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Water facts 16

Living Wetlands: An Introduction to Wetlands

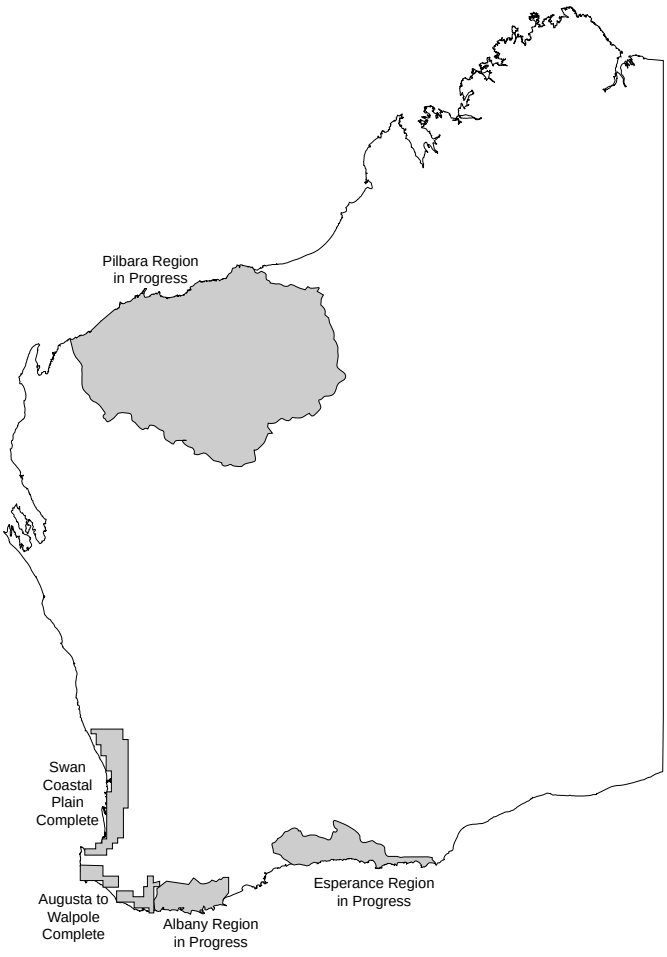
Our Wetlands

Western Australia's wetlands are biologically productive systems that support a diverse and distinctive array of plants and animals, many of which are unique. Many wetlands are highly valued for their scenic beauty and popularity as recreation areas. Despite this, it is estimated that a significant proportion of the State's wetlands have been destroyed since European settlement. On the Swan Coastal Plain alone, it is estimated that between 70 to 80 per cent of all wetlands have been filled, drained or cleared. The wetlands which remain are highly vulnerable to impacts from urban and rural encroachment. It is therefore very important that they are protected and managed in an ecologically sustainable way.

Wetlands are complex, diverse ecosystems which are directly linked to the landscape that surrounds them. The health of wetlands is not just dependent upon the biological, chemical and hydrological processes taking place within them, it is also significantly influenced by the activities occurring within their catchments. Wetlands are dynamic ecosystems which change, not only over days, months and years, but also over decades and centuries. These changes can take place in response to climatic cycles, random events such as storms and fires or as a result of human activity within the catchment of the wetland.

What is a wetland ?

A wetland can be defined as an area of seasonally, intermittently or permanently waterlogged soil or inundated land, whether it is fresh or saline, flowing or static. "Living Wetlands" is a concept primarily concerned with basin and flat wetlands such as lakes, sumplands (swamps), damplands and palusplains (seasonally waterlogged flats). The management and protection of channel wetlands such as rivers and creeks is outlined in a separate Factsheet called "Living Streams". The Water and Rivers Commission is undertaking extensive mapping, classification and evaluation of wetlands around the State.

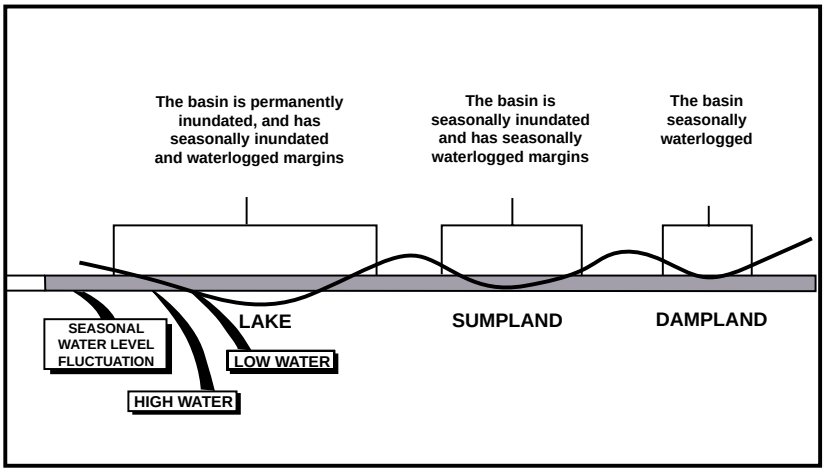


The current extent of the Water and Rivers Commission's wetland mapping in Western Australia.

Wetlands can be classified according to their landform and water permanence.

	Basin	Flat
Permanently Inundated	Lake	Uncommon
Seasonally Inundated	Sumpland	Floodplain
Seasonally Waterlogged	Dampland	Palusplain

Source: Wetlands of the Swan Coastal Plain Volume 2B: Wetland mapping Classification and Evaluation (Hill et al 1996).



Source: Wetlands of the Swan Coastal Plain Volume 2A: Wetland mapping Classification and Evaluation, Main Report (Hill et al 1996).

The value of wetlands: why are they so important?

Wetlands are important life support systems that shelter and sustain an enormous diversity of wildlife. Many of these species depend on the resources that wetlands provide for their survival. Wetlands are places where sediments collect, soils and landforms are created, nutrients are recycled and water is purified. They are also places that we can use for recreation and enjoyment. Well managed wetlands present attractive features which can significantly raise the value of surrounding properties.

