Shelley McMurtrie

Fish, Invertebrates, Birds, and Their Habitat

Adult and larvae of the mayfly Nesamaletus

Angus McIntosh, Canterbury University

Male common bully (Gobiomorphus cotidianus) *guarding its eggs*

Shelley McMurtrie

Freshwater crayfish, Paranephrops

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3.1 Introduction

This chapter describes the habitat preferences of fish, invertebrates, and birds that are currently found, or could possibly survive in or around Christchurch's urban waterway and wetland systems. Information in this chapter can be referred to in the design stage of any waterway restoration project, to ensure the restored habitat is capable of supporting the desired ecological community. It is therefore important to read this chapter before reading design considerations provided in *Chapter 9: Restoring Waterway Form*, *Chapter 10: Restoring Wetlands*, and *Chapter 11: Riparian Planting*, so that a more informed decision about the most appropriate restoration design and procedure can be made. For an overview of the range of habitats found in Christchurch, see Christchurch City Council (2000).

Instream and streamside habitats and their residents exist in a finely balanced relationship. Figure 3-1 demonstrates the types of links that exist between different species and feeding groups (trophic levels) within a stream system. This food web is an idealised and simplified web that includes aquatic organisms that could occur in a healthy stream environment; an instream habitat including a macrophyte community and a heterogeneous substrate (with coarse and some fine substrates). The birds included are relatively common to Christchurch.

When restoring a stream, the links between the different trophic levels need to be considered in order to create a habitat that can support a diverse and functioning community. To do so, the habitat preferences of smaller organisms (the invertebrates), need to be satisfied. Invertebrates play an important role in food webs, as they bring terrestrial carbon (from plants) into the stream food web and transfer biomass of aquatic primary producers to higher consumers (fish and birds, Winterbourn 2000).

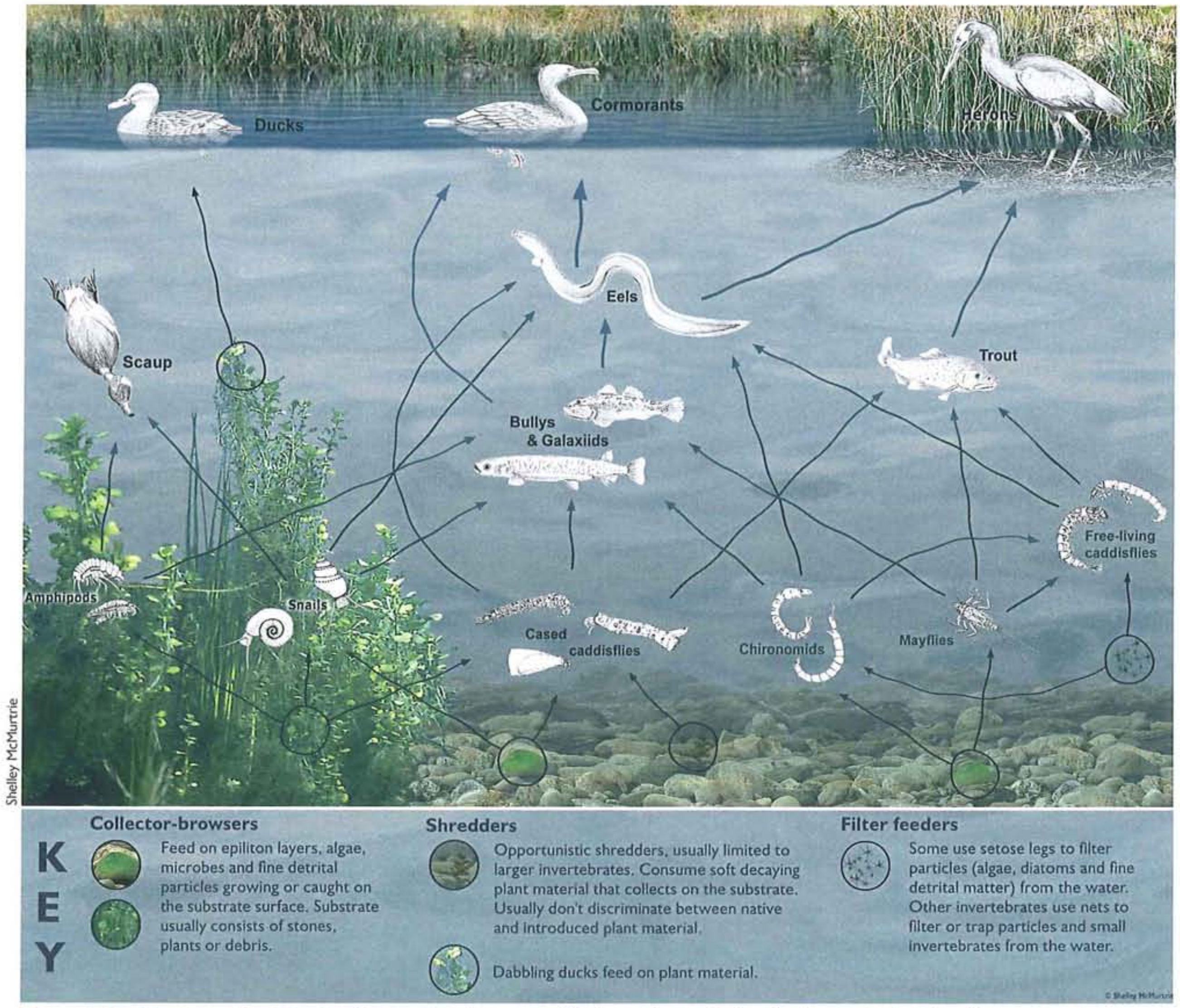


Figure 3-1: Conceptualised food web showing the types of links and trophic levels that exist in a healthy waterway system. Caddisflies and mayfly from Winterbourn et al. (2000), amphipods from Chapman & Lewis (1976).

3.2 Instream Communities and Their Habitat

3.2.1 Fish Species in Christchurch

Of the 35 indigenous freshwater fish species in New Zealand, 13 are found in the Christchurch district, of which five are considered well-distributed and common (Table 3-1).

The shortfin eel is the most common fish in the city waterways because it has low requirements for instream cover, and is highly tolerant of indifferent water quality. As a juvenile fish, the shortfin can climb over weirs, and by burrowing into silt it can survive in waters devoid of vegetation.

Juveniles of the larger longfin eel (which can grow up to 1 m in the city) can also climb. Adults prefer some shelter provided by instream and overhanging vegetation, logs, and undercut banks. Riparian and instream vegetation is more important for this species, and they are less likely to be found in badly degraded habitats.

Two of the four species of bully are widespread throughout Christchurch waterways (Table 3-1). Common and upland bullies occur in rivers, streams, and drains throughout the city. The non-migratory upland bully is the only species that is found above substantial instream obstructions, as it does not require access to the sea. The aptly named but secretive giant bully, largest of the four, is restricted mainly to the tidal reaches of the Avon River/Ōtākaroro, although it can be found as far upstream as Cashmere Stream in the Heathcote River/Ōpāwaho catchment. The bluegill bully has, in the past, been recorded from the central city area of the Avon River/Ōtākaroro, but now appears to be quite rare in the Christchurch area.

Canterbury mudfish are endemic to Canterbury and were once abundant in wetlands that were present in the Canterbury region. Agricultural modification of these wetland habitats has lead to the threatened status of this species. Canterbury mudfish do not migrate and do not appear to thrive where other fish species are present, due to increased competition and heavy predation from eels and trout. The adult's tolerance

Table 3-1: Indigenous and introduced fish in streams around Christchurch (including the Waimakariri River mainstem).

