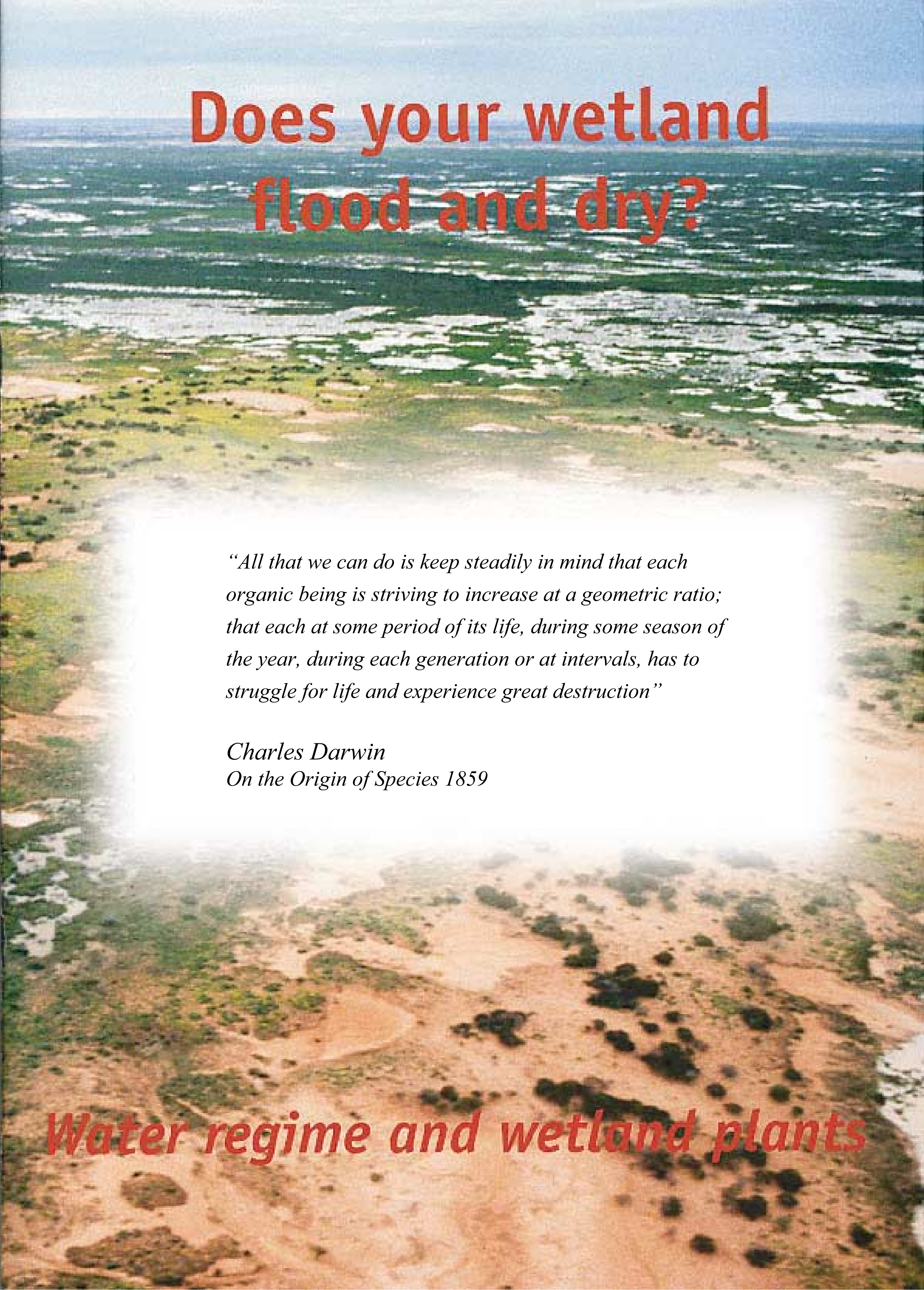

Does your wetland flood and dry?

"All that we can do is keep steadily in mind that each organic being is striving to increase at a geometric ratio; that each at some period of its life, during some season of the year, during each generation or at intervals, has to struggle for life and experience great destruction"

Charles Darwin
On the Origin of Species 1859

Water regime and wetland plants

This hand book has been produced from the results of wetland research projects funded by the Land and Water Resources Research and Development Corporation (LWRRDC) and Environment Australia (EA), in association with the New South Wales Department of Land and Water Conservation (DLWC) and Botany, University of New England (UNE).

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LWRRDC GPO Box 2182 Canberra ACT 2601. September 2000.
ISBN 0 642 76042 X
Brock, Margaret A., Casanova, Michelle T. and Berridge, Sally M. (2000). *Does your wetland flood and dry? Water regime and wetland plants.* LWRRDC, UNE, DLWC and EA.

There are two companion booklets in this series:

1. Brock, Margaret A. (1997). ***Are there seeds in your wetland? Assessing wetland vegetation.***
2. Brock, Margaret A. and Casanova, Michelle T. (2000). ***Are there plants in your wetland? Revegetating wetlands.***

These booklets cover other aspects of wetland revegetation and management. They are published by LWRRDC and UNE, and available (postage and handling costs only) from the Agriculture, Fisheries and Forestry-Australia Shopfront at Core 2, Cnr Broughton and Blackall Streets, Barton ACT 2600. Phone: 1800 020 157.

Land & Water Resources Research & Development Corporation
UNE The University of New England
LAND & WATER CONSERVATION
Environment Australia

Does your wetland flood and dry?

Water regime and wetland plants

Contents

Should wetlands flood and dry?

When Europeans arrived in Australia they quickly became aware that the variation in climate was extreme. Early settlers bad periods of 'good' rains, when pasture growth was plentiful and water readily available. These 'good' times were followed by 'dry' times when rivers and ponds dried to water boles, or disappeared. They also experienced 'flood' times when rivers flooded and washed away their roads, homes and livestock. They called the dry times 'drought' and the wet times 'flood' and times of perfect pasture growth 'normal'. The extremes were regarded as aberrations of the 'normal' conditions. However, as records show, extremes of wet and dry are not abnormal - they are part of the natural pattern.

Engineering feats in the 20th century made water supplies more predictable and encouraged human habitation and population growth. Weirs were constructed on rivers; dams and tanks were dug on agricultural land; many shallow wetlands were drained and others made deeper and more permanent. For example, the Snowy River Hydroelectric Scheme provided power for the cities and water for inland irrigation areas. Dams were built across rivers to contain floods and provide water during drought. These activities caused a decline in the number and types of wetlands.

Australia naturally has a variety of wetland types: floodplains that flood seasonally or hold water only once every ten years; paddocks that get boggy when it rains; swamps that fill with water most years; episodic lakes that appear within a couple of weeks of heavy rainfall then last for two or three years before drying; semi-permanent ponds; springs that bubble groundwater constantly, and rivers that flow to the sea.

Wetlands provided habitats for diverse groups of living things (biota)—plants, frogs, insects, birds and other animals, but since so many wetlands have been drained, parts of our landscape are now dominated by semi-permanent dams, tanks and rivers that never dry out because they are kept full for irrigation. Reduction in the numbers, variety and distribution of wetlands has reduced the habitats available for the wetland biota.

We can reverse some of these changes. Dams and drainage channels can be removed. Restoration of the natural periods of wet and dry in wetlands may be all that's needed for regeneration of the natural plant and animal communities.