Booragoon Lake, Bird Lookout. *Photo: M. Allen*

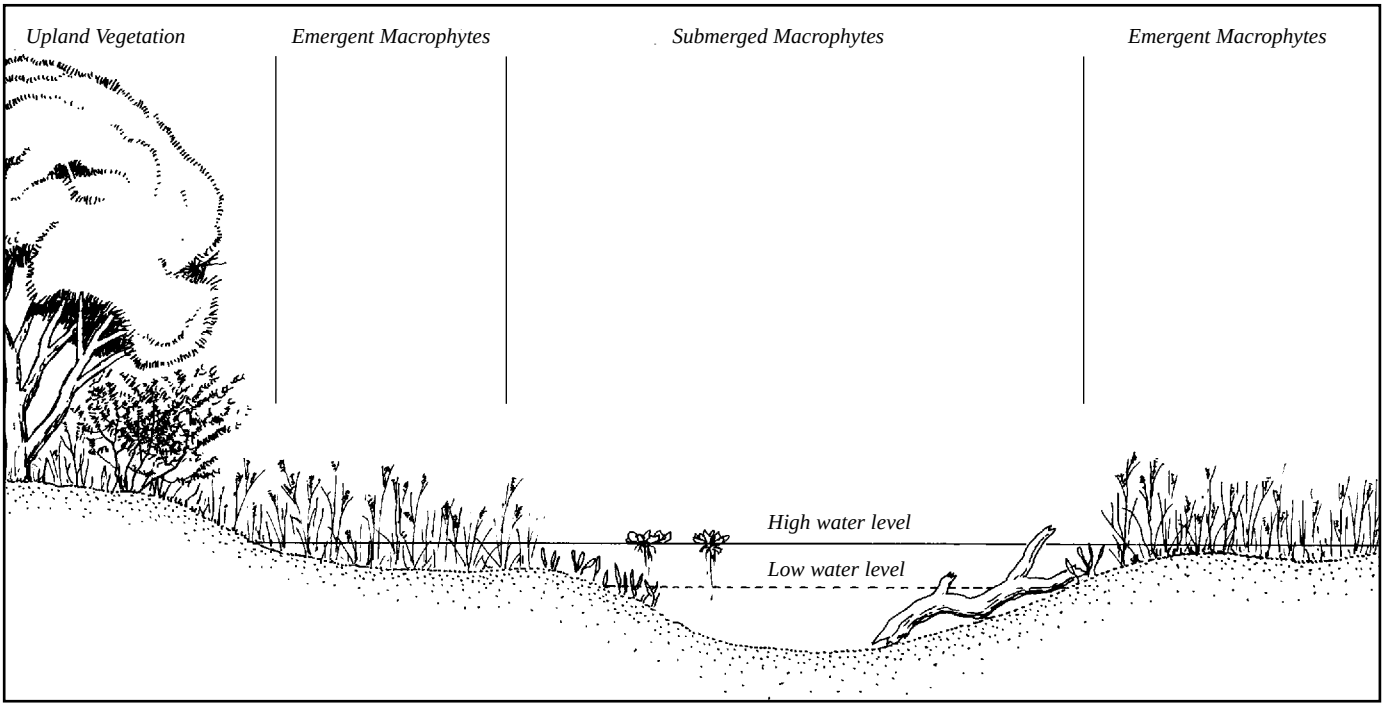
Natural values

Biodiversity

The term biodiversity refers to the variety of life forms and natural systems found in a particular area. It includes all of the resident plant and animal species, the genes they contain and the ecosystems they form. Western Australia's wetlands are remarkably diverse in physical and biological composition and in the ecological processes and functions they support. All the plant and animal species in a wetland are part of a complex ecological network where individual organisms interact with each other and the non-living environment around them.

Wetlands contain a rich diversity of fauna including invertebrates, such as dragonflies and aquatic beetles, waterbirds, fish and frogs. Reptiles such as snakes and lizards are commonly found in upland vegetation adjacent to wetlands, as are the southern brown bandicoot and the water rat. Two species of turtle are associated with Swan Coastal Plain wetlands — the long necked turtle, which is relatively common, and the western swamp turtle which is probably now found in only two natural wetlands and is considered to be Australia's most endangered reptile. A captive breeding program for this species has been established at the Perth Zoo with the support of a number of government agencies.

Several types of vegetation are found in healthy wetlands. Wetland-dependent terrestrial vegetation is situated on the higher ground that slopes down towards the wetland, forming a distinct community around the wetland. On the edge of the wetland, where the drier ground merges with the waterbody and the soil is waterlogged or inundated for a significant portion of the year, fringing vegetation such as sedges, rushes, paperbark trees and aquatic plants are usually abundant. The fringing vegetation will usually contain emergent macrophytes, which are plants that live in shallow water and have leaves that protrude above the water surface. Submerged macrophytes can be found attached to the sediments of the lakebed and live completely underwater. Floating aquatic plants are found in some wetlands and derive their nutritional requirements entirely from the water column.



A simplified profile of wetland plant communities.

Wetland vegetation plays an important role in filtering nutrients, providing habitat and stabilising soil. It also contributes to the landscape and amenity of an area and creates the opportunity for passive recreational activities such as bird watching, photography and bush walking.

Natural flood management

Wetlands generally occur in depressions in the landscape. Floodplain wetlands occur adjacent to rivers and provide for temporary storage of peak floodwater flows by enabling the water to disperse over the floodplain. This reduces downstream flood levels and thereby reduces the impact of flooding. Both basin and floodplain wetlands provide areas to temporarily contain the large volumes of water produced during wet weather. These wetlands also filter out nutrients and suspended particles and thereby improve the quality of the water as it drains away.

Biological filter

In recent years wetlands have been promoted as being excellent "biological filters" as they have the ability to improve the quality of water that passes through them. Nutrients enter wetlands in either dissolved or particulate form via surface water flows or groundwater discharge. They may then be incorporated into the wetland sediments, to be taken up by plants and animals or remain in the water column. The sediments comprise the major long-term store of nutrients in a wetland.

Healthy fringing and aquatic vegetation acts as a biological filter that improves water quality. Vegetation can trap (filter) some of the nutrient-laden sediments flushed from the catchment in surface water runoff and reduce the amount of nutrients entering the wetland. Wetland vegetation can remove some nutrients directly from the water (eg. uptake by algae and aquatic vegetation) or by assimilation from the sediments (via emergent rooted plants and microbes growing in the root zone). Plants that are useful in nutrient stripping in wetlands include the pithy sword sedge (*Lepidosperma longitudinale*), articulated sedge (*Baumea articulata*), duckweed (*Lemna minor*), thin duckweed (*Spirodela*), bulrush (*Typha orientalis, T. domingensis*) and fennel pondweed (*Potamogeton pectinatus*).

Where wetland plants are being used to remove nutrients from eutrophic (nutrient-enriched) wetlands, the leaves and accumulated sediment should be periodically harvested and removed from the wetland floor. This prevents accumulation and recycling of nutrients within the system. It is generally only phosphorus that is a problem in nutrient accumulation as it has no gaseous phase, unlike carbon and nitrogen which may be cycled back into the atmosphere as carbon dioxide and gaseous nitrogen through chemical and biological breakdown.

Habitats

Habitat refers to the environment upon which a living organism is dependent. Wetlands provide a variety of habitats in which plants and animals live for all or part of their life cycles. A diversity of fauna utilise wetland habitats for a range of activities, such as foraging for food, breeding and loafing. In the case of some waterbirds, wetlands provide resources critical to successful migration.

