Bird species of concern at wind farms in New Zealand

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ABSTRACT

Wind generation currently contributes about 1.5% of New Zealand's energy production, but the forecast rapid expansion in wind farm construction is likely to take this to close to 20% over the next 10 years. To date, no published studies are available giving accounts of the impacts of wind farms on birdlife in New Zealand; therefore, part of the challenge is to determine which species are likely to be adversely affected by wind farm construction and operation here. This resource document provides a brief summary of the threat ranking, distribution and movements of native and migrant bird species on the North and South Islands of New Zealand, and the potential impacts that wind farms may have on them (displacement, habitat loss and collision fatalities). The following species warrant particular consideration when present as residents in the vicinity of a wind farm, or when likely to be moving through a wind farm area on migration or during local movements: all kiwi, Australasian crested grebe (*Podiceps cristatus*), all penguins, threatened species of herons and allies, blue duck (*Hymenolaimus malacorhynchos*), brown teal (*Anas aucklandica*), New Zealand falcon (*Falco novaeseelandiae*), waders (Charadrii), and cuckoos. More research is required into the migratory behaviour of several native species to determine which wind farm sites are most likely to result in collision fatalities. In addition, data on the rates of avoidance of wind turbines by birds flying through wind farms is required, especially for those undertaking nocturnal migrations. The number of collision fatalities at New Zealand wind farms needs to be determined using systematic searches that take account of searcher efficiency and scavenger activity.

Keywords: New Zealand, native bird species, threat ranking, distribution, movements, wind farm impacts, collision fatalities, habitat loss, displacement

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1. Introduction

In New Zealand, energy production by wind farms is still in the early stages of development compared with Europe and North America. However, it is poised for rapid expansion in the next 10 years to make a significant contribution to total energy production (Ashby 2004; Rodgers 2006). Thus, it is an opportune time to learn from the adverse effects that wind farms have had on birds elsewhere. Wind farms can have a significant effect on birds through collision fatalities, such as occurred in California in the late 1980s, where large numbers of birds of prey, including threatened species, were killed by wind turbines and their associated structures (Erickson et al. 2001; Smallwood & Thelander 2004). Wind farms may also affect bird populations as a result of habitat loss or disturbance resulting in birds moving to habitat elsewhere. However, while adverse impacts on birds have occurred, many wind farms exist where recorded bird mortality is non-existent or minimal, including facilities in Africa, Asia, Europe, Australia, Canada, USA and South America (Kingsley & Whittam 2005; Percival 2005). For example, in the UK, there had been no significant ornithological problems reported at wind farms in 2005, despite there being 101 wind farms comprising 1234 turbines with a capacity of 979 MW present at that time (Drewitt & Langston 2006); this was mainly because their locations were away from important bird populations and their flight paths (Percival 2005).

Reviews of the impacts of wind farms on birds have concluded that the effects are variable, and can be species-, season- and site-specific (Percival 2000; Langston & Pullan 2003; Kingsley & Whittam 2005; Drewitt & Langston 2006; Powlesland 2009). Therefore, the challenge in New Zealand is to identify which bird species are likely to be adversely affected by wind farms, and the particular features of the environment and wind farm structures that increase the risks to species, so that adverse effects can be avoided or minimised.

One way to avoid adverse impacts to bird populations is through informed wind farm site selection. To enable this, ecological issues at a site need to be evaluated prior to construction. The presence of one or more of several key features, with regard to the birdlife present, have been found to contribute to a site being undesirable for a wind farm (Percival 2000; Langston & Pullan 2003; Kingsley & Whittam 2005; Drewitt & Langston 2006; Powlesland 2009): a high density of birds or high frequency of movements through the site; landscape features that concentrate bird movement; presence of a species prone to collisions with turbines; and/or presence of a species prone to displacement by the presence or motion of turbines or people carrying out maintenance activities. This is particularly important in the case of threatened species (Miskelly et al. 2008), as even a small increase in mortality from collision fatalities (as little as 1% for long-lived species with low productivity) or displacement from scarce habitat can result in a species going into decline (Dierschke et al. 2003, cited in Drewitt & Langston 2008).

The main species groups that have been found to be most often impacted by wind farm developments elsewhere have been swans, geese, ducks, waders, gulls, terns, large soaring raptors, owls and nocturnally migrating passerines (Percival 2000; Langston & Pullan 2003; Stewart et al. 2004; Kingsley & Whittam

2005; Powlesland 2009). However, it needs to be emphasised that the presence of a species belonging to one of these groups at a proposed wind farm site does not necessarily mean that the site will be inappropriate for a wind farm. Rather, it is the characteristics of the site that are important, as adverse impacts have often been found at sites with particular features that attract the species or concentrate its movements through it (Orloff & Flannery 1992; Marti 1995; Erickson et al. 2001).

This report summarises the threat ranking, distribution and movements of native and migratory bird species on the North and South Islands of New Zealand, and the potential impacts wind farms may have on them. It does not include species that are vagrants. This is the second document on the potential impacts of wind farms on birds that has been prepared for Department of Conservation (DOC) staff, and hopefully it will be of use to the wind farm industry too. The first document reviewed international literature on the impacts of wind farms on birds in other countries (Powlesland 2009).

2. Potential impacts of wind farms on New Zealand bird species

There has been no published research on the impacts of operational New Zealand wind farms on birds. In other countries, wind farms have been reported to have three main types of detrimental impacts on birds: collision fatalities, habitat loss and displacement (Powlesland 2009).

Collision fatalities result from birds striking revolving blades, towers, nacelles, and associated powerlines and meteorological masts. There is also evidence of birds being violently forced to the ground by turbulence behind the turbine created by the moving blades (Drewitt & Langston 2008). An important issue is whether or not collision fatalities are sufficiently great in number to cause a population decline (Langston & Pullan 2003; Drewitt & Langston 2008). Even when fatality rates per turbine are low, such mortality can contribute to population decline when wind farms consist of large numbers of turbines (individually or cumulatively). Even relatively small increases in mortality rates (0.5% or more) may have a significant impact on some populations of birds, such as threatened species, or long-lived species with low productivity and slow maturity (Dierschke et al. 2003, cited in Drewitt & Langston 2008; Langston & Pullan 2003).

Wind farm development results in habitat loss for birds (Percival 2000), as a result of land being taken up by turbine bases and access roads, and secondary effects, such as altered hydrology. The presence, motion and/or noise of turbines may deter birds from using areas close to them.

Birds may be disturbed and displaced from wind farm sites as a result of increased activity by people during construction and maintenance, as well as new or improved road access, especially in areas where there was little human activity before the wind farm existed. Roads and bridges may also improve access for predators of ground-dwelling or ground-nesting birds, such as wandering dogs (*Canis lupus*), possums (*Trichosurus vulpecula*) and hedgehogs (*Erinaceus europaeus*).

While the distribution and habitat requirements of most New Zealand species are reasonably well known (Heather & Robertson 2005; Robertson et al. 2007; volumes 1–7 of the Handbook of Australian, New Zealand and Antarctic birds (Marchant & Higgins 1990, 1993; Higgins & Davies 1996; Higgins 1999; Higgins et al. 2001; Higgins & Peter 2002; Higgins et al. 2006)), their movement or migration routes, flight characteristics (e.g. manoeuvrability, altitude under various weather conditions, diurnal versus nocturnal), and reaction to wind turbines (displacement, flight avoidance) are not well known. Therefore, when assessing the likely impact of a proposed wind farm on New Zealand birdlife, wind farm proponents and opponents are presently reliant on results from studies in other countries, while being mindful that reactions of birds to such developments tend to be species-specific.

In the sections that follow, the threat ranking, distribution and movements for each native bird taxon (species, subspecies and those entities as yet without formal taxonomic rank) occurring on the North and South Islands of New Zealand are presented, along with the potential impacts wind farms may have on them. Information is also provided for two species of introduced gamebirds (Canada goose *Branta canadensis* and mallard *Anas platyrhynchos*), because they are widespread through New Zealand, can occur in large flocks during the non-breeding season, and information from other countries suggests that they are likely to be involved in collisions with wind turbines sited near wetlands.

Throughout this document, the threat ranking of each native taxon has been taken from Miskelly et al. (2008). The threat ranking system used by Miskelly et al. (2008) is described in Townsend et al. (2008). The resident native taxa are divided into four super-categories: 'Extinct', 'Threatened', 'At Risk', and 'Not Threatened'. The 'Threatened' and 'At Risk' super-categories are further split into various categories. For Threatened taxa, these are 'Nationally Critical', 'Nationally Endangered' and 'Nationally Vulnerable', and for At Risk taxa they are 'Declining', 'Recovering', 'Relict' and 'Naturally Uncommon'. It is not possible to give a brief description for each of these categories because they are based on more than one parameter (e.g. number of mature individuals, number of sub-populations, area of occupancy, population trend), so that taxa can qualify for a particular conservation ranking by meeting one of several criteria (Townsend et al. 2008). Two additional categories are used for species that may or may not be considered threatened internationally. These are 'Coloniser' (a taxon that arrived in New Zealand without assistance from people and has been successfully reproducing in the wild for less than 50 years), and 'Migrant' (a taxon that predictably and cyclically visits New Zealand as part of its normal life cycle, but does not breed here) (Townsend et al. 2008). Taxa that do not qualify for any of the above categories are regarded as 'Not Threatened'.

All taxa of birds in New Zealand, whether native or introduced, are *absolutely protected* under the Wildlife Act 1953, unless the species is listed on one of Schedules 1–6 of the Act (Anon. 2006), in which case the taxon is not absolutely protected, but has a lower level of protection. A few of the taxa discussed in this report are listed in Schedules 1 or 2. Those taxa listed in Schedule 1 are declared to be *game*. Game species are administered by Fish & Game New Zealand, which has responsibility for managing game bird populations for the benefit of recreational hunters. These taxa are protected, except to holders of current game licences, who may hunt or kill these birds, or have them in their possession, subject to any conditions stated on the licence (Anon. 2006). Taxa listed on Schedule 2 are *partially protected*. This means that if any of these taxa cause injury or damage to land or property, they can be hunted or killed by the occupier of that land, or by anyone else with the occupier's permission; otherwise, they are protected.

2.1 KIWI (FAMILY APTERYGIDAE)

There are five taxa of kiwi on the North and South Islands, all of which are Threatened. The Haast tokoeka (*Apteryx* (Haast)) and the rowi or Okarito brown kiwi (*A. rowi*) have a threat ranking of Nationally Critical, and the Fiordland tokoeka (*A. australis*), great spotted kiwi (*A. haastii*) and North Island brown kiwi (*A. mantelli*) are Nationally Vulnerable. Populations of kiwi can occur from sea level to about 1500 m a.s.l. (Heather & Robertson 2005). Kiwi are patchily distributed from Northland to Fiordland, inhabiting scrub, tussockland, native forest, exotic plantations and swamps. Occasionally, kiwi venture out from native vegetation into adjacent farmland pasture to feed at night (Heather & Robertson 2005). Juveniles sometimes move considerable distances in search of available territories or mates.