Fish Species	Scientific Name	Relative Abundance
Indigenous Fish		
Shortfin eel	*Anguilla australis*	common
Longfin eel	*Anguilla dieffenbachii*	common
Inanga (whitebait)	*Galaxias maculatus*	common
Common bully	*Gobiomorphus cotidianus*	common
Upland bully	*Gobiomorphus breviceps*	common (most widespread bully in the South Island)
Giant bully	*Gobiomorphus gobioides*	common, but restricted distribution
Common smelt	*Retropinna retropinna*	common, but restricted distribution
Black flounder	*Rhombosolea retiaria*	occasional
Bluegill bully	*Gobiomorphus hubbsi*	rare
Lamprey	*Geotria australis*	rare
Canterbury mudfish	*Neochanna burrowsius*	rare, but true distribution unknown
Canterbury galaxiid	*Galaxias vulgaris*	restricted distribution (Waimakariri River and tributaries)
Torrentfish	*Cheimarrichthys fosteri*	restricted distribution (Waimakariri River and tributaries)
Introduced Fish		
Trout	*Salmo trutta*	common
Goldfish	*Carassius auratus*	occasional, but only in ponds and lakes
Perch	*Perca fluviatilis*	rare
Quinnat (Chinook) salmon	*Oncorhynchus tshawytscha*	restricted distribution (Waimakariri River and tributaries)

of low dissolved oxygen levels and ability to survive in moist conditions during droughts have allowed mudfish to survive drought conditions and, persist in habitats too harsh for other fish species. Although there is no recorded natural occurrence of Canterbury mudfish in the Christchurch metropolitan area, the potential does exist for populations to be established in restored wetlands.

Inanga (adult whitebait, Figure 3-2) are found in diverse freshwater habitats, including lowland and coastal rivers, streams, lakes, and swamps that they can reach in their migration from the sea. In Christchurch they are typically found in the slow-flowing regions of the city's downstream rivers, some tributary waterways, and in Travis Wetland.

Unexpectedly good small trout recreational fisheries exist in the middle and lower reaches of the Styx River/Pūrākaunui, Heathcote River/Ōpāwaho and Avon River/Ōtākaroro, despite these rivers draining a largely urban catchment. This good fortune can be attributed to acceptable food and water quality, steady flows, improved riparian management, and the dispersed nature of sufficient spawning habitat in the middle and upper reaches. Flows in the upper Avon/Ōtākaroro tributaries, however, have become increasingly ephemeral in recent years, jeopardising the quality of trout spawning and rearing habitat in these reaches, and trout numbers are also declining in the Styx River/Pūrākaunui.

Providing Habitat for Inanga

It is essential to provide both spawning and rearing habitat for inanga to maintain or increase inanga populations. To assist spawning, plant tall riparian grasses (especially *Carex secta*) in the tidal areas of downstream rivers, especially at the high spring tide level. Adult fish lay their eggs during high spring tides when terrestrial grasses are normally submerged (Figure 3-3). Eggs incubate in the root mat of the grasses (Figure 3-4), and hatch at the next spring tide (about 2–4 weeks later). Rearing habitats for inanga could include dense plantings of emergent raupo in shallow water, close to inanga spawning grounds, which would reduce trout predation and also provide refuge from eels.

During late summer, diverting stock or pedestrian traffic away from inanga spawning areas will help to protect these ecologically sensitive reaches. Postpone mowing a site for several months in late summer so that the grasses can reach a suitable length to support egg development. Refer to Richardson & Taylor (2002) for more detailed guidelines on restoring inanga habitat.

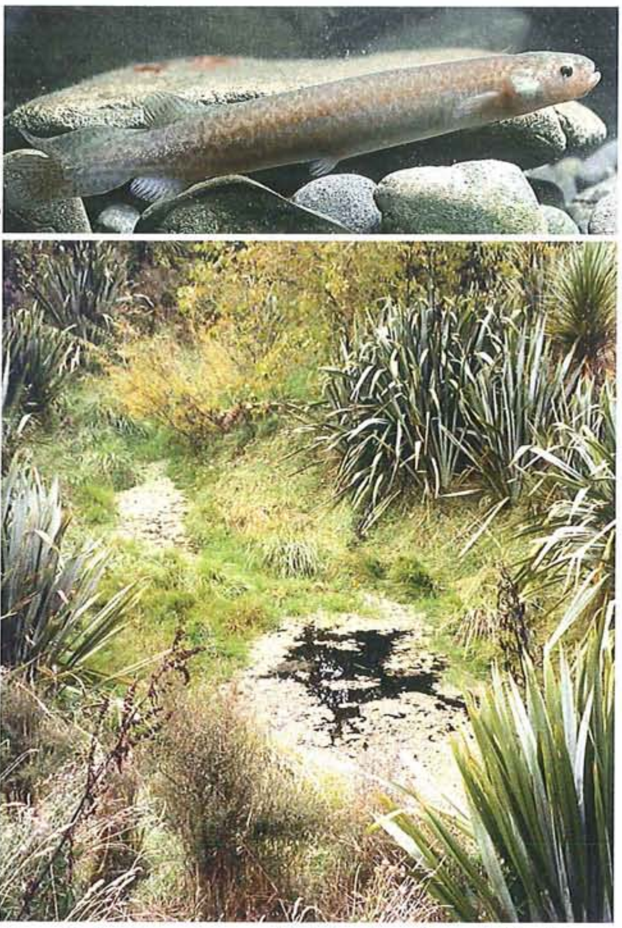
Tony Eldon

Figure 3-2: Adult Inanga (Galaxias maculatus).

Mark Taylor

Figure 3-3: Inanga spawning site along the Heathcote River/Ōpāwaho, during low tide (1999). The distribution of egg clusters (arrows) form a band at the high spring tide level, indicative of the usually short time interval when spawning takes place.

Figure 3-4: These tiny inanga eggs (about 1 mm diameter; see arrows) have been laid amongst the root mat of thick native grasses. The thick vegetation cover will ensure they remain moist until they hatch—generally 1-2 weeks later when they become inundated by the next high spring tide.



Angus McIntosh

Leanne O'brien

Figure 3-5: Canterbury mudfish (top) prefer periodically flowing or still water, isolated from other waterways (above).

Figure 3-6: Key macrophytes (aquatic plants) needed for successful Canterbury mudfish spawning.

Providing Habitat for Canterbury Mudfish

The original habitat of the Canterbury mudfish (Figure 3-5) is uncertain; by the time this fish was first described in 1926, its habitat was thoroughly modified. It is known they do not need extensive habitats, and can form dense populations if conditions are favourable (Figure 3-5). Their hardiness means they could be established in habitats unsuitable for other fish species, where they may control aquatic insects like mosquitoes and midges. Still or periodically flowing habitats isolated from other waterways (to prevent other fish access) are the most suitable sites for Canterbury mudfish introduction.

Mudfish can survive the habitat drying out for short periods (i.e. several weeks) by burrowing into the mud, where they aestivate. However, in order to survive this period they need to find an area that is aerated and remains damp (Ling 2001). Thus, while ephemeral habitats may be suitable, it is necessary to provide submerged logs as moist refuge for when it dries out (L. O'Brien, personal communication).

Canterbury mudfish require aquatic vegetation for successful spawning (O'Brien, unpublished data). The key plant species that should be established are water milfoil (*Myriopyllum*), manihi (*Potamogeton cheesemanii*), retoreto (*Azolla filiculoides*), and duckweed (*lemna minor*, Figure 3-6). Ideally, overhanging and emergent marginal vegetation would provide daytime refuge but heavy shading by trees should be avoided.

It is essential that a thriving invertebrate community is established before considering the introduction of Canterbury mudfish. Some of the key food taxa include the crustacean *Daphnia,* as well as copepods. An indication that a habitat could be able to sustain a mudfish population is the presence of damselflies, as these invertebrate predators have similar resource requirements.

3.2.2 Aquatic Invertebrates in Christchurch

The streams of urban Christchurch are typically dominated by the ubiquitous snail *Potamopyrgus antipodarum* (Suren & McMurtrie 2003). The most diverse invertebrate group are aquatic fly larvae (Diptera), in particular the non-biting midges (Chironomidae). The algal-feeding purse caddisfly (*Oxyethira*) is also relatively common throughout Christchurch (Suren & McMurtrie 2003), being positively affected by increased algal production. Other common invertebrates include snails (*Physa, Gyraulis*) and crustaceans (the amphipod *Paracalliope*, cladocerans, and ostracods). Such community composition is common in urban streams where the natural stream habitat is greatly modified.

There is an absence of many 'clean water' species, including mayflies (Ephemeroptera, Figure 3-7) and stoneflies (Plecoptera), and a poor representation of caddisflies (Trichoptera, Figure 3-7) in most of the city's urban streams. The freshwater crayfish, *Paranephrops*, is also rarely seen. In Christchurch the naturally low-lying aspect and low velocity of some streams would naturally preclude the presence of many EPT taxa. However, the decline or absence of EPT (Ephemeroptera, Plecoptera and Trichoptera) taxa in the City's waterways is a typical response of stream communities to catchment development (Quinn & Hickey 1990a). This is largely a result of a general degradation of instream and riparian habitats.

