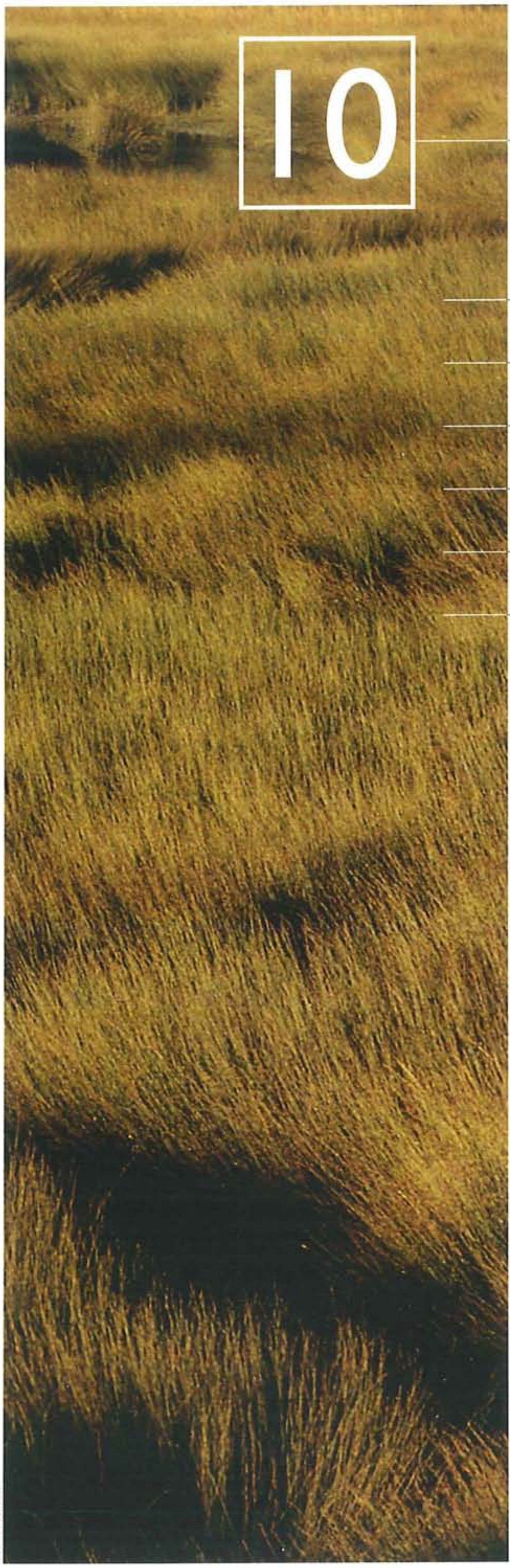

Kelvin McMillan

Restoring Wetlands

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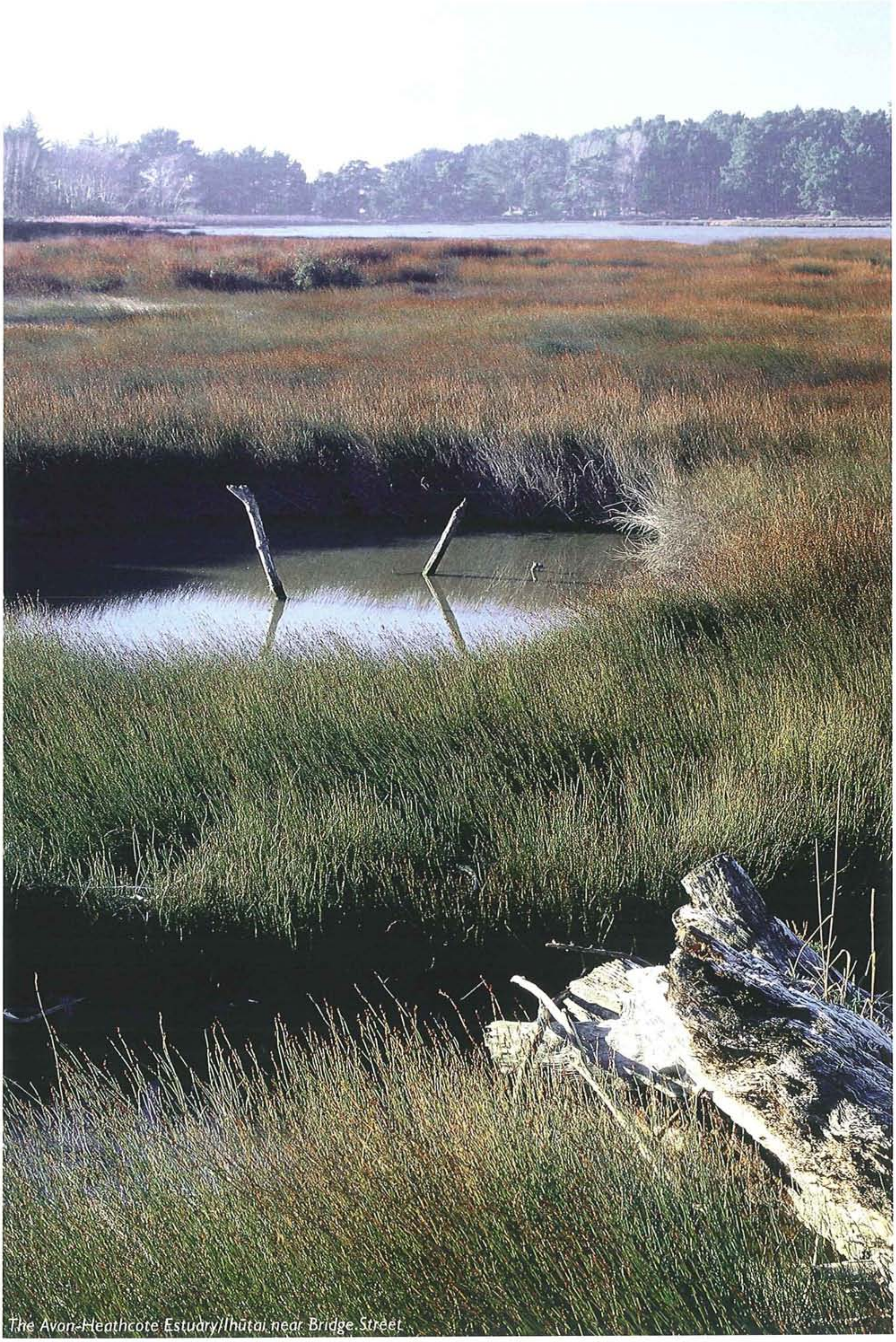

The Avon-Heathcote Estuary/Ihutai near Bridge Street

Kelvin McMillan

10.1 Introduction

Christchurch was originally built on a series of swamps. Today, little remains of those freshwater wetlands, with only 50 wetland remnants currently identified. These wetlands exist in a range of sizes, conditions, and locations. The Groynes, Ōtūkaikino wetland, Riccarton Bush, Travis wetland, and Cashmere Valley are significant examples of swamp wetlands. Saline wetlands still exist in the city's estuaries. Many of these wetlands are in a precarious state; they face threats from surrounding land use that greatly limit their viability, especially as many are small. It is now a priority to protect, conserve, and where appropriate, restore remaining natural wetlands in the Christchurch area.

This chapter identifies the types of wetlands found in Christchurch and outlines general considerations for restoring or creating new wetlands. Wetlands are extremely complex systems, and so the scope of this chapter is not sufficient to provide specific restoration techniques. Restoring or creating wetlands should never be undertaken without the input from a range of wetland system specialists. For further reading, Zelder (2001) provides information for restoring tidal wetlands, and although an American publication, much of it may be applicable to New Zealand.

10.2 What are Wetlands?

Wetland is "a collective term for permanently or intermittently wet land, shallow water, and land water margins. Wetlands may be fresh, brackish, or saline, and are characterised in their natural state by the plants and animals that are adapted to living in wet conditions" (Buxton 1991).

Wetlands occur in a variety of situations depending on landform, wetness, and associated features like substrate, nutrients, etc. These can be grouped together to define actual wetland type, where certain features of the local environment dominate. Thus a wetland may comprise a coastal lagoon or estuary, a swamp, a marsh, a freshwater lagoon, a mountain bog, or even temporarily wet land. Wetlands can also occur at the interface between dry land and open water, such as in river or lake margin wetlands.