The purpose of this booklet is to help you understand more about the importance of wet and dry times in wetlands by:

- Asking and answering relevant questions about the water regime in your wetlands;
- Selecting and monitoring wetlands;
- Measuring water level above and below ground, as well as water presence or absence;
- Comparing the vegetation of the wetlands at different times;
- Considering what water regimes are likely to encourage the development of particular vegetation and habitats in your wetland; and
- Deciding whether making your wetland water regime closer to a natural pattern is desirable or practical.

What is your vision for your wetland?

Where is the best place to begin?

First you need to read, plan and find out as much information as you can about wetlands in your area. If you wish to change the vegetation or water regime, you can then do it in a way that is appropriate to the area in which you live. Consider the possible effects of changes at the local, catchment and landscape scales (see pages 17, 18 and 19).

You may wish to change your wetland to look the same as it was in photos from earlier times. Or, after you have assessed your wetland, you may find that it is functioning well as it is now, and changes are not necessary.

We suggest you make monitoring and the collection of sound information the basis of your decision-making.

Cycles of wet and dry: the long term view

Healthy, functioning wetlands dry out sometimes, just as snow melts on the mountains and sand dunes are shifted by the winds. Flood and drought are a part of the cycle of life in wetlands: changes from season to season and year to year are both normal and necessary.

In natural wetlands vegetation may take years or even decades to develop into fully functioning habitats.

Remember that wetlands are dynamic systems, so your vision for your wetlands needs to be open to change. In fact, change is the name of the game.

What is water regime?

Water regime is a term used to describe the pattern of water presence and absence in a wetland. Wetlands include standing water such as ponds, puddles and dams, as well as flowing water – creeks, streams and rivers.

This booklet concentrates on still-water wetlands where **timing, frequency, duration, extent, depth and variability** of water presence determine the pattern of flooding and drying.

In streams and creeks, **flow** is usually the dominant feature. It combines with timing, frequency, duration, extent and depth of water presence to give the water regime pattern.

The **timing** of water presence in a wetland can be very predictable, e.g. in tidal wetlands, or the wet tropics where floods occur each wet season. Even in these systems, the **extent** of flooding may vary, depending on monthly tidal cycles and the amount of rainfall.

In contrast the **timing** of water presence can be unpredictable in inland river wetlands (e.g. Lake Eyre or the Great Cumbung Swamp) where levels rise only after sustained flooding in the wetland's catchment in any season.

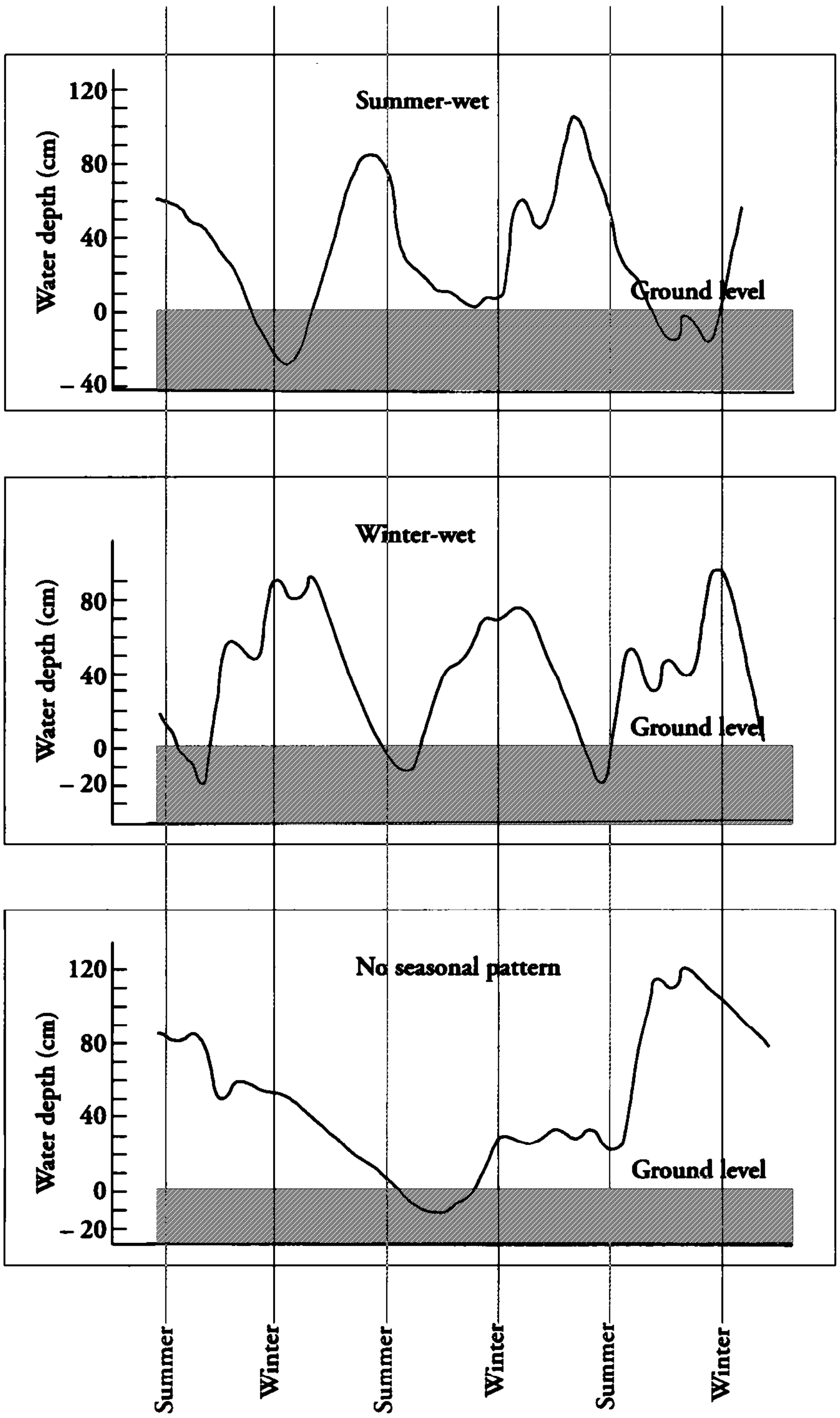
Important features of water regime

Water regime describes the pattern of flooding and drying, high water and low water in wetlands. It's all about:

- **When** it floods and dries – the *timing* of flooding and drying;
- **How often** it floods and dries – the *frequency* of wet and dry cycles;
- **How long** it floods and dries for – the *duration* of wet and dry times;
- **How far** the water spreads in a flood – the *extent* of flooding;
- **How deep** the water in the wetland can be – the *depth* of flooding;
- **How variable** the pattern of flooding and drying is – the *variation* in wet and dry cycles; and
- **How it flows** – *the direction and rate of flow* in a running water wetland.

1. Some examples of water regimes

The graphs below (Figure 1) illustrate the pattern and timing of flooding and dying in three Australian wetland types over a period of three years. To the right (Figure 2), is a set of photos illustrating water level and vegetation changes with the seasons for each of these patterns in experimental wetlands. Note that, within each pattern, the depth and timing of flooding can vary from year to year. Compare and contrast the water levels and vegetation you can see in each pattern. Note also, that when a wetland is 'dry' water may be present below the ground surface, and its depth can be measured (see page 13).