Greater species diversity is found in some of the outlying Canterbury rural streams or water races. For example, the Ōtūkaikino and its tributaries support diverse invertebrate communities (McMurtrie 2001), several EPT taxa have been found in water races in the Paparua district (McMurtrie et al. 1997), and the predominantly rural Styx River/Pūrākaunui has, in the past, supported a reasonably diverse range of mayfly and caddisfly taxa (Robb 1980, 1989):

- mayflies: *Coloburiscus, Zephlebia, Deleatidium*
- stoneflies: *Spaniocerca, Zelandobius* (the Ōtūkaikino and water races only)
- caddisflies (cased): *Helicopsyche, Hudsonema alienum, H. amabile, Oecetis unicolor, Olinga feredayi, Oeconesus maori, Oxyethira albiceps, Paroxyethira hendersoni, Pycnocentrodes, Pycnocentria evecta, Triplectides obsoleta*
- caddisflies (free-living): *Aoteapsyche colonica, Hydrobiosis parumbripennis, Neurochorema confusum, Polyplectropus puerilis, Psilochorema bidens.*

The Styx River/Pūrākaunui does support a more diverse invertebrate community than the other two large Christchurch waterways; the Heathcote/Ōpāwaho and Avon/Ōtākaroro Rivers. This is likely a consequence of the urbanised nature of these latter rivers. Unfortunately there is evidence to suggest that relative abundance and diversity of many invertebrate groups in the Styx River/Pūrākaunui has seen some decline (Eldon & Taylor 1990).

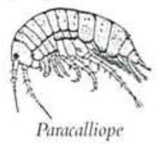
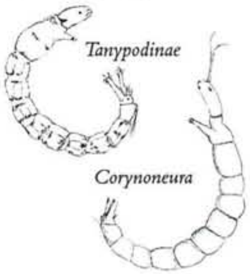
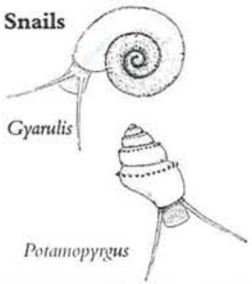
It is possible that the prolonged absence of some insect species from Christchurch's urban streams now precludes their re-establishment in suitably enhanced areas due to a lack of colonists in the local area (A. McIntosh, University of Canterbury, personal communication); the distance that adult insects would need to travel from outlying areas may be too great. It is also possible that sediment quality could be a limiting factor in Christchurch's urban streams. However, the presence of 'clean water' insects in surrounding rural streams (e.g. the Ōtūkaikino) is encouraging, and it may be possible to re-introduce some species into suitably naturalised urban stream environments, provided there are no sediment contamination issues. The Council, in collaboration with NIWA (National Institute of Water and Atmospheric Research), Canterbury University, and environmental consultants are currently researching the potential effects of sediment contamination.

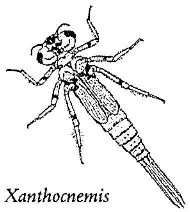
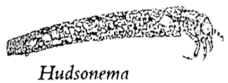
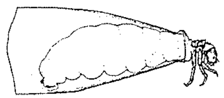
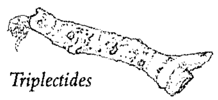
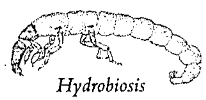
3.2.3 Habitat and Feeding Preferences of Fish and Invertebrates

Table 3-2 and Table 3-3 (on the following pages), provide general information on the habitat and food preferences of invertebrate and fish groups found in Christchurch waterways. They include the major groups that could potentially survive in a suitably naturalised urban stream, and include those groups shown in Figure 3-1. These tables are designed as general guidelines only, and are not an exhaustive account. Food and habitat preferences of individual species vary, and many will exhibit different diet and habitat preferences at different life cycle stages, or in different sized streams. The tables can be used to ensure key habitat requirements are provided for whenever waterway restoration is planned.

Figure 3-7: The aquatic larval stage of the mayfly Nesamaletus *(top) and free-living caddisfly* Polyplectropus *(above) is found in 'clean water' habitats and some rural streams, but is absent from Christchurch's urban streams.*

Table 3-2: General feeding and habitat preferences of some of the aquatic invertebrates found in the Canterbury region. They include common species currently found in urban streams and more 'clean water' groups that could potentially survive in suitably restored sections of streams.

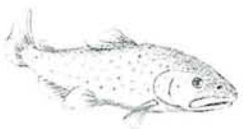
Group	General Feeding Preferences*	General Habitat Preferences	Tolerance of Habitat Modification
Amphipods 	**Collector-browsers** *Paracalliope, Paraleptamphopus.* Omnivorous; scavenges for suitable food or browses on fine film coating plants and other substrates.	Often found among overhanging grass, macrophyte beds, and clean gravels. While they are intolerant of silty conditions, they can be found in soft sediment streams with well established macrophyte beds. Prefers moderate flows at a range of depths. Is often found in macrophytes where water velocity is low.	*Paracalliope* is found in some Christchurch streams. They can tolerate some fluctuation in dissolved oxygen levels that occurs in macrophyte beds, but are intolerant of fine sediment. *Paraleptamphopus* is a subterranean species, which has been found in Canterbury, including some urban streams (Steamwharf Stream). Not often found in invertebrate samples due to their subterranean nature.
Chironomids 	**Collector-browsers/Filter Feeders** Includes all chironomid larvae in New Zealand. Consume a mixture of algae (mainly diatoms) and detritus. **Predators** Tanypodinae (later instars).	Many chironomids are burrowers, thus are found in fine sediments or algal mats. Orthoclads may be associated with algae (filamentous or algal mats) growing on stones or macrophytes. Some Chironominae prefer cobble to boulder substrates (*Tanytarsini*)	*Chironomus* species are most tolerant of pollution, high sedimentation, and low dissolved oxygen levels. *Chironomus zealandicus* is often found in organically polluted streams and other eutrophic waters. Orthocladinae can tolerate some sedimentation and mild organic pollution, and are often found where there are algal blooms. Podonominae and Diamesinae are typically intolerant of habitat modification, and are usually restricted to cold mountain streams. Diamesinae are occasionally found in Christchurch urban streams in low numbers. Chironomids have short generations so can survive ephemeral habitats.
Mayflies 	**Collector-browsers** *Deleatidium, Nesamaletus, Zephlebia.* Feed on detritus and epilithon layers growing on stones. **Filter Feeders** *Coloburiscus.* Use setose legs to filter particles (algae, diatoms, and fine detrital matter) from the water.	All groups prefer well oxygenated flowing water and small cobbles to boulders that are clear of fine sediment. **Filter Feeders:** Prefer moderate to fast velocities. **Collector-browsers:** Prefer moderate velocities.	Typically regarded as clean water species that have high oxygen demands. Scarce where water temperatures are > 21.5 °C. Deleatidium has the broadest habitat preferences of the mayflies, and is sometimes common in open lowland streams, including rural streams (with sufficient oxygen and little sedimentation). Not currently found in Christchurch urban streams, but present in some rural streams. *Coloburiscus* and *Nesamaletus* aren't found in Christchurch urban streams, probably due to their 'clean habitat' and high velocity requirements. Have been found in some Christchurch rural streams.
Snails 	**Collector-browsers** *Gyraulus, Potamopyrgus, Physa.* Use their radula to scrape the epilithon layers from substrates (macrophytes, debris, stones etc).	*Potamopyrgus* has broad substrate preferences, from fine sediment to boulders, macrophytes, algal mats, debris, and any other stable substrate. Often associated with macrophyte beds or algal blooms (filamentous and algal mats). Broad velocity preferences (low to moderate velocities), including areas of no flow. Found in a wide range of depths.	*Potamopyrgus* is ubiquitous throughout New Zealand; it is found almost anywhere where there is permanent water. It is typically tolerant of moderately degraded habitats. Can tolerate some fluctuation in dissolved oxygen levels that occurs in macrophyte beds or as a result of mild nutrient enrichment. Has a moderate tolerance to high water temperatures (96 hr LT_{50} = 30–32 °C). *Gyraulus* and *Physa* are also tolerant of nutrient enrichment and are common in still and running water. Found in many Christchurch rural and urban streams and ponds.