Healthy fringing vegetation around a wetland acts as a biological filter. *Photo: A. Hill*

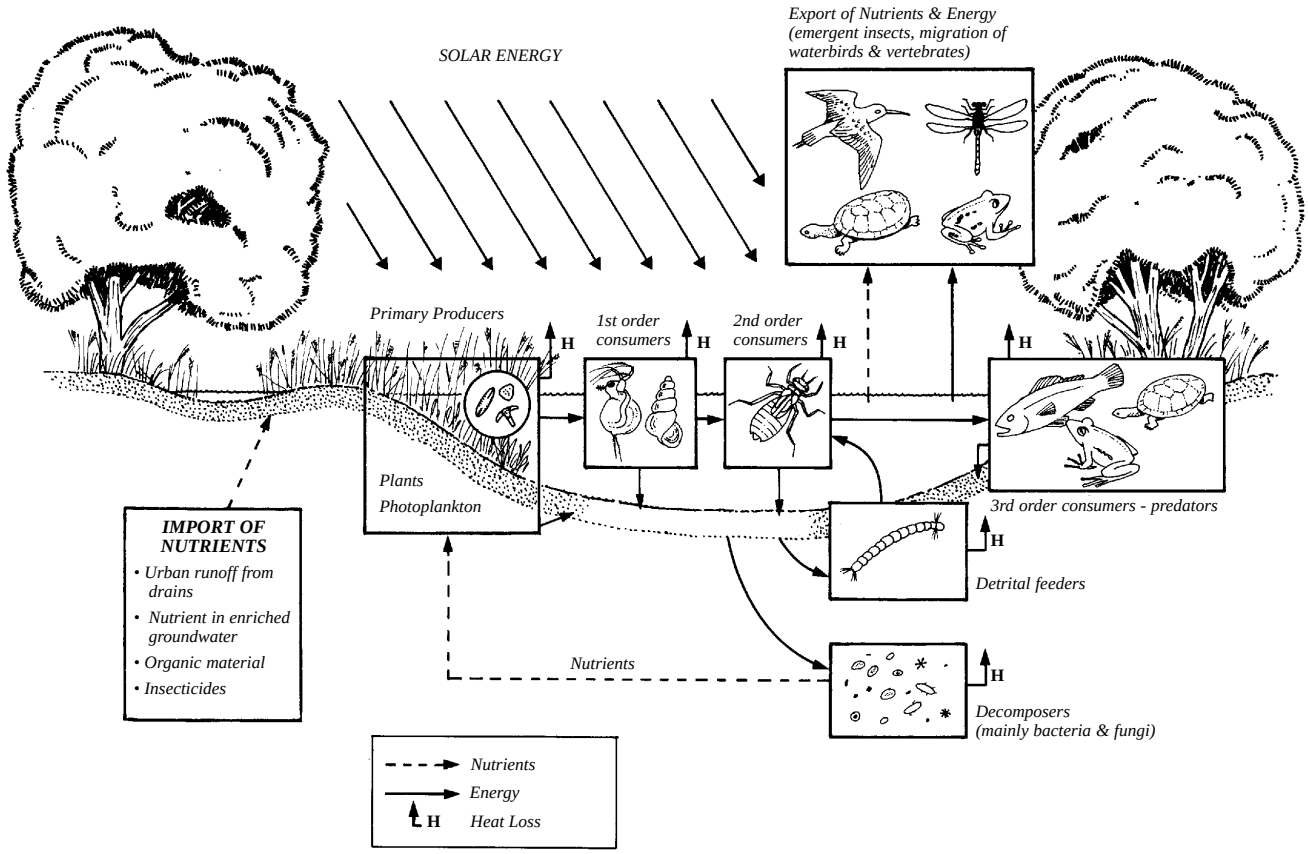
Wetland and upland vegetation provides feeding and breeding habitat for frogs, waterbirds, insects and mammals. Areas of bare sand, rocks, logs and open water provide a range of habitat requirements for many aquatic and terrestrial animals. They are utilised as substrates for attachment, for breeding, shelter from predators and for obtaining food. Aquatic plants provide microhabitats and food for a variety of invertebrate species.

Many species of migratory waterbirds move between continents on a seasonal basis as part of their lifecycle. Waders, such as stints, sandpipers and turnstones, migrate annually over the period April to September from their breeding areas in Siberia to wetlands in Australia. Mudflats and shallow water in these wetlands are rich feeding areas for waders such as the red-necked stint, the curlew sandpiper and the sharp-tailed sandpiper who probe, spear and scoop the water and flats for tiny animals. Emergent sedges, rushes and grassy bank areas attract many water birds, providing nesting habitat for ducks, swans, ibis, and herons. These areas are also suitable breeding grounds for many native frog species.

A living system

Wetlands are complex communities where a diversity of species interact with each other and with the non-living environment. Wetland plants produce energy through the process of photosynthesis. This energy becomes available to other organisms higher up in the food chain through direct grazing on plant biomass or indirectly through the breakdown of organic matter. Dead leaves and branches from fringing vegetation, such as sedges, rushes and overhanging trees, fall into wetlands. This material is broken down by microscopic fungi and bacteria, which assimilate energy and nutrients. In turn these microbes become food for larger animals within the food chain. Larger animals may also assist in microbial activity by consuming organic material, creating food for the microbes by breaking it down into smaller particles with a greater surface area.

Animals that consume and break down organic matter can be divided into a number of functional feeding groups. **Shredders**, including species of caddis fly larvae and amphipods, break down dead plant material to produce detritus (fine dead and decaying organic matter), releasing nutrients in the process. **Filter feeders**, such as small bivalves, consume the minute particles of organic matter that are suspended in the water column. **Collectors**, such as worms, take small particles of organic matter from the sediment. **Scrapers**, such as snails, scrape fine algal growth from rocks and logs. Algae and aquatic plants utilise the nutrients that are released for growth and they are then in turn consumed by shredders and scrapers. The **predatory** species which can be found within a wetland range from dragon and damsel flies, water mites, backswimmers, water boatmen and adult beetles through to fish, frogs, birds and turtles.



Complex interactions exist between the living and non-living parts of a wetland environment.

Human use of wetlands

Environmental services

Stormwater management

As wetlands generally occur in low lying areas, they are often used to store stormwater following heavy rainfall to prevent small-scale flooding on local roads. While direct drainage into wetlands is a technique that has commonly been used in urban areas, it can result in significant wetland degradation and is no longer considered acceptable. Effects of direct drainage can include the drowning of wetland trees (by prolonged inundation) and eutrophication and associated nuisance algal blooms caused by the influx of nutrient-rich water.

To protect the values of wetlands Water Sensitive Urban Design principles should be used in urban development. Water Sensitive Urban Design is a modern approach to urban planning and design that seeks to improve water quality through the use of best management practices. A range of methods can be used to manage stormwater in an environmentally sensitive manner, including the use of up-catchment retention or detention basins to reduce stormwater flows and the use of properly designed artificial wetlands to reduce nutrient and pollutant levels in stormwater before it enters a wetland or waterway.

A stormwater drain enters a significantly modified wetland in an urban environment. Stormwater drains are a common sight in many urban wetlands.

