroachment into saltmarsh areas. Terrestrial or freshwater species may become established if areas have been drained, used for cattle grazing, receive excess stormwater flow, and sedimentation. All these factors drop the salinity of the soil reducing the competitive advantage that the salt tolerant species have for survival in a saline environment. Natural fluxes in ecotone occur, so it is necessary to account for these natural processes in assessment, the first step to assess whether any encroachment has or is occurring. A historical record of change is required to be conclusive about changes, and then the continuing threats can be assessed.

By looking at the boundary from historical aerial photographs, GIS, or local knowledge, determine whether encroachment of mangroves or terrestrial vegetation on saltmarsh has or is occurring. If so, use the table below to determine the threat of continuing loss of saltmarsh areas.

A 10x10m quadrat placed at the upper edge of the saltmarsh, before the natural ecotone with terrestrial species, and one above the natural ecotone between the mangroves and saltmarsh (slightly uphill of established mangrove trees). This process is repeated 4 times along the boundaries to determine whether encroachment is occurring. The score is given as an overall for the wetland.

Step 6: At 4 points along the terrestrial edge of the saltmarsh, and four points along the estuarine edge of the saltmarsh determine the level of encroachment on the saltmarsh. This is done by determining whether encroachment is:

- Definite - definite impacts might include introduced grass species or weed species occurring into the terrestrial edge of the saltmarsh, or large numbers of mangroves seedlings established in the estuarine edge
- Suspected - you cannot determine that the above is definitely happening score the impact as suspected
- Not occurring - If there is no impact or no obvious encroachment on the saltmarsh, score the impact as not occurring

PLANT ENCROACHMENT	Impact Level	SPECIES PRESENT AND COMMENTS
Mangrove Encroachment		
Terrestrial, Freshwater, Weed Species Encroachment		
OVERALL		

Step 7: Use your overall impact level of encroachment to convert to a score in the table below.

Encroachment Conversion Table			
Level	Definite	Suspected	Not Occurring
Score	0	2	3

Step 8: Transfer the scores from the percentage cover, Species, and encroachment conversion tables, to calculate the Saltmarsh Condition Index.

SALTMARSH CONDITION INDEX	
Cover Score	
Necrosis Score	
Crab Burrow Score	
Snail Density Score	
Encroachment Score	
TOTAL	**/18 x 100 = %**

Seagrass Condition

Seagrasses are specialised aquatic flowering plants that form complex meadows in brackish and marine waters. Seagrass is affected by changes in water quality, and assessments of their condition can assist in determining the health of the estuarine waters. Seagrasses are a key component of coastal and estuarine ecosystems, performing a number of important ecological functions. Seagrasses stabilise sediments, reduce wave and current energy, and decrease the turbidity of the water, Seagrasses provide habitat, food sources and important breeding areas for fish and other aquatic organisms. Seagrasses are sensitive to varying light and nutrient availability. In turbid waters seagrasses are limited to shallow areas where sufficient light is available for photosynthesis. In catchments where a high degree of clearing has taken place, high turbidity in the estuary may limit seagrass distribution. Nutrient availability may also limit their distribution in low nutrient environments. By measuring a few aspects of a seagrass meadow, it is possible to get an idea of their condition. Looking at the cover and depth can tell us if the seagrass is being affected by water quality parameters in the estuary. Physical impacts such as anchoring, dredging and clearing also have major impacts on seagrass meadows.

Cover

As with other aquatic and terrestrial plants, the percentage of vegetation cover can give an indication of the health of the ecosystem being studied. Does the seagrass meadow have an even, dense coverage with little of the substrate visible? Or are there bare patches of sand, and only a sparse covering of seagrass? These measurements assist in determining how healthy the seagrass meadow is. Cover can be reduced by a number of human induced factors including dredging, boat propellers and moorings, sedimentation and toxic runoff. Natural pressures such as storms, floods and extreme low tides can impact the cover of seagrass too. Look for indications of these influences when assessing the condition of the seagrass.

High - >60% cover. The majority of the quadrat is covered by seagrass.
Mod – 30 – 60% cover. Approximately 1/3 to 1/2 the quadrat is covered by seagrass, with the remainder visible substrate.
Low - <30% cover. The majority of the quadrat is void of seagrass. Substrate is mostly visible.

Seagrass meadows Tweed Catchment. Photo: Adam Gosling, WetlandCare Australia

Step 1: Usinq a quadrat sampling system with 1 x 1 m quadrats, sample 10 locations along the transect to assess seagrass condition. In each quadrat the percentage covered by vegetation should be recorded.

COVER											
	1	2	3	4	5	6	7	8	9	10	Avg % Cover
Area (%) of 1 m^2 quadrat covered by vegetation											

Step 2: The Average percentage cover from above can then is translated into a score using this table. Use this score to calculate the Seagrass Condition Index in Step 8.