Only a small percentage of the variety of wetland types within New Zealand occur in Christchurch. Its small area, lack of variety of landform and climate, and its highly modified nature, restrict their development to a few that are suited to the situations the city environment has to offer. Those which are well-represented are listed in the following sections. Some of these have been summarised in Table 10-1, which also provides examples from the Christchurch area.

Table 10-1: Examples of wetland types in Christchurch.

Wetland Type	Description	Examples
Estuary (saltmarsh) and lagoons	Marshland regularly inundated with sea water.	Margins of the Avon-Heathcote Estuary/Ihūtai and Brooklands Lagoon/Pūharakekenui.
Estuary to river margin and tidal river channels	Coastal marshland and tidal river margins flooded by tide but with freshwater inflow that reduces salinity.	Lower reaches of the Avon/Ōtākaroro, Styx/Pūrākaunui, Heathcote/Ōpāwaho Rivers.
Swamp (freshwater basins)	Permanent depressions or land regularly inundated with slow flowing water. Support a range of freshwater wetland plant species.	Travis wetland, Cockayne Reserve, Horseshoe Lake, Ōtūkaikino wetland.
River and lake margins (freshwater)	Wetland marginal vegetation along flowing streams and rivers.	Upper reaches of the Avon/Ōtākaroro, Styx/Pūrākaunui, Heathcote/Ōpāwaho Rivers.
Ephemeral (brackish pools)	Shallow (20 cm) pools in coastal locations. Muddy edges and/or low turf. Good for sandpipers.	Charlesworth Street wetland, Cockayne Reserve.
Dune slack and dune lakes	Hollows and basins between dunes. Support marsh vegetation.	Brooklands Spit, Bottle Lake Forest.
Constructed wetlands	Specifically for stormwater treatment. See *Chapter 6.7: Constructed Wetlands.*	Tranzrail constructed wetland.