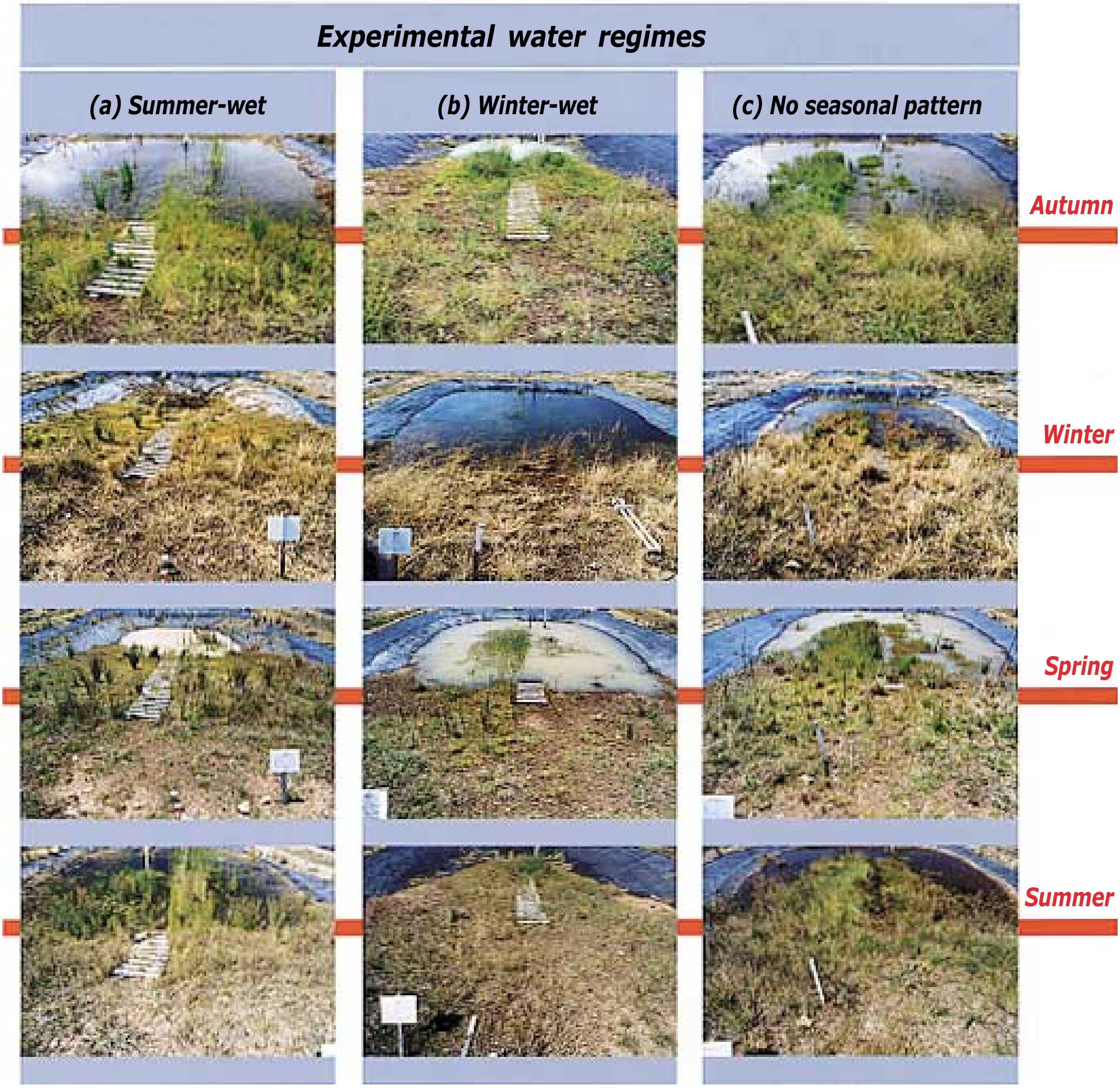


A *summer-wet* wetland, typical of northern Australia, fills in the summer wet season and dries in autumn.

A *winter-wet* wetland, typical of southern Australia, fills in autumn and winter and usually dries out in spring and summer.

A *no seasonal pattern* wetland, typical of the New England Tablelands in northern NSW, can flood or dry at any time of year depending on the rainfall patterns. Such wetlands may stay flooded or dry for a few years at a time.

Figure 1. Timing of flooding and drying in three Australian wetland types



The above photos of experimental wetlands at the University of New England were taken during the seasons of 1999–2000. In each pond, water levels are manipulated and changes in vegetation monitored.

The water levels and vegetation can be compared:

- Vertical comparisons show the seasonal changes within each water regime;
- Horizontal comparisons show differences between regimes within each season.

For example, in summer (bottom horizontal row), the *winter-wet* pond (centre) is almost dry and invaded by terrestrial plants, while the *summer-wet* and (by chance) the *no seasonal pattern* ponds are full, and have extensive beds of submerged and amphibious plants.

Figure 2. Seasonal water levels and vegetation for three water regime patterns in experimental wetlands: (a) summer-wet, (b) winter-wet and (c) no seasonal pattern

Why are flooding and drying important?

• When a wetland floods

Water seeps into the soil and soaks the resting eggs of animals and plant seeds. A flush of nutrients is released from the soil. Drought-tolerant plants revive and start growing, while germinating seeds of water-loving plants shoot and spread leaves on the mud surface.

During the days and weeks after flooding, a succession of small animals hatch, grow, reproduce and die. Wetland plants and animals take life-or-death risks with the season, growing and reproducing while the water remains. If the water stays, longer-lived species might survive to reproduce – fish recolonise the flood plains, and river redgums germinate and grow in concentric rings around water holes.

• When a wetland dries

As the water recedes, new plants germinate on the exposed mud. The fall in water level lets more light reach the bottom.

Some plants and animals produce drought-tolerant seeds, eggs and spores, which remain until the next flood. Fish and turtles retreat to waterholes, and water birds fly away. The wetland becomes colonised by mud-loving and terrestrial plants which take up nutrients released by the death of the water-loving microbes. The wetland is then occupied by dryland plants and animals until the next flood.

• Why is water regime important?

A particular water regime will favour certain species. It will therefore affect the composition of the community developing from seeds and eggs in the soil.

Continuous flooding or drying creates habitats that are similar over large areas for long periods. When water levels fluctuate, habitats change in conjunction with the water levels. The variety of habitats then created within the wetland encourages diversity amongst the biota. Table 1 (page 7) shows some of the habitats you might find in a wetland.

Rapid flooding and drying induced by pumping water into or out of a wetland is often stressful for plant establishment and growth. Allowing water levels to fluctuate naturally favours the biological diversity of a wetland. Australia has many unique wetland species, as well as some that are widespread throughout the world. Our unique species are adapted to cope with flooding and drying.

Wetlands that are artificially and permanently flooded or dry may not give plants important seasonal cues for growth and flowering. Timing, duration and extent of flooding and drying is often important for the germination, establishment and reproduction of wetland species.

Are water regime and plant communities related?

We know from research results that:

• When a wetland floods, it needs to stay wet for long enough to let plants germinate, grow, flower and set seed so that the seed bank (store of seeds in the soil) can be replenished;

• The seeds of many wetland plants are long-lived and remain viable for years while the wetland is dry, while others are short lived. Flooding needs to be frequent enough for the seeds of a variety of species to germinate (e.g. once a year for annual species with a short-lived seed bank; once every 5–10 years for many wetland herbs, shrubs and trees);

• Differing water regimes stimulate various plant communities to grow, even from the same seed bank source;

• Human activities such as damming and draining wetlands have altered the natural cycles of flooding and drying;

• Making a wetland permanently full can lead to dominance by a few species;

• Making a wetland too dry can reduce the extent and diversity of wetland plant communities.