Damselflies  *Xanthocnemis*	**Predators** *Xanthocnemis, Austrolestes.* Ambush predators that prey on small crustaceans and insect larvae (including chironomids and their own species).	*Xanthocnemis* is found on vegetation in the water, including overhanging grass, reeds and macrophytes (floating when young and rooted when older). Streambed substrate type is unimportant, as it is not a benthic invertebrate. Less is known about the aquatic stage of *Austrolestes*. It is found on vegetation and detritus in the water. Will swim into soft sediment if disturbed. Both prefer low flows, including still water or minimal current. Mainly found in lakes and ponds or still areas at the sides of rivers and streams.	Probably tolerate some fluctuations in oxygen concentration that occurs in macrophyte beds or as a result of mild nutrient enrichment. Often found in slow flowing margins of rural and urban streams or ponds with sufficient aquatic vegetation.
Cased caddisflies  *Hudsonema*  *Oxyethira*  *Triplectides*	**Collector-browsers** *Olinga, Pycnocentria, Pycnocentrodes, Hudsonema.* Use algae as an important food source. **Shredders** *Oeconesus, Olinga, Triplectides.* **Herbivores** *Oxyethira, Paroxyethira* (algal piercers). **Predators** *Hudsonema* (preys on snails by prizing the soft body out of the shell).	**Collector-browsers:** Substrate preferences are small cobbles to boulders, macrophyte beds, algal mats, or debris. Low to medium velocity preferences, and may tolerate some sedimentation. **Shredders:** Prefer coarse substrates (small cobbles–boulders or wood) that trap coarse detritus. Tolerate some sedimentation. **Herbivores:** Algal piercers, associated with filamentous algae. Broad velocity preferences, but often found in macrophyte or algal beds were velocity is low. **Predators:** Broad substrate preferences; small cobbles to boulders, macrophyte beds, algal mats or debris. Low to medium velocity preferences.	*Pycnocentria, Pycnocentrodes, Olinga* are common throughout New Zealand in forested or open lowland streams and are also found in modified streams (low numbers found in a few Christchurch urban streams). *Oeconesis* is found in small streams and seepages amongst leaf litter or moss. Uncommon in Christchurch urban streams. *Triplectides* tolerates low salinity. Found in low numbers in some Christchurch urban streams. *Hudsonema* is abundant in low gradient shallow streams and lakes. Found in low numbers in some Christchurch urban streams. Algal piercers (*Oxyethira, Paroxyethira*) often found in degraded habitats, where there are macrophyte beds and algae. Most common caddisfly larvae in Christchurch urban streams.
Free living caddisflies  *Hydrobiosis*  *Aoteapsyche*	**Collector-browsers** Early instars of most species. **Filter Feeders/Predators** Polycentropodidae (*Polyplectropus*), Hydropsychidae (*Aoteapsyche*). Use nets to capture small insects and detritus. **Predators** Mainly Hydrobiosidae (*Hydrobiosis, Psilochorema, Neurochorema*). Prey on chironomids, mayflies, worms, snails.	**Filter Feeders/Predators:** Prefers small cobble to boulder substrates clear of heavy siltation, with low to medium velocities. *Polyplectropus* is found in pools and slow flowing areas, on coarse substrates or in macrophyte beds. **Predators:** Prefer small cobble to boulder substrates and low to moderate velocities.	Most prefer forested streams, but *Neurochorema, Hydrobiosis, Psilochorema,* and *Polyplectropus* are also found in more open lowland streams, and sometimes in streams with some modification (the latter three caddisflies have been found in Knights Stream, in Christchurch's rural area). Hydropsychid larvae often found at lake outlets. *Aoteapsyche* is common in lowland streams with sufficient water velocity, including some Christchurch rural streams and water races. Can tolerate some sedimentation.

*Most invertebrates in New Zealand streams are generalists, and many will consume food in proportion to its availability. Refer to Figure 3-1 for definitions of different general feeding preferences.

Based on information sourced from Chapman & Lewis (1976), Rowe et al. (1987), Quinn & Hickey (1990a, b), Jowett et al. (1991), Collier et al. (1995), Winterbourn (1995, 2000), Death (2000), Jowett (2000), McIntosh (2000a), Quinn (2000), Monson & Emberson (2001), and Suren & Jowett (2001). Chironomid and snail drawings by Shelley McMurtrie, amphipod from Chapman & Lewis (1976), remaining images from Winterbourn et al. (2000).

Table 3-3: Feeding and habitat preferences of some fish found in the Canterbury region that could potentially survive in suitably restored sections of streams, ponds, or wetlands.

Fish Species	Feeding Preferences	Habitat Preferences
Bullies  *Gobiomorphus cotidianus* (common bully) *G. breviceps* (upland bully) *G. gobioides* (giant bully)	**Feeding Habits:** Take invertebrates from the substrate. **Diet:** Opportunistic foragers; will consume invertebrates in proportion to their abundance. Main diet includes chironomids and mayfly larvae, with smaller proportion of other diptera and free-living caddisfly larvae, and sometimes snails. Giant bully is probably nocturnal, emerging from its cover during the night.	Bullies (bar upland bullies) require access to/from the sea, although there are also land locked populations of common bullies. **Upland bully:** Edge dwellers, preferring shallow, slower flowing margins of runs and riffles, with pebble to small cobble substrates. Also found in ponds/lakes. **Common bully:** Prefer intermediate habitat (between that of bluegill and upland bullies) in swift, shallow water with gravel or finer sediments. Also found in ponds/lakes. **Giant bully:** Prefers estuaries and nearby coastal waters (< 2 km inland). Secretive, inhabits cover along stream margins and beneath boulders during the day. Little known about biology. **Redfinned bullies** are rare in Canterbury and **bluegill bullies** require very fast water (thus are unlikely to be found or survive in most Christchurch urban streams that are slow flowing).
Eels  *Anguilla dieffenbachii* (longfin) *A. australis* (shortfin eel)	**Feeding Habits:** Predominantly nocturnal feeder, which increases with age. Locates prey by odour. Feeding may decrease or cease during winter. **Diet:** Extremely variable diet, which varies with size and abundance of prey. Small eels consume cased caddisfly larvae and snails, but prefer soft-bodied invertebrates like mayfly and free-living caddisfly larvae, crustaceans, and chironomids. Larger eels will include fish (bullies, galaxiids, and small trout) in their diet. Very large longfin eels may also take mice and ducks.	Broad habitat requirements for both species (wide range of depth and velocity preferences, not restricted to any particular habitat), although longfins require more cover. Some preference for shallow water for earlier life stages. For larger eels, cover becomes an important factor limiting habitat suitability. Longfin elvers prefer fast flowing rapids with gravel substrates, whereas older eels prefer pebbles to small cobbles. Shortfin eels are found in fine sediments–gravel. Both species can tolerate low dissolved oxygen levels and varying temperatures, and can survive out of water for some time. They require access to/from the sea.
Galaxiids  *Galaxias maculatus* (inanga) *Galaxias vulgaris* (Canterbury river galaxiid)	**Feeding Habits:** Diurnal and nocturnal feeders that mainly use mechanical cues (i.e. their lateral line) to detect prey. Stays close to the substrate when feeding, but will take prey from the substrate or drift. **Diet:** Opportunistic foragers; will consume invertebrates in proportion to their abundance. Consume whole range of invertebrates in New Zealand streams, including mayfly, chironomid, other diptera, caddisfly larvae, and stonefly larvae. Some galaxiids (e.g., kokopu species) consume terrestrial invertebrates.	**Inanga:** Diverse habitat preferences. Found in lowland and coastal rivers, streams, lakes, and swamps. Adult stage most abundant above the influence of the tide, but still common in brackish, tidal estuaries. Weak swimmers, so unable to migrate past long, swift rapids or small falls. Adults will shoal in open gently flowing or still water. In faster water are found in small numbers amongst the marginal vegetation. For spawning require dense vegetation (grasses and rushes) on low-lying banks in the tidal reaches of waterways. Require access to/from the sea. **Canterbury River Galaxiids:** Probably limited to the Waimakariri River catchment.
Canterbury Mudfish  *Neochanna burrowsius*	**Feeding Habits:** Generalised opportunistic predators that will feed on any suitably sized invertebrate they come across. Young are diurnal, but become more nocturnal with age. **Diet:** When young will eat chironomid larvae and crustaceans, but when older will diversify diet to include other diptera larvae, snails, and worms. May be good for keeping mosquito larvae populations down.	Prefers still or gently flowing water. Found in modified habitats such as drains, irrigation races, weedy margins of fast flowing streams, and swampy areas (without other fish). Can survive in ephemeral waterbodies by burrowing into the mud, and can tolerate low dissolved oxygen levels. Seldom coexist with other fish (possible exception is the upland bully), and so will occupy habitats that exclude other fish due to isolation or sub-optimal habitat.
Trout  *Salmo trutta*	**Feeding Habits:** Mainly visual predators that feed during the day, especially at dusk and dawn. Maintains position in water column when feeding and takes prey from the drift or large invertebrates moving on the substrate. **Diet:** Opportunistic foragers; will consume invertebrates in proportion to their abundance, with preference for larger prey. Feed almost exclusively on chironomids and amphipods when young, but diversifies feeding to include mayflies, caddisflies, snails, and some terrestrial invertebrates when older. Larger trout will also consume small fish (bullies, galaxiids), koura (freshwater crayfish), and even small mice.	Require a variation of velocities and depths. Often use deep pools for cover and riffle/run habitats for feeding. Often need velocities > 0.3 m/s in run habitats (Campbell & Scott 1984). Generally found in streams with moderate stability. Small trout found along channel margins with coarse cobble substrates. When larger will move to deeper water with boulders, debris, and submerged vegetation. Need clean gravel substrates with reasonable flow (average 0.47 m/s) for spawning. While there are sea-run trout, trout can complete their life cycle without access to/from the sea.