Cover Score	SCORE
High - >60% cover	6
Mod – 30 – 60% cover	4
Low - <30% cover	2

Depth

High turbidity over extended periods limits the depth at which seagrasses can survive. In clearer water they will generally grow at deeper depths than where highly turbid waters exist. Measuring the depth of the deepest point of the seagrass bed at high tide can give an indication of how turbid the water is, and be linked to the overall water quality of the estuary, lake or lagoon (Scheltinga et al. 2004). Low nutrients in clear water can be another limiting factor for seagrass. In low nutrient environments, there is not enough energy available for seagrass to survive. Some nutrients and sediment is necessary so that seagrasses can uptake the required nutrients from the substrate.

Step 3: Estimate the average seagrass depth and circle the corresponding score. Use this score to calculate the Seagrass Condition Index in Step 8.

SEAGRASS DEPTH	SCORE	OBSERVATIONS & COMMENTS
DEEP Deepest edge of seagrass bed is > 2m OR Water is < 2m deep at deepest point, with seagrass growing to deepest points of estuary, lake or lagoon	3	
MODERATE Deepest edge of seagrass bed is between 0.3 – 2 m OR Water is < 0.3 m deep at deepest point with seagrass growing to deepest point estuary, lake or lagoon	2	
SHALLOW Deepest edge of seagrass bed is < 0.3 m	1	

Seagrass depth ranges adapted from: CSIRO, 2002, 2005.

Epiphyte Density

An epiphyte is a plant that grows on, or by attaching itself to another plant. Algaes are common type of epiphytes found growing on seagrass. Increased growth of algae often occurs with increased nutrient loading of the water. This process of increased nutrient loading is known as eutrophication. Algal growth on seagrass leaves limits their potential and ability to photosynthesise, causing stress to the plant. Large amounts of this growth can lead to death of seagrass meadows. Some epiphyte growth is naturally found on seagrass, as is the seasonal variation in the amount of epiphyte coverage. Epiphyte cover is obtained by estimating the percentage of seagrass covered by epiphytes in a $1m^2$ quadrat. The methodology for obtaining the result is:

Seagrass with epiphyte cover. Photo: *Adam Gosling, WetlandCare Australia*

Step 4: Selecting a number of individual seagrass blades within the quadrat (approx. 10), and estimate the cover on each of the blades (approx. 50%). Then look at the whole quadrat and estimate the overall coverage of epiphytes on the seagrass (approx. 50 %).

Epiphyte Cover	Quadrats 1 -10										
	1	2	3	4	5	6	7	8	9	10	Avg.
Individual Leaf Cover (%)											
Overall Quadrat Cover (%)											

Step 5: The calculation for overall coverage is determined as follows: 50 % (individual leaf cover) x 50 % (overall quadrat cover) = 2500 / 100 = 25 % true seagrass epiphyte cover (Koss et al. 2005).Use the following table should be used to simplify the calculation

True Epiphyte Density Calculation Table			
Individual leaf cover	Overall quadrat cover	Calculation ÷ 100 =	True Epiphyte Cover
X		/ 100	%

Step 6: Use the table below to convert the true epiphyte cover percentage to a score. Use this score to calculate the Seagrass Condition Index in Step 8.

Epiphyte Density Score					
True Epiphyte Density	< 20 %	20 – 40 %	40 – 60 %	60 – 80 %	> 80 %
Score	3	5	4	2	1

Step 7: Take the cover score, seagrass depth, and epiphyte cover score and enter them into the table below.

Step 8: Add the scores together and perform the calculation to get the final Seagrass Condition Index.

SEAGRASS CONDITION INDEX	
Cover Score	
Depth Score	
Epiphyte Score	
TOTAL	**/14 x 100 = %**

Great Egret feeding amongst seagrass beds at low tide. Photo: *Adam Gosling, WetlandCare Australia*

SECTION 4: Results

Wetland health interpretation table

Index	Index Value	Comments
Connectivity Index proximity /8 roads /4 area /8 adjacent landuse /8		
Human Disturbance Index		
Acid Sulfate Soils Index		
Associated Vegetation Index diversity /5 species number /5 weeds /5		
Habitat Index		
Hydrological Change or Tidal Restriction Mapped Changes & Structures /2 Presence of Structures /5 Vegetation Indicators /3		
Paperbark Condition Index		

Wetland Establishment Index girth circumference /5 peat depth /5		
Fringing Vegetation Index diversity /5 species number /5 weeds /5 width /5		
Bank Condition erosion /8 pugging /8 bank gradient /4		
Water Quality pH /3 EC /3 Turbidity /3 Nitrate /3 Ammonium /3 Phosphate /3		
Mangrove Condition Complexity /4 Foliage Cover /3 Foliage Health /3 Monoculture /2		
Saltmarsh Condition Cover /5 Necrosis /4 Crab Burrows /3 Snail Density /3 Encroachment /3		
Seagrass Condition Cover /6 Depth /3 Epiphyte Density /5		

Health guide interpretation table

Health rating	Health Index
Excellent	**>85%**
Very good	**> 75% - 85%**
Good	**> 65% - 75%**
Medium	**> 55% - 65%**
Poor to average	**>45% - 55%**
Poor	**35% - 45%**
Very poor	**<35%**

What Now?