Risk of wind farm impacts

Being flightless, kiwi are obviously not at risk of collision with turbine rotors. If a wind farm was built in kiwi habitat and required the clearance of vegetation for roads, turbines and associated structures, it would result in a small proportion of habitat being lost (Fox et al. 2006). It seems unlikely that kiwi would be displaced from tussockland or scrub/forest adjacent to a wind farm as a result of turbine noise, given that they encounter much wind-in-vegetation noise in the various habitats they occupy. Kiwi could fall into pits or trenches dug for the bases of turbines or for cables. Roads to previously inaccessible sites would create the danger of kiwi being hit by vehicles at night, and also allow increased access to people with dogs, which is of concern as wandering dogs are particularly destructive to kiwi populations (Heather & Robertson 2005).

2.2 GREBES (ORDER PODICIPEDIDAE)

The population of the southern crested grebe (*Podiceps cristatus*) is listed as Nationally Vulnerable. This species has a population of about 350 individuals occurring in the South Island (Jensen & Snoyink 2005). Individuals breed mainly on alpine and subalpine lakes of the eastern South Island, particularly in Canterbury and Otago, but a few birds occur on lowland lakes and lagoons along the West Coast and Fiordland. Southern crested grebes make local movements to gather at a few Canterbury upland lakes to moult and overwinter, and then disperse in spring to breed (Sagar & O'Donnell 1982). A variable but significant proportion of the population now moves to Lake Forsyth (Wairewa), near Christchurch, each winter (e.g. 65% in 2006, 40% in 2007; the number probably being related to the extent of ice on high-country lakes), returning to the upland lakes to breed in spring (Pollock 2006).

The New Zealand dabchick (*Poliocephalus rufopectus*) has a threat ranking of Nationally Vulnerable. About 1700 individuals occur in the North Island, mainly on lakes, dams and sewage ponds of Northland, the Volcanic Plateau, eastern provinces from the Bay of Plenty to Wairarapa, and western provinces from southern Taranaki to Wellington (Heather & Robertson 2005). Birds flock during the non-breeding season, often on sewage ponds. Long-distance movements of this species are rarely seen, so it is assumed that they fly mainly at night (Heather & Robertson 2005).

The Australasian little grebe (*Tachybaptus novaehollandiae*), with a threat ranking of Coloniser, was first seen in New Zealand in the 1960s, and has since become well established in Northland (Heather & Robertson 2005). Birds inhabit small lakes and farm ponds. Given the species' recent colonisation of New Zealand from Australia, individuals are quite capable of making occasional extensive movements.

Risk of wind farm impacts

Grebes have suffered few collision fatalities with wind turbines in other countries (Erickson et al. 2001; Kingsley & Whittam 2005). Given the lack of sightings of grebes involved in long-distance flights (Cramp 1977; Marchant & Higgins 1990), it is assumed that all species fly mainly at night. It is therefore possible that all three species would be at risk of collisions with turbines if wind farms were sited near grebe habitat or on their migration routes. Unless turbines were sited in wetlands or resulted in altered hydrology (e.g. flow and quality of water entering a pond or lake), they would be unlikely to result in loss of habitat for these species in New Zealand. However, grebes in Europe have been displaced from wetlands following the construction of turbines close by (Langston & Pullan 2003). It is possible that grebes in New Zealand could be displaced by wind farms built in or close by to occupied habitat.

2.3 ALBATROSSES, PETRELS AND SHEARWATERS (ORDER PROCELLARIIFORMES)

Few colonies of albatrosses, petrels or shearwaters (tube-nosed seabirds) remain on the North and South Islands, although efforts are being made to re-establish colonies of some species by translocation of late-stage nestlings, e.g. Hutton's shearwater (*Puffinus huttoni*) onto Kaikoura Peninsula (G.A. Taylor, National Office, DOC, pers. comm.). Most remaining colonies are found on headlands or coastal cliffs: the northern royal albatross (*Diomedea epomophora*) (Naturally Uncommon) at Taiaroa Head near Dunedin; small colonies of the sooty shearwater (*Puffinus griseus*) (Declining) on Banks Peninsula, Cape Wanbrow near Oamaru, and headlands along the Otago coast and West Coast of the South Island; and small colonies of the grey-faced petrel (*Pterodroma macroptera*) (Not Threatened) on scattered headlands of the northern North Island as far south as New Plymouth on the west coast and Gisborne on the east coast (Heather & Robertson 2005). In contrast, two species fly some distance inland to their colonies: the Hutton's shearwater (*Puffinus huttoni*) (Declining), which flies to the Seaward Kaikoura Range, and the Westland petrel (*Procellaria westlandica*) (Naturally Uncommon), which flies to the coastal foothills of the Paparoa Range. In addition, a few species fly overland between their breeding colonies and feeding areas; for example, Cook's petrels (*Pterodroma cookii*) (Relict) fly across the Northland and Auckland regions at night when flying between Hauturu/Little Barrier Island and the Tasman Sea (Heather & Robertson 2005).

Risk of wind farm impacts

Tube-nosed seabirds have been reported among collision fatalities at a wind farm in Australia. The Woolnorth wind farm, consisting of 62 turbines (1.7–3.0 MW each), is situated on the northwest tip of Tasmania, adjacent to Bass Strait. Construction started in 2002 and was completed in 2007. Seabird collision fatalities up until late 2004 involved five common diving petrels (*Pelecanoides urinatrix*), four short-tailed shearwaters (*Puffinus tenuirostris*), two white-faced storm petrels (*Pelagodroma marina*), one Wilson's storm petrel (*Oceanites oceanicus*), and one fairy prion (*Pachyptila turtur*) (Rae 2005). It is of note that while breeding colonies of the short-tailed shearwater and fairy prion are known of in the general vicinity of the wind farm, and the common diving petrel has been recorded there, neither of the storm petrels has been recorded in the area (Blakers et al. 1984). Seabirds from New Zealand coastal colonies would probably be unlikely to suffer collision fatalities at wind farms unless turbines were erected close to their colonies. However, any turbines erected along the flight paths of species that fly inland would be likely to result in collision fatalities, particularly for the Hutton's shearwater and Westland petrel, which fly to and from their colonies at night, particularly around dusk and dawn. Nocturnal seabirds, especially fledglings, can become disorientated (particularly during periods of fog) and are then prone to being attracted to artificial lights. Thus, lighting on turbines would pose a significant risk to these nocturnally active seabirds if wind farms were sited near their colonies. The flight characteristics of these birds could also increase their risk of colliding with wind farm structures. For example, the northern royal albatross is a bird of soaring flight that flies relatively quickly but with poor manoeuvrability, much like a few species of large soaring raptors that have suffered significant mortality at wind farms elsewhere (Barrios & Rodriguez 2004; Hunt & Hunt 2006). For this reason, even though Taiaroa Head may be suitable for electricity generation from wind, turbines near the colony would present a very high risk of causing collision fatalities for the albatrosses.

Development of a wind farm within a tube-nosed seabird colony may also result in habitat loss. Nest sites (whether surface sites or burrows) could be destroyed as a result of structures being built, especially turbine bases and roads, and any altered hydrology may result in burrows becoming prone to flooding. It is unknown how most tube-nosed seabird species would react to the siting of a wind farm within or close to their breeding colony. However, given that young pairs of northern royal albatross at Taiaroa Head established nest sites out of view of the observatory, probably as a result of people within the observatory being evident to the birds (Robertson 1993), it is possible that some seabird species might be displaced from areas close to turbines that people regularly frequent.

2.4 PENGUINS (ORDER SPHENISCIFORMES)

Four taxa of penguins breed in coastal habitats of the North and South Islands. The yellow-eyed penguin (*Megadyptes antipodes*), whose threat ranking is Nationally Vulnerable, has nesting colonies patchily distributed along the east coast of the South Island, from Banks Peninsula to Bluff (Heather & Robertson 2005). The blue penguin (*Eudyptula minor*) (Declining) has nest sites patchily distributed around both the North and South Islands, while the white-flippered blue penguin (*Eudyptula minor albosignata*) (Nationally Vulnerable) is restricted to coastal areas of Banks Peninsula (Heather & Robertson 2005). The Fiordland crested penguin (*Eudyptes pachyrhynchus*) (Nationally Vulnerable) has nesting colonies in coastal forest of South Westland and Fiordland (Heather & Robertson 2005). Generally, nest sites of these species are less than 500 m inland, although they can be up to 1 km inland (D. Houston, Wellington Conservancy Office, DOC, pers. comm.).

Risk of wind farm impacts

Obviously, penguins are not at risk of collision with turbine rotors. Development of a wind farm within a nesting colony of any of these four penguin taxa would result in loss of habitat, such as nest sites. In addition, the presence, motion and noise of turbines close to nest sites may result in the displacement of wary penguin species, such as the yellow-eyed penguin and Fiordland crested penguin. Blue penguins nest at coastal sites in some towns and cities, and are associated with at least one tourist venture (people watching penguins coming ashore at Oamaru), so the established colonies are unlikely to be displaced by wind farm activities. All four taxa may be vulnerable to falling into pits or trenches dug during wind farm construction.

2.5 GANNETS (FAMILY SULIDAE)

The Australasian gannet (*Morus serrator*) is Not Threatened, being abundant and widespread. Mainland coastal gannet colonies occur at Muriwai near Auckland, Cape Kidnappers near Napier, Waimaru Point in Pelorus Sound, and at the tip of Farewell Spit (Heather & Robertson 2005). The gannet is a relatively large bird (weighing 2.3 kg and having a wingspan of 200 cm; Marchant & Higgins 1990) that spends much time in soaring flight at sea. While gannets also spend a lot of time foraging in coastal waters, including in harbours, estuaries and sounds, they tend not to fly overland other than at their nesting colonies. Gannets favour windy coastal sites for their colonies.

Risk of wind farm impacts

North Atlantic gannets (*Morus bassana*) have been found to collide with turbines (Langston & Pullan 2003). Collision fatalities are likely to have the most detrimental impact on the Australasian gannet as a consequence of a coastal wind farm development, due to the gannet's soaring flight and poor manoeuvrability during light or gale-force winds. Therefore, wind farms should not be sited near gannet colonies. The species would suffer moderate habitat loss if a wind farm development necessitated nests being removed, such as for road construction. Gannets are generally indifferent to people and artificial structures (Cramp 1977), tolerating people's close approach when nesting (e.g. tourist operations), and roosting and nesting on artificial structures. Therefore, it seems unlikely that gannets would be displaced by wind farms at coastal sites, especially if any wind farm was sited at least a few hundred metres from a colony.

2.6 SHAGS (FAMILY PHALACROCORACIDAE)

Seven species of shag occur in a variety of wetland and coastal habitats on both the North and South Islands.

The black shag (*Phalacrocorax carbo*), which is Naturally Uncommon, occurs at coastal and inland wetlands through the North and South Islands (Heather & Robertson 2005). Black shags will fly several kilometres daily between colonies or their overnight roost sites to reach feeding areas, including making overland flights. While juveniles are known to wander widely, there is no evidence for annual long-distance migration (Sim & Powlesland 1995; Heather & Robertson 2005).

The pied shag (*Phalacrocorax varius*) (Nationally Vulnerable) occurs from Northland to Southland, foraging mainly in coastal waters and harbours. It nests in trees overhanging sheltered coastal waters, and occasionally on artificial structures (Heather & Robertson 2005). In addition, four colonies are known of in trees at inland freshwater lakes: Pupuke, Auckland; Elterwater and Rotorua, Marlborough (Heather & Robertson 2005); and Hakanoa, Huntly (pers. obs.). Pied shags in New Zealand appear to be sedentary, except for some juvenile dispersal along coasts. Individuals make some overland flights from coastal waters to nearby colonies and roost sites, such as from Wellington Harbour to Karori Sanctuary (pers. obs.).