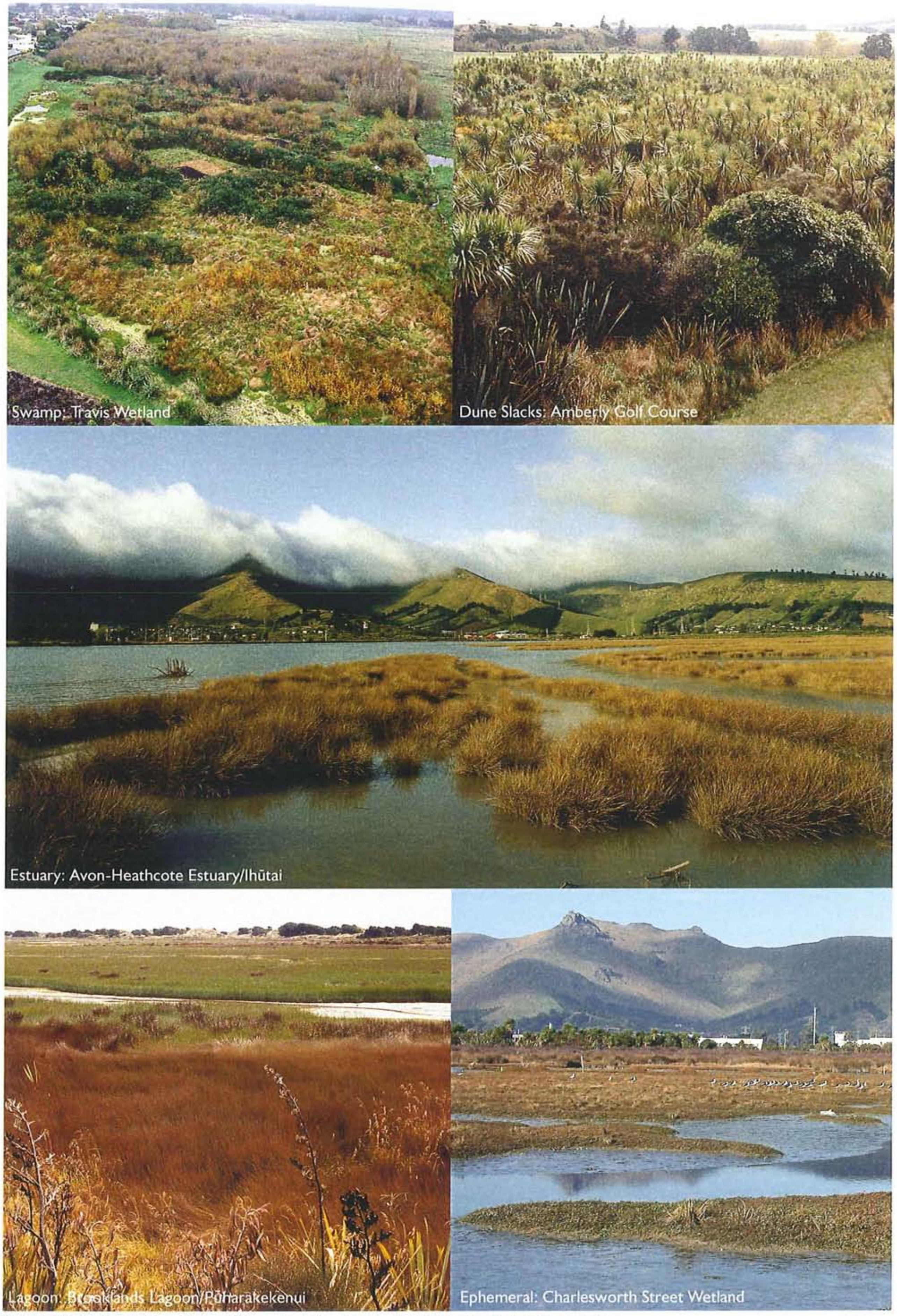

Figure 10-1: Examples of the different wetland types found in the Christchurch area.

Wetland Types

Swamps: Basin wetlands which are predominantly permanently wet from through-flowing waters (Figure 10-1). The water level may be constant, or vary from season to season. Because the water derives from a land source (as opposed to rain-fed systems called bogs), nutrient levels are high (termed eutrophic), and they may accumulate organic silt, but seldom form proper peat.

Lagoons: Wetlands that occur in coastal enclosures, which are shallow and separated from the sea by a sand bar or strip of land (Figure 10-1). Occasionally they may receive sea water, but do not experience typical tidal fluctuations of an estuary. Waters are brackish as a result, and the water level fluctuates somewhat unpredictably.

Estuarine: Wetlands that are partially enclosed by land, but that are open to the sea and subject to regular fluctuations of the tide (Figure 10-1). The salinity regime depends on the mixing of sea and freshwater from rivers, and the nature of the vegetation reflects this balance.

Ephemeral: Wetlands that appear only at certain times of the year, especially winter (Figure 10-1). The plants occupying such situations when wet are short-lived and tolerant of the wetness, while normal dryland plants occupy the site in drier conditions.

River and lake margins: Wetlands that occur at the interface between land and water bodies that may be flowing (rivers) or stationary (lakes). They form distinct wetness sequences, comprising of a plant zonation pattern with depth. The characteristic vegetation is the same as for swamps, unless the fluctuations in water level are highly predictable.

Dune slacks and lakes: Wetlands that occur in hollows between sand dunes. The water may be above the sand surface (dune lake) or below it (dune slacks, Figure 10-1). These are typically brackish, and subject to changing water table levels.

Other important wetland types that are not found in Christchurch include the following:

- *Bogs:* Wetlands fed solely by rainfall. Bogs have low fertility (termed oligotrophic), owing to lack of nutrients entering the system. They accumulate peat from the plants, but not silt. Typical plants include the moss *Sphagnum*, wire rush, and others tolerant of the low nutrients.
- *Fen:* Wetlands that are intermediate between swamps and bogs, where there is a mixture of rain- and stream-derived waters. Nutrients are present in only moderate amounts (termed mesotrophic).
- *Marsh:* Wetlands that undergo fluctuations in water level that are considerable and seasonal. They include tarns and tarn-lakes, some farm ponds and hydro-electric lakes.
- *Geothermal:* Wetlands where the dominant factor is high water temperature.

There are many other terms that have been used to describe wetlands in both New Zealand and overseas (e.g. carr, turlough, and pakihi). The New Zealand Ministry for the Environment has been developing a standard set of descriptors for wetlands in New Zealand, and the descriptions and terms used above follow those standards.