If we understand the effects of water regime, we can either accept what is there, or change the vegetation by altering the water regime.

Habitats in your wetland

Habitat	Water presence	Plants you might find
Terrestrial (land) zone		***Terrestrial species***
Above the highest water level	Dry. Water never or rarely reaches here (above ground)	Eucalypts, wattles, sheoaks, pasture grasses and dryland plants
Edge zone		***Amphibious and terrestrial species***
Between the water's edge and the highest water level	Water sometimes reaches this area	Reeds, grasses, herbs, pasture weeds and legumes
At the water's edge	Water level fluctuates here	Sedges, rushes, knotweed, water milfoil, grasses and other flowering plants including some amphibious shrubs, trees and vines
In shallow water	This area sometimes dries out	Some algae, waterwort, rushes, reeds
Submerged zone		***Submerged and amphibious species***
In deep water	This area rarely dries	Some algae, ribbonweed, pondweed
The water itself	This habitat disappears when the wetland dries out	Microscopic algae, liverworts, plants without roots
The water surface	This habitat disappears when the wetland dries out	Floating duck weed, floating fern

Table 1. The habitats in a wetland and the plants that occupy them

Assessing water regimes and habitats

This section will show you how to:

- Clarify the aim of your monitoring, and design it appropriately;
- Keep useful records of your wetland monitoring;
- Measure and compare the water regime in the wetlands; and
- Assess and compare the habitats and biota in the wetlands.

1. Aims and types of studies

Wetlands differ in their water regime, vegetation, history, management and other human influences. This means that we caní always generalise from one wetland to another, because the relative impact of each of these influences will differ with each wetland.

The **amount** of useful information you can gain from your study will depend on both the quality and quantity of the information you gather (your data).

The **way** in which you design your data-gathering also will have a strong effect on its usefulness. It is better to be clear at the outset about your aims for your monitoring project.

Why are you doing the monitoring? Is it just to gain information about your wetland? Or is it to gain information so that you can manage your wetland, perhaps by bringing about appropriate changes to the water regime? Your answers to these questions will help you decide how best to do the monitoring.

In the next column there are three options for you to consider, with the likely benefits and limitations of each option.

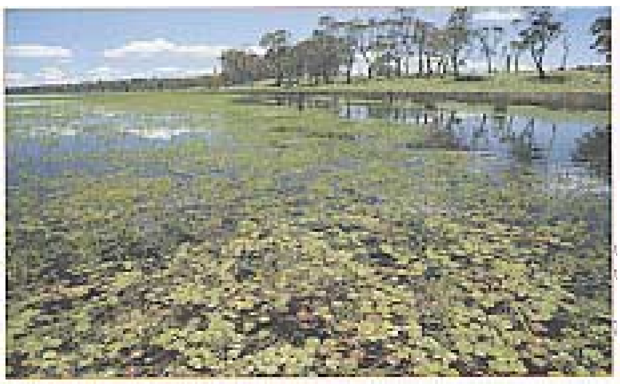


Photo: C. Cooper

Spring establishment of edge vegetation in Lhangothlin Lagoon, NSW, after filling in winter.

Some options for your study

1. Monitoring one wetland......

Checking out changes over a few seasons.

You gain experience in monitoring, plus information about the water regime and habitats in that one wetland. **Limitations:** It would be unwise to generalise from one wetland to other wetlands.

2. Monitoring two wetlands......

Doing a 'Before and After' study.

At the start of your study you would monitor two wetlands for sufficient time to determine their similarities and differences (the 'Before' bit), Then, for the 'After' bit, you would continue to monitor one wetland without changing anything ('Control' wetland) while you change the water regime in the other wetland ('Impact' wetland) and continue the monitoring. **You gain** information about both wetlands **and** you can measure the impact of the change. **Limitations:** It would still be unwise to generalise from your pair of wetlands to other wetlands.

3. Monitoring more than two wetlands......

More and better information.

Do the 'Before and After' study with ten wetlands, keeping five as the control group and five as impact wetlands. **You gain** a specific understanding of the way in which water regime influences wetland habitats. This can be used to generalise patterns for similar wetlands. **Limitations:** Few of you will have access to a large group of wetlands with permission to make changes. You may not have the time and resources to do the study. You will also need to use statistical methods to analyse your data.

2. Describing wetlands and their habitats

Plant and animal habitats vary over time relative to the water regime. We can use the distribution of wetland plants to help assess the types of habitats that arepresent.

Identifying habitats

Wetland water regimes can be identified by both 'historical' and 'real time' measurements.

The historical approach involves finding records which may show how the wetlands came to be, how old they are and how they have been modified.

If you know what the water regime used to be or how it has been modified, you might get some clues on the changes that could return it to a more natural water regime. Some modified wetlands appear to be natural, but actually the habitats might be quite different from the original wetland.

One way to explore the history of the wetlands is to ask someone who has lived nearby for some time. Begin by asking questions such as 'How old is this dam (lake, swamp, pond)?' 'Has it ever dried out?' and 'Has the water ever been used for anything?'

Other useful sources are local historical societies: old maps, old photos of picnic spots. Even the journals of explorers can tell you something of the history of a wetland and its variation in water levels. In the past, surface water was vital to the settlers, so wetlands often got a mention in historical records. A local Aboriginal community might have even more extensive knowledge of a wetland's history.

The 'real time' approach requires you to visit your wetland over time, and assess how the habitats and vegetation are changing, Use the information relating habitats, plant types and water presence (or absence) to help you (see Table 1, page 7).

Photo: C. Cooper

The 16 experimental wetlands at the University of New England. The ponds were given different water regimes, and habitats and plant communities that developed from seed banks were monitored. See Figure 2 (page 5) for some results.

Photo: G. Smith

Mother of Ducks Lagoon, Guyra, NSW. Low water, winter 1995.

Photo: C. Cooper

Mother of Ducks Lagoon, Guyra, NSW. Full in summer 1996.

3. Choosing wetlands and keeping records

Changes in the wetlands will probably be slow and gradual. Keeping records will allow you to track the changes.