The little black shag (*Phalacrocorax sulcirostris*) (Naturally Uncommon) occurs widely through the North Island, and a few individuals are also seen in the northern South Island each winter (Heather & Robertson 2005). While individuals do forage alone, little black shags usually form flocks of 10–150 birds to herd and feed on schools of small fish in coastal saltwater and inland freshwater habitats. Little black shags disperse widely from colonies in the central North Island after breeding, with flocks reaching Northland and Wellington (Heather & Robertson 2005). Individuals occasionally move overland from coastal waters to overnight roost sites, but routes taken during long-distance movements between breeding and wintering sites are unknown.

The little shag (*Phalacrocorax melanoleucos*) has a threat ranking of Naturally Uncommon. Little shags forage and nest at coastal and inland wetlands through the North and South Islands, and even forage in subalpine lakes (Heather & Robertson 2005). After breeding, little shags congregate at sites with abundant food sources, such as harbours and estuaries (Robertson 1992). The routes taken and flight characteristics (e.g. flight altitude) during movements between breeding and wintering sites are unknown. This species makes overland flights between coastal foraging sites and overnight roost sites (pers. obs.).

The New Zealand king shag (*Leucocarbo carunculatus*) (Nationally Endangered) has a population of about 650 birds, all of which are found in the Marlborough Sounds (Schuckard 2006). The main colonies are situated on small islets, and the birds confine almost all movements (foraging and dispersal) to Pelorus and Queen Charlotte Sounds, and coastal waters nearby.

The Stewart Island shag (*Leucocarbo chalconotus*) (Nationally Vulnerable) occurs from Maukiekie Island, North Otago, to Foveaux Strait and around Stewart Island/Rakiura (Heather & Robertson 2005). Individuals are not known to venture inland, remaining in coastal waters year round. After breeding, some birds disperse to gather in large flocks near the Waitaki River and in Te Waewae Bay (Heather & Robertson 2005).

The spotted shag (*Stictocarbo punctatus*), which is Not Threatened, is patchily distributed at estuaries, harbours and coastal waters of mainland New Zealand, nesting mainly on coastal cliff ledges or rocky islets (Heather & Robertson 2005). Large flocks form after the breeding season, such as are found in the Nelson, Kaikoura and South Canterbury areas. While most birds remain within 200 km of their nesting colonies, some long-distance movements have been recorded (Heather & Robertson 2005). Spotted shags are rarely, if ever, seen flying overland, except adjacent to their breeding colonies.

Risk of wind farm impacts

Although shags have rarely been involved in collisions with wind turbines in other countries (< 0.1 fatalities per turbine per year) (Kingsley & Whittam 2005; Percival 2005), this would need to be verified for New Zealand species if wind farms were to be located beside wetlands and at coastal sites. Since most New Zealand shag species nest on vegetation about or within wetlands, or on cliff ledges or vegetation, there seems little likelihood of wind farm developments impacting shags as a result of habitat loss, unless it resulted in the removal of vegetation supporting a colony. The most likely impact that a wind farm would have on shags would be displacement. At Blyth Harbour wind farm, UK, black shags were displaced from their breakwater roost site during construction of the wind farm, but returned once the farm was operational (Still et al. 1995, cited in Langston & Pullan 2003). It is not known how each of the seven New Zealand species would react to wind farm developments, but it is worth noting that most species occur in harbours that have cities associated with them (e.g. Auckland, Wellington) and often roost on artificial structures, and so seem fairly tolerant of people and their activities and structures. It is not known whether wind farms sited beside wetlands or on ridges that shags fly along or over when moving between nesting colonies and foraging sites would result in shags flying much further each day to go around turbines, and thus impact on breeding success. This could be of particular concern for black shags, little black shags and little shags.

2.7 HERONS AND ALLIES (ORDER CICONIIFORMES)

All seven species of this order that occur on the North and South Islands are considered in this section.

The white-faced heron (*Ardea novaehollandiae*), which is Not Threatened, occurs in a wide variety of mainly lowland habitats, including coastal estuaries, lagoons, rivers, lakes and farmland (Heather & Robertson 2005). Individuals are mainly solitary, but do form loose flocks in winter on damp or flooded pasture and at estuaries. White-faced herons are regarded as sedentary, apart from some movement to coastal estuaries, margins of inland lakes, and damp or flooded pasture outside the breeding season and during droughts (Marchant & Higgins 1990; Heather & Robertson 2005). Routes taken and heights flown during movements between breeding and wintering sites are not known.

The white heron (*Egretta alba*), which has a threat ranking of Nationally Critical, numbers about 100 adults in New Zealand and breeds at just one site—on forest adjacent to the Waitangiroto River in South Westland (Miller 2001). Following breeding, white herons disperse widely, reaching Northland and Southland. Migration routes taken by white herons in New Zealand have not been studied, but the occasional individual has been seen heading well inland, appearing to be taking a direct route over significant ranges (Field 2006; Rowe & Rowe 2006).

The reef heron (*Egretta sacra*) (Nationally Vulnerable) is found in low numbers about much of coastal New Zealand, particularly where mangroves, inlets or rocky shores occur (Heather & Robertson 2005). The main population centres of this species in New Zealand are in Northland, Coromandel and the Marlborough Sounds (Heather & Robertson 2005). While the extent of juvenile dispersal is unknown, adults appear to be sedentary, making localised coastal foraging movements (Edgar 1978).

The cattle egret (*Bubulcus ibis*), which has a threat ranking of Migrant, arrives from eastern Australia mainly during March–May and leaves during October–November (Heather & Robertson 2005). Birds arrive along the western coasts of the North and South Islands, stay for a while to feed, and then move on to congregate at a few favoured sites, where they invariably associate with cattle herds on damp pasture. Favoured sites include locations on the eastern North and South Islands, such as Awaiti (Bay of Plenty), Lake Hatuma (Hawke's Bay), Lake Ellesmere (Te Waihora) (Canterbury), and West Taieri and Stirling (Otago) (Heather & Robertson 2005; Robertson et al. 2007). It is not known which routes birds take during movements through New Zealand, such as from arrival sites to favoured sites.

The nankeen night heron (*Nycticorax caledonicus*) (Coloniser) was first found nesting along the Whanganui River in 1997 (Marsh & Lovei 1997), and its present distribution seems to be restricted to that river system. Birds roost gregariously by day in the dense cover of trees, and disperse at dusk to forage mainly during twilight and at night about wetlands (Heather & Robertson 2005).

The Australasian bittern (*Botaurus poiciloptilus*), which is Nationally Endangered, is widely distributed in the North and South Islands, particularly in Northland, Waikato, the Bay of Plenty, Manawatu, southern Wairarapa and along the West Coast (Heather & Robertson 2005). It favours freshwater wetlands, particularly those providing a dense cover of raupo (*Typha orientalis*) or reeds (Heather & Robertson 2005; Robertson et al. 2007). Bitterns forage mostly at night (Heather & Robertson 2005), and some are thought to move from inland sites to coastal wetlands for autumn and winter (Marchant & Higgins 1990).

The royal spoonbill (*Platalea regia*) has a threat ranking of Naturally Uncommon, but is locally common at several tidal wetlands of the North and South Islands (Heather & Robertson 2005). It is a gregarious species, breeding, feeding and roosting in small flocks. Breeding occurs at Parengarenga Harbour (Northland), Kapiti Island (Wellington), Vernon Lagoons (Marlborough), Maukiekie and Green Islands (Otago), Omaui and Pig Islands (Southland), and Okarito (South Westland) (Heather & Robertson 2005). Following breeding, spoonbills disperse to traditional wintering sites, including Parengarenga, Rangaunu and Whangarei Harbours (Northland), Mangere oxidation ponds (Auckland), Kaituna Cut/Maketu (Bay of Plenty), Ahuriri Estuary (Hawke's Bay), Foxton Estuary (Manawatu), Farewell Spit, Motueka and Waimea Estuaries (Nelson), Estuary of the Heathcote and Avon Rivers/Ihutai and Lake Ellesmere (Te Waihora) (Canterbury), and Invercargill Estuary (Southland) (Heather & Robertson 2005). Royal spoonbills may fly several kilometres between their nesting colonies and foraging sites; for example, those nesting on Kapiti Island visit coastal mainland wetlands (travelling at least 5 km) to carry out much of their foraging (pers. obs.). The routes taken and flight characteristics during movements between breeding and wintering sites are unknown. Juveniles disperse long distances (Marchant & Higgins 1990), with banded individuals from the Vernon Lagoons colony having been seen from Northland to Southland (Heather & Robertson 2005).

Risk of wind farm impacts

Members of the Ciconiiformes, including the cattle egret, have been involved in collisions with wind turbines resulting in fatalities in other countries (Erickson et al. 2001; Langston & Pullan 2003). Herons and allies often have a slow, ponderous flight (Heather & Robertson 2005), and during strong headwinds may struggle to make headway and can be buffeted off course. Thus, they would seem to be vulnerable to flying into turbines during such conditions when on migration or flying between roosts and foraging areas. It seems unlikely that wind farm developments would result in loss of breeding sites for these species, given that most breed beside or within wetlands or on coastal islands—unlikely choices for wind farm sites. However, if turbines were sited in wetlands and resulted in altered habitat characteristics (e.g. hydrology), there may be negative impacts for herons and allies through reduced prey abundance. It is unknown whether wind farms sited adjacent to wetlands (either inland or coastal) would displace individuals or flocks of these species. The present distribution of wind farms in New Zealand on upland ridges and hilltops seems to present little risk to such species, unless their routes of travel intercept such sites.

2.8 SWANS AND GEESE (SUBFAMILY ANSERINAE)

The black swan (*Cygnus atratus*) has a threat ranking of Not Threatened. The population probably became established in New Zealand as a result of some birds arriving naturally from Australia and others being introduced in the 1860s (Worthy & Holdaway 2002). Today, the species is distributed through mainland New Zealand, from the coast to many inland wetlands. Habitats occupied include estuaries, lakes, and artificial ponds of rural and urban areas (Heather & Robertson 2005). Studies in 1956–1980 indicated that the national population comprised a number of discrete or partially discrete regional populations (Williams 1981). Each of these populations had a major breeding area and one or more coastal (estuarine or marine) feeding and moulting areas within its range. Ranges of adjacent populations overlapped such that a winter feeding area or moulting site was shared. The main breeding sites within each region were Lakes Omapere, Whangape and Waahi (Northland/Waikato); Lakes Rotorua, Rotoehu, Rerewhakaaitu and Taupo (Taupomoana) (Rotorua); Lakes Tutira, Poukawa, Hatuma and Runanga (Hawke's Bay); scattered coastal lakes from Wanganui to Waikanae (Manawatu); Lake Wairarapa and Vernon Lagoon (Wairarapa/Marlborough); Okarito Lagoon (West Coast); Lakes Ellesmere (Te Waihora), Forsyth (Wairewa), Emma and Clearwater, Bromley wetlands, and Washdyke and Wainono Lagoons (Canterbury); and Lakes Waihola and Tuakitoto, Upper Taieri wetlands, and Waituna Lagoon (Otago/Southland) (Williams 1981). The main wintering sites were Parengarenga Harbour, Rangaunu Harbour, Kaipara Harbour, Tauranga Harbour, Kawhia/Aotea Harbours, Porirua Harbour, Havelock Estuary, Farewell Spit, Whanganui Inlet, Estuary of the Heathcote and Avon Rivers/Ihutai, Awarua Bay and Oreti Estuary (Williams 1981). Numbers of swans at these estuarine and marine sites vary considerably throughout the year: peak numbers occur in late summer, but numbers may also increase rapidly in mid- to late winter if water levels on the major freshwater wetlands rise and preclude access to lake plants, the swans' preferred food. Despite increased eutrophication of many lowland lakes over the past 25 years, swans are still present at all the main sites listed above, and the present pattern of dispersal is likely to be similar to that of the past (M.J. Williams, Victoria University of Wellington, pers. comm., 5 February 2009). It is not known which routes are taken by swans moving between their breeding and wintering sites. Black swans are known to make nocturnal flights (Marchant & Higgins 1990), and they have been heard calling in flight at night over forest of the Mamaku Plateau, west of Rotorua (G.A. Taylor, pers. comm., 20 July 2007), indicating that movements between distant sites can occur over land.