Water supply

Wetland water levels are determined by groundwater and surface water flows. Groundwater-dependent wetlands are mainly expressions of seasonal changes in local groundwater levels which respond to rainfall or the lack of it. Surface water-dependent wetlands have relatively little or no inflow from groundwater, and include wetlands perched on impervious soils such as clay. These wetlands are recharged through direct rainfall and from surface water runoff generated by rainfall elsewhere in the catchment.

Abstraction (pumping) of groundwater causes a decline or 'drawdown' in groundwater levels in the area surrounding the bore and can reduce water levels in nearby wetlands. The magnitude of the drop in groundwater levels and the size of the area influenced by the drawdown depend largely on the rate and quantity of abstraction, the rate of recharge and soil transmissivity (the rate of movement of groundwater through soil).

Many domestic, industrial and agricultural developments abstract groundwater via on-site bores. A significant proportion of Perth's scheme water supply comes from groundwater from the Gnangara and Jandakot Mounds, located to the north and south of Perth respectively. The growing population of Perth is placing a higher demand on groundwater. The abstraction limits set by licence conditions ensure that minimum water levels are maintained to support the ecological values and functions of wetlands in the area surrounding the borefields. It is important to maintain a wetland's seasonal hydrological regime to sustain plant and animal diversity. A number of significant wetlands are monitored to ensure that their water levels and water regimes are maintained, and to ensure that the criteria set by the Water and Rivers Commission provide adequate protection.

Grazing

Wetlands in rural areas are often used for summer pasture, as stock watering points and as a water resource for irrigation. Many graziers regard wetlands as valuable assets, as wetland vegetation provides good feed for livestock after pastures have dried or withered. Stock access should be carefully managed through fencing and the provision of stock watering points away from the wetland to prevent wetland degradation through overgrazing and trampling.

Unrestricted access by stock can turn a wetland into little more than a muddy depression. *Photo: A. Hill*

Cultural and heritage value of wetlands

Cultural significance

Many wetlands have cultural significance to Aboriginal people. Archaeological remains such as stone arrangements, marked trees, rock shelters, burial sites, grinding depressions, art work, and engraving sites have been found close to wetlands. Sites of archaeological and ethnographic significance to Western Australia's Aboriginal heritage are recognised and protected under the Aboriginal Heritage Act 1972 – 1980.

Wetlands can be highly productive and were often a plentiful source of food for Aboriginal people. Fish, eggs, snakes, lizards, freshwater mussels and birds found in wetland environments were important components of the Aboriginal diet. The seasonal drying of wetlands enabled Aboriginal people to capture stranded turtles, while selected parts of the wetland plants Eleocharis and Typha were roasted or eaten raw. Food wasn't the only resource provided by wetland environments — the waterproof bark of paperbark trees was used by Aborigines as a building material.

Recreation, relaxation and contemplation

Wetlands, estuaries, rivers and streams can provide a form of refuge for people seeking to escape the stresses of urban life. Healthy wetland ecosystems can provide a range of passive recreational opportunities including bush walking, picnicking, photography, canoeing and bird watching. Wetlands can form part of shady green corridors in housing developments, offering a close, convenient place for relaxation and enjoyment.

Education and research

Wetlands are an educational resource for people of all ages, from primary school children to university scientists. They provide the opportunity to study and explore the natural environment in urban areas where little native vegetation remains. In Western Australia, young people can learn about wetlands through Ribbons of Blue, a program aimed at teaching primary and secondary school students to monitor wetland health through macroinvertebrate and water quality sampling. This program offers a practical framework for environmental education, and is an important strategy in promoting environmental awareness in the community. At a tertiary level, wetland research is needed on an ongoing basis to gain a better understanding of wetland ecosystems and their biological, ecological, chemical and hydrological processes, so that we may manage them sustainably.

Programs such as Ribbons of Blue teach schoolchildren the value of their local environment and ways to look after it.

Degradation and loss of wetlands

Loss of wetlands through land development

Clearing and salinisation

Salinisation is one of the main causes of wetland degradation in the wheatbelt region. It is a consequence of the widespread clearing of deep-rooted native vegetation and its replacement with shallow-rooted annual crops and pasture species which use less water than the original vegetation. This has resulted in a rise in the water table, increased runoff, waterlogging and the upward movement of salt, which had accumulated in the subsoil layers over thousands of years. A combination of increased inundation, waterlogging and salinisation has resulted in the widespread death of native wetland vegetation in the wheatbelt. Extensive areas of wetland habitat have been lost, resulting in a decline in the diversity of faunal species found in many wheatbelt wetlands. Aside from causing the loss of vegetation and habitat, increased salinity is directly toxic to many animal species.

Drainage, infilling and clearing

Extensive clearing and draining of wetlands has taken place in the south-west of the State to enable agricultural activities, such as cropping, grazing and market gardening. This has resulted in the loss of wetland habitat, increased erosion and sedimentation and transport of nutrients via surface drains. On the Swan Coastal Plain alone, it is estimated that 70 to 80 per cent of all wetlands have been filled, drained or cleared of native vegetation.

Urban development

Urbanisation has directly affected wetlands through clearing, drainage and landfill to enable residential development. Water in many urban wetlands has also been polluted through:

- nutrients from septic tanks leaching into groundwater, which then seep into wetlands;
- high fertiliser use on gardens in urban areas, which contributes significant nutrient loads to surface and groundwater. (High levels of nutrients in wetlands can promote excessive algal growth, eutrophication and, in some cases, botulism); and
- discharge of stormwater, which may contain nutrients, heavy metals, hydrocarbons and pesticides.

Following urbanisation there is also a significant increase in the volume of surface water entering wetlands. This takes place because of the large areas of impervious surfaces that occur within urban catchments (for example roads, paving and roofs).

Road runoff in urban areas often contains floating oil residues which can prevent oxygenation of the water column and result in suffocation of aquatic fauna. Heavy metals, such as lead, tend to bioaccumulate in the fatty tissue of animals and have a long-term effect on faunal populations by reducing reproductive success and offspring survival rates.

Lake Monger - Inappropriate use of buffer zones can lead to erosion, altered hydrological regimes and a decline in wetland water quality. The foreshore around Lake Monger is now being restored to create an effective buffer.

Altered water regimes

The hydrological regime of a wetland is the pattern of change in water availability on an annual basis. For example, the water regime of a sumpland (or swamp) involves seasonal inundation of the wetland during winter and seasonal drying of the wetland over summer. In addition to the influence of seasonal changes, the hydrological regime of wetlands changes over time in response to climatic factors such as variations in annual rainfall.

The hydrological regime of many wetlands has been altered by development. A wetland's hydrological regime can be modified in a number of ways, such as:

- lowering of groundwater levels through abstraction of groundwater, which in some cases can result in seasonal or permanent drying out of a wetland (where the wetland's hydrology is dominated by the expression of groundwater);
- increased water levels through urbanisation and discharge of stormwater into a wetland; and
- increased groundwater levels as a consequence of clearing in the wetland catchment, resulting in increased water levels in the wetland (where the wetland's hydrology is dominated by the expression of groundwater).

