

# A national biodiversity hot-spot from the treatment of urban wastewater — the Bromley Oxidation Ponds and Te Huingi Manu Wildlife Refuge, Christchurch

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## ABSTRACT

In pre-European times, the extensive wetlands of Christchurch/Otautahi supported tens of thousands of resident and migratory wetland birds. The annual lifecycle of many species involved a period either breeding, moulting, wintering, or transiting through the Christchurch area. The development of a city and its surrounding agricultural hinterland completely transformed the pre-European landscape to the point where more than 90% of local wetland area was destroyed. However, wetland birds have proven to be highly resilient with many species continuing to breed locally or occurring as seasonal visitors. Currently, peak numbers of wetland birds using Christchurch waterways and wetlands exceed 40 000 individuals of more than 45 species. Many of these wetland birds utilise human-created (artificial) habitat and up to half of them congregate at one site, the Bromley Oxidation Ponds.

The 240 ha Bromley Oxidation Ponds and c. 100 ha of surrounding pastureland comprise the Te Huingi Manu Wildlife Refuge. The site is located adjacent to the western shoreline of the Avon-Heathcote Estuary and is managed by the Christchurch City Council. The primary function of the oxidation ponds is to treat the wastewater generated by a city of 350 000 people. However, an important secondary function is to provide breeding, feeding and roosting opportunities for wetland birds. Currently some 5000 New Zealand scaup (*Aythya novaeseelandiae*), comprising 15–20% of the World population, 7000 Australasian shoveler (*Anas rhynchos*), 4000 grey teal (*Anas gracilis*), 2500 paradise shelduck (*Tadorna variegata*), 2500 Canada goose (*Branta canadensis*) and 1000 black swan (*Cygnus atratus*) moult or winter on the Bromley Oxidation Ponds, establishing the site as one of New Zealand's most important sites for waterfowl.

Three of the six ponds have well-vegetated islands, which provide nesting habitat for eight species of waterfowl and three species of cormorant. A predator control programme in place since 1997 and an abundant source of food in the form of aquatic invertebrates combine to produce high rates of breeding success. 150–200 pairs of the endemic New Zealand scaup breed annually on the ponds, producing more than 1000 fledglings. These have spread to recolonise waterways throughout Christchurch and the Canterbury Plains, leading to an unprecedented population recovery in this once near-threatened species over the last 10 years.

## INTRODUCTION

Christchurch City and nearby Lake Ellesmere occupy a central nodal point on the east coast of the South Island that has, for many thousands of years, been a major centre for bird life. In pre-European times the interconnected network of wetlands located between the Rakaia River mouth in the south and the Waipara River mouth in the north constituted one of the largest expanses of lowland wetland

in New Zealand (Turbott 1969). Elsewhere in the South Island, the ranges and mountains comprising the Southern Alps, Kaikouras and eastern foothills extend in an arc north to south from Marlborough to Southland. Throughout these mountains, and within their associated river catchments, lakes, tarns and grasslands are found large breeding populations of wetland birds. No doubt for thousands of

<sup>1</sup> Editor's note: now known as the Greenspace Unit.

years and continuing into the present day, tens of thousands of wetland birds fly down to the coastal lowlands from inland breeding areas following the end of the breeding season and congregate in the Christchurch-Lake Ellesmere area. Some use the Christchurch-Lake Ellesmere area as a moulting site, some as a migration transit stop and others as a post-breeding dispersal or wintering site.

Consequently, in this part of New Zealand there are major seasonal movements of wetland birds migrating from river systems, inland grasslands and mountains to the coastal lowlands. These birds congregate at the small number of coastal wetlands on the east coast of the South Island, and many subsequently migrate northwards to the northern South Island and to the North Island (Owen 1992). It is estimated for example that 20–50% of the total population of South Island Pied Oystercatcher pass through Christchurch on migration (Crossland 1993) and 75% of New Zealand Shoveler pass through Lake Ellesmere annually (Williams 1982; O'Donnell 1985).