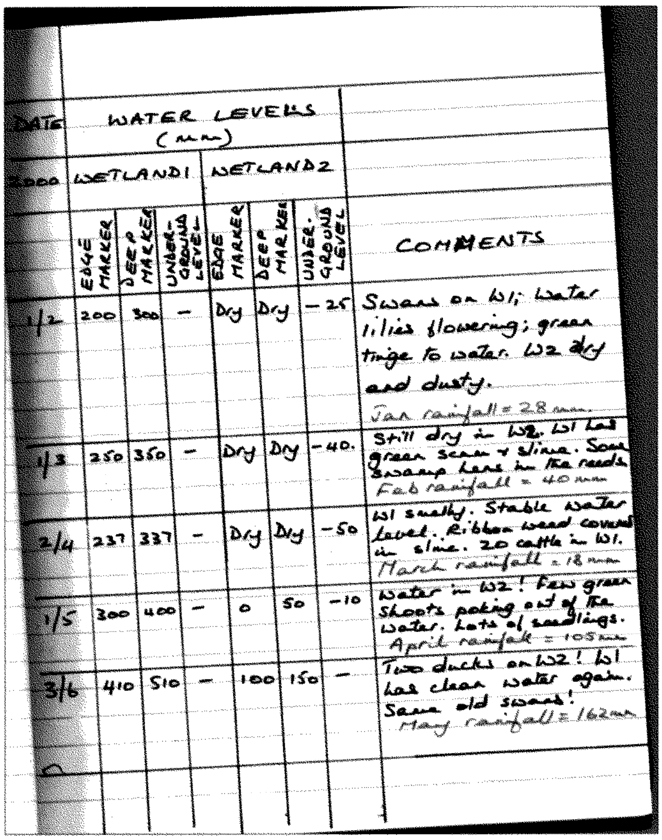
Choosing wetlands for the study

In choosing wetlands, consider access: are they easy or hard to get to? What about ownership? You need the ownerís permission to visit and monitor them. For public wetlands, you need permission from the land manager (e.g. local council, National Parks). Let the owners of the wetlands know what you are doing, and ask for their permission and cooperation.

It may be easier to find a modified wetland than one with a relatively natural water regime. Many wetlands in parks and gardens have their water levels artificially maintained. Wetlands in rubbish tips and wasteland may have a more natural water regime, but they may have been modified in other ways.

You may be lucky enough to be near a nature reserve or a national park that has wetlands whose water regime is relatively unmodified.

Farm dams and reservoirs are often deeper and therefore more permanent than natural wetlands. Many farm dams are dug on the site of swamps and natural wetlands so you might be able to compare adjacent areas.



DATE 2000	WATER LEVELS (mm) WETLAND 1			WETLAND 2			
	EDGE MARKER	DEEP MARKER	UNDER-GROUND LEVEL	EDGE MARKER	DEEP MARKER	UNDER-GROUND LEVEL	COMMENTS
1/2	200	300	–	Dry	Dry	–25	Swans on W1; water lilies flowering; green fringe to water. W2 dry and dusty. Jan rainfall = 28 mm
1/3	250	350	–	Dry	Dry	–40	Still dry in W2. W1 has green scum + slime. Some swamp hens in the reeds. Feb rainfall = 40 mm
2/4	237	337	–	Dry	Dry	–50	W1 smelly. Stable water level. Ribbon weed covered in slime. 20 cattle in W1. March rainfall = 18 mm
1/5	300	400	–	0	50	–10	Water in W2! Few green shoots poking out of the water. Lots of seedlings. April rainfall = 105 mm
3/6	410	510	–	100	150	–	Two ducks on W2! W1 has clear water again. Same old swans! May rainfall = 162 mm

Figure 3. Entries in a data book

Timing of monitoring

Your monitoring should last at least one year – longer if possible. Decide how often you want to record water levels and habitats: weekly, fortnightly, monthly or seasonally.

You can have a regular date for monitoring water levels, and measure more frequently when changes are rapid, such as during an extended dry time or a flood.

Keeping written records

Keep all your information together. Record the date, your measurements and other observations (e.g. rainfall, stock access, bird sightings) in a small bound exercise book or diary. Keep your records descriptive and objective – like a scientific journal that others could use in the future (see Figure 3 below).

Photographic records

Photographs of your wetland habitats are an excellent supplement to your written records. Dedicate an album to your wetland photos. Each time you visit to measure the water level, take an overview photo or panorama, plus a series of close-ups of each habitat or plant community type. Remember to date the photos too. Create some ‘photo points’, or include an existing marker (e.g. a tree) in a panorama to help you get the same shot each time, and then changes are easier to track. Figure 4 (page 11) shows changes within and between years recorded at one wetland.

(a)

Drier year in 1995. Water levels are low and mud is exposed at the edge of the wetland.

(b)

Wetter year in 1996. Exposed mud is flooded and covered with emergent vegetation.

(c)

Dry lagoon edge in October 1995.

(d)

Vegetation band germinating in November 1995.

(e)

Extensive established fringing vegetation dominated by native amphibious species *Persicaria* in January 1996.

(f)

Flooded lagoon edge with submerged and amphibious aquatic species in March 1996.

Figure 4. Water level and vegetation changes between (a, b) and within (c, d, e, f) years at Llangothlin Lagoon, New England Tablelands, NSW

4. Describing water regimes above and below ground

You will need to record the water levels of your wetlands over a period of time in order to understand the pattern of the water regime. You can measure water depth both above and below ground.

Measuring water level above ground

Placing the depth markers

Measuring at the deepest point gives the **absolute water level.** Reach the deepest area in each wetland by wading, swimming or boating to that point and place a marker there. It is easiest to mark the deepest point when the wetland is shallow. A second marker closer to the edge will give you a second reading – the **relative water level.** Sometimes permanent markers such as a dead tree or a fence running across the wetland may already be present. Use these if they are suitable. The **water level fluctuation** can be measured by the rise and fall on any marker.

Calibrate your markers by noting both measurements when the markers are in the water, and calculating how much you must add to the readings on the shallower marker to give you the absolute water level. Also, by making the measurements on the depth markers large and facing the shore, they can be read through binoculars from the edge.

When there is a lot of ooze on the bottom it can be hard to know where the water stops and the bottom begins! Measure to where the bottom is firm, or measure from the top of the post down to the surface of the sediment. To do this you need to know the total length of your marker (x). Measure the distance from the top of the marker to the water surface (y), and then (x) – (y) will give you the depth.

For really deep water, use a rope with a weight on one end. Lower the weight into the water until the rope goes slack, indicating that the weight has hit the mud. Take up the slack until the rope is just taut again and measure the rope.

Markers of all sorts can be lost or broken (or vandalised or removed!), so sometimes measuring the water level in a couple of different ways each time will be safer.

Equipment

Essential: **Depth markers.** Use your imagination! Make a marker out of a long pole, a star post, a wooden post, or a rope or chain plus anchor and a float. It will be useful to put some measurements on your markers before you start. Start at zero for the end which will be resting at the bottom of the water, and put waterproof marks and numbers every 0.1 m or 0.5 m all the way to the top.

You will also need gumboots or waders, your record book, pencil and ruler or tape measure.

If you wish to relate water regime to rainfall, keep a rain gauge nearby.

Photo: C. Cooper

Recording water levels from a depth marker.

When the water disappears: measuring underground water levels

During dry times the water can disappear from the surface of a wetland, but it can still be present underground where it may be accessed by deep-rooted plants.

If you are keen to see what happens to the water when the wetland 'dries', you can measure the water level underground. To do this you need to make a test well.

Step 1. Creating a test well

Dig a hole (l-2m deep) with a post hole digger and put some free-draining sand or gravel at the bottom. Line the hole with a piece of drainage pipe that has holes already drilled in it. Fill the gap between the hole and the pipe with sand, then cement the pipe at the ground surface (see Figure 5 below).

Step 2. Measuring the water level

Measure the distance from the top of the pipe to the water level with a plumb bob (see box) and calculate the depth of the water underground (see Figures 6 and 7 below).

Step 3. Calculate the distance from the soil surface to the water.

For example (see Figure 6):

Distance from top of pipe to water = 120cm (a)

Distance from top of pipe to ground = 80cm (b)

Distance from ground level to water

= (a) – (b) =120 cm – 80cm = 40cm.

i.e. The water level is 40 cm below the ground.