The Canada goose (*Branta canadensis*) is listed as Introduced and Naturalised. This species became established in New Zealand following introductions during 1905–1920. Canada geese are now common through much of the South Island where pasture that the birds graze on is associated with wetlands, such as estuaries, rivers, lakes and ponds. The species' distribution continues to expand in the North Island following transfers in the 1970s (Heather & Robertson 2005). The species has been described as a partial migrant in New Zealand, with some birds being sedentary while others make seasonal movements depending on location, age and food availability (Heather & Robertson 2005). Some Canada geese in the South Island move between their breeding sites in high-country areas to coastal lakes and estuaries in November–February to moult, remaining there over winter and returning to the high country in spring. However, where the quality of high-country pastures has been improved, especially near lakes, birds are able to remain year round. North Island populations have proven remarkably sedentary (Heather & Robertson 2005), with large resident populations as a result of the more benign northern climate and the extensive availability of quality pasture adjacent to lakes at which geese were released. The flight paths taken by geese travelling between their breeding and moulting areas have not been studied.

Populations of both the black swan and Canada goose are managed by Fish & Game New Zealand, a crown entity with a statutory mandate to manage New Zealand's gamebird species on behalf of recreational hunters. Management of these species includes setting rules for the numbers and times of year that birds can be taken by hunters, with the aim of achieving sustainable harvesting and managing some areas of gamebird habitat.

Risk of wind farm impacts

Swans and geese have been killed as a result of collisions with wind turbines in other countries (Langston & Pullan 2003; Kingsley & Whittam 2005; Percival 2005). Given the difficulty members of this group have in getting airborne, their ponderous mode of flight (compared with ducks), and the fact that they can struggle to make headway during strong headwinds, it is not surprising that some collisions with turbines have been recorded. Since the migration routes of black swans and Canada geese in various regions of the country are unknown, it is not possible to suggest the possible frequency with which swans or geese might pass through a particular area proposed as a wind farm site. However, if wind farms are sited near wetlands and coastal habitats where black swans and Canada geese congregate in large numbers, it would almost inevitably result in collisions. While habitat loss would be expected to be minor for these species if a wind farm was sited where they forage or nest, it is unknown whether the operation of a wind farm would result in displacement of the birds from nearby habitat.

2.9 SHELDUCKS (SUBFAMILY TADORNINAE)

The paradise shelduck (*Tadorna variegata*) has a threat classification of Not Threatened. It is a common and widespread species, inhabiting pasture, arable land and wetlands through New Zealand (Heather & Robertson 2005). All birds leave their breeding territories or flock sites (non-breeders) to gather at traditional moulting sites on farm ponds, lakes, tarns and riverbeds during December–February (Williams 1979). Large flocks, of over 1000 birds in some cases, congregate at these moulting sites. Birds then move back to their breeding territories in March–April. Most breeders travel less than 30 km between their breeding and moulting sites (Williams 1979).

Risk of wind farm impacts

Given the widespread distribution of this species through New Zealand, it is likely that any place chosen for a wind farm would receive visits from paradise shelducks, either as residents or as migrants passing through. Wind farms have resulted in collision fatalities and displacement of some species of northern hemisphere ducks and geese, including one shelduck (*Tadorna tadorna*) (Langston & Pullan 2003; Kingsley & Whittam 2005). However, since the impact of wind farms on birds tends to be species-specific (Powlesland 2009), and no studies have investigated this issue in New Zealand, it is unknown how the paradise shelduck would react to wind turbines in their environment. The construction of turbines, roads and wind farm buildings could result in habitat loss (pasture) for the species. Given that the species is not particularly wary, inhabiting farm and city wetlands, displacement is likely to be a minor issue.

2.10 DUCKS (SUBFAMILY ANATINAE)

Seven species are considered in this section.

The blue duck (*Hymenolaimus malacorhynchos*) has a threat ranking of Nationally Vulnerable. This species is restricted to fast-flowing mountain streams and rivers in native forests or tussock grasslands (Heather & Robertson 2005). In the North Island, blue ducks are found on rivers of Egmont National Park, the Volcanic Plateau, and from the Raukumara Range to the northern Ruahine Range. In the South Island, individuals are widespread in rivers along the Southern Alps/Ka Tiritiri o te Moana, as well as in Kahurangi National Park (Robertson et al. 2007). Banding studies have shown that adults are sedentary on their breeding territories year round, while juveniles disperse up and down their natal river system and occasionally shift between catchments (Heather & Robertson 2005).

The mallard (*Anas platyrhynchos*) was released in New Zealand in the 1890s and 1930s (Heather & Robertson 2005) and has a threat ranking of Introduced and Naturalised. The grey duck (*Anas superciliosa*) is a New Zealand native species and has a threat ranking of Nationally Vulnerable. Because the two species interbreed and the New Zealand population now appears to be an extensive hybrid swarm (Williams & Basse 2006), these two species are considered jointly, and called mallard/greys. This hybrid population is found through New Zealand, especially in estuaries, rivers, lakes, ponds, drainage ditches and urban wetlands (Heather & Robertson 2005). Mallard/greys breed in all of these environments and generally maintain a continuous presence in breeding habitat throughout the year (Williams 1981). During the post-breeding moult (December–February), flocks of thousands may occur on large shallow lakes, such as Lakes Wairarapa, Whangape, Waikare, Ellesmere (Te Waihora), Waihola and Tuakitoto (M.J. Williams, pers. comm., 5 February 2009). These flocks have usually dispersed by April, or are forced to do so by gamebird hunting in early May. It is not known whether mallard/greys have favoured routes when moving between breeding and moulting sites.

The grey teal (*Anas gracilis*) is Not Threatened, and is distributed through much of New Zealand, particularly in shallow coastal lakes, swamps and lagoons with extensive marginal cover (Heather & Robertson 2005). Pairs remain together year round, with most joining large flocks for the moult in late summer; they do not disperse to breed again until about July. Banding studies in the 1960s and 1970s showed that some birds were highly mobile, dispersing the length of New Zealand (Marchant & Higgins 1990). Similarly, a satellite-tagging study in Australia showed that individuals were able to travel up to 343 km within a day (Roshier et al. 2006).

The brown teal (*Anas chlorotis*) consists of two subspecies: the North Island brown teal (*A. c.* "North Island"), which has a threat ranking of Recovering, and the South Island brown teal (*A. c.* "South Island"), which is Nationally Critical. The species has a wild population numbering about 1000 birds, of which only 300–400 occur on the mainland (Heather & Robertson 2005). The majority of the mainland birds occur in coastal farmland of Northland, with small numbers in Coromandel, Horowhenua and Fiordland. Brown teal are strongly territorial during the breeding season, but congregate into flocks at nearby traditional sites in summer–autumn.

The Australasian shoveler (*Anas rhynchotis*) is Not Threatened. It frequents shallow, lowland, fertile wetlands, including sewage ponds, flooded pasture and muddy estuaries. Shovelers are widespread through New Zealand, but are most numerous in Waikato, Otago and Southland (Heather & Robertson 2005). They are rarely seen on high-country or deep inland lakes, or on flowing water (Williams 1981). Birds moult communally in January–March at sites characterised by their remoteness and/or lack of human disturbance (Caithness et al. 2002). Only five moulting sites have been located: Waituna Lagoon in Southland, Ram Island Lagoon in Otago, Bromley sewage ponds in Christchurch, Lindsay Lakes of the Esk Valley, Hawke's Bay, and Lake Whangape in Waikato (M.J. Williams, pers. comm., 5 February 2009). Following the moult, the extent and timing of dispersal and aggregation of shovelers in New Zealand remains something of a mystery; aggregations outside the breeding season can occur on any major lowland lake at any time (M.J. Williams, pers. comm., 5 February 2009).

The New Zealand scaup (*Aythya novaeseelandiae*) (Not Threatened) is a diving duck that feeds on bottom weeds and invertebrates. Scaup occur in wetlands with extensive littoral zones at depths of 2–8 m, such as hydro lakes, coastal dune lakes, reservoirs, large farm dams and sewage ponds (Heather & Robertson 2005). Although widespread, this species has a patchy distribution, with most scaup occurring in Northland, Waikato, Rotorua, Taupo, Hawke's Bay, West Coast, and North Canterbury (including wetlands of Christchurch) (Heather & Robertson 2005). Flocking occurs during autumn and winter on some wetlands; birds then disperse by September to breed (Heather & Robertson 2005).

Risk of wind farm impacts

Duck species have been present in collision statistics at several wind farms in other countries (Erickson et al. 2001; Langston & Pullan 2003; Kingsley & Whittam 2005; Percival 2005). However, because there is little information available about the movements of New Zealand species (e.g. flight altitude, flock size, routes taken, impact of weather), it is not possible to indicate which wind farm sites might coincide with a migration route, and whether a particular species would be likely to fly through, over or around the turbines. If turbines were sited in wetlands and resulted in altered habitat quality (e.g. flow regimes), this would likely result in habitat loss for species with narrow habitat requirements. However, the most important consideration for this group is disturbance effects by wind farms sited near significant waterfowl areas (Langston & Pullan 2003). Based on a meta-analysis of wind farm studies, Stewart et al. (2004) concluded that wind farms reduced the abundance of many bird species, with Anseriformes (swans, geese and ducks) experiencing the greatest declines in abundance. The general consensus from other reviews of the impacts of wind farms on birds (e.g. Langston & Pullan 2003; Kingsley & Whittam 2005) is that wind farms are likely to have less impact on birds when located away from areas of high bird density, be this where birds congregate or at sites along their migration routes. This is particularly pertinent to ducks because some New Zealand species congregate in thousands to moult and feed during autumn–winter, and some species move considerable distances, probably as flocks at night (Marchant & Higgins 1990), to reach traditional flocking sites. Therefore, it is likely that any wind farm positioned at or close to a site where ducks congregate would have some negative impact on the population (collision fatalities, habitat loss and/or displacement).