10.3 External Factors Affecting Wetlands

When restoring existing natural remnant wetlands, or when creating new wetlands, the following external factors affecting wetlands and their inhabitants need to be considered.

Wetland Plants

Plants in wetlands are affected by the following:

- *Water level:* Some plants require consistent water levels, while others require fluctuating water levels. Unnatural fluctuations or inappropriate flooding regimes can destabilise proper wetland processes.
- *Sediment:* Large sediment loads can harm plants by smothering them or affecting the amount of light they receive. Sediment can eventually infill basin wetlands. Plants can be affected by very high contaminant loads in the sediment.
- *Light:* Plants have specific light requirements. Too much shading by trees and other vegetation can cause die-back of aquatic plants.
- *Nutrients:* A change in nutrient levels can alter the plant communities present. In extreme situations, eutrophication can result in low oxygen levels in the water. Grazing stock, water runoff from farm or forestry land, and bird populations can all increase nutrient levels.
- *Water flow and wave action:* Some plants require flowing water, while others require minimal flows. Wave action affects the soil under the water as well as the shoreline, which in turn affects plant communities.
- *Substrate:* The nature of the soil above and below water in the wetland affects the plant communities by effecting aeration and nutrients.
- *Invasive plants:* Invasive plant species threaten native plant communities; aquatic, marginal, and

terrestrial. These invasive plants can be dispersed by wildlife or grazing stock, and transported on the water's surface. They can often out-compete less invasive native plant species.

Angus McIntosh

Figure 10-2: Canterbury mudfish are an endangered native fish of the Canterbury region. They cannot co-exist with other fish (bar bullies) due to predation and competition.

Figure 10-3: Paradise shelducks and pied stilts feeding in the Charlesworth Street wetland around low tide.

Figure 10-4: Paradise shelducks prefer wetlands where there is low vegetation on waterway banks.

Wetland Fish

Fish in wetlands are affected by the following:

- *Access:* Because many native fish require access to and from the sea, it is important to ensure that wetlands remain linked to the sea via waterways, and that there are no structures that will impede fish access. Refer to *Chapter 13.2.3: Designing Fish-friendly Culverts and Weirs.*
- *Water flow and depth:* Fish access to wetlands can be restricted when flow and depth of water are altered by abstraction, drainage, diversion, and structures such as culverts and pipes.
- *Water level fluctuations:* Natural water fluctuations are important for fish food sources, as well as for spawning. Unnatural fluctuations or artificially fixed levels can affect water quality, depleting food supply and limiting spawning.
- *Vegetation:* Riparian vegetation provides cover, stabilises banks, cools water, and provides food for fish. The type of aquatic plant community will determine the fish species that are present.
- *Competition and predation:* Competitive and/or predatory introduced species are likely to reduce the stock of native fish species (Figure 10-2).

Chapter 3.2: Instream Communities and Their Habitat, provides information on habitat and vegetation preferences of fish that may be found in wetlands.

Wetland Birds

Birds in wetlands are affected by the following:

- *Water levels:* Natural fluctuations are important for feeding and breeding (Figure 10-3). Unnatural fluctuations can adversely affect a breeding bird's food supply and roosting.
- *Vegetation:* Vegetation provides food and shelter for birds. Vegetation type and condition determines what bird species will be present (Figure 10-4).
- *Nesting:* Birds may have specific requirements for nest sites, and are sensitive to disturbance when breeding. Any factors that decrease the number or suitability of sites adversely affect the birds.
- *Territory and home ranges:* Some birds may require wetland areas of a specific size. Bird population densities therefore reflect the size and type of the wetland and the quality of habitat.
- *Wetland networks:* These networks are particularly important for migratory species. Habitat corridors that link wetlands enable less mobile species to move from one wetland to another.

Refer to *Chapter 3.3: Birds and Their Habitat,* for habitat and vegetation preferences of wetland birds.

10.4 Design Considerations

10.4.1 Wetland Components

Functional Components of Wetlands

For wetlands to function appropriately, particular environmental conditions need to be met. These are termed the functional components of the wetland, and it is the combination of these that will determine the living or biotic components of the wetland.