From early December onwards, and lasting to June/July when birds begin to return to their breeding grounds, Christchurch experiences a massive annual influx of wetland birds. Peak numbers surpass 40 000 individuals, comprising more than 45 regularly occurring species. Collectively, Christchurch urban and peri-urban habitats support a wetland bird population that is comparable to those found in some of New Zealand's most important wetland systems such as Farewell Spit and large harbours of the northern North Island.

Christchurch City also has one of the highest avian biodiversities of any part of the country, whether an urban or wilderness area. There have been more than 160 bird species recorded here since 1850 and some 91 species are annual or near-annual visitors to Christchurch City and its coastal waters (Crossland 2004). This should not be a surprise as Christchurch has a wide range of habitats as diverse as any area of comparative size in the country. Within an area of c. 450 km<sup>2</sup> are two tidal estuaries; rocky, sandy and stony shorelines; coastal cliffs; sandspits, dunelands, tidal and

freshwater wetlands of various kinds; spring-fed waterways; a large braided river; a range of volcanic hills; sub-alpine tussock grasslands; dry plains native grasslands; lowland wet grasslands; pasture and croplands; tree plantations; mixed native/exotic woodlands; native forest and regenerating bush; gardens, parks and a great variety of urban environments (CCC 2000).

Prior to European settlement in 1850, much of the area now occupied by the city was covered in wetlands of various types. In contrast, the Christchurch environment of today is highly urbanised — the central city is arranged in a grid pattern and the suburbs sprawl in all directions. However, throughout the city there remain significant habitat patches, some of which are of relatively large size. These include the Botanic Gardens and Hagley Park in the centre of the city, Riccarton Bush, Travis Wetland (a major freshwater wetland in north eastern Christchurch), Styx Mill Basin, Bottle Lake and Kainga Forests, the Waimakariri River (one of New Zealand's largest braided rivers), Brooklands Lagoon and the Avon/Heathcote estuary area (two estuaries on the eastern side of Christchurch).

### **BROMLEY OXIDATION PONDS AND TE HUINGI MANU WILDLIFE REFUGE**

The focus of this paper is the Bromley Oxidation Ponds, and the surrounding farmland, which together comprise the Te Huingi Manu Wildlife Refuge. This area is a human-constructed habitat. Until the late 1950s it was an area of the old sewage treatment farm, where the sewage of the city was dumped in paddocks and semi-natural lagoons, and ultimately let out to the estuary after a basic level of treatment. Later, in 1962 the old sewage farm was replaced by large constructed oxidation ponds, in common with many other major cities.

When the Christchurch oxidation ponds were designed and constructed at Bromley, the planners and engineers of the day had the foresight to incorporate a wildlife habitat element in addition to the primary function of treating wastewater. The oxidation ponds were built in an area of old dunes and swampland on the western

shoreline of the Avon-Heathcote Estuary. The tops of sand dunes were retained as islands and planted up with trees and dense shrubbery. A few swampy areas were retained along the estuary shoreline, however most of the swampland in basins between the old dunes were lost.

Wetland birds were quick to colonise the newly created oxidation ponds, particularly migratory and wintering species. Having lost their natural habitats, many species took up the newly created habitats available to them in and around the oxidation ponds. Bird counts were started almost immediately with Fish and Game (or the Acclimatisation Society as they were then known) conducting regular bird surveys to monitor waterfowl numbers from 1962 onwards (NCAS 1962 to the present). Since the early 1980s, I have maintained a monitoring programme regularly undertaking counts of wetland birds and producing detailed information on the populations that live at these ponds (e.g., Crossland 1993, 1999).