Equipment

Essential a post hole digger; 10L of sand; 1L of 10 mm gravel; a known length (l-2m) of 50mm drainage pipe with holes drilled at 10cm intervals on at least two sides; cement, sand and water to make approximately 10L of concrete, and a plumb bob for measuring the water level (a weighted tape measure or a wooden ruler on a string is ideal for this).

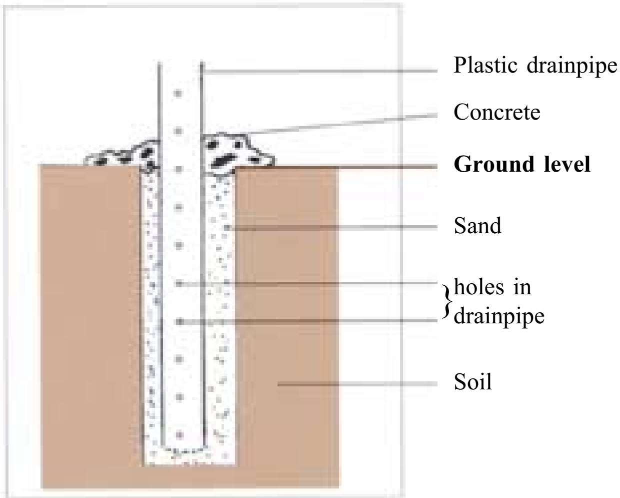


Figure 5. Components of a test well.

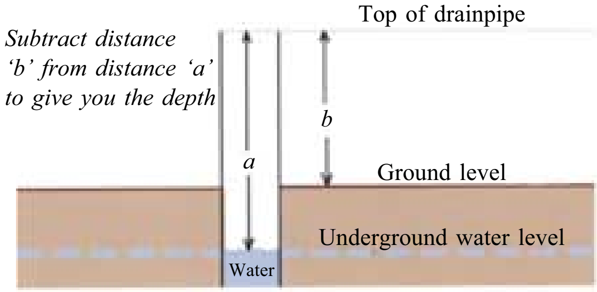


Figure 6. Calculating the underground water level.

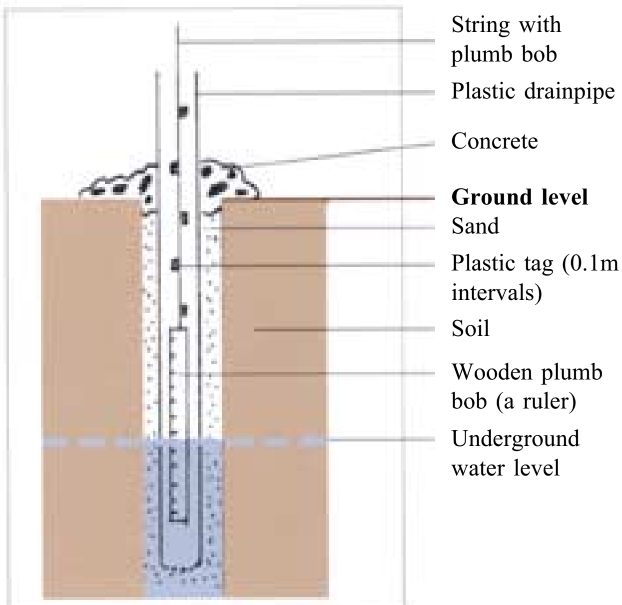


Figure 7. Using a plumb bob to measure the depth of underground water below the surface.

Figures 5 - 7. Measuring underground water

Mapping changes in habitats and water levels

You will need a basic map on which to record water levels and vegetation at each visit. Copy the basic map and stick copies in your book as you record the changes. The habitat monitoring can be done at the same times you visit the wetland to measure water levels.

Step 1. Mapping wetland features

Draw a map of each wetland, marking in the main features, directions, some measurements and a scale. This will be your basic map (see Figure 8). Choose fixed points (e.g. trees or posts) as references for your measurements and estimates of length, width and shape. Use paces, tape measure and compass to help. Measure the distances between fixed points with tape or string and record them on your map. Repeat at intervals around the wetland. Put a scale on the map.

Step 2. Water levels

Mark the current water level and depths. Mark in the waterís edge in relation to the highest water mark.

Step 3. Habitats

Indicate on your map where plant communities are growing in the terrestrial, edge or submerged zones. (Refer to Table 1, page 7 and the other two booklets in this series – see inside front cover).

Step 4. Repeat visits

Check whether vegetation and water levels have changed in each of the seasons. You might also choose to record during or after major wetting or drying events. Figures 9 and 10 are examples of the records you could make.

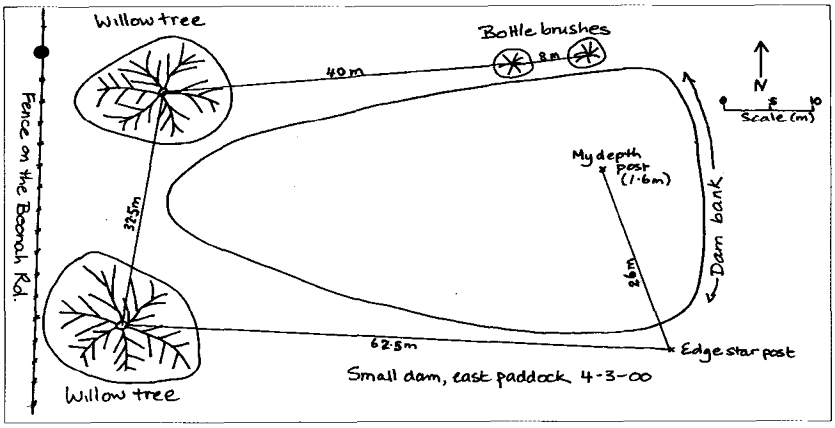


Figure 8. Basic map. A small dam, showing the main features and measurements. Note trees, fence line and two markers: a depth marker in the deepest part of the dam, and a starpost for a useful reference point.

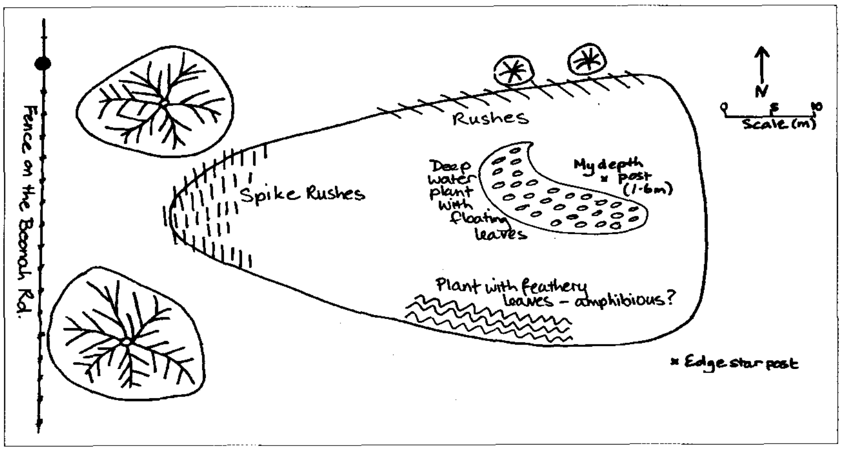


Figure 9. Small dam on 'Boomavale' east paddock. Water levels and habitats in autumn. 8-3-00.