The fish species mentioned in this table are generally opportunistic predators, consuming prey in proportion to their abundance. Based on information sourced from Campbell & Scott (1984), Sagar & Eldon (1983), McDowall (1990), Glova et al. (1992), and McIntosh (2000a). Drawings by Shelley McMurtrie.

3.2.4 Monitoring Instream Communities

There are several different survey methodologies developed by research groups in Christchurch that can be used to monitor instream communities and the health of waterways. At present, the Christchurch City Council is making use of the USHA (Urban Stream Habitat Assessment) and SHMAK (Stream Health Monitoring Action Kit) surveys, both of which have been developed by NIWA, as well as the Waterwatch Kaitiaki Wai kit developed by Lincoln University (Table 3-4).

While all three kits can be used for studying waterway health, each varies in the level of detail gathered, the type of waterway system they can monitor, and the end-user audience.

3.3 Birds and Their Habitat

3.3.1 Native Birds on the Increase

A remarkable comeback of native bird species to the Christchurch area began in the mid-to-late 1980s. Local populations of at least 26 native bird species began to expand and to re-populate habitats within and around the city. These birds include a number of original natives plus seven 'new' natives (Table 3-5, over page).

Numbers of these native birds have increased because many of the factors that led to the demise of native birds last century have abated, or have been countered through habitat restoration, predator control, and legal protection from hunting.

Table 3-4: Various kits used in Christchurch to assess and monitor waterway health.

Name and Contact	Description
USHA (Urban Stream Habitat Assessment) Author: National Institute of Water and Atmospheric Research (NIWA), Christchurch Suren et al. (1998)	This is a detailed methodology specially designed to assess the habitat and biological health of urban streams. It allows managers to: • assign a stream to a specific stream type, based on large-scale, regional factors (catchment topography, rainfall, etc) • obtain a score for the habitat quality of an urban stream for its specific stream type (USHA score) • obtain a score for the biological health of an urban stream, based on the invertebrate community (UCI score). The USHA protocol can also be used to help assess the effects of different restorations.
SHMAK (Stream Health Monitoring Action Kit) Author: NIWA, Christchurch Web site: http://www.niwa.cri.nz	Designed for use by New Zealand farmers to monitor the health of streams running through their land. Involves collecting data on stream biology, habitat, land use, and farm management, which can be collected at three different levels of detail/intensity. This kit enables farmers to: • keep a record of long term trends and short term impacts • alter land management practices and observe the effects on stream health. Can be used by other community groups, schools, Fish and Game officers, and local and regional council staff.
Waterwatch Kaitiaki Wai Author: Lincoln University	This kit has been developed by staff at Lincoln University to provide water quality monitoring resources and equipment to schools free of charge. It provides: • a person to assist schools with water quality monitoring • a biological and habitat parameters manual • a procedures manual for water quality • equipment to test water quality, loaned to schools • activity/data sheets • a teacher resource manual.

3.3.2 Providing Habitat for Wetland Birds

The prospect of restoring a substantial native component to the bird life found in Christchurch has never looked more promising. In terms of bird population dynamics, the momentum is already well established. Appropriate waterways and wetlands treatment will create and enhance conditions to ensure that the return of native birds to the city is sustainable in the long term.

The key to improving native bird populations is to provide good habitat. High quality habitats not only attract birds, but make their occupation of seasonal or permanent sites viable. It is important to mitigate against disturbance, minimise predation impacts, and protect water habitats from pollution.

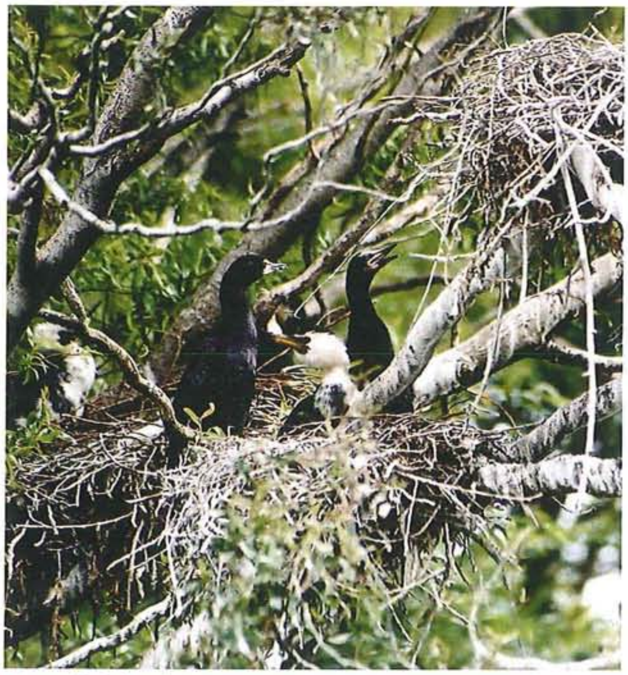


Figure 3-8: Little cormorants require canopy trees for nesting. These are nesting in a willow tree growing on a promontory in Musgroves Pond.

Wide buffer zones, dense vegetation along waterways, and a high margin-to-water ratio (i.e. indented shoreline with bays, peninsulas, spits, backwaters, and islands) for lakes and ponds generally provide good habitats for most wetland birds (Crossland in prep). Reduction in lawn areas reduces habitat available for mallards and Canadian geese, which sometimes displace smaller native species and congregate in large numbers, causing water quality problems.

Where appropriate, look for opportunities to restrict predator access by creating islands, moats, safe roost sites, fences, and other barriers. Install boardwalks, bird hides, observation platforms, and plant to screen people's movements to reduce human disturbance.

Planting suitable native plant species along riverbanks and within wetland areas provides habitat and shelter for the frogs, fish, mice, and insects that are a source of food for some birds. These plants also provide seeds and leaves which are eaten by waterfowl.

Some birds require tall trees for roosting and nesting (Figure 3-8). Retain existing tall trees, including exotics such as eucalyptus, willow, Norfolk pine and macrocarpa, and plant native trees (such as kowhai, kahikatea, totara, and pokaka) that could eventually replace them.

Research has found a positive correlation between the volume of foliage (i.e. plant biomass), its richness, and bird populations (Crossland in prep). Greater provision of indigenous vegetation attracts larger numbers and more varieties of native birds. Many

Table 3-5: Native bird species that have begun to expand and repopulate habitats within and around the Christchurch area. Information collated from Crossland (1994, 1999, in press).

Native Bird Species		Recent Colonists From Australia
Bellbird	Pied cormorant	Little black cormorant
Kereru	Little cormorant	White-faced heron
Grey warbler	Spotted shag	Royal spoonbill
Fantail	Variable oystercatcher	Grey teal
Tomtit	Wrybill	Australasian coot
Paradise shelduck	Banded dotterel	Spur-winged plover
New Zealand shoveler	Pied stilt	Welcome swallow
New Zealand scaup	White-flippered penguin	
Australasian bittern	Black-billed gull	
Black cormorant		

introduced birds also benefit from plant biomass, but prefer to eat and spread exotic plant fruits. Equally, some exotic plants are important sources of food for native birds, particularly during autumn and winter.