Currently, the Bromley Oxidation ponds comprise a series of six ponds. They are aligned into two parallel lines of three ponds, with wastewater entering from the metropolitan sewage treatment plant on the western side and discharging into the estuary on the eastern side. The first two ponds are large and open without any islands. Water quality is relatively poor as they receive the wastewater newly discharged from the treatment plant. Consequently, bird numbers on these two ponds are relatively low. The discharge then flows through to the four ponds closest to the estuary. The water quality progressively improves as the treatment process nears completion and wastewater reaches the discharge points. These four ponds, closest to the estuary and with better water quality, support very large numbers of birds — in fact peak numbers of more than 15 000 waterfowl and 3000 other species (cormorants, gulls, terns, swallows, spoonbills, herons, kingfisher, coot, pūkeko, etc.) have been regularly recorded (Fig. 1 & 2). What is remarkable about the Bromley Oxidation Ponds is that of those 15 000 waterfowl, only 2000 to 4000 are introduced birds — e.g., mallards and Canada geese — the rest are all native.

Currently, the effluent is discharged into the Avon-Heathcote Estuary after treatment. However, this practice will soon cease. The treatment of Christchurch's wastewater has been the focus of a major consultation process over the last few years, and as a result, the oxidation ponds will soon change from a complex of six ponds (in two parallel series of three), into a seven series link of ponds with a piped outfall which will bypass the estuary and discharge into the sea.

Although nutrients from the oxidation pond discharge have greatly enriched the Avon-Heathcote Estuary (Owen 1992), it is anticipated that the cessation of discharge into the estuary will not adversely affect the abundance of most bird species. The oxidation ponds will be retained and enhanced, guaranteeing habitat for species such as scaup and shoveler which strongly depend on them. Conversely, many of the bird species found in the estuary do not need the oxidation ponds, but together the two habitats combine to support large populations.

In addition to the 15 000 or so birds on the Bromley ponds, there are approximately that many again in the estuary. At peak times, more than 32 000 wetland birds occur in this combined area of c. 10 km<sup>2</sup> — one of the highest densities of wetland birds found anywhere in New Zealand.

#### **AUSTRALASIAN SHOVELER (ANAS RHYNCHOTIS)**

The most abundant bird now found on the oxidation ponds — in fact the most abundant native waterfowl species in Christchurch — is the Australasian shoveler. Large flocks, peaking annually at 5000 to 7000 birds occur on the oxidation ponds for about eight months of the year, and in total over 8000 Shoveler occur on the wetlands and waterways of Christchurch.

For more than 20 years, waterfowl researchers have been searching for the elusive moulting grounds of shoveler. This species tends to congregate in certain selected sites where they moult their flight feathers and are unable to fly for a period. During the 1970s and early

1980s four moulting sites were discovered — two in the North Island and two in the South Island. All moulting sites were characterised by their remoteness, lack of human disturbance, and by the presence of dense, emergent vegetation (Caithness et al. 2002). After a gap of two decades, Department of Conservation researchers recently discovered large numbers of shoveler moulting on the Bromley Oxidation ponds, thereby identifying Bromley as the fifth known New Zealand moulting site and the only human-created site in the world where any of the four species of shoveler are known to moult.

### **GREY TEAL (*ANAS GRACILIS*)**

The next most abundant species at the Bromley Oxidation Ponds is the grey teal. The New Zealand population of this species seems to have increased greatly over the last few years. In 2003, there have been many more grey teal than usual on wetlands in the Christchurch area and reportedly in other parts of New Zealand. Up to 4000 of these birds were present on the Bromley Oxidation Ponds and Avon-Heathcote Estuary in autumn/winter 2003, whereas during the past 20 years numbers have not exceeded 2000 birds. It is possible that this increase may involve a recent influx of birds from Australia as occurred in a well-documented invasion during 1957 (Falla et al. 1978). Every few years in Australia, a major rainfall event occurs in the interior. This causes the central lakes to fill, which in turn results in a movement of birds inland to take advantage of the ideal breeding conditions (Kingsford & Norman 2002). Two or three years later a drought hits — as occurred in 2002 — and there is an exodus of birds from the interior to coastal regions. This radiating exodus of birds often continues beyond the continent's margins with influxes of birds reaching Tasmania, the eastern Indonesia, Timor, Papua New Guinea, and across the Tasman Sea to New Caledonia, Norfolk Island and New Zealand.