2.11 RAPTORS (ORDER FALCONIFORMES)

The swamp harrier (*Circus approximans*) has a threat ranking of Not Threatened. It is widespread through New Zealand, and is most commonly seen in farmland, wetlands and coastal habitats (Heather & Robertson 2005). Banding studies have shown that there is considerable movement of harriers in both directions across Cook Strait, especially of young birds in autumn and winter (Heather & Robertson 2005). Adults also disperse from their breeding home ranges in late summer, and sometimes use a regular wintering area up to 100 km away. Harriers are known to congregate at abundant food sources during the non-breeding season, and also to roost communally (Heather & Robertson 2005).

The New Zealand falcon (*Falco novaeseelandiae*) occurs in three forms: the Nationally Vulnerable bush falcon, which breeds in native and exotic forest of the North Island, mainly south of a line from northern Taranaki to Whakatane, and in forests west and south of the Southern Alps/Ka Tiritiri o te Moana in the South Island; the Nationally Vulnerable eastern falcon, which breeds in tussockland and rough farmland in hills along the eastern side of the Southern Alps/Ka Tiritiri o te Moana; and the Nationally Endangered southern falcon, which is found in coastal Fiordland (Heather & Robertson 2005). Adults of all three races are sedentary, but juveniles wander widely in autumn and winter, and account for most sightings in farmland, orchards and towns.

Risk of wind farm impacts

In several studies in other countries, raptors have been cited as being prone to collision with wind turbines, particularly the large, less manoeuvrable species, such as eagles (Erickson et al. 2001; Langston & Pullan 2003; Kingsley & Whittam 2005; Percival 2005). It would therefore seem that the harrier, which flies mainly by soaring and gliding, might be more vulnerable to collision with turbines than the more manoeuvrable falcon. However, falcons are known to become 'prey fixed' when pursuing their prey in order to follow their prey's every move (Seaton 2007), and have been recorded flying into houses at such times. Therefore, if falcons were hunting within a wind farm, there would be the potential for them to collide with turbine blades (Seaton 2007). In addition, fledgling raptors, through their naivety and poor flying skills, may also be prone to colliding with turbine blades. Studies of radio-tagged falcons are currently underway to determine movements, home range and collision risk in relation to two wind farms: one study is at the proposed TrustPower wind farm near Lake Mahinerangi, inland Otago; and the other is at the Meridian Energy operational wind farm at White Hill near Mossburn. To date, most wind farms in New Zealand have been sited in hill-country farmland, often near native bush, which is habitat that both harriers and falcons could occur in. There have been no studies of the routes taken by harriers during their long-distance movements, and so it is not possible to indicate where these overlap with present or proposed wind farms.

Given the variety of habitats that both harriers and falcons use (Heather & Robertson 2005), it is unlikely that any operational wind farm in New Zealand at present (Powlesland 2009) would result in habitat loss sufficient to cause a significant reduction in the area occupied by either species at a national level. In addition, their temporary residence in rural and urban environments containing a variety of artificial structures suggests that neither species is likely to suffer from wind farm development, other than minor displacement as a result of turbine size, motion or noise. However, if construction of a wind farm occurred near a nest of either species, it is possible that it would result in adults spending less time at the nest, which could lead to nest failure, or even abandonment. For falcons, another possible impact of wind farm development that needs to be monitored for would be the abandonment of traditional nest sites. Given their large home ranges and low density, the displacement of falcons from nests may be significant for the local population.

2.12 RAILS AND ALLIES (ORDER GRUIFORMES)

Six species are considered in this grouping, all of which are often associated with wetlands, tend to be secretive and fly reluctantly when disturbed, but are capable of sustained flight, mainly at night (Marchant & Higgins 1990; Heather & Robertson 2005).

The banded rail (*Rallus philippensis*) has a threat ranking of Naturally Uncommon. Banded rails inhabit saltmarshes, mangroves and occasionally freshwater swamps (Heather & Robertson 2005). They are largely confined to wetlands of the northern North Island (Northland, Auckland, Waikato, Coromandel Peninsula and Bay of Plenty) and northern South Island (Nelson and Marlborough Sounds regions) (Heather & Robertson 2005). While adults are sedentary, remaining on their territories all year, juveniles are assumed to disperse widely (Marchant & Higgins 1990).

Four subspecies of the weka (*Gallirallus australis*) are recognised, two of which occur on the mainland: the Nationally Vulnerable North Island weka (*G. a. greyi*), which has a disjunct distribution, with mainland populations at Russell, Kawakawa Bay, Ohope and Poverty Bay (R. Burns, East Coast/Hawke's Bay Conservancy Office, DOC, pers. comm., 21 December 2006); and the Declining western weka (*G. a. australis*), which has a widespread distribution through the Marlborough Sounds, Golden Bay, northwestern Nelson, northern Westland south to about Hokitika, and sporadically through Fiordland (Heather & Robertson 2005). The flightless weka inhabits forest, scrub, open country with good cover, such as rough farmland, and the margins of wetlands. Adults remain on their territories year round, but some adults and juveniles move extensively in search of suitable vacant habitat, including swimming across waterways (Coleman et al. 1983; Heather & Robertson 2005).

The spotless crake (*Porzana tabuensis*) has a threat ranking of Relict. This species inhabits wetlands with dense beds of reeds, sedges and/or rushes (Heather & Robertson 2005). Spotless crakes are widely distributed in freshwater wetlands through the North Island and northern South Island (Robertson et al. 2007). The movements of this species have not been studied in New Zealand, but anecdotal records suggest that some individuals, probably juveniles, fly far at night (Marchant & Higgins 1990; Heather & Robertson 2005).

The marsh crake (*P. pusilla*), with a threat ranking of Relict, inhabits wetlands with dense beds of reeds, sedges and/or rushes (Heather & Robertson 2005). It occurs sparsely in both freshwater and estuarine wetlands of the North and South Islands (Heather & Robertson 2005). As for the spotless crake, the movements of this species have not been studied in New Zealand, but anecdotal information for the species in Australia indicates that some populations are migratory or dispersive (Marchant & Higgins 1990).

The pukeko (*Porphyrio porphyrio*) is Not Threatened, and is abundant and widely distributed from Northland to Southland. Pukeko inhabit a variety of habitat types, including wetlands, estuaries and damp pastures in both rural and urban areas (Heather & Robertson 2005). They occur as pairs or groups, and tend to be sedentary in favourable habitat. However, in some districts, flocks gather at persistent wetlands each autumn–winter or when conditions become unfavourable, such as during droughts (Williams 1981; A. Crossland, Christchurch

City Council, pers. comm., 6 August 2007). Pukeko are often heard calling in flight at night (A. Crossland, pers. comm., 6 August 2007), when they seem to make their long-distance flights (Heather & Robertson 2005).

The Australian coot (*Fulica atra*) has a threat ranking of Coloniser. This species inhabits freshwater ponds and lakes, favouring sheltered bays fringed with vegetation (Heather & Robertson 2005). Birds feed mainly on submerged aquatic plants and invertebrates, which they acquire by diving, but will come ashore to graze on grasses. The species is widely distributed through New Zealand, with the exception of Northland, Wellington, Nelson, the West Coast and Southland, where it is largely absent (Robertson et al. 2007). Having colonised New Zealand from Australia in the 1950s (Heather & Robertson 2005), it is evident that coots are highly mobile (Marchant & Higgins 1990), presumably mainly at night, since individuals have not been recorded flying between wetlands by day.

Risk of wind farm impacts

Wind farms in New Zealand are mainly located on hill country, making them unlikely to pose a major threat to the populations of the above rails and allied species, which are mainly found in lowland wetlands. However, if future wind farms were sited close to wetlands then the situation may change. While these species seem to be mainly sedentary (Heather & Robertson 2005), some individuals make long-distance movements by flying at night. Since two *Fulica* species and one *Porzana* species have been reported killed as a result of collisions with turbines in other countries (Kingsley & Whittam 2005), the New Zealand species may be vulnerable to such mortality as well. Any ecological change to part or all of a wetland (e.g. depth and flow of water, area of edge vegetation, increase in abundance of mammalian pests) as a result of a wind farm development may result in habitat loss for these rail species. It is not known whether turbines sited near wetlands inhabited by these species would result in birds being displaced from part or all of a wetland. The construction of a wind farm could pose additional risks to weka, as they could fall into pits dug for the bases of turbines or trenches for cables. In addition, roads to previously inaccessible sites may result in rails getting run over, and allow increased access to people with dogs, which are known predators of adult weka (Heather & Robertson 2005).

2.13 WADERS (SUBORDER CHARADRII)

There are 13 native or migrant species considered in this grouping, many of which are associated with coastal and/or riverbed wetlands through their annual cycles. Although other wader species occur in New Zealand, they are not considered on an individual basis here because of their irregular occurrence and/or the low numbers involved (Sagar et al. 1999). However, the impact of wind farm development on these species is likely to be similar to that of the more numerous species described. Waders are strong and direct fliers, and often form into large flocks during the non-breeding season when roosting (occasionally tens of thousands) or flying (hundreds). Many waders, including New Zealand species, migrate at night, departing in the late afternoon or early evening (Fuller et al. 2009). They prefer to start migrating when tailwinds or only light headwinds prevail.

The New Zealand pied oystercatcher (*Haematopus finschi*), with a threat ranking of Declining, has an estimated population of over 130 000 birds (Dowding & Moore 2006), most of which breed on riverbeds or farmland in the eastern South Island during July–January (Heather & Robertson 2005). Pied oystercatchers disperse to coastal sites soon after breeding (late December to early February), where they are found on estuaries from Northland to Southland. Significant wintering sites are in northern parts of the South Island (Farewell Spit, Golden Bay, Motueka Estuary and Estuary of the Heathcote and Avon Rivers/ Ihutai) and in the North Island (Manukau Harbour, Kaipara Harbour and the Firth of Thames). About 20% of the population (mainly subadults) stays at the main wintering sites throughout summer (Heather & Robertson 2005). While the locations of the species' main wintering and breeding sites are known (Dowding & Moore 2006), much still remains to be revealed about migration routes taken by this species and its migratory behaviour. Baker (1975) stated that the migration of pied oystercatchers consisted of a series of short flights, and that migrating flocks were usually small (2–20 birds). However, based on the absence of sightings of their colour-banded birds at stop-over sites, Sagar & Geddes (1999) suggested that at least the southward migration was undertaken in a single long flight. Small flocks have been seen travelling during the day along beaches and over other coastal habitats as though on migration (Dowding & Moore 2006), and also migrating overland at a few sites, such as at Nelson (D. Melville, Wakefield, Nelson, pers. comm., 10 February 2008). In addition, pied oystercatcher flocks have been seen departing the Firth of Thames in late afternoon and heading south over land during months when they would be expected to migrate, suggesting that they fly through the night (Dowding & Moore 2006; P. Battley, pers. comm., 18 July 2007). Recent studies at Taharoa Beach, Kawhia, using radar and observers, indicated that the northern migration of pied oystercatchers in 2008 occurred mainly in January, with a few flocks passing the site up until late March (Fuller et al. 2009). This species probably leaves the South Island at dusk, flying through the night to arrive at northern harbours during daylight (Fuller et al. 2009). Fuller et al. (2009) estimated that 57% of the 120 000 oystercatchers migrating to the North Island took a route along the North Island west coast, the rest going via the eastern coast. In contrast, on the southern migration, which occurred during July–August in 2008, an estimated 91% of the birds travelled south via the North Island west coast (Fuller et al. 2009). Mean oystercatcher flock size at Taharoa was 16 on the northern migration and 33 on the southern (Fuller et al. 2009).