Significant wetland functional components include:

- *Water:* Wetlands need water to function; without it a wetland will become dry land. The water regime will play an important role in wetlands, depending upon factors such as seasonality and level fluctuations.
- *Nutrients:* Wetland types respond to these, varying from an adequate supply, as in swamps, to systems that are nutrient limited, such as bogs. If nutrients are excessive, then over-eutrophication can occur and the wetland becomes dysfunctional.
- *Landform:* Wetlands require certain landforms to either hold or discharge the water from the system. Most stationary systems occur in basins, but others such as stream and river margins have flowing waters.
- *Salinity:* Wetlands that are fed by saline waters from the sea have distinct salt-tolerant species that are adapted to the peculiar conditions that an excess of salt provides. Plant tolerance is for salt content, rather than the amount of water.
- *Aeration:* Many wetlands naturally have anaerobic soil conditions, which can severely limit the plants and animals which can survive there. In order to survive, such organisms must have systems of obtaining oxygen.
- *Substrate:* Wetland soils vary from muds to sands and peats. These have considerable influence on the plants and animals at the site, predominantly by the effect on aeration and nutrients, as well as effecting drainage.

Biotic Components of Wetlands

Biotic components comprise the living organisms that live in the wetland, either permanently or temporarily. They occur there because of the makeup of the environmental components described above, and are the consequence of those conditions.

Actual species, numbers, and the communities that the biotic components form are highly dependent on a combination of environmental factors. However, they themselves can modify those factors, or add additional stresses or conditions by their own actions. For instance, birds will often add nutrients to the wetland, which will modify the plant species composition in the areas where their actions are greatest. A tall stand of raupo will modify the hydrological (water) regime and create light limitations at the substrate surface, thereby affecting other vegetation in the area.

It is, however, especially important to understand that wetlands are environments of "stress". The organisms that occur there do so because the conditions are harsh, and other plants and animals are absent because they cannot tolerate the level of stress. The harsher the conditions, the greater the stress, and consequently the more tolerant the plants and animals must be. A consequence of this is the reduction in the number of species able to tolerate the extreme end of the stress gradient. Often it is as single plant species (monotypic) that is most tolerant.

For those who promote biodiversity, such monotypic plant communities will seem undesirable. However, for a functioning wetland system with its harsh conditions, monotypic plant communities are to be expected, and is actually highly desirable. Making the conditions in the wetland more suitable for more species will increase plant diversity, but at the expense of the wetland specialists.

The biotic components of a wetland comprise the following trophic levels:

- *Producers:* These are the plants, which are the most permanent and obvious components of the wetland. They form distinct associations of species of similar tolerance to the environmental stresses, and are therefore usually highly patterned in their distribution within the wetland. They convert light to energy (using chloroplasts), and so provide the basic energy source that powers the food chain of the wetland.
- *Consumers:* Animals that feed either directly on the plants of the wetland, or on each other. These are directly dependent upon the composition of plants and animals that occur there. They vary from invertebrates to birds and mammals, and include people.
- *Decomposers:* These comprise the animals that feed upon detritus, and the bacteria and fungi that breakdown the dead material, to recycle the nutrients back through the system. In some wetlands they are insufficient to break down all the organic material, and in such situations peat accumulates.

10.4.2 Design and Management Considerations

The design and management objectives for natural wetlands are to protect, conserve, and restore their natural values. The single most significant difference between designing a wetland and restoring a wetland is that the latter already has its landform component as part of the system. After that point, the two become somewhat similar. Several publications may be useful regarding the management of New Zealand wetlands, including Buxton (1991), Partridge (1989), and Crossland (in prep).

It is important to identify whether any wetland is planned for use as part of a stormwater treatment system. Constructed wetlands provide a very effective means of stormwater quality and quantity control, but their design and management is different from a natural wetland. As a general rule, stormwater should be directed to constructed wetlands and other treatment systems, whereas natural wetlands should only receive treated stormwater.

Refer to *Chapter 6.7: Constructed Wetlands*, for design guidelines on constructed wetlands for stormwater treatment. Management and design considerations for natural wetlands are outlined below.