In support of the theory that the apparent sudden increase in grey teal numbers may have involved an influx from Australia are sightings of other Australian waterbirds in New Zealand this year (2003). A similar species, the chestnut teal (*Anas castanea*), has turned

up in parts of the North Island, while in the Christchurch area the chestnut-breasted shelduck (*Tadorna tadornoides*), an Australian cousin of the paradise shelduck (*Tadorna variegata*) has been recorded at both the Bromley Oxidation Ponds and on the Kaiapoi Oxidation Ponds.

### **NEW ZEALAND SCAUP (*AYTHYA NOVAESEELANDIAE*)**

The greatest success story at Bromley is the population recovery of the endemic New Zealand scaup (Fig. 3).

In the mid-1980s there were no more than 200 scaup on Christchurch waterways. This species had undergone 130 years of decline in the face of hunting, habitat loss and predation. Much of the literature states that scaup in the South Island have retreated to high country lakes, and are not supposed to be able to recolonise shallow lowland waterways because of competition with dabbling ducks (e.g., Williams 1963, 1985). During the 1990s and 2000s this species appears to have broken all the rules and the Christchurch population has undergone a 30-fold increase from 200 birds to almost 6000.

In 1991, the first pair of scaup were observed nesting in the oxidation ponds. In 2002, more than 200 pairs bred and produced more than 1000 young.

The oxidation ponds have had a predator control programme in place since 1997. The area could be viewed as a 'wet mainland island'. Rats, mustelids, feral cats and domestic animals are all controlled, aiming to prevent predation of eggs, chicks, fledglings, and adult birds on nests. At the same time, the oxidation ponds have abundant food for scaup in the form of midges and their larvae. The adult scaup have a dozen islands on which to nest and more than 200 ha of ponds to raise their young. There is predator control, minimal disturbance and an abundant food supply. These conditions combine to generate an enormously productive breeding population, which has been the powerhouse behind the recolonisation of Christchurch waterways, and now a recolonisation of the Canterbury hinterland.

For the first time in a century, scaup are widespread and abundant on Christchurch ponds and waterways. Furthermore, they have expanded their habitat preference to include shallow water, flowing water, and latterly even salt water. The scaup population has recovered to the point where 20% of the estimated world population occur on Christchurch urban waterways. Further afield, they are spreading over the Canterbury Plains and wintering flocks have recently returned to Lakes Ellesmere and Forsyth, where they had not been seen for many decades. I suspect that it is unprecedented — or one of the few cases in the world — where an endemic waterbird has increased and undertaken such rapid and large-scale population recovery generated from within an urban environment. Most instances where native waterbirds have restored their populations are in some wilderness area where they are fully protected, but in this case scaup have done it here in an urban environment, in the city.

#### **PARADISE SHELDUCK (*TADORNA VARIEGATA*)**

Following close on the population recovery heels of scaup are other waterbirds, most notably the paradise shelduck. These birds breed as separate pairs in farmland and riparian areas all over the Canterbury hinterland. Then, in late December through January to early February, they congregate on large open water bodies to moult. At this time, some 2500 paradise shelduck form a large moulting flock at the Bromley Oxidation Ponds.

When paradise shelduck leave the moulting ground, they tend to spend another two to three months in the general Christchurch area, visiting other ponds, wetlands and grasslands. In fact, what has happened in the last few years is that paradise shelduck have become bolder and are including suburban parks, playing fields, river banks and gardens in the range of habitats they visit. Some have stayed in the city to breed (where they nest in holes in exotic trees, and even in roof-tops and old chimneys). Paradise shelduck are now even taking up residence beside public swimming pools (Fig. 4)!

#### **GREY DUCK (*ANAS SUPERCILIOSA*)**

Another bird that was recently rediscovered, and one that was a surprise, is the grey duck. The effective decline of this bird has been overlooked in this country for many decades, through its hybridisation with the introduced mallard (*Anas platyrhynchos*). Christchurch, and in particular its Botanic Gardens, is held up as the ultimate example where these duck hybrids are found, and a number of books published on New Zealand birds discuss this fact (e.g., Falla et al. 1978).