You now have a standardised Wetland Health Indices for your wetland. You can use these as a means of:

- Standard health comparisons between wetlands
- Prioritisation of wetlands for rehabilitation / preservation
- Identification of key threats / issues
- Identification of specific changes in your wetland over time
- Timely implementation of protection / restoration measures

Wetland**Care** Australia is implementing a regional (and hopefully in the future, national) comparative database that can be used for inclusion in a Decision Support Database to assist with prioritisation of wetlands for better management through the Catchment Management Authorities and other sources of funds.

We would appreciate it if you inform us of the health index of any wetlands you have monitored for inclusion in our database. Not only will this provide us with a more comprehensive database, but will also allow you to compare your wetland health and wetland characteristics with other wetlands that have been surveyed by using this Manual.

SECTION 5: Management Options Flow Chart

Identify your lowest scoring indices!

Connectivity

- **Fragmentation / Loss of Connectivity**
  - Encourage natural regeneration by excluding stock or using strategic grazing regime
  - Replant area with local native vegetation
  - Try to link areas of vegetation by creating 'corridors' (e.g. riparian areas)
  - Restore hydrological connectivity/fish passage by removing or modifying flow impediment structures
- **Adjacent Landuse Pressure**
  - Identify the source of landuse pressure and attempt to minimise. Try a collaborative approach with other landowners if possible
  - Vegetation buffers &/or fencing can reduce a number of impacts like excessive nutrients, sediment & noise pollution

Human Disturbance

- **Vehicle, Boat, Human Damage**
  - Minimise damage by restricting access to your wetland by using: signs, fencing, bollards, vegetation buffers &/or boat wash baffles to dissipate wave energy (e.g. mangroves, other aquatic vegetation)
- **High Fire Incidence**
  - Maintain fire breaks where appropriate
  - Ensure wetland is receiving sufficient natural inflow of water and prevent over-drainage.
  - Encourage endemic, fire tolerant species. Use low intensity fires or slashing to reduce fuel loads.
- **Rubbish**
  - Try to minimise public access to wetland or native vegetation areas where appropriate
  - Organise regular rubbish collection where possible. For large sites, consider registering for 'Cleanup Australia Day' and seek volunteers
- **Water Pollution (e.g. sediments & nutrients)**
  - Try to identify source of pollution & minimise if possible
  - Vegetation buffers and restored wetlands or constructed water polishing reed beds can have significant benefits in improving water quality through filtration and nutrient recycling
- **Feral / Domestic Animals / Stock Impacts**
  - Consider fencing & excluding stock or strategic grazing/stock management regime
  - Control domestic animals (including pets) near wetlands or native vegetation areas
  - Contact local authorities if you would like to seek advice regarding feral animal control

Acid Sulfate Soils (ASS)

- **Drains**
  - Drains act to lower the groundwater level & expose ASS layers. Maintain groundwater by using weirs and/or by infilling unwanted drains
- **Scald**
  - Usually occurs as a result of lowered groundwater table. Consider infilling drains or using weirs where possible, retaining fresh water in the area of the scald, which will encourage revegetation
  - Liming and mulching small areas or ridging & furrowing may raise the pH sufficiently for vegetation to establish. It is important to exclude stock from scalded areas to allow rehabilitation

Wetland Vegetation

- **Diversity**
  - Ensure suitable conditions for natural regeneration (e.g. controlling pests & weeds, & excluding stock) or through planting additional local species
  - If species diversity is very low for that vegetation community type, plantings may be necessary
- **Weeds**
  - Adopt long-term weed control & monitoring procedures
  - Ensure best control methods are adopted to ensure success & minimise impacts on native vegetation
  - Encourage shading for weed control for both terrestrial & aquatic weeds

Potential Habitat

- **Poor Habitat Potential**
  - Encourage natural regeneration or revegetate with locally endemic species
  - Try to exclude stock & domestic animals from sensitive areas
  - Retain dead trees & fallen trees/logs as habitat for native fauna
  - Control pest species which threaten native vegetation & fauna (e.g. feral pigs, goats, cane toads, indian myna birds, foxes and cats)