Substrate

Substrate type affects plant composition and growth, invertebrate communities, and other factors. The correct substrate conditions are critical for proper plant and animal colonisation and growth in wetlands. An analysis of existing soil conditions should be conducted before wetland restoration or creation. Refer to *Chapter 4: Soils and Geomorphology of Christchurch,* for basic information of the soil types found in Christchurch.

Soils of former wetlands will be more suitable for native plant and animal species than soils at newly created sites (Callaway 2001). This is because created wetlands often have problems such as soil deficiencies, generally related to coarse soil texture, low organic matter, and sometimes high acidity (Langis et al. 1991, cited in Callaway 2001). For example, the use of coarse substrates can lead to additional substrate related problems such as differences in drainage, water holding capacity, nutrient retention, cation exchange, etc (Figure 10-5).

Hydrology and Topography

Hydrology is directly affected by local topography (i.e. landform). The variation in both elevation and flow that are associated with a complex topography are required for heterogeneous hydrological processes, which in turn create variable vegetation and animal communities. Thus, while it is easier to construct smooth surfaces and edges, such features are not natural for wetlands and will not assist the natural functioning of a wetland.

Wetland vegetation can affect the hydrology regime; vegetated wetlands can reduce peak water levels downstream during flooding. Wetlands also release water slowly, maintaining groundwater levels and stream flows during summer or drought conditions.

Wetlands with fluctuating water levels are inherently different from those with essentially stable water levels. Design thus needs to determine the total hydrological regime. Fluctuations may be seasonal (as in tarns; not found in Christchurch), diurnal (as in estuaries), or unpredictable (as in lagoons). Plant species ranges and zonation in relation to flooding reflect the hydrological dynamics.

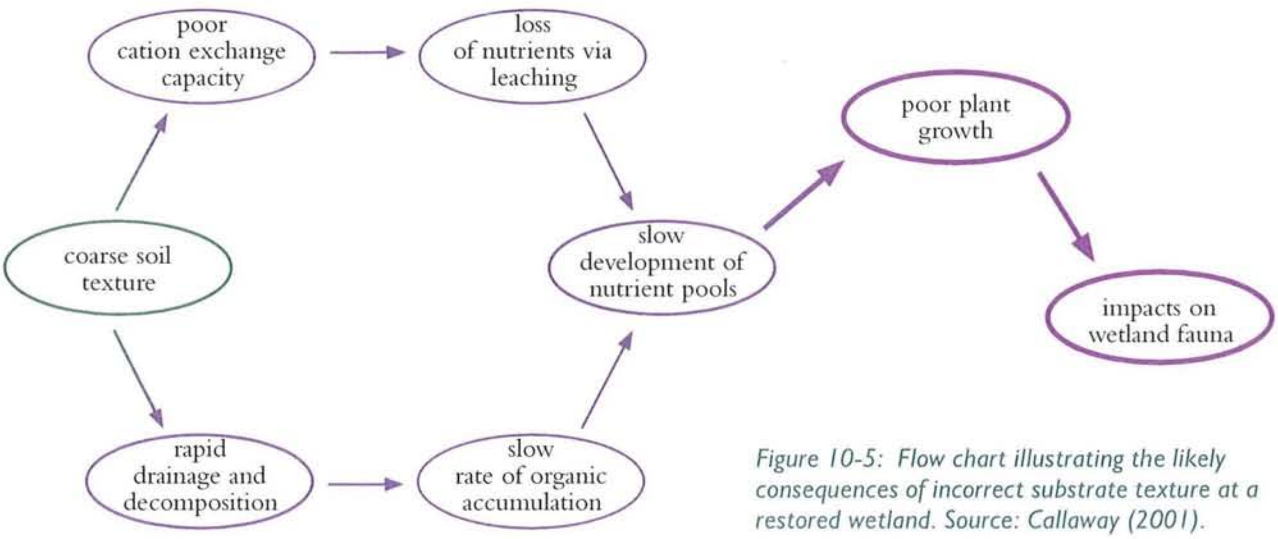

Figure 10-5: Flow chart illustrating the likely consequences of incorrect substrate texture at a restored wetland. Source: Callaway (2001).

Other wetlands will have stable levels maintained by outlets, and these will have a different series of plants adapted to such levels. In some situations the visible water of a wetland is often only a small part of a vast connected groundwater reservoir.