Crossland (in prep) reports that the size of a wetland does not limit necessarily the quality or diversity of bird species that it can support (provided they are larger than 2 ha). However, a wide range of factors need to be considered in designing wetlands, particularly shape, depth, and vegetation (also see *Chapter 10: Restoring Wetlands*). The following species used in restoration plantings will provide good bird habitat in wetland areas:

- sedges (*Carex secta, C. virgata, C. geminata, C. maorica*)
- rushes (*Juncus gregiflorus, J. pallidus, J. sarophorus*)
- cabbage trees (*Cordyline australis*)
- New Zealand flax (*Phormium tenax*)
- toe toe (*Cortaderia richardii*)
- kowhai (*Sophora microphylla*), kahikatea (*Dacrycarpus dacrydioides*), totara (*Podocarpus totara*), and pokaka (*Elaeocarpus hookerianus*) for roosting sites.

In addition to plant species assemblage, the placement of wetland habitats in context with the wider environment can also impact on the suitability or use of the habitat by wetland birds. According to Crossland (in prep), Christchurch underlies three main flyways which are important paths for bird movement (Figure 3-9):

- Estuary-Ellesmere Flyway
- Waimakariri-Estuary Flyway
- Coastal Flyway.

The placement of restored wetland or waterway habitats along the known flyways will provide useful annual habitat for migrating wetland birds. Research and monitoring has shown that sites located under flyways in Christchurch attract a greater species richness and higher numbers of wetland birds than other sites (A. Crossland, personal communication).

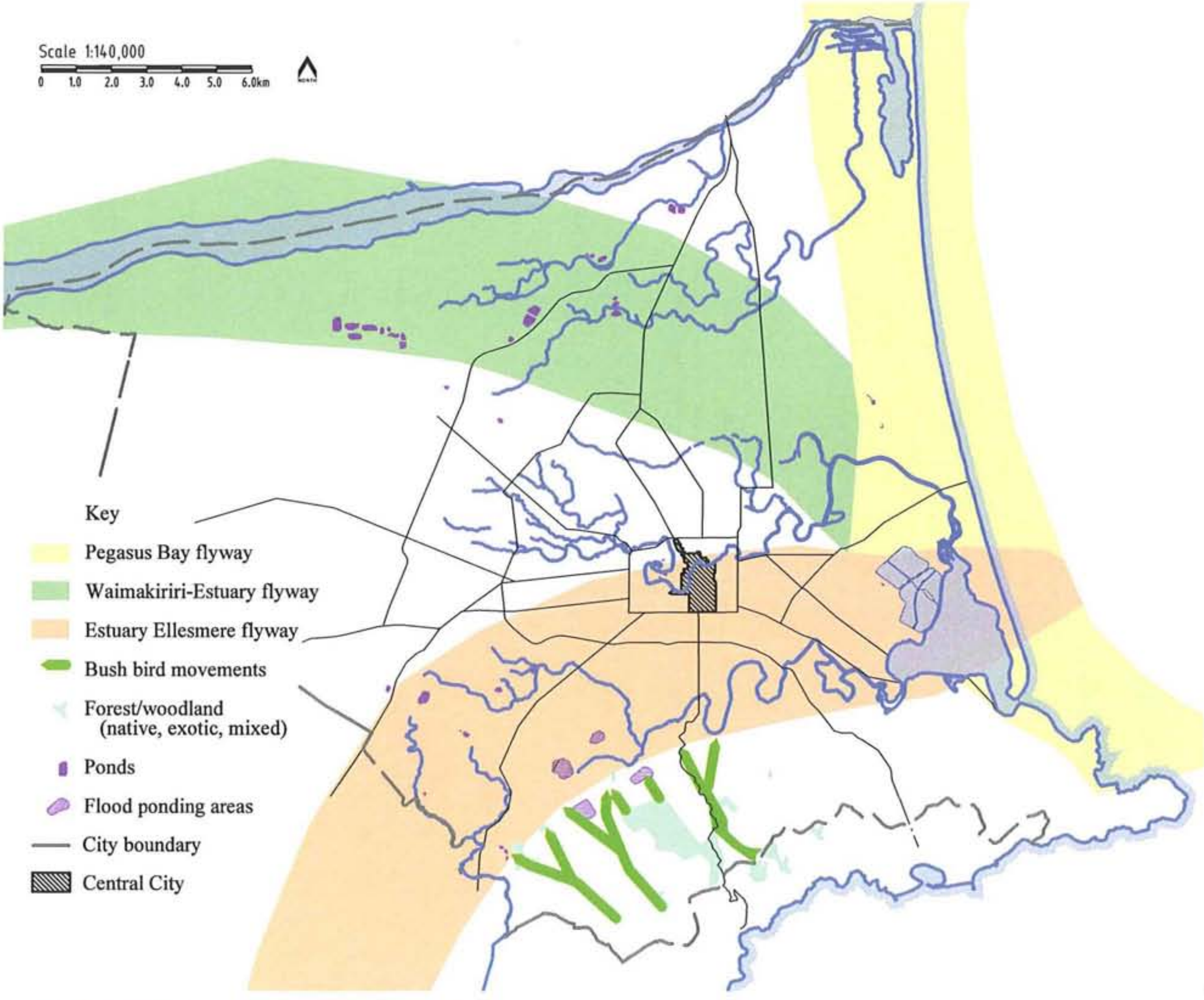


Figure 3-9: Bird flyway paths over Christchurch.

Table 3-6: Summary of habitat preferences for wetland birds found in Christchurch's waterways and wetlands.

Group	Species	Waterbody or Broad Habitat Preferences		Terrestrial and Marginal Vegetation Preferences	
		General Preferences	Waterbody Depth and Size Preferences	Vegetation Preferences	Roosting and Nesting Preferences
Introduced waterfowl	**Swans**	Coastal lagoons, freshwater habitats (including ponds, lakes, deep slow flowing rivers) with macrophytes and partially flooded grasslands.	Open expanses of shallow water, generally < 1 m deep. Usually favour larger waterbodies.	Prefer dense marginal vegetation. Resident birds prefer raupo, rushes, or willow vegetation, while transients are less fussy.	Nest amongst dense ground vegetation such as raupo, rushes, tall grass.
	Geese	Shallow wetlands (estuarine and freshwater) with areas of open water and adjacent farmland. May become pests where farmers are growing crops or on pasture.	Open expanses of shallow water, generally < 1 m deep. Usually favour larger waterbodies.	Avoid waterbodies with dense marginal vegetation. Prefer low grassy/turf edges to waterbodies.	Nest amongst tall grasses, rushes, raupo, or sometimes in the open.
	Mallard duck	Broad habitat preferences, including freshwater and estuarine habitats and open grassland.	Size and depth of waterbody not important, but generally prefer water that is < 1 m deep.	Less abundant on waterbodies with dense marginal vegetation. Prefer low grassy/turf edges to waterbodies.	Prefer some open, shallow gradient 'beach' or grassed areas for exiting the water and for roosting. Nest in thick vegetation, or in tree hollows.
Native waterfowl	**Grey duck**	More natural wetlands, with macrophytes. Includes estuaries, coastal lagoons, tidal marshes, swamps, and lakes. Rarely found in modified sites.	Size and depth of waterbody not important, but generally prefer water < 1 m deep.	Prefer dense marginal vegetation. Do best in wetlands where natural habitat is retained.	Nest in dense ground vegetation or in tree hollows.
	Grey teal	Areas of open water in estuarine and freshwater habitats, including lakes, ponds, estuarine mud flats, and tidal rivers.	Open expanses of shallow water, generally < 1 m deep. Usually favour larger waterbodies.	Prefer dense marginal vegetation, such as wooded margins and tall swamplands. However also occur on waterbodies with bare margins.	Nest close to or over the water, on or in dense vegetation, tree hollows, nest boxes.
	Shelduck (Paradise Shelduck)	Areas of open water including freshwater, estuarine habitat and grassland, including some city parks. Feed mainly on land but prefer to be near water. Moult in flocks on waterbodies.	Size and depth of waterbody not important, but generally prefer water that is < 1 m deep.	Less abundant on waterbodies with dense marginal vegetation. Prefer low grassy/turf edges to waterbodies.	Nest amongst tall vegetation, in/under logs, in tree hollows (up to 20 m high), or in rabbit burrows.
	Shoveler	Lakes, ponds, brackish coastal lagoons, and tidal estuaries. Entirely aquatic feeding habits.	Open expanses of shallow water, generally < 1 m deep. Usually favour larger waterbodies.	Prefer dense marginal vegetation, such as raupo and rushes, however also occur on waterbodies with bare margins.	Prefer taller vegetation for roosting. Nest in dense ground vegetation (tall grass or swamp vegetation) and occasionally in tree stumps.
	Scaup	Large areas of open, slow flowing or lentic freshwater, including lakes, slow flowing rivers, and coastal lagoons. Entirely aquatic feeding habits.	Open expanses of water with depths of 1–3 m (deeper than other ducks).	Prefer dense marginal vegetation such as raupo, rushes, and willows. However also occur on waterbodies with bare margins.	Nest in dense ground vegetation or under logs.
	Australasian coot	Freshwater habitats with open, still, or slow flowing water.	Open waterbodies, with depths up to 7 m.	Prefer dense marginal vegetation such as raupo and willows.	Nest on platforms anchored or floating on the water, usually attached to overhanging vegetation.
	Cormorants and Shags	Open areas of water, freshwater, or coastal habitats. Entirely aquatic feeding habits but roost on land, posts, and trees. Generally less tolerant of disturbance than waterfowl.	Variable sized but deep (often 1-3 m) waters. Little cormorants prefer smaller, shallower (< 0.5 m deep) waters.	Prefer open waterbodies with trees overhanging or close to water for roosting and nesting.	Use trees, especially on spits, headlands, islands, and indented bays for roosting. Use structures emerging from or closely overhanging water for drying their wings.