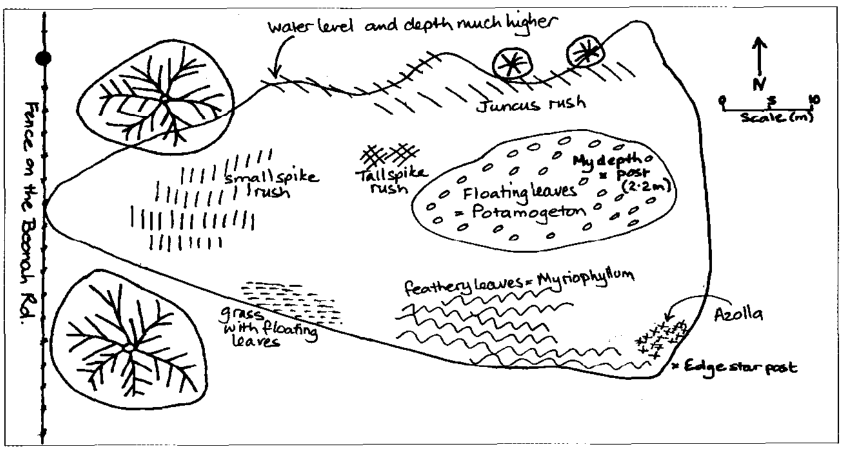


Figure 10. Small dam on 'Boomavale' east paddock. Water levels and habitats in spring. 16-9-00.

Figures 8 - 10. Mapping wetland features

Putting it all together: interpreting your findings

This section guides you in comparing the water regimes, wetland habitats and vegetation over time in the wetlands you are studying. Use the questions to guide your thoughts, and answer each question for each of the wetlands in your study.

1. Water level changes over time

As you measure the water levels in your wetland you can plot them onto a graph like Figure 1 (page 4). You can record the water levels from all the wetlands on the same graph using different coloured lines or symbols, or you can plot them on different graphs. Are the patterns the same for all wetlands? Compare your water regime patterns with those given in Figure 1.

What are the characteristics of your wetlands?

As you record water levels you can start to think about the patterns and processes that give your wetlands their character and make them habitats for birds and other organisms.

- Do your wetlands follow a winter-wet or a summer-wet pattern?
- Is the pattern of water presence and depth related to season?
- Does the maximum depth vary from year to year?
- Does the timing of flooding vary each year?
- How often do they flood in each year?
- How long does the water stay?
- Do they reach the same depths?
- Do they ever dry out?
- Do they have the same surface areas exposed during dry times?
- Do all parts of the wetland experience the same water regime?
- Are all your wetlands the same for all these qualities?
- If they are different, how do they differ?

Add more of your own questions and answers.

'...the reeds gradually decreased in body, until at length, they ceased or gave place to bulrushes. There were general appearances of inundation, and of the subsidence of water, but none that led us to suppose that any channel existed beyond the flooded plains.'

Explorer Charles Sturt (1828) writing about Mosquito Brush, South Australia.

2. Habitat changes over time

While you are recording habitat changes in your wetland you can consider what makes a wetland valuable. Table 1 (page 7) lists some common habitats in wetlands, and the maps or photographs you have made will give you a picture of habitats as they change over months and seasons.

- How many different sorts of habitats are there in your wetlands?
- Does the extent of each habitat change over time?
- Do all your wetlands have the same plants/ plant groups in them?
- How many kinds of plants are in each wetland?
- Do the plants change with time?
- Do the plants change with water regime?
- Do you think time and water regimeinteract to determine what plants grow? e.g. do different plant communities grow as a result of flooding in spring compared with flooding in autumn?
- Do the wetlands have similar biological diversity (species richness) in them?
- What kinds of animals use the wetlands?
- Are the animals the same in all wetlands?
- How are the wetlands similar or different?

Add more of your own questions and answers.

Did you notice whether:

- Shallow habitats with amphibious plants change as the water levels rise and fall;
- The plants tolerate or respond quickly to water level changes;
- Permanently flooded habitats tend to have submerged plants that do not tolerate drying;
- Terrestrial edge habitats tend to have weedy plants that do not tolerate flooding;
- A mosaic of many groups of plants provides a diverse set of conditions for biota in a wetland; and
- Fast lowering or raising of water levels by pumping or increased drainage leaves edge habitats bare of plants?

3. Analysing your results

• Monitoring one wetland

If you have monitored only one wetland, you can plot the changes in your water regime and plant habitats over the time of the study. From these results you can follow and interpret the changes in your wetland.

• Monitoring two wetlands

If you have monitored two wetlands, you can compare and contrast the pair. If you have made changes to one, you can follow the results of your 'Before and After' study on a graph (see Figure 11 and box at right).

• Monitoring more than two wetlands

If you have monitored more than two wetlands in a 'Before and After' study using replicate 'Control' and 'Impact' wetlands, as outlined on page 8, you can analyse your results as explained in the box. Your results should be suitable for deciding whether water regime is influencing the habitats in a way that could be generalised for other wetlands.

Analysing 'Before and After' studies

Following a 'Before and After' study using 'Control' and 'Impact' wetlands, your results could be displayed as a graph where a point of change is displayed (see Figure 11 below).

If you wish, you could analyse your results using statistics (see page 20 for a reference on biological statistics). For example, you could do a Two-Way Analysis of Variance on the variables that you measured (e.g. number of plant species or habitats).

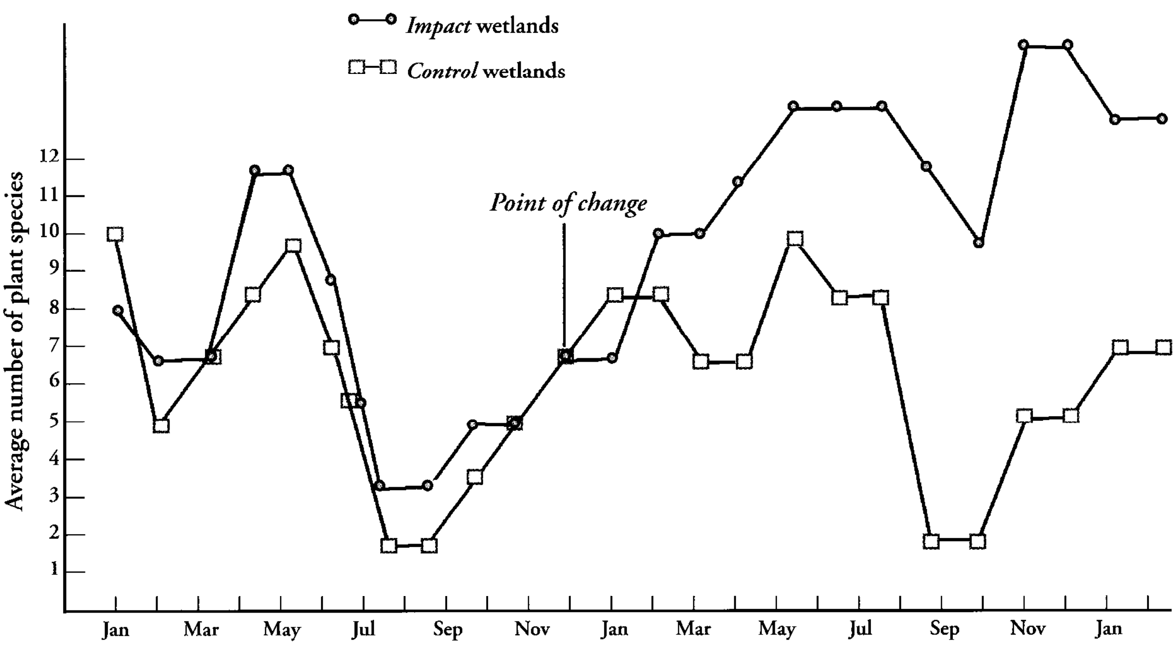


Figure 11. Average number of plant species plotted over time in control and impact wetlands

What can be changed to restore a more natural pattern of water levels?