Wetland creation involves constructing an appropriate landform for the holding or flow of water, where such had not previously existed before. Therefore the most important considerations involve estimates of water inputs and outputs to the proposed design.

The inputs come from:

- flow: determination of stream/river inputs across the surface
- rainfall: determination of direct inputs from rain
- water table: determination of inputs from bores or an intersecting water table.

The outputs go to:

- flow: determining outlet flows by streams across the surface
- evaporation: determining loss from water surface
- groundwater: determining porous loss through a soil or gravel base.

This will enable a balance of inputs and outputs that will determine the viability of the system in any particular location, and thus the design of the wetland. In freshwater systems in Christchurch this will involve the creation of a stream with wetland margins, or a basin, which can have standing water or be completely vegetated. The water regime balance will help determine parameters such as stream width, basin depth, and whether it needs additional water.

Habitat

Wetlands comprise a transition sequence from water to dry land. Depending on the hydrological regime and other factors, there are clear sequences of vegetation types. These range from land dwelling vegetation, through increasing wetness, to aquatic vegetation (macrophytes) in permanent water. This diversity of habitat and plant types provides for a diversity of animal species and communities.

Induced changes to the water level regime are clearly the greatest threat to these habitats. The traditional response to naturally low-lying wet areas has involved drainage and infilling to make land usable for other purposes (e.g. agriculture or urban). The consequence of such development is the destruction of unique habitats used by many specialist plants and animals.

Different wetland habitats will reflect the range of landforms (i.e. topography), nutrients (including salinity), and hydrological and hydraulic conditions present at any location. These different types of wetlands provide habitat for different species and ecological communities. It is important that different wetland types in Christchurch are recognised and opportunities are taken to protect, conserve, and restore them wherever possible within this range of diversity. Examples of wetland types in Christchurch have been listed in Table 10-1.

Wetland protection, restoration, and management must consider the larger area of which the system is a part, to achieve sustainable outcomes. This includes catchment properties, especially upstream effects but including downstream effects in tidal systems. A transitional buffer between residential development or farmland and a wetland will greatly assist the management of a wetland, by ameliorating these adverse effects.

Vegetation Patterns

Planting of wetlands needs to ensure that the plants are placed in the appropriate hydrological regime. If this does not occur, they will be replaced by other species, which are often weeds. Failure to do this often results in continuous ongoing management because the wetland functioning is not in harmony with the vegetation patterns created.

Functional Life

Basins and wetlands have a finite functional life for drainage or wetland values. This is because wetlands are always in a process of change, often referred to as succession. Succession is the natural tendency of plant species to replace each other as environmental conditions change.

Natural successional processes result in accumulation of organic matter and silt, moving towards a drier, less wet state. For wetlands, this usually involves slow infilling of a lake or basin with sediment and plant detritus, which accumulates as peat below the water level. Therefore wetlands are in a state of flux, usually in a trend to becoming dry land. This succession process will likely be sped up in urban and rural areas through increased sedimentation and nutrient levels.

One major consideration in the construction of wetlands is their intended life. It needs to be decided whether succession will be allowed to proceed and new wetlands created elsewhere to compensate, or if wetlands will need to be rejuvenated by eventual dredging and replanting. Initial design will impact on a wetlands effective life; if basins are created too shallow, they become in-filled rapidly, necessitating immediate and even continuous management.

Culture, Recreation, and Education

Wetlands provide opportunities for environmental education, passive recreation, and cultural harvest. However, wetland wildlife and some wetland plants are very sensitive to disturbance. Thus wetland access by people and pets should always be considered carefully (Figure 10-6). Design elements available to manage public access and protect wildlife include:

- signage and interpretation: clearly outline the desirable and expected behaviour
- formed tracks and boardwalks: locate these away from sensitive areas
- fences: simple post and wire fences can effectively isolate sensitive areas
- shrub planting: densely planted shrub associations provide shelter and screening for wildlife
- islands and moats: these provide both refuges and nesting sites for wildlife. Note that some predators are not deterred by water
- also refer to *Chapter 16: Public Access*.

10.5 References

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Figure 10-6: This viewing platform (right) at Travis Wetland provides views of the open wetland area (above), without significantly disturbing the local environment.