The variable oystercatcher (*H. unicolor*) (Recovering) numbers about 4500 birds (Dowding & Moore 2006). It is distributed along much of the North and South Island coasts (Robertson et al. 2007). Some pairs remain on their territories year round, but others join small flocks, mainly at estuaries, during the non-breeding season (Heather & Robertson 2005). Distances between territories and flocking sites tend to be less than 60 km (Dowding & Moore 2006).

The pied stilt (*Himantopus himantopus*), which has a threat ranking of Declining, had a population estimated to number about 30 000 birds in 1994 (Sagar et al. 1999). Pied stilts breed from July to December in loose colonies of up to 100 pairs near shallow water in a variety of wetland habitats, including on riverbeds, lake or pond margins, and alongside flooded or boggy pasture. Breeding pairs can be found through the North and South Islands wherever suitable habitat occurs, including at coastal and inland sites (Heather & Robertson 2005). During December–February, birds on riverbeds of the South Island move to northern North Island harbours to overwinter (Dowding & Moore 2006). Coastal breeders of both islands and birds that breed in the northern North Island are usually sedentary or make local seasonal movements, typically of less than 20 km (Dowding & Moore 2006). Pied stilts have been heard calling as they fly high overhead on migration by day or night (Heather & Robertson 2005), including over inland forested areas (G.A. Taylor, pers. comm., 20 July 2007). Stilts return to their lowland breeding grounds in June–July, and to inland sites during August–October (Heather & Robertson 2005). Fuller et al. (2009) estimated that of the 30 000 pied stilts migrating between the North and South Islands, about 50% used the western North Island route, with the rest taking the eastern route.

The black stilt (*H. novaezelandiae*) has a threat ranking of Nationally Critical, and the total population numbers only about 245 birds, including those in captivity (Cleland et al. 2007). During the breeding season (August–February), this species is mainly confined to riverbeds, and lake and pond margins of the Mackenzie Basin, inland South Canterbury (Heather & Robertson 2005). After the breeding season, most of the population moves to river deltas of major lakes in the Mackenzie Basin, but 10–15% of individuals move to estuaries of the eastern South Island and western North Island (Dowding & Moore 2006; Robertson et al. 2007). Currently, there is little information available on the routes taken by birds migrating to and from sites outside the Mackenzie Basin. Observations at coastal sites in Canterbury suggest that after leaving the Mackenzie Basin, black stilts regularly pass through four coastal Canterbury sites: Lake Ellesmere (Te Waihora), Wainono Lagoon, Washdyke Lagoon and the Ashley Estuary (Dowding & Moore 2006). Regular records from Taranaki estuaries suggest that a few black stilts migrate along the west coast of the North Island (Dowding & Moore 2006).

The New Zealand dotterel (*Charadrius obscurus*) is composed of two subspecies: the Nationally Vulnerable northern New Zealand dotterel (*C. o. aquilonius*) and the Nationally Critical southern New Zealand dotterel (*C. o. obscurus*). The northern subspecies numbers about 1700 birds (Dowding & Davis 2007) and is spread widely around the coast of the North Island, mainly north of a line between Taranaki and Hawke's Bay (Dowding & Moore 2006). This subspecies uses a variety of habitat types when breeding, including sandy beaches near stream or river mouths, sandspits at the mouths of estuaries, and lawns, bare earth or shingle in urban areas (Dowding & Moore 2006). Some birds remain on their breeding territories year round, while others undertake small-scale movements (< 50 km) to flock sites typically at or near tidal estuaries, where they join up with juveniles. Peak numbers at flock sites occur in February–March, and the first birds return to their breeding sites in late April. The southern subspecies numbers about 250 birds (Dowding & Moore 2006). Breeding is confined to Stewart Island/Rakiura, and pairs are widely distributed inland on subalpine herbfields and rocky areas (Dowding & Moore 2006). In January, most birds leave their hill-top breeding sites and move to one of three wintering sites until August: Paterson Inlet/Whaka a Te Wera-Mason Bay and Cooks Arm of Port Pegasus/Pikihatiti, both on Stewart Island/Rakiura, and Awarua Bay in Southland (Dowding & Moore 2006). In addition, there have been a few sightings of banded southern New Zealand dotterels at several coastal South Island sites, including Farewell Spit.

The banded dotterel (*Charadrius bicinctus*) is Nationally Vulnerable and has a total population of about 50 000 birds (Heather & Robertson 2005). Individuals breed from Northland to Southland, including at coastal habitats and far inland along riverbeds (Heather & Robertson 2005). Their main breeding habitats are open, stable areas of shingle, sand or stones on riverbeds, lakeshores, seashores, fields, or mountain tops and slopes (Bomford 1986). They especially occur on shingle riverbeds of Hawke's Bay, Manawatu and Wairarapa, and on the braided riverbeds of Marlborough, Canterbury, Otago and Southland (Heather & Robertson 2005). They breed from July to February (Dowding & Moore 2006). Internal migration begins in late December and continues until March–April (Pierce 1999). The majority of dotterels from inland regions of the southern half of the South Island migrate to Australia (c. 30 000 birds), but coastal breeding birds in the South Island are mostly sedentary (Pierce 1999). Inland birds north of Canterbury mostly move within New Zealand, particularly to harbours in the North Island, but have regionally specific patterns, e.g. Westland birds move mainly to Farewell Spit, Marlborough birds to the northern North Island and Farewell Spit, southern North Island birds either locally or to the Auckland region, and most Hawke's Bay and Volcanic Plateau birds to the Bay of Plenty and Auckland (Pierce 1999). Although post-breeding movements occur in stages, with many dotterels forming post-breeding flocks before migrating to wintering grounds, pre-breeding movements tend to be direct from the wintering to breeding grounds, and occur during July–September (Pierce 1999; Dowding & Moore 2006). Of the 12 500 banded dotterels estimated to migrate between the North and South Islands, Fuller et al. (2009) estimated that about 50% took the western North Island route, with the rest following an eastern route.

The black-fronted dotterel (*Charadrius melanops*) (Coloniser) arrived in New Zealand in the late 1950s. It now numbers about 1700 birds (Heather & Robertson 2005). Individuals breed on shingle riverbeds of the eastern and southern North Island, south of Wairoa and Wanganui. Black-fronted dotterels are found sparsely in the northeastern South Island and in increasing numbers on the shingle riverbeds of smaller rivers in Canterbury, Otago and Southland (Heather & Robertson 2005; Robertson et al. 2007). During the non-breeding season, most black-fronted dotterels are fairly sedentary, remaining on rivers or moving locally when river levels rise, gathering at muddy sites about lakes, lagoons, estuaries and sewage ponds. In addition, some non-breeding flocking has begun to occur in the South Island at Lakes Elterwater and Ellesmere (Te Waihora), and at Spider, Wainono and Washdyke Lagoons (Heather & Robertson 2005).

The wrybill (*Anarhynchus frontalis*) is listed as Nationally Vulnerable and has a population of 4500–5000 birds (Dowding & Moore 2006). It has a restricted distribution, breeding on the braided riverbeds of Canterbury and Otago, particularly those of the Upper Waitaki Basin, and upper Rangitata, Rakaia, and possibly Waimakariri Rivers (Riegen & Dowding 2003). Most wrybills migrate northward in the second half of December and early January to spend the non-breeding season at North Island estuaries, especially at the Firth of Thames, and on the Manukau and Kaipara Harbours (Heather & Robertson 2005). The peak of migration back to the breeding grounds occurs in mid-August (Heather &

Robertson 2005). Observations suggest that the northward migration is rapid and probably direct (Hay 1984, cited in Dowding & Moore 2006), since few birds have been seen at sites between the breeding and wintering areas. Some birds have been seen at Farewell Spit, Waimea Inlet and Manawatu Estuary, and others at Porangahau, Ahuriri and Wherowhero, suggesting that once they have reached the North Island, some individuals take a western coastal route to Auckland harbours, while others follow an eastern coastal route (Dowding & Moore 2006). Of the 5000 wrybills migrating between the North and South Islands, Fuller et al. (2009) estimated that about 90% did so along the North Island west coast during each northern and southern migration. During the southward migration, it is not clear whether any birds fly directly to the breeding grounds, but many certainly stop off at sites along the South Island east coast, such as Washdyke and Wainono Lagoons, and Lake Ellesmere (Te Waihora) (Dowding & Moore 2006).

The Pacific golden plover (*Pluvialis fulva*) (Migrant) is ranked as being of Least Concern in the 2008 IUCN (International Union for Conservation of Nature) Red List of Threatened Species (IUCN 2008). Between 300 and 1200 individuals visit New Zealand each summer, but very few remain during winter (Sagar et al. 1999). In New Zealand, they are mainly found at coastal sites from Northland to Southland, foraging over exposed *Zostera* and *Sarcocornia* beds at estuaries or over marsh-turf about the fringes of freshwater wetlands (Heather & Robertson 2005; Robertson et al. 2007). The migration routes travelled by Pacific golden plovers while in New Zealand are unknown.

The spur-winged plover (*Vanellus miles*) is Not Threatened. This species was first found breeding in New Zealand in the 1930s, but has since colonised all suitable habitat (mainly grassland or bare ground) the length and breadth of the country (Robertson et al. 2007). The total population probably now numbers several tens of thousands. Spur-winged plovers use a variety of habitats, including farmland, rough grassland, wetland margins, estuaries, grassy areas adjacent to airport runways, and large lawns in suburban areas (Heather & Robertson 2005). They breed from June to January, during which time pairs aggressively defend their territories and young against all comers. After the breeding season, flocks of what are presumed to be juveniles and non-breeders form, which can consist of several hundred birds (Heather & Robertson 2005). Spur-winged plovers have occasionally been seen making long flights by day and are often heard calling in flight at night (Heather & Robertson 2005).

The turnstone (*Arenaria interpres*) (Migrant) is in the Least Concern category of the 2008 IUCN Red List of Threatened Species (IUCN 2008). About 2500 individuals have visited New Zealand in recent summers, and 50–500 have stayed over winter (Southey 2009). Turnstones occur at coastal sites, especially wave platforms, estuaries and coastal lagoons, from Northland to Southland, but they tend to favour particular sites, especially Parengarenga, Rangaunu, Kaipara, Manukau and Tauranga Harbours, the Firth of Thames, Farewell Spit, Motueka Estuary, Lake Grassmere/Kapara Te Hau, Kaikoura Peninsula, and Awarua Bay (Heather & Robertson 2005). However, small numbers are likely to turn up at any coastal lagoon or estuary, especially when migrating southwards through the country in late September–October, or northwards in March–April.