Wetland or Swamp Birds	**Pukeko**	Wetlands, lake margins, river marshes, poorly drained pastures. Cannot tolerate dry habitats.	No preferences as pukeko use riparian habitats.	Prefer dense vegetation for roosting and nesting. Favour open wet grassland, swamp, and marshland for feeding.	Dense vegetation for nesting and roosting (e.g. rushes, raupo, sedges, long grass,) and occasionally trees (e.g. Ngaio and wilow).
	Marsh crake	Favours densely vegetated margins around freshwater or tidal waterbodies, including marshes, swamps, lakes, ponds, and stream margins.	Prefer large wetlands, but will survive in small wetlands if habitat is good and there is little predation or disturbance.	Densely vegetated margins. Typically found in raupo and *Carex* swamplands.	Nest in tall vegetation (particularly saltmarsh or swamp vegetation), often over water.
	Herons	Both freshwater and estuarine habitats; any sizeable area of wet grassland or shallow water (flowing or lentic). Includes rocky shores, sand flats, estuarine mud flats, lagoons, lakes, ponds, saltmarshes, wet paddocks, and riverbanks.	Any sizeable wet area.	Favour open habitats for feeding.	Prefer trees for roosting and nesting.
	Bitterns	Densely vegetated margins of freshwater and tidal wetlands with brackish pools and slow flowing water for feeding. Sensitive to disturbance and shy of humans and domestic animals.	Prefer densely vegetated wetlands with discrete areas of shallow water for feeding.	Extensive tall, dense vegetation. Often found in dense raupo beds as well as amongst sedges, flax, and willow swampland.	Require dense wetland vegetation. Roost and nest close to ground level.
Waders	**Stilts**	Wetland habitats, including estuaries, marshes, tidal areas, sandpiper pools, lake shores, and wet grassland. Susceptible to predation and disturbance, thus need islands or other safe areas inaccessible to predators.	Mudflats and pools, shallow open water, up to 0.2 m deep for feeding.	Feed in open habitats as well as amongst sparse low swamp vegetation such as rushes.	Vegetated islands for roosting. Nest in open or amongst vegetation (< 0.5 m) on the ground, or on islet or bank.
	Dotterels	Wide range of open habits with flat terrain (fresh or brackish water, sandpiper pools, or grassland (dry or wet). Attracted to shallow surface water.	Prefer muddy/turf margins.	Prefer open terrain with short grass/turf vegetation or bare substrates.	Nest on ground in open areas and riverbeds. Roost on slightly raised drier ground, shingle bars, sand spits, etc.
	Spur-winged plover	Broad habitat preferences including braided rivers, wetlands, farmland habitats, and mudflats.	Don't require surface water.	Prefer open terrain with short grass/turf vegetation or bare substrates.	Nest and roost on ground in open areas and riverbeds.
	Sandpipers	Open, flat areas, especially brackish pools with muddy margins (called sandpiper pools), saltmarsh edges, and estuarine mud flats. May occur inland.	Shallow water (< 0.05 m) or muddy/turf margins.	Prefer open terrain with short grass/turf vegetation or bare substrates.	Migratory species from Northern Hemisphere, so don't nest here. Roost on slightly raised drier ground or sand spits.
	Godwits	Areas with soft sand or mud including mud flats, tidal rivers, and coastal areas. Do not generally occur inland.	Shallow water (< 0.1 m deep) or muddy margins.	Prefer open terrain with short vegetation, favouring bare mud or sand flats.	Same as above.
	Oystercatcher	Open wet habitats including estuarine mud flats, beaches, shallow lake shores, damp short grassland, or braided shingle riverbeds.	Shallow water (< 0.1 m deep), muddy/turf margins and wet grassland.	Prefer open terrain with short grass/turf vegetation or bare substrates.	Nest on ground in open areas and riverbeds. Islands, sand bars, spits, wide beaches, or short grassland for roosting.
Weak link to waterbodies	**Kingfisher**	Broad habitat preferences, from flowing water to ponds, all types of wetlands, open country, and wooded habitats.	N/a	Require roosting sites such as tree branches, fence posts, or telegraph poles.	Elevated perch (on trees, logs, fences, power lines) over the waterbody for sighting prey.
	Swallows	Broad habitat preferences; any waterbody (fresh, flowing, lentic) with abundant emerging insects and open country or urban environments.	N/a	N/a	Use stable structures (bridges, culverts, trees) for nest sites (generally on the underside).

Based on information sourced from Crossland (1994, in prep).

Table 3-6 (previous page) broadly outlines the habitat preferences of birds found in the Christchurch region that are associated with water. This information can be used to ensure key habitat requirements are provided for wherever waterway restoration is planned. Bird species that have become locally extinct but have potential for re-introduction efforts are not included. Further information may be found in Crossland (1994, 1996, 1997).

Crossland (in prep) provides an extensive review of various freshwater bird habitats in Christchurch, the potential for enhancement of these areas, and some design considerations. This report also lists opportunities for habitat improvements for the following systems:

- "English-style" freshwater rivers and streams
- rivers, streams, lakes, and swamps with dense willow margins
- rivers and streams with indigenous margins
- drains and ditches
- braided shingle riverbeds
- freshwater lowland lakes and ponds
- shingle pits
- ornamental ponds
- tall freshwater lowland swamps
- kahikatea swamp forest
- cabbage tree woodland
- lowland wet grassland
- short grassland.

Shelley McMurtrie

Figure 3-10: The wetland/pool habitat created in Papanui Stream at Erica Reserve attracts nesting pukeko.

Table 3-7 gives a list of restored waterways and wetland around Christchurch that provide some wetland bird habitat.

3.3.3 Providing Habitat for Bush Birds

Harsh winter conditions prompt bush birds to fly down from Port Hills bush reserves into the city, where they seek food in local parks and gardens. An observer standing on the hills above Christchurch can see that the city's parks and gardens merge into a large woodland.

By increasing the amount of suitable vegetation in gardens, and by adding trees and shrubs that produce food in winter, it is possible to turn Christchurch woodland into a food-filled forest for native birds.

Table 3-7: Demonstration sites for wetland bird habitat. Refer to the Wetland Bird brochure, available from the Christchurch City Council, for further information.

Site	Location
Erica Reserve	Grants Road, Papanui (Figure 3-10)
Wigram Retention Basin	Access off Warren Crescent, Hillmorton (note: no mature trees at present)
Janet Stewart Reserve	Corner of Marshland and Lower Styx Roads, Marshlands
Avon Loop	Avon River/Ōtākaroro; between Barbados Street and Fitzgerald Avenue, Central City East
Corsers Stream	Brooker Avenue; off New Brighton Road, Burwood
Angela Stream	Travis County Estates; frontage of Travis Wetland, Travis Road, Burwood

Native plant species provide food that helps birds to survive during winter (Table 3-8), whereas most introduced species do not bear fruit during this season. Using Table 3-8, plant a range of native species so that fruit is available all year. Plant native trees in patches near other plantings on adjacent properties to maximise the "patch size" of habitats in a neighbourhood. Some introduced plants such as cherry, rowan, apple, plum, tree lucerne, strawberry tree, gum, wattle, and banksia also provide food and habitat for native birds.