Changes in water regime, such as prolonged inundation or drying, has the potential to adversely affect the life cycle of many wetland plants and animals. Most wetland plants can tolerate short-term changes in water levels. Some species even rely on seasonal changes in water levels to produce conditions which are favourable for reproduction and growth. Altered water regimes can, however, affect plant distribution, productivity and seed germination. Prolonged changes in water levels will result in the death of wetland vegetation, changes to vegetation structure and loss of habitat.

Wetlands have frequently been used as detention basins for the treatment of urban stormwater, often resulting in significant rises in wetland water levels. For example, Yangebup Lake has a large number of drains discharging into it from urban and semi-rural catchments, resulting in a substantial increase in water level and permanent inundation of the wetland. Historically, the lake dried out on a regular basis during the summer months. Prolonged flooding has resulted in depletion of oxygen levels in the root zone of wetland plants, leading to the death of some sedges, rushes, trees and shrubs fringing the water body.

Other forms of degradation

Weed invasions

Weeds are a serious threat to wetlands and to wetland restoration projects. They are often vigorous, hardy and compete strongly for space, light, nutrients and water in areas where native plant species occur. This is not because native species are inherently weak, but rather because,

unlike the native species, the weed species no longer have to contend with the grazing animals and disease organisms found in their own natural environment. The spread of introduced weed species is closely linked to the disturbance of native vegetation through activities such as clearing, grazing and dumping of garden refuse. Frequent fires in urban wetlands and surrounding bushland also favour weed invasion and establishment.

The disposal of aquatic plants from ponds and aquariums into or near wetlands can lead to serious weed invasion. Aquatic weeds spread rapidly, often forming dense mats above or below the water that can limit light entering a wetland and deplete oxygen needed by aquatic fauna. Weed invasion threatens wetland biodiversity, leading to a decline in species and habitat diversity. Weeds degrade wetland ecology in a number of ways, such as:

- restricting native plant regeneration and growth through competition;
- reducing the resources available for feeding, breeding and shelter of most native fauna; and
- increasing fire risk as a result of increased fuel loads.

Wetlands and fire

Some wetlands have adapted to a natural cycle of burning. However, even for these wetlands fires can be detrimental depending upon their size, intensity and frequency. In some south-west ecosystems, infrequent fires may stimulate regeneration and regrowth in native vegetation and create a diversity of faunal habitats.

Frequent burning of wetland vegetation results in changes in species composition. In the short term this change results from the different regeneration strategies used by plants. Plants that regenerate quickly from rootstock, fire resistant parts of the plant or from seed will initially dominate. If fire occurs too frequently, some plant species may be lost if they are unable to reach reproductive maturity between fires. Long term changes in species composition may occur if a species cannot re-establish in the post-fire environment due to a deficient seed bank or intense grazing. The long-term effects of inappropriate fire regimes include the depletion of some seed stocks, the loss of peat soils and changes in the composition of plant communities.

The effect of fire on the survival of wetland fauna depends on the extent and intensity of the fire. Most vertebrate groups can escape low intensity fires by sheltering until the fire front has passed or by avoiding the fire edge. Low frequency, high intensity, broadscale summer fires have the most dramatic impact on the survival of fauna. Mortality rates as a direct consequence of the fire are often high among goannas, possums, wallabies and some bird species. While some animals escape broadscale summer fire by fleeing from the fire front, a number of others such as lizards and native rodents survive in burrows, while amphibians take refuge in pools of permanent water. Post fire mortality of fauna is also very high as a consequence of predation in the open conditions and scarce food resources.

As many wetlands are now islands of natural habitat amongst cleared farmland and urban development, the effects of a complete burn may be catastrophic, wiping out local populations of plant and animal species. For this reason it is important that "island wetlands" are never completely burnt. A mosaic burning approach could be adopted in some wetlands where it is environmentally appropriate, using a series of small burns over several years to provide a range of pre-fire and post-fire habitats.

Pests and feral animals

The most common nuisance insect pests associated with wetlands are midges and mosquitoes. These species occur naturally in wetland ecosystems, but may have increased in population size due to changes in wetland ecology.

Midges (*chironomids*) are non-biting insects that occur in all wetlands but may form nuisance swarms in nutrient-enriched wetlands where there is excessive algal growth and algal blooms. Once an algal bloom collapses, decomposing organic matter provides an abundant food source for larval midges. Nuisance midge swarms are most common in nutrient-enriched wetlands during the summer months when water temperature and light levels are high, promoting heavy algal growth. In nutrient-enriched wetlands, midge larval densities can reach 40,000 larvae/m^2. As the adult midges emerge from the water, usually at dusk, they are attracted to lights in adjacent urban areas, in some cases becoming an extreme nuisance to local residents.

Mosquitoes can significantly restrict the enjoyment of outdoor activities. In the case of some species, mosquitoes can act as vectors for serious diseases such as Ross River Virus and Australian Encephalitis. The larval and pupal stages of the mosquito life cycle are aquatic and it is only the adult mosquito that is regarded as a pest. Adult female mosquitoes require a blood meal in order to obtain the necessary protein required to produce a large numbers of eggs (usually between 100 – 500 eggs). The majority of mosquito species are active for only part of the year, and this is often determined by the seasonal availability of breeding sites. Other species breed opportunistically, following rains, or in artificial wetlands such as drains or stormwater basins. Mosquitoes are most prolific in very temporary water bodies, such as tidal salt marshes.

The ***mosquitofish*** (*Gambusia holbrooki*) was introduced into Western Australian wetlands from North America in 1934 as a biological control agent for mosquitoes. The mosquitofish feeds near the water surface and preys upon a wide range of native invertebrates in addition to mosquito larvae (for example rotifers, crustaceans, molluscs and the larvae of beetles). It is a prolific breeder and tolerates a wide range of environmental conditions competing with and preying upon many native fish species. The mosquitofish is no longer considered an appropriate method of mosquito control, as it may remove other beneficial species from the water body.

There are a number of **feral animal** species which pose a significant threat to the health of wetlands. The most common are cats, foxes and rabbits. Cats and foxes are efficient predators and can have a devastating impact upon native fauna in bushland and wetland areas. Rabbits can seriously hinder rehabilitation efforts as they selectively graze fresh regrowth or new seedlings and spread weed seeds through their faeces. Rabbits become sexually mature at three to four months and may have up to six litters a year, depending upon environmental conditions. When resources become scarce rabbits will graze upon bark, roots and almost any plant material available

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Pollution, contamination and nutrient enrichment

Pollutants can enter a wetland from either "point" or "diffuse" sources. A ***point source*** of pollution is one which discharges polluted water directly into a wetland or waterway from a single localised source. For example, the discharge of wastewater from an industrial area directly into a wetland via a drainpipe. A ***diffuse source*** of pollution is one without a clearly defined point of discharge and may originate from a variety of sources dispersed over a wide area. An example of a diffuse source of pollution is the excessive application of fertiliser to several hectares of agricultural land. Nutrients that are not taken up by crops may then leach through the soil profile and enter the wetland through groundwater or be transported into the wetland via overland surface water flow.