Once you have measured the water level changes in your wetland, you may want to restore all or part of a more natural water regime. If this is your choice, you must realise that what you do to your wetland will have implications 'downstream' so any changes need careful consideration.

There are three different scales at which you can approach wetland management, and all are important.

- The local scale: your wetland and its surroundings;
- The catchment scale: your wetland and all its sources of water, groundwater and drainage lines; and
- The landscape scale: your wetland, its catchment, nearby catchments of local wetlands and rivers, all the way downstream to the sea.

Local-scale changes for your wetlands will be easiest to carry out, as they are more likely to be under your control. However, before taking action it would be wise to talk over your ideas with the local catchment management committee and others involved in the management of water at the catchment and landscape scales. You may also need to obtain approval for all or part of your proposed changes.

What could be changed?

In theory, any of the components of water regime could be changed:

- The *timing* of flooding;
- The *frequency* of flooding;
- The *duration* of flooding;
- The *extent* of flooding;
- The *depth* of flooding;
- *Variability* in all the above factors, plus
- The amount and rate of *flow.*

In practice, some of these will be easier to restore than others (see pages 18 and 19).

Restoration of all the aspects of a natural water regime may not be compatible with other uses of the wetland.

Photos: J. Holmes (NPWS)

Views of claypan wetlands on the Paroo River floodplain: local scale (left), catchment scale (middle) and landscape scale (right).

1. The local scale

You might be able to change:

- **The amount of available habitat, or the surface area that floods** by changing the slope of the sides. Relatively minor earthworks can double the amount of habitat. Making parts of a shallow wetland deeper can also increase habitat diversity.
- **Drains.** If drains direct water away from or towards your wetland, you can block or redirect these to modify the water regime.
- **Water-retaining structures.** It may be possible to raise or lower dams or water-retaining structures associated with your wetland.

Clearly such actions must be compatible with other wetland and catchment activities. Approval may be required from wetland managers, local councils and land and water management authorities.

What affects the water regime of a wetland on a local scale?

- Wetland size;
- Wetland shape and topography;
- The presence of drains which direct water onto or away from the wetland;
- The presence of dam walls or water-retaining structures such as barrages that affect water inflow or outflow.

Even multi-use wetlands such as farm dams can become richer habitats if care is taken in their design or redesign. For more details about how to revegetate, see the companion booklets detailed inside the front cover.

2. The catchment scale

- Where wetlands have been made permanent by weirs or dams, water levels can be made to fluctuate more naturally only if this can be incorporated into the water management plan.
- Where wetlands are now permanently dry, or flooded at inappropriate times (eg. Summer in southern Australia), management plans could be changed to flood in more appropriate seasons.
- Landcare and Rivercare projects such as reforestation of catchments and the fencing of riparian zones can improve the quality of wetland habitat at the catchment scale.

What affects water regime on a catchment scale?

Water regime in individual wetlands will be influenced by catchment-scale processes such as:

- Weirs on rivers and streams;
- Tree planting or deforestation in surrounding areas;
- Extraction of groundwater; and
- Changed land use (e.g. paved areas around urban ponds).

Photo: H. Aston

Photo: M. Casanova

Winton Swamp (Victoria), April 1959 (left). The outflow from this natural canegrass and river redgum swamp was dammed in 1970 to form Lake Mokoan, an irrigation storage dam (right, Sept. 2000). Although erosion and high carp numbers have also affected water quality in the lake, the change in water regime has meant that the river redgums have drowned, the water is generally turbid, and blue-green algal blooms are an annual problem. Managers are working toward restoring the former vegetation through a number of measures including water regime manipulation.

3. The landscape scale

Clearly at the landscape scale it may be more difficult to bring about change. River, catchment and landscape committees may need to reverse past decisions in order to restore more natural regimes.

Incorporating the best available science into water management is part of responsible landscape practice for the 21st century.

What affects water regime at a landscape scale?

The supply of water to some of our most extensive and valuable wetlands can be affected by:

- Structures such as hydroelectric and irrigation schemes;
- Flood mitigation works; and
- Regional water supplies.

Protecting and enhancing our wetlands: bringing about change

If you have carried out the exercises in this and the other two companion booklets, you will have a wealth of information to share with others. You will have records of your activities, and you may have started to develop some healthy functioning wetlands. You will have gained in knowledge and experience. You will know about the local, catchment and landscape effects on your wetlands. You are now in a position to help others to develop a realistic perception of the life of a wetland in Australia.

You can do this by:

- Sharing your knowledge, experience and ideas on the benefits of flooding and drying in wetlands with wetland managers;
- Discussing the consequences (both positive and negative) of major and minor water regime changes with other wetland managers;
- If you are a teacher, you can get your students involved in monitoring wetlands;
- Helping to increase community awareness of the importance of managing and valuing our natural resources through poster presentations, discussions on flooding and drying in wetlands at Landcare or Rivercare meetings or other fora, using your own work as an example.

Photo: C. Jones

Sharing ideas on wetland water regime and vegetation at a Landcare field day. Northern Tablelands, NSW.

References

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3. Roberts, J. and Marston, F. (2000). *Water regime of wetland and floodplain plants in the Murray-Darling Basin.* CSIRO Land and Water, Canberra. Technical Report 30/00.

4. Roberts, J., Young, W. and Marston, F. (2000). *Estimating the water requirements of plants of floodplain wetlands: a guide.* Land and Water Resources Research and Development Corporation, Canberra. Occasional Paper 04/00.

Contacts

1. Inland Rivers Network. 33 George Street Sydney 2000.
Phone: 02 9241 6267; **Email:** <coordinator@irnnsw.org.au>

2. Coast and Wetlands Society Inc. PO Box A225 Sydney South NSW 1235.

3. Trust For Nature (Victoria). 2/385 Little Lonsdale Street Melbourne 3000.
Email: <trustfornature@tfn.org.au>

4. Wetland Care Australia (Head Office). PO Box 437 Berri SA 5343.
Phone: 08 8582 3677; **Web site:** http://www.wetlandcare.com.au
Mailing list for WetlandLink Bulletin (quarterly newsletter):
Phone: 02 6881 6069; **Email:** <wca@linknet.com.au>

5. The Wetlands Centre of Australia (Shortlands Wetlands Education Centre).
PO Box 292 Wallsend NSW 2287.
Phone: 02 4951 6466; **Email:** <swc@hunterlink.net.au/wetlands>

6. The University of New England Experimental Wetlands – demonstration site for the influence of water regime on wetland communities. Contact: Margaret Brock.
Phone: 02 6773 5299; **Email:** <mbrock@dlwc.nsw.gov.au>

7. The Murray-Darling Basin Commission.
Website: www.mdbc.gov.au (Use the search term 'wetlands').

8. Environment Australia.
Website: www.environment.gov.au (Use the search term 'wetlands and waterways').