What we have discovered is, like other native birds that come into Bromley from remote areas after the breeding season (from banding data we know that many of the shoveler come from Southland, and many of the Canada geese come from the headwaters of the Waimakariri River), pure grey ducks also come into Christchurch. Large numbers of these birds arrive at the oxidation ponds and moult, just like the shoveler.

I have confirmed their identity by examining preyed-upon grey duck that have been killed by harrier hawks. There are about five or six major features to identify grey ducks, including plumage, feather features, and feet colour. Maybe for arguments sake they are only 92% pure, and perhaps there are no totally pure-breed grey ducks left, but we do have the opportunity at Bromley to conserve these phenotypically true-to-type birds and to help them in the future to recover their populations.

One way we can do this is to reduce the numbers of mallard. The trend over the last 20 years has been declining numbers of mallard using the oxidation ponds. When I first began counting birds at Bromley in the mid-1980s there were more than 6000–7000 mallard at peak times. Now there are no more than 1000–1500. For typical counts of 15 000 waterfowl (swans, geese and ducks), most are native and only 2000–4000 are introduced. This is a real reversal of a long-term trend in Christchurch.

The big problem with management of mallard ducks is that people like to feed them, and apart from defecating in the water and making it unsafe to swim they also tend to dominate the

waterways. In Christchurch, we are being more proactive, and trying to discourage people from feeding the mallards and trying to encourage native waterfowl to take over the waterways. This seems to be succeeding. Again, it is the large population of native waterfowl at Bromley that makes this possible; it's the engine that's driving the recolonisation of native waterbirds across the city and the wider Central Canterbury hinterland.

### **PROBLEM BIRDS — CANADA GEESE (*BRANTA CANADENSIS*) AND BLACK SWAN (*CYGNUS ATRATUS*)**

We do have some problems with birds. The Bromley Oxidation Ponds and adjacent estuary and farm paddocks tend to attract large flocks of Canada geese. Upwards of 2500 birds occur in autumn/winter, with another 1000 or more at nearby Travis Wetland. Limiting numbers is difficult as the bulk of the population are seasonal migrants from the South Island High Country. In the late 1990s, there were some much-publicised problems with an attempted cull, causing a hugely negative public response. As a consequence, the City Manager at the time directed that there would be no more shooting of geese on council land in Christchurch, and over the intervening years the numbers have built up.

Now, the Christchurch City Council is looking at constructive ways of working with Fish and Game, the Department of Conservation, Environment Canterbury, and other organisations to try to reduce their numbers in an acceptable manner. Our latest thinking is that it may be appropriate to utilise council land as a sacrificial crop for geese, drawing them into our reserves and keeping them away from private pastures and agricultural land where they have the potential to cause substantial economic damage. Furthermore, in some of our lowland wet grasslands we have found that flocks of Canada geese are actually more effective than cattle and more cost-efficient than hand mowing in maintaining a grass sward height around springs and pools which is ideal for other wetland birds. Nutrient enrichment problems do not seem much different from those generated by cattle and the problem of cattle pugging soft wetland soils is avoided.

The black swan is another common bird on the Bromley Oxidation Ponds. Many people may not realise that they have recently been reclassified as an indigenous bird. South of Christchurch, black swan congregate in large numbers at Lake Ellesmere. However, when conditions there are unfavourable (i.e., lake levels are too high or too low) and feeding conditions deteriorate, large numbers of swans move to Christchurch wetlands. They follow a major bird migration flyway which follows the east coast of the South Island, bypasses Banks Peninsula and passes parallel to the Port Hills over south and eastern Christchurch (Fig. 5). There can be as many as 1000 black swans on the Bromley Oxidation Ponds and adjacent estuary at times when Lake Ellesmere is unsuitable. However, when conditions are favourable at Lake Ellesmere, numbers at Bromley may fall to only 200 or so.