A wide range of potential pollutants enter wetlands from diffuse and point sources, including nutrients, hydrocarbons, pesticides, herbicides, heavy metals, and litter (such as plastic containers and wrappings, bottles and metal cans).

Agricultural drains can be a significant source of pollution in rural wetlands and may contain high nutrient and sediment loads. Excessive fertiliser use for growing pasture or commercial vegetable crops can lead to elevated nutrient levels in both surface and groundwater and consequent eutrophication of wetlands. Urban pollutants can reach a wetland from a range of sources including stormwater runoff from urban areas, fertilisers used in parks and residential gardens, leachate from landfill sites and septic tanks, and leakage from underground fuel storage tanks.

Upon entering a wetland, heavy metals can accumulate in the tissues of plants and wildlife resulting in physiological disorders. Metal poisoning can reduce species diversity and abundance and alter the structure of food webs. Toxic forms of heavy metals affect biota as a consequence of their highly reactive nature. For example, lead ingested by waterbirds is absorbed into their bones and organs, in some cases causing illness and death. Bioaccumulation (where concentrations of toxins increase progressively up the food chain to higher order consumers) is also a significant concern.

Algal blooms consist of large growths of phytoplankton such as green algae, diatoms or Cyanobacteria. In urban areas, algal blooms commonly occur in wetlands that are surrounded by development and receive stormwater via drains. In rural areas, they may occur in wetlands that are surrounded by intensive agriculture.

Some species of Cyanobacteria are toxic to birds, wildlife and humans (for example *Nodularia, Anabaena* and *Microcystis*). Following the collapse of a bloom, algae can accumulate as a surface scum or in wetland sediments. Bacteria and fungi then break down the dead algae, consuming large quantities of oxygen in the process. Low dissolved oxygen concentrations in the water column may then cause the death of fish and invertebrates. Anaerobic conditions also encourage the growth of the bacterium *Clostridium botulinum* (botulism) which produces a toxin that causes paralysis and death in waterbirds. Depletion of oxygen can also trigger biochemical processes that release phosphorus normally bound to the sediments. This in turn may fuel further algal blooms.

Inadvertent damage, vandalism and littering

Uncontrolled recreation, vandalism and littering can result in significant and long-term impacts on wetlands, such as the loss of native vegetation, disturbance of native animals, increased erosion and the introduction of weeds. In wetlands surrounded by urban development, domestic pets can affect wetland fauna populations by disrupting feeding and breeding cycles and in some cases through direct predation.

Over grazing (pastoral regions)

Unrestricted grazing in wetlands can considerably degrade native plant communities and wetland water quality. Livestock such as sheep, cattle and horses not only damage

wetland vegetation through grazing and trampling but also destabilise wetland banks, leading to erosion. Other impacts may include soil compaction, selective grazing (of more palatable species), weed invasion, degradation or loss of habitat, and elevated nutrient levels in the wetland itself.

Lake Kogolup - wetlands can lose habitat value and may be severley degraded when cleared for agricultural and stock grazing purposes.

Acidification

Wetland environments can become acidic (have a pH of less than 7) for several reasons. Some wetlands (usually seasonal, coloured wetlands), in south-western Western Australia are naturally acidic. However, acid rain, acid mine drainage and the presence of acid sulphate soils can all lead to an uncharacteristically low pH. Clearing of native vegetation and replacement with pasture can also lead to wetland acidification when the pasture produces nitrogen. The nitrogen is turned into nitric acid by bacteria, which then flows into the waterbody and lowers the pH. Lowered water levels in areas of acid sulphate soils can lead to wetlands drying out and wetland sediments being exposed to the air. This causes the sulfides in the soil to oxidise and produce sulfuric acid upon rewetting, which then lowers the pH of the water. Lowering of the water table and exposure of sulfides in the soil are both thought to be the main cause of the acidification of two Perth wetlands, Lake Gnangara and, more recently, Lake Jandabup. There has been limited research into this issue, although studies are currently being conducted on Lake Jandabup.

Acidification can have a dramatic effect on wetland ecology. Flora and fauna that are less tolerant of acidic conditions may be reduced in number or die off completely. If acidification takes place suddenly, mass deaths of fish or other organisms may occur. There can be other, less visible effects on wetland fauna, such as habitat reduction, growth abnormalities, a drop in breeding success and chronic toxicity caused by the release of heavy metals from wetland sediments in the acidic conditions. Acidification may ultimately lead to a loss of species diversity and a complete change in the ecology of the waterbody to acid-tolerant species.

Mechanisms for wetland protection and management

Treaties and conventions

The Commonwealth Government is signatory to a number of international treaties and conventions which have been developed for the conservation of internationally significant wetlands and migratory waterbirds. The Convention on Wetlands of International Importance, commonly referred to as the Ramsar Convention (after the city in Iran where the conference first took place), aims to promote the conservation of wetlands and has developed guidelines for the wise use of wetlands. The concept of wise use seeks to modify human use of wetlands, to maintain benefit to present generations while preserving the values and functions of wetlands for future generations. The Ramsar Convention also seeks to protect specific large wetlands of international significance. There are nine Ramsar sites in Western Australia: the Ord River Floodplain and Lakes Argyle and Kununurra (Kimberley region), Roebuck Bay (near Broome), Eighty Mile Beach, the Peel-Yalgorup system (near Mandurah), Forrestdale and Thomsons Lakes (near Perth), Lake Warden (near Esperance), the Vasse-Wonnerup system (near Busselton) and Lake Toolibin (near Narrogin).

Many migratory waterbirds fly between the northern and southern hemispheres each year as part of their life-cycle. Therefore, conservation of migratory birds requires international action and cooperation. Migratory birds, such as shorebirds and waders, breed during June and July in the arctic regions of Eastern Europe, China, Alaska, and parts of Japan. These birds then migrate through south-east Asia to spend the non-breeding season in Australia before returning to the northern hemisphere in the following year. Migratory birds require stop-offs and shelter for all three phases of their annual life-cycle: breeding, migration and non-breeding.

Australia is signatory to two agreements for the protection of migratory birds, one with the Japanese government called the Japan-Australia Migratory Bird Agreement (JAMBA) and another with the Peoples Republic of China

Forrestdale Lake – recognised as a wetland of international significance under the Ramsar Convention but increasingly subjected to the pressures of urbanisation.

called the China-Australia Migratory Bird Agreement (CAMBA). Under these agreements Australia is obliged to protect migratory birds and their important habitats by:

- preserving and enhancing important habitats used by migratory birds listed in the agreements;
- encouraging joint research programs and sharing the information gained;
- establishing sanctuaries and other facilities for the management and protection of migratory birds and their habitats;
- preventing damage to migratory birds and their habitats, and encouraging their conservation;
- meeting regularly to report on progress and develop new initiatives; and
- generally prohibiting the removal, sale, purchase or exchange of migratory birds and their eggs.