For native vegetation to be useful to native birds, plantings should be of reasonable size and create a closely linked system of vegetated areas throughout the city and surrounding area. To establish these green links, create new native areas near existing ones.

Kereru (wood pigeon) are vegetarian, while bellbird and silvereye eat insects as well as fruit, flowers, and leaves. Fruit is an especially important energy source because of its high sugar content. Fantail, grey warbler, and shining cuckoo eat insects, moths, caterpillars, and spiders that are often found only in native vegetation.

Table 3-8: Fruit and flowering table for native plants.

Plants		Nectar and Fruit Availability											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
harakeke, New Zealand flax (*Phormium tenax*)	D	nectar										nectar	nectar
hinau (*Elaeocarpus dentatus*)			fruit	fruit	fruit	fruit							
horoeka, lancewood (*Pseudopanax crassifolius*)	S	nectar	nectar		fruit	fruit	fruit	fruit	fruit	fruit			nectar
horopito, peppertree (*Pseudowintera colorata*)				fruit	fruit	fruit	fruit		nectar	nectar	nectar	nectar	nectar
houhere, houi, narrow-leaved lacebark (*Hoheria angustifolia*)	D	nectar	nectar										
kahikatea, white pine (*Dacrycarpus dacrydioides*)	W, S			fruit	fruit	fruit							
kaikomako (*Pennantia corymbosa*)		nectar	fruit	fruit	fruit	fruit						nectar	nectar
kanuka (*Kunzea ericoides*)	D	nectar										nectar	nectar
kapuka, broadleaf (*Griselinia littoralis*)	S			fruit	fruit	fruit	fruit			nectar	nectar	nectar	
karamu (*Coprosma robusta*)	W, S		fruit	fruit	fruit	fruit	fruit	fruit	fruit				
karamu (shining) (*Coprosma lucida*)	W, S			fruit	fruit	fruit							
kawa kawa (*Macropiper excelsum*)	F	nectar	fruit	fruit	fruit	fruit							nectar
kohuhu (*Pittosporum tenuifolium*)				fruit	fruit	fruit	fruit	fruit		nectar	nectar	nectar	
kotukutuku, tree fuchsia (*Fuchsia excorticata*)		both	fruit	fruit	fruit	fruit					nectar	nectar	nectar / both
kowhai (*Sophora microphylla*)	D										nectar	nectar	
lemonwood (*Pittosporum eugenioides*)	#					fruit	fruit	fruit	fruit	fruit	nectar	nectar	
mahoe (*Melicytus ramiflorus*)	S, F	nectar	nectar / both	fruit	fruit	fruit							nectar
makomako, wineberry (*Aristotelia serrata*)	S	fruit	fruit	fruit	fruit							nectar	nectar
manatu, lowland ribbonwood (*Plagianthus regius*)	D										nectar	nectar	
mapou (*Myrsine australis*)	#		fruit	fruit	fruit	both	both	both					
matai, black pine (*Prumnopitys taxifolia*)	W, S, #			fruit	fruit	fruit	fruit	fruit					
mikimiki, small-leaved Coprosmas	W, S	fruit	fruit	fruit	fruit	fruit	fruit	fruit					fruit
ngaio (*Myoporum laetum*)		nectar	nectar / fruit	fruit	fruit	fruit	fruit					nectar	nectar
pate (*Schefflera digitata*)	F	nectar			fruit	fruit	fruit	fruit	fruit	fruit			nectar
pokaka (*Elaeocarpus hookerianus*)				fruit	fruit	fruit						nectar	nectar
putaputaweta, marbleleaf (*Carpodetus serratus*)	#	nectar	fruit	fruit	fruit	fruit	fruit	fruit					nectar
rohutu, NZ myrtle (*Lophomyrtus obcordata*)		nectar	nectar	nectar	fruit	fruit	fruit	fruit					
tataramoa, bush lawyer (*Rubus cissoides*)		fruit	fruit	fruit							nectar	nectar	
ti kouka, cabbage tree (*Cordyline australis*)				fruit	fruit	fruit	fruit	fruit				nectar	nectar
titoki (*Alectryon excelsum*)	S, F, #	both	both	both	fruit	fruit	fruit					nectar / both	both
totara (*Podocarpus totara*)	W, S		fruit	fruit	fruit	fruit	fruit						
weeping mapou (*Myrsine divaricata*)	S, #		fruit	fruit	fruit	fruit			nectar	nectar			
whauwhaupaku, five finger (*Pseudopanax arboreus, Pseudapanax anomalus*)	S		fruit	fruit	fruit	fruit	fruit	both	both	both	both / nectar	nectar	

Key

D = dry fruit
F = frost tender
W = wind pollinated
S = male & female flowers on separate plants
# = fruit takes 9 months to ripen
fruit = ripe fruit
nectar = nectar available
both = both

Information collated from Allan (1982), Wilson & Galloway (1993), and Burrows (1994).

3.3.4 Riparian Habitats as Wildlife Corridors

The long, sinuous, unbroken character of many waterways encourages birds to use them as movement corridors. Wetland birds move up and down the waterway itself, while land birds travel through and forage within riparian habitats. While many native birds are able to move between habitat patches, they usually prefer continuous wooded waterway margins that facilitate their dispersion through the city.

Willows and other exotic trees are the dominant tall vegetation along Christchurch waterways. Although exotics can serve as wildlife corridors (e.g. bellbirds fly along the Heathcote/Ōpāwaho River), many exotics lose foliage during the crucial autumn and winter months, severely limiting their habitat potential. Fruit and nectar sources are also missing from most exotic trees, and those that do produce suitable fruit do not bear them through winter. Establishing indigenous vegetation along waterways, especially those that provide food (Table 3-8) and nesting sites for native birds, will help to increase native bird populations.

Figure 3-11: Many insects found in the riparian zone, like this damselfly (Austrolestes), *have a terrestrial adult stage and an aquatic larval stage (inset).*

Figure 3-12: The riparian zone provides predation sites for predatory invertebrates, like this praying mantis (Orthodera novaezealandiae). *The consumption of the adult stage of aquatic invertebrates, by terrestrial predators such as this praying mantis, will create an energy link between stream food webs and terrestrial food webs.*

3.4 Terrestrial Invertebrates and Their Habitat

There has been little detailed research on terrestrial invertebrates found in the riparian zone, even though they form an important food source for many organisms and represent one of the greatest levels of biodiversity. Understanding invertebrate diversity and habitat requirements will assist in restoring their habitat. Monson & Emberson (2001) provide information on selected native terrestrial invertebrates found in Christchurch with different ecological roles.

There is a close relationship between the instream environment and surrounding terrestrial environment for terrestrial insects that have an aquatic larval stage (Figure 3-11). Their adult terrestrial stage can last for varying periods, from a few days to a few months. Vegetation is important to this terrestrial adult life phase, as adult survival and fecundity during this time can effect the population dynamics.

Riparian zones can perform several functions for terrestrial invertebrates (Collier & Scarsbrook 2000):

- Completion of metamorphosis.
- Sites for mating.
- Provide refuge areas from predators, especially during moulting.
- Provide refuge from high air temperatures for invertebrates that require cooler temperatures (e.g. adult stoneflies prefer temperatures < 22–23 °C).
- Food sources for adults to allow development and maturation of eggs, or to supply energy required for dispersal flight (the exception is mayflies, which have a non-feeding adult stage). Food sources used by insects include algae, fungi, lichen, bark, rotten wood, nectar, and honeydew.
- Predation sites for birds, spiders, and predatory insects (Figure 3-12), which provide an energy link from the stream to terrestrial food webs.

3.4.1 Planting for Terrestrial Invertebrates

Different plant species will support a different composition and number of invertebrates, so diverse planting is recommended. While there is insufficient information to recommend specific plant species, Macfarlane (1999) suggests species that suffer more insect damage (e.g. five finger, kawakawa), may be more appropriate to integrate into plantings than species which suffer little damage (e.g. akeake).

Both monitoring and research will contribute to determining which plant species are most beneficial for invertebrates, as well as the impact of mulching and weed control on ground-dwelling invertebrates.

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