### **CORMORANTS AND SHAGS**

An often-overlooked aspect of avian biodiversity in this country — and one that is particularly relevant in cities — is the enormous diversity of our cormorants and shags. New Zealand has some 12 to 14 species, compared to five in Australia, five in North America and just two in Northern Europe. In Christchurch, five different species occur with total numbers exceeding 3000 individuals. Three species — black cormorant (*Phalacrocorax carbo*), pied cormorant (*Phalacrocorax varius*) and little cormorant (*Phalacrocorax melanoleucos*) have breeding colonies in Bromley Oxidation Ponds, while spotted shags (*Stictocarbo punctatus*) have large colonies on cliffs at nearby Scarborough and Godley Head.

Pied cormorants were shot out of existence through Canterbury and Otago last century (Stead 1927, 1932). In the early 1950s a small colony became established in trees at the mouth of the Motunau River, which is about 150 km north of Christchurch. By the mid-1980s that colony had expanded to 200 or more birds, and during winter months birds began to visit the oxidation ponds and the estuary.

In 1989 there was a major windstorm in Christchurch and some of the pine trees on

one of the islands in the oxidation ponds, where black cormorants nested were toppled, leading to the transfer of the colony to a larger stand of trees on an adjacent island. Pied cormorants began to roost with them and shortly after commenced nesting also. The colony has quickly grown to c. 200 black and c. 250 pied cormorants. From this breeding station at Bromley, the pied cormorant has now recolonised Pegasus Bay and Banks Peninsula right down to the mouth of the Rakaia River. While the pied cormorants are mainly coastal and estuarine feeders, the black cormorants range widely over coastal and inland habitats. Every morning about half of the colony fly over south-eastern Christchurch to Lake Ellesmere — a 30–40 km trip. My observation base is up on Victoria Park, about 300 m above sea level on the Port Hills, and I have seen flocks of as many as 48 birds spiralling on the thermals, passing over every day.

Another bird that has become part of Christchurch's airspace is the little cormorant. One colony is at Bromley and three other colonies are in different parts of the city, including the Botanic Gardens. These birds have now reoccupied most of Christchurch's waterways. The whole piscivore cormorant guild, the whole fish-eating guild, has come back to our waterways and these birds can be seen flying over all the quarters of the city now.

#### OTHER BIRD SPECIES

Proper management of oxidation ponds, apart from other aspects such as maintenance of water quality, also involves the periodic drawing down of ponds — i.e., draining the water and clearing out the deposited silt. Where possible, the timing of this at the Bromley operation coincides with the time of year that migratory wading birds are passing through. Species such as Arctic-breeding sandpipers and native stilts and plovers are then attracted to the shallow, wet pond/mudflat habitat created. Migratory species use these drawn down ponds as feeding and roosting habitat while native waders and waterfowl often nest.

In recent years new habitat types have been created for birds in the oxidation ponds.

For example, we have created new islands designed to attract nesting coastal birds, including threatened species such as black-fronted terns (*Sterna albostratus*), white-fronted tern (*Sterna striata*), Caspian tern (*Sterna caspia*) and black-billed gull (*Larus bulleri*).

#### CONCLUDING REMARKS

The Bromley Oxidation Ponds and adjacent lowland wet grassland farm paddocks (together comprising the Te Huingi Manu Wildlife Refuge) combined with the Avon-Heathcote Estuary are a major hot-spot for avian biodiversity — significant not just for Christchurch but for bird populations of national and international importance.

Successful long-term management of the area will require an integrated approach which fully understands the habitat and seasonal requirements of birds and balances these needs with human demands, including the requirement to treat waste water and in the wider estuary area to provide a recreational resource for the people of Christchurch.

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**Fig. 1** Waterfowl and royal spoonbills (*Platalea regia*) at Bromley Oxidation Ponds. (Photo: A. Crossland).