National and State Policies

Wetlands Policy of the Commonwealth Government of Australia

The goal of the Wetlands Policy of the Commonwealth Government of Australia is to conserve, repair and manage wetlands wisely. The objectives and principles of the policy recognise the national importance of wetlands and aim to ensure that there is a consistent approach to wetland management by all Commonwealth organisations with responsibilities in this area. A principal aim of the policy is to ensure that Commonwealth Government actions are consistent with the provisions of the Ramsar Convention and the "wise use" principles for wetland management.

The policy states that the Commonwealth Government's primary role in wetland conservation is best achieved through partnership and cooperation with other governments, the business sector and the community. The Commonwealth Government is committed to assisting national and international efforts in wetland conservation and management through the demonstration of best practice, and the provision of models, tools and expertise to guide management.

State Wetlands Conservation Policy

The Western Australian State Wetlands Conservation Policy was released in August 1997 and established five principal objectives with respect to the conservation of wetlands in the State:

- to prevent the further loss or degradation of valuable wetlands and wetland types, and promote wetland conservation, creation and restoration;
- to include viable representatives of all wetland types and key wildlife habitats and associated flora and fauna within a State-wide network of appropriately located and managed conservation reserves which ensure the continued survival of species, ecosystems and ecological functions;
- to maintain, in viable wild populations, the species and genetic diversity of wetland-dependent flora and fauna;
- to maintain the abundance of waterbird populations, particularly migratory species; and
- to greatly increase community awareness and appreciation of the many values of wetlands, and the importance of sound management of wetlands and their catchments in the maintenance of those values.

A State Wetland Coordinating Committee has been established to coordinate the implementation of the policy and the activities of relevant agencies with respect to wetlands. Successful implementation of the policy will require a cooperative approach between government agencies, the private sector, conservation groups and the community generally. The State Wetlands Conservation Policy encourages community participation through the promotion of wetland conservation, the facilitation of voluntary efforts to conserve, restore and enhance wetlands, and the provision of sound advice concerning wetland values and the management of wetlands and their catchments.

Salinity Action Plan – wetland elements

Rising watertables and the discharge of saline groundwater can have a significant impact upon wetland ecology. The effects of salinisation include death of fringing vegetation, loss of invertebrate and fish species and loss of habitat for waterbirds and other fauna. The Salinity Action Plan was released in 1996 and aims to:

- reduce further deterioration and wherever possible recover existing salt-affected land;
- protect and restore key water resources and high value wetlands;
- maintain biological and physical diversity; and
- protect designated infrastructure affected by salinity (for example roads and buildings).

The protection of key wetlands and biodiversity is dependent upon the implementation of catchment-scale solutions. The Salinity Action Plan aims to develop and implement a coordinated Wetlands and Natural Diversity Recovery Program targeting key catchments over several years to ensure that critical and regionally significant areas, particularly wetlands, are protected in perpetuity. To date, four wetlands and associated catchments have been selected as recovery catchments; Lake Toolibin (Narrogin), the Muir-Unicup wetland system (Manjimup), Lake Bryde (near Lake Grace) and the Lake Warden System (Esperance).

Since the release of the Salinity Action Plan more research has been undertaken into the problem, the outcomes of which indicate that actions must be taken across a wider area and more quickly than originally anticipated. The Salinity Strategy was developed as a result of this research and was released in March 2000. This latest document identifies salinity management strategies and outlines specific management tools to be used. One of the new initiatives for wetland protection set out in the Strategy is the development and implementation of management plans for high priority wetlands located outside designated conservation areas. This will be carried out by the Water and Rivers Commission in partnership with the community.

Bush Forever

Bush Forever is a whole-of-government initiative that identifies regionally significant bushland and recommends it for protection. Bush Forever was released in December 2000 and includes some Swan Coastal Plain wetlands. Inclusion of these wetlands is based on the Water and Rivers Commission's wetland mapping, classification and evaluation work and Department of Environmental Protection studies. Bush Forever wil be implemented over the next 5 to 10 years and will be an important initiative for protecting some of the wetlands in the Perth region.

Wetland EPPs

Environmental Protection Policies (EPPs) are developed under the Environmental Protection Act (1986) by the Environmental Protection Authority (EPA). The Swan Coastal Plain Lakes EPP was developed for the protection of the environmental values of lakes on the Swan Coastal Plain. The policy recognises the significant conservation values of lakes and the need to protect them from encroaching rural and urban development. The lakes that were listed for protection are those which consisted of 1,000 m^2 or more of standing water as at December 1991. The policy specifically prohibits unauthorised filling, mining, excavation, discharge or disposal of effluent and the drainage of water into or out of a protected lake. Significant penalties may apply where a protected lake is degraded by one of these activities. The Department of Environmental Protection has recently released a revised draft of the Swan Coastal Plain Lakes EPP for comment, which, if implemented, invokes a number of changes to the existing EPP.

The South West Agricultural Zone Wetlands EPP aims to prevent the further degradation of valuable wetlands and to promote the rehabilitation of wetlands in the south-west agricultural zone of the State. Under the EPP anyone can nominate a wetland, which they consider to have significant environmental values, for inclusion on the register of the EPP. Before a wetland on freehold land is listed the EPA assesses the nomination and must gain the landowner's agreement to protect the wetland. Where the wetland occurs on Crown Land and agreement cannot be reached with the relevant management agency, the final determination is made by the Minister for the Environment in consultation with the minister responsible for the agency concerned. There are two categories of wetland listed under the EPP: Table 1 wetlands which have a high degree of value for nature conservation or provide habitat for rare or

endangered flora or fauna; and, Table 2 wetlands which may have significant natural or human use functions but do not have a high degree of naturalness (ie. they have been significantly modified).

The protection of wetlands listed under the South West Agricultural Zone EPP is to be achieved through a range of mechanisms including:

- development and implementation of land and water management plans that promote the conservation of wetlands on a regional, catchment and farm basis;
- prevention of activities that degrade wetlands such as filling, clearing, disposal of effluent, removal of water, construction or alteration of drainage and excavation and mining. (Penalties exist for contravention of the EPP);
- monitoring of the condition of protected wetlands;
- owners of wetlands on land held in freehold being encouraged and assisted to maintain, enhance and rehabilitate wetlands on a voluntary basis;
- priority will be given to the conservation of Table 1 wetlands and the implementation of catchment management strategies for these wetlands; and
- development of Best Management Practices for agriculture in the policy area.

Living wetlands are areas of great natural beauty. As valuable assets they should be carefully managed to ensure that present and future generations have the opportunity to enjoy the many benefits that they provide.

Role of the Water and Rivers Commission

The role of the Water and Rivers Commission in wetlands conservation is described in the 1997 Wetlands Conservation Policy for Western Australia. It states that the primary objective of the Commission's management of wetlands is "to support both ecologically sustainable development and conservation of the environment, for the long term benefit of the community. The Water and Rivers Commission has a significant role in wetland management with respect to classification and evaluation, ensuring an integrated approach to the management of catchments and for managing water quantity and quality regimes where they have the potential to affect environmental, cultural and other wetland values". The Commission also provides advice to the public and to other agencies in regard to wetland management issues and is involved in community education programs such as Ribbons of Blue, which aims to teach wetland monitoring skills to WA school children.