The Lesser (red) knot (*Calidris canutus*) (Migrant) is ranked as being in the Least Concern category of the 2008 IUCN Red List of Threatened Species

(IUCN 2008). Between 37 000 and 50 000 lesser knots visit New Zealand from the Arctic each summer, and about 3000 remain in winter (Southey 2009). Lesser knots are unevenly distributed around the coast, with large concentrations (10 000+) regularly occurring at Kaipara and Manukau Harbours, and Farewell Spit (Heather & Robertson 2005; Southey 2009). In addition, smaller flocks of 250–1000 birds regularly occur at Mangawhai Estuary, Tauranga Harbour, Manawatu Estuary, Golden and Tasman Bays, and in Southland coastal lagoons. Small groups occur at many estuaries and coastal lagoons, especially as transients during migration in September–October and March–April. Monitoring of colour-banded lesser knots in New Zealand by members of the Ornithological Society of New Zealand has revealed that the species is fairly mobile, with birds moving frequently between estuaries during summer (93% of young knots and 72% of adults were seen away from their banding site) (Battley 2009). While the species' distribution in New Zealand is essentially coastal (Southey 2009), the routes taken between sites are largely unknown (Battley 2009).

The eastern bar-tailed godwit (*Limosa lapponica*) (Migrant) is in the Least Concern category of the 2008 IUCN Red List of Threatened Species (IUCN 2008). This species is the most common Arctic wader to visit New Zealand, numbering about 80 000 individuals each summer (Southey 2009). About 10% of the previous summer's total of eastern bar-tailed godwits remains in New Zealand over winter (Sagar et al. 1999; Southey 2009). As for the lesser knot, most godwits arrive in September–October and depart in March–April. Godwits occur at many New Zealand estuaries, especially inlets and tidal mudflats. The following top ten sites all have mean summer counts in excess of 3000 birds: Manukau Harbour, Farewell Spit, Kaipara harbour, the Firth of Thames, Tauranga Harbour, Rangaunu Harbour, Ohope/Ohiwa Harbour, Parengarenga Harbour, Kawhia Harbour and Whangarei Harbour (Sagar et al. 1999; Southey 2009). Monitoring of eastern bar-tailed godwits through the use of satellite tags, dataloggers or individual colour-band combinations indicated that, on reaching New Zealand, a few godwits stopped short of their 'home' estuary for a while before continuing on to their final destination; however, once they reached their 'home' estuary, most individuals remained there throughout summer (Battley 2009). Just 6% of adults (local movements between adjacent estuaries) and 20% of immatures (both local and long-distance movements) were recorded moving about New Zealand (Battley 2009). The routes and flight altitudes of godwits moving within New Zealand are poorly known, but both overland and coastal movements have been recorded (Battley & Horn 2006; Battley 2009).

Risk of wind farm impacts

To date, the Charadrii have not featured prominently in turbine collision-fatality statistics in other countries (Erickson et al. 2001; Kingsley & Whittam 2005; Percival 2005). Wind farms in New Zealand are currently located mainly on pastoral hill country, suggesting that they are unlikely to result in collision fatalities of the above wader species, which mainly occur on lowland wetlands and at estuaries. However, because most species are involved in annual migrations, either between breeding and wintering sites (native species) or between feeding sites (mainly Arctic migrants), and because little is known about routes taken and altitudes flown at by each species, it is not possible to indicate the collision risk at most current and planned wind farms for each species. While no actual collision statistics are available, the potential risk to waders of collision fatalities has been studied at the proposed Taharoa wind farm near Kawhia (Fuller et al. 2009). This study indicated that the site lies on a north–south migration route for waders, in particular pied oystercatchers. Collision risk modelling (using precautionary values from the Band model and Monte Carlo simulations) was undertaken, which predicted a potential mean annual mortality of 28 pied oystercatchers and a potential mean of two wrybills (Fuller et al. 2009). Population modelling suggested that these predicted levels of potential mortality would result in relatively minor long-term population effects on the two species when projected over a 50-year period.

Many of the long-distance movements made by waders are likely to involve nocturnal flights, and it is not known how readily individuals are able to detect and avoid flying into turbines at night in various weather conditions. It is unlikely that a wind farm development would result in significant habitat loss or damage for waders unless turbines and other structures were sited in wetlands used by waders. Turbines sited by wetlands in other countries have resulted in displacement of waders through disturbance effects (Langston & Pullan 2003).

2.14 GULLS AND TERNS (FAMILY LARIDAE)

Three gulls and four terns are considered in this grouping, all of which are native species and breed on the North and/or South Islands.

The black-backed gull (*Larus dominicanus*) (Not Threatened) is locally common and widespread through the North and South Islands (Heather & Robertson 2005; Robertson et al. 2007). Black-backed gulls usually nest communally on islets, islands, coastal dunes, sandspits, boulderbanks and riverbeds, and isolated pairs also nest on coastal headlands and even on roofs of buildings (Heather & Robertson 2005). This species has benefited greatly from human settlement in New Zealand, especially as a result of readily available food supplies from fishing boats and rubbish dumps, about towns and cities, and on farmland. The black-backed gull occupies a wide range of habitats, including estuaries, harbours, coastlines, rivers, lakes, farmland at all altitudes, and even some alpine areas. Individuals are largely sedentary, but do commute daily between coastal roost sites and feeding sites, which can be up to 30 km apart (Heather & Robertson 2005).

The red-billed gull (*Larus novaehollandiae*) has a threat ranking of Nationally Vulnerable, despite being widespread in coastal habitats through New Zealand (Robertson et al. 2007) and being locally common (Heather & Robertson 2005). Birds begin to congregate at breeding colonies in July, but do not breed until October–February (Heather & Robertson 2005). Colonies are associated with upwellings of inshore waters where planktonic euphausiids (which make up a large part of the diet of the breeding red-billed gulls) occur (Mills et al. 2008). The three largest colonies, containing 5000+ pairs each, are on the Three Kings Islands, Mokohinau Island and at Kaikoura. There are also colonies of 1000+ pairs each at Nelson, Nugget Point, Goose Bay, and Kapiti and Mana Islands (Gurr & Kinsky 1965), as well as an inland colony at Lake Rotorua. Following breeding, the gulls disperse widely to congregate at feeding sites, which include harbours, estuaries, towns and cities, with some birds moving more than 400 km. During wet weather in autumn and winter, red-billed gulls often forage over water-logged paddocks and sports fields to feed on invertebrates (Heather & Robertson 2005). Individuals will travel 20 km or so each day between roost and feeding sites.

The black-billed gull (*Larus bulleri*) has a threat ranking of Nationally Endangered, probably as a result of predation by introduced mammals and disturbance by people at breeding colonies. Black-billed gulls nest mainly on open shingle margins or islands in braided riverbeds of the eastern South Island (Heather & Robertson 2005). Elsewhere, including in the North Island, a few small colonies are situated on coastal sandspits, boulderbanks and shellbanks, and riverbeds. Foraging occurs over a variety of habitats during the breeding season, including rivers, lakes, farmland and native forest. Breeding occurs from September to February, after which most birds disperse to mainly coastal habitats, such as open coastlines, estuaries, harbours, parks of coastal towns and cities, and wet pasture (Heather & Robertson 2005).

The black-fronted tern (*Sterna albostriata*), which has a threat ranking of Nationally Endangered, has a total population of about 5000–10 000 birds (Heather & Robertson 2005; Keedwell 2005). The species suffers from a wide range of threats, with the main threat being the impact of introduced mammalian predators (Keedwell 2005). During the breeding season (September–February), birds are mainly found in the eastern South Island, with colonies of up to 223 nests (average c. 50) along braided riverbeds from Marlborough to Southland (Heather & Robertson 2005; Keedwell 2005; Robertson et al. 2007). When breeding, they forage over wetlands, pasture and forest. Outside the breeding season, most black-fronted terns move to South Island coastal sites to feed mainly on planktonic crustaceans at sea and pasture invertebrates (Heather & Robertson 2005). A few black-fronted terns cross Cook Strait to winter mainly in coastal areas of the Bay of Plenty, Hawke's Bay and Wairarapa (Heather & Robertson 2005).

The Caspian tern (*Sterna caspia*) (Nationally Vulnerable) has a population in New Zealand numbering about 3000 birds, including about 1000 breeding pairs (Heather & Robertson 2005). Breeding colonies are widely scattered from Northland to Southland, mainly on remote estuarine sandspits and shellbanks, but a few pairs nest inland along riverbeds and lake shores near Rotorua and in Canterbury (Heather & Robertson 2005). The main colonies are at Rangaunu, Whangarei, Kaipara, Whangapoua and Kawhia Harbours, Mangawhai Estuary, Bowentown, Tauranga Harbour, Matakana Island, Ohope Spit, Lake Onoke Spit, Farewell Spit, Waimea Estuary, Vernon Lagoon, Lake Ellesmere (Te Waihora) and Invercargill Estuary (Heather & Robertson 2005). During autumn and winter, North Island birds tend to remain within 100 km of their colonies, but many South Island birds move north, congregating mainly at coastal river mouths and lagoons (Heather & Robertson 2005). These dispersal movements are likely to be along coastlines, because when seen inland, these birds are generally flying along river courses; however, a small flock was seen flying overland between Wellington and Makara (H. Robertson, National Office, DOC, pers. comm., 20 June 2008).

The white-fronted tern (*Sterna striata*) has a threat ranking of Declining. In 1998, the population was estimated to number about 15 000 pairs (Powlesland 1998). The species occurs around much of the New Zealand coastline, and breeding colonies are mainly situated on sandy beaches, sandspits, shinglebanks or shellbanks, and rocky islets (Heather & Robertson 2005). Significant breeding colonies have been found at Nelson Boulder Bank, Motueka Sandspit, Kaikoura Peninsula, Invercargill Estuary, Waioeka River Estuary, Tapora in Kaipara Harbour, Sugarloaf Islands at New Plymouth, Wairoa River mouth and Motu River mouth (Higgins & Davies 1996). Although few sites are used consistently year after year and there is no strong tendency for white-fronted terns to nest near their natal locality, it appears that birds do return to the same geographical area to breed (Mills & Shaw 1980). In autumn, large numbers of young and some adults migrate to the southeastern coast of Australia, and return to New Zealand coastal waters during August–October (Higgins & Davies 1996). White-fronted terns are known to fly about at night (Heather & Robertson 2005), but to what extent they do so is not known.

The New Zealand fairy tern (*Sterna nereis davisae*) (Nationally Critical) is New Zealand's rarest indigenous breeding bird, with a population of just 35–40 birds (Hansen 2006). This species is threatened by introduced mammalian predators, disturbance by people and habitat modification. The present distribution of the New Zealand fairy tern is restricted to Northland. Individuals breed during October–February on low-lying sandspits near sheltered estuaries at the following four sites: Mangawhai Heads, Waipu Estuary, Papakanui Spit and Pakiri Beach (Hansen 2006). During the non-breeding season, most fairy terns are found within the extensive Kaipara Harbour wetland (Heather & Robertson 2005); they are believed to fly directly across southern Northland, but the routes are not known.

All these species are strong fliers, and while most are closely associated with wetlands while breeding, the gulls and the black-fronted tern can be found foraging over agricultural lands at any time of year. The gulls also venture into urban and city environments, particularly during the non-breeding season.