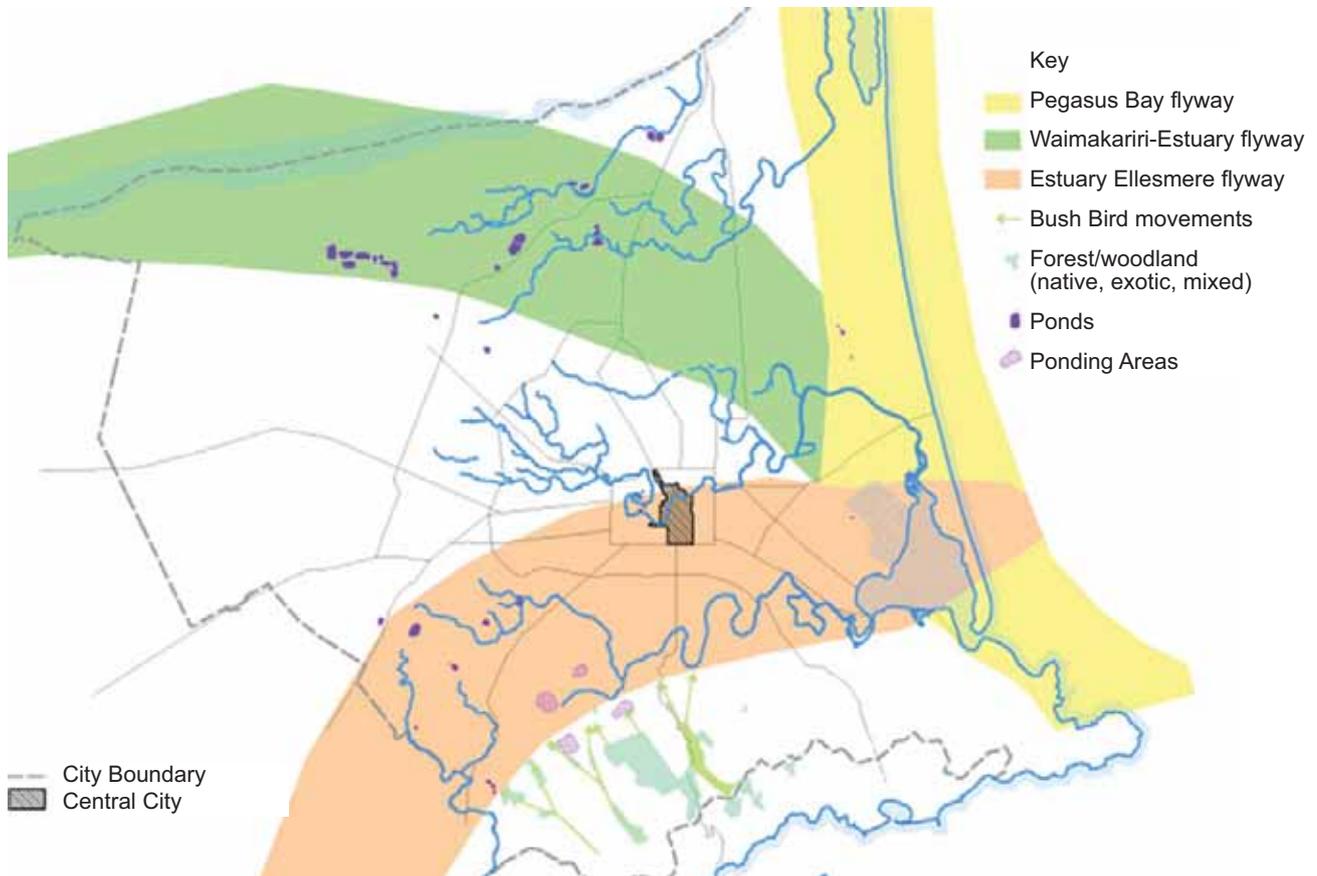
**Fig. 2** New Zealand shoveler (*Anas rhynchos*), grey teal (*Anas gracilis*), New Zealand scaup (*Aythya novaeseelandiae*) and mallard (*Anas platyrhynchos*) flocking at the Bromley Oxidation Ponds. (Photo: A. Crossland).



**Fig. 3** New Zealand scaup (*Aythya novaeseelandiae*). (Photo: A. Crossland).



**Fig. 4** Paradise shelduck (*Tadorna variegata*) on a swimming pool in metropolitan Christchurch. (Photo: A. Crossland).



**Fig. 5** Bird migration flyways over Christchurch and surrounds.