An attractive suburban wetland- a place the whole community can enjoy. *Photo: Unknown.*

Glossary of Terms

assimilation: The incorporation of nutrients and other substances into the parts of a living organism or ecosystem.

bioaccumulation: The concentration of a persistent substance (eg. organochlorine insecticide) by the organisms of a food chain so that at each successive trophic level the amount of the substance relative to the biomass (total weight of the organisms at that trophic level) is increased.

biodiversity: The number or variety of species in an environment or ecosystem.

catchment: The area from which a wetland, stream segment, estuary or groundwater aquifer receives water derived from rainfall.

eutrophic: Rich in plant nutrients.

eutrophication: A natural process of accumulation of nutrients leading to increased aquatic plant growth in lakes, rivers, harbours and estuaries. Human activities contributing fertilisers and other high nutrient wastes can speed up the process, leading to algal blooms and deterioration in water quality.

hydrology: The study of water, its properties, distribution and utilisation above, on and below the earth's surface.

hydrological regime: (In the context of a wetland) The pattern of water availability in a wetland over a yearly cycle.

impervious (soil): Soil that resists the entry and passage of water.

inundated: Flooded; underwater.

invertebrates: Animals without backbones.

macroinvertebrates: Invertebrates big enough to be seen with the unaided human eye, although they can be very small. Aquatic invertebrates are termed macroinvertebrates if they are retained on a 0.25mm mesh net. The main groups are worms, snails, arachnids (e.g. spiders and mites), crustaceans (e.g. prawns) and insects.

macrophyte: Rooted aquatic plants (e.g. water lilies, sedges), as opposed to phytoplankton and other small algae.

(groundwater) mound: Unconfined (shallow) groundwater sometimes forms "mounds" where the water table slopes away from a high central area with groundwater flowing outward to ocean or rivers. The Gnangara Mound is 70 metres above sea level at its highest point.

photosynthesis: Conversion of carbon dioxide and water to carbohydrates and oxygen using light energy.

sediments: Sand, clay, silt, pebbles and organic material carried and deposited by water or wind.

sedimentation: The process by which sediment is deposited.

trophic level: A level (or group) of particular organisms within a food chain e.g. the first trophic level is the producer level, which consists of green plants or other autotrophs that trap energy and produces food substances. The second trophic level consists of primary consumers (herbivores) and secondary consumers (carnivores) exist at subsequent trophic levels.

wetland classification: A process whereby wetlands within a landscape are identified (mapped) and categorised according to their type using information about their geomorphology, vegetation etc. The table on page 2 for the terminology used by the Water and Rivers Commission in the classification of wetlands on the Swan Coastal Plain.

wetland evaluation: A subjective process whereby the wetlands that have been classified are then'graded' based on an assessment of their values or 'beneficial uses'. The Water and Rivers Commission's evaluation process places wetlands into one of three management categories: Conservation, Resource Enhancement, or Multiple Use. Conservation category wetlands are those which support high levels of attributes and functions and thus preservation of these wetlands is given the highest priority.

Further reading

Wetland Mapping, Classification and Evaluation

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Invertebrate identification and monitoring

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Davis, J. and Christidis, F. (1997), *A guide to wetland invertebrates of southwestern Australia*. Western Australian Museum, Western Australia.

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Wetlands and fire. WN02, Issue 1. Advisory notes for Managers on River and Wetland Restoration.

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Algal Blooms. Water Facts 6. July 1998.

For Further Information

The Swan Catchment Centre at 108 Adelaide Terrace, East Perth, has a small resource library and can help to put you in touch with relevant advice and community groups for projects in the Swan Avon region. Phone: (08) 9221 3840, Facsimile: (08) 9221 4960.

Specific advice can be obtained from the following organisations:

Living with wetlands (educational video)
Water and Rivers Commission (08) 9278 0300 or regional offices.

Controlling feral animals
Agriculture Western Australia (08) 9368 3333

Controlling nuisance insects (mosquitoes)
Environmental Health Service, Health Department of Western Australia, (08) 9385 6001

Funding opportunities
ALCOA of Australia (08) 9221 3840 (funds on-ground works for community bushland and wetland projects to complement the Swan Canning Cleanup Program).

Gordon Reid Foundation for Conservation (08) 9340 5270

Natural Heritage Trust (08) 9325 0000, or free call 1800 198 231, Website: www.nht.gov.au

One Billion Trees Program, Greening Australia (Western Australia) Inc (08) 9335 8933

TRAILS funding, administered by Trailswest, part of the Ministry of Sport and Recreation, Ken Asman (08) 9387 9700. (Grants for planning, construction, upgrading and promotion of bush walking, mountain bike riding and horse riding trails. Matching contributions in dollars are required).

Introduction of fish and other animals
Department of Conservation and Land Management (08) 9334 0333 or any region or district office
Fisheries Department (08) 9482 7333

Recognition of Aboriginal sites
A booklet on the recognition of Aboriginal sites can be obtained from the Aboriginal Affairs Department 197 St George's Terrace, Perth (08) 9235 8088

Reporting pollution
Swan River Trust (08) 9278 0400, pager 016 982 027.

Water and Rivers Commission (08) 9278 0300 or regional offices

For hazardous or major chemical spills Statewide dial '000'

Revegetation using native species and vegetation management
Agriculture Western Australia at the Catchment Centre Pinjarra (08) 9531 1954

APACE (08) 9336 1262

Australian Trust for Conservation Volunteers (08) 9336 6911

Greening Australia (Western Australia) Inc (08) 9335 8933

Kings Park and Botanic Garden (08) 9321 5065

Native Environmental Systems (08) 9377 5621

Swan Catchment Centre, Environmental Weeds Action Network Coordinator (08) 9221 3840.

Wildflower Society of WA (08) 9383 7979 (Tuesday, Thursday, 10:00am-2:30pm)

Ecosystem Management Services (08) 9375 3751

School and community projects

Cockburn Wetlands Education Centre, Hope Road Bibra Lake (08) 9417 8460

Ecoplan - Department of Environmental Protection (08) 9222 7000

Men of the Trees (08) 9250 1888

Ribbons of Blue (08) 9278 0300

Swan Catchment Centre (08) 9221 3840

Water level measurements

Hydrologic Technology Centre, Water and Rivers Commission (08) 9361 7323

Wetland Education Centres

Herdsman Lake Wildlife Centre (08) 9387 6079

Cockburn Wetlands Education Centre (08) 9417 8460

Denmark Wetland Education Centre (08) 9848 2061

Rockingham Regional Environmental Centre (08) 9591 3077

Capel Wetlands Centre (08) 9780 3665

For more information contact

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