Hydrological Change

- **Structures Affecting Hydrology**
- **Vegetation Indicators**
  - Where possible modify or retrofit structures to increase flow into wetlands. Drop-boards or weirs to retain water in wetland, or tidal floodgates to allow flushing of tidal wetlands
  - Similarly, changes in wetland community associated vegetation may reflect changes in hydrology. Alterations may be possible to re-introduce a more natural hydrological regime including re-introducing natural wetting & drying cycles & reconnecting wetlands where possible

Paperbark Wetlands

- **Paperbark Condition**
  - Tree death may be due to disturbance of ASS, fire regime, pollutants, weed growth (particularly vines) hydrological change or cattle damage (all addressed previously)
  - Excessive pest invasion (galls, necrotic leaf spots) may be a result of an unbalanced ecosystem (too many insects). Encourage insect predators (e.g. birds, bats, fish) by improving potential habitat (e.g. by retaining dead trees, fallen branches (including snags), riparian vegetation, feral animal control, weed control & stock exclusion)
- **Wetland Establishment**
  - Prevent clearing, retain leaf litter & fallen branches, prevent fire (especially from peat layer). If peat layer is underdeveloped as a result of oxidation of ASS, try to reinstate natural groundwater levels.

Freshwater Wetlands

- **Fringing Vegetation**
- **Bank Condition**
- **Water Quality**
  - Fence off & exclude or control stock access to allow natural regeneration or revegetate with local species (If banks are unstable, it may be necessary to batter and revegetate)
  - Ensure a mix of species types including macrophytes, emergent vegetation, riparian vegetation & terrestrial species. This will also assist in bank stabilisation.
  - Exclude stock access or provide controlled stock crossings to improve water quality (will reduce sediment & nutrient levels)

Estuarine Vegetation

- **Mangrove Condition**
- **Saltmarsh Condition**
- **Seagrass Condition**
  - Ensure wetland is receiving natural flow &/or tidal regime & is being regularly flushed
  - Fence off & exclude stock to allow natural regeneration & prevent pugging / compaction
  - Prevent vehicular access or excessive human disturbance
  - Maintain or establish vegetative filter strips to reduce sediments & nutrients entering wetlands

SECTION 6: Landholder Survey

If you are a landholder who is seeking assistance in improving the management of your wetland and would like further assistance from Wetland**Care** Australia in managing your wetland or sourcing funding for wetland works, please fill in the below survey and return it, with a SITE MAP to PO Box 114 Ballina NSW 2478.

Background information on your wetland

1. How big is this wetland on your property? (please tick)

Under 1ha

1-5 ha

5-10 ha

larger than 10 ha

2. Are there other wetlands on your property? (please tick) Yes No

2a. If Yes, how many and how big are they? (please indicate how many of each size wetland you have in the box provided)

Under 1ha

1-5 ha

5-10 ha

larger than 10 ha

3. Have you undertaken any improvement works on your wetlands to date? (please tick) Yes No

3a. If yes, what have you done?

Grazing

Fencing

Fire management

Weed control

Drain cleaning

Drain filling or blocking

Floodgate manipulation

Clearing

Other (please describe on the lines provided)

………
………
………
………

Your wetland into the future

4. What are your future intentions for the wetlands on your property?
………
………
………
………

5. How would you like to utilise your wetlands?

Grazing only

Wildlife area only (for birds, fish, natural vegetation)

Recreation only (fishing, birdwatching, boating etc)

Mixed use (Grazing & wildlife & recreation)

other (please describe below)

………
………

6. What activities would you like to carry out on your wetlands in the future?

Fencing

Weed control

Feral animal control drainage management

Floodgate management

Tree/shrub/reeds planting

Bird hide construction

Landing/boardwalk

Other (please specify in the space provided below)

………
………
………
………

Photo: *Adam Gosling, WetlandCare Australia*

7. Do you see any obstacles to carrying out these activities? Yes/No

7a. If yes, what are these obstacles

Lack of money

Don't know how to do what I want to do

Don't know how to get started

Lack of time

Other (please describe below)

………
……

8. What information/ support would you like to undertake activities on your wetlands?

Ideas about what is possible in my wetlands

Technical information

Help with planning

Labour

Money

Other (please describe)

…….
…….

9. What type of incentives would encourage you to manage your wetlands?

Tax concession

Rate rebate

Direct payment for costs incurred

Conservation agreement (money provided in return for managing the wetland for a specified time)

Signage

Personal recognition

Other (please describe below)

………
………
…….

Thank you for answering this survey. When we have collated all results we will send out copies to all participants.

Do you need additional advice on this survey or other wetland matters?
Call Wetland**Care** Australia on **(02) 6681 6169**

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