Risk of wind farm impacts

Gulls and terns have suffered low rates of mortality at wind farms in other countries (Erickson et al. 2001; Langston & Pullan 2003; Kingsley & Whittam 2005; Percival 2005), with the exception of three sites in Belgium (Everaert 2003; Everaert & Stienen 2007). At one of these sites, Zeebrugge, turbines were sited close to gull and tern nesting colonies, and Everaert & Stienen (2007) calculated that the mean number of collision fatalities (mainly gulls and terns) per turbine per year in 2004 and 2005 was 20.9 and 19.1 birds, respectively, which are particularly high rates of mortality. These findings emphasise the importance of siting wind farms correctly: they should not be built where high densities of birds or high frequencies of bird movements occur (e.g. near nesting colonies), where birds congregate to feed during the non-breeding season, or on migration routes (Powlesland 2009). The occasional dead gull (species not indicated) has been found at wind farms in New Zealand (Rodgers 2006). The black-backed gull is the most likely species to collide with wind farm structures, as most wind farms are presently situated on hill-country farmland; however, a few deaths as a result of collision fatalities away from nesting colonies would have no impact at the population level on this species. Similarly, the red-billed gull population is also unlikely to be adversely affected should wind farms become established in coastal areas away from sites where the gulls congregate, as this species is very adaptable, having taken advantage of feeding opportunities in people-modified environments (farmland, cities). In contrast, the conservation of the black-billed gull could be detrimentally affected by any additional mortality suffered as a consequence of wind farm developments.

Although terns have been found dead as a result of collisions with wind farm structures in other countries (Langston & Pullan 2003; Kingsley & Whittam 2005; Percival 2005), the impact of wind farm developments on New Zealand terns will largely depend on their location. It is likely that the black-fronted tern population would only be compromised if wind turbines were erected within or adjacent to eastern South Island wetlands where nesting colonies occur or terns congregate to forage. Likewise, the Caspian tern population would only be impacted if future wind farms were sited in coastal wetland habitats frequented by the species. Wind farms may pose a threat to white-fronted terns, which are known to fly about at night, but it is not known how vulnerable they would be to flying into wind farm structures in coastal situations. The coastal wetlands and migration routes used by the New Zealand fairy tern would be unsuitable sites for wind farm development.

It is not known how vulnerable New Zealand gulls and terns would be to habitat loss as a result of wind farm development at or near their nesting or foraging sites. Such developments would likely have the most detrimental impact if sited where a species traditionally nests, such as at a red-billed gull nesting site close to upwelling waters where planktonic euphausiids occur. However, such an issue is unlikely to be a concern for riverine species that readily change the location of their nesting colonies within a breeding season. Whether any of our gull or tern species would be displaced from breeding or foraging areas as a result of a wind farm development nearby is unknown, but it seems unlikely for the black-backed gull and red-billed gull given their occurrence in rural and urban environments.

2.15 PIGEONS (FAMILY COLUMBIDAE)

One native pigeon is present in New Zealand, the kereru or New Zealand pigeon (*Hemiphaga novaeseelandiae*). It has a threat ranking of Not Threatened, and is widespread and locally common (Robertson et al. 2007). Kereru occur in native forest and scrub, in exotic plantations, farmland, rural and urban gardens, and parks of towns and cities. Kereru can be highly mobile in their daily and seasonal movements in search of food sources, with the home ranges of some individuals extending up to 100 km in length (Heather & Robertson 2005; Powlesland et al. 2008). Some of these flights involve travel to offshore islands or over high-country ridges between forested catchments at heights within and above the rotor sweep zone of commercial turbines (50–150 m a.g.l.).

Risk of wind farm impacts

Four species of pigeon have been reported among collision fatality statistics at wind farms in other countries (*Zenaida macroura*, *Columba livia*, *C. oenas*, and *C. palumbus*) (Erickson et al. 2001; Kingsley & Whittam 2005). Kereru could potentially fly through or over any New Zealand wind farm site, whether on high-country or coastal farmland. In addition, kereru carry out display flights, involving a bird flying steeply to as high as about 50 m above the canopy, stalling with the body vertical and wings and tail spread, and then gliding down to an exposed perch (Mander et al. 1998). Although kereru are active only by day, they are not the most agile of fliers, and have a history of flying into power cables, moving vehicles and windows (pers. obs.). Thus, there would appear to be a moderate risk of kereru collision fatalities if wind farms were sited close to forest patches where kereru are common. It is unlikely that a wind farm development would result in significant habitat loss for kereru unless turbines were sited in forest, and vegetation that provided key seasonal food sources needed to be cleared. Given that kereru forage and nest in suburban gardens and next to busy main roads, it also seems unlikely that wind farms sited near kereru habitat would result in displacement.

2.16 PARROTS (FAMILY PSITTACIDAE)

There are four species considered under this heading, all of which are forest-dwelling.

The kaka (*Nestor meridionalis*) is separated into two subspecies: the North Island kaka (*N. m. septentrionalis*), which is Nationally Vulnerable, and the South Island kaka (*N. m. meridionalis*), which is Nationally Endangered. Both subspecies have a disjunct distribution, being mainly associated with large tracts of central North Island podocarp forest, western South Island beech (*Nothofagus* spp.) forest, and offshore islands that are free of mammalian predators (Robertson et al. 2007). In addition, individuals are now occasionally seen considerable distances from the species' main range, including in exotic plantations, orchards, and some town and city parks (Greene et al. 2004; Heather & Robertson 2005), as a result of intensive control of introduced predators in forests during the past 10 years, the establishment of new populations through translocation and supplementary feeding (e.g. at Pukaha Mount Bruce National Wildlife Centre and Karori Sanctuary), and the propensity of some juvenile kaka to wander widely.

The kea (*Nestor notabilis*) (Naturally Uncommon) inhabits mainly forest, scrub and alpine habitats of the South Island high country, from northwestern Nelson and Marlborough south to Fiordland. It is also found in lowland forest areas, particularly on the West Coast (Heather & Robertson 2005; Robertson et al. 2007). Studies of banded or radio-tagged kea have indicated that individuals commonly make movements of 10 km, and can move up to 98 km (Higgins 1999). Kea also make altitudinal movements, probably in response to snow cover, weather conditions or the availability of seasonal food sources (Higgins 1999). The species is inquisitive and can be destructive, as evident by their activities at tents, huts, car parks and ski fields (Heather & Robertson 2005).

The red-crowned parakeet (*Cyanoramphus novaezelandiae*) has a threat ranking of Relict. The species is now largely confined to offshore islands, with only isolated records from the North and South Islands in the last 10 years (Robertson et al. 2007). Even though the red-crowned parakeet is regarded as sedentary, individuals or small flocks are occasionally seen flying 50–2000 m over sea between neighbouring islands or between ridges (Higgins 1999). Such movements are assumed to occur in response to changes in food availability.

The yellow-crowned parakeet (*Cyanoramphus auriceps*) is Not Threatened. This species is widely distributed through forests of the central North Island, and the Southern Alps/Ka Tiritiri o te Moana and associated ranges from Nelson/ Marlborough to Fiordland (Robertson et al. 2007). The movements of this species are poorly known; Higgins (1999) found that radio-tagged birds in Eglinton Valley usually moved less than 2 km, with such movements considered to be in response to the availability of seasonal food sources.

Risk of wind farm impacts

No parrots or parakeets were reported among wind farm collision fatalities in other countries by Erickson et al. (2001), Langston & Pullan (2003), Kingsley & Whittam (2005) or Percival (2005). All New Zealand species are strong fliers. While each species is active by day, both kaka and kea are also occasionally active at night (Heather & Robertson 2005). Since parrots are generally both intelligent and inquisitive, some interaction between them and wind farm structures could be expected. However, to date no collision fatalities have been reported at the Brooklyn wind turbine, Wellington, despite some of the c. 60 kaka inhabiting the nearby Karori Sanctuary regularly flying over the predator-proof fence-line (R. Empson, Karori Sanctuary, pers. comm., 18 September 2007). Given their inquisitiveness, kea may be vulnerable to collision fatalities with rotors of turbines, especially naïve, recently-fledged birds; however, it is not known whether such mortality would be sufficient to have an impact at the population level. The distributions of kea and the two parakeet species do not overlap with wind farms at present. If a wind farm was erected within the range of kea, no doubt all equipment would be thoroughly investigated to determine its potential as a food source or as an object to play with. With this in mind, it is of note that several kea have been found suffering from lead poisoning after attempting to eat lead-head nails and flashings on roofs at ski resorts and towns (Alley 2002).

It is unknown whether the construction of a wind farm within habitats occupied by any of these parrots or parakeets would result in significant habitat loss unless it required the destruction of an important key seasonal food source. Given that kaka are occasionally seen in several towns and cities, and kea occur in a few towns and ski resorts, it is unlikely that the construction or operation of a wind farm would cause either species to be displaced from an area. Unless forest was cleared to establish a wind farm, there seems little likelihood of individuals of either species of parakeet being displaced by wind farms, as both species have restricted distributions (mainly islands for the red-crowned parakeet and mainly extensive tracts of mature forest for the yellow-crowned parakeet).

2.17 CUCKOOS (FAMILY CUCULIDAE)

Two species of cuckoo occur in New Zealand, both of which migrate to the tropics to overwinter.

The shining cuckoo (*Chrysococcyx lucidus*) (Not Threatened) is widely distributed through both the North and South Islands from October to March (Heather & Robertson 2005; Robertson et al. 2007). This cuckoo's main host is the grey warbler (*Gerygone igata*), so it is mainly found in forest and scrub habitats where the warbler occurs, including exotic forests and urban areas up to about 1200 m a.s.l. Shining cuckoos are regularly heard calling in flight at night (Heather & Robertson 2005), so it is assumed that this is when most of their long-distance flights occur. Nothing is known about their migration routes or the altitudes at which they fly, except that some fly low enough for their calls to be heard.

The long-tailed cuckoo (*Eudynamys taitensis*) has a threat ranking of Naturally Uncommon. Its distribution mainly reflects that of its forest-dwelling hosts, the whitehead (*Mohoua albicilla*) in the North Island, and the yellowhead (*M. ochrocephala*) and brown creeper (*M. novaeseelandiae*) in the South Island. In the North Island, long-tailed cuckoos occur mainly in the forests of the Volcanic Plateau, both native and exotic, from Mount Taranaki to East Cape, and in the forests of the Tararua and Ruahine Ranges (Robertson et al. 2007). In the South Island, they are mainly found in forests of the Southern Alps/Ka Tiritiri o te Moana and associated ranges from Nelson/Marlborough to Fiordland (Robertson et al. 2007). Long-tailed cuckoos are regularly heard calling in flight at night (Heather & Robertson 2005), but the migration routes and flight altitudes that birds typically use are unknown.

Risk of wind farm impact

Four species of Cuculidae have been represented in wind farm collision fatality statistics in other countries (Kingsley & Whittam 2005). At this stage, it is not possible to predict whether wind farm developments in New Zealand will have a negative impact on either the shining cuckoo or long-tailed cuckoo. Since both fly at night, they may be vulnerable to flying into wind turbines, especially those situated within forest or close to forest edges. A programme of intensive monitoring for carcasses at a few wind farms would be required to determine whether fatal collisions occur and their likely impact on populations. However, due to the small size (16 cm, 25 g) and cryptic colouration of the shining cuckoo, it is likely to be difficult to find any corpses of this species unless they fall on to concrete bases or short sward. Whether wind farm development would result in habitat loss for or displacement of either cuckoo species is likely to depend on how their host species react to such developments.

2.18 OWLS (ORDER STRIGIFORMES)

The morepork (*Ninox novaeseelandiae*) is Not Threatened, and is found in native and exotic forest and forest patches from sea level to the bushline, including in urban areas (Heather & Robertson 2005). Thus, this species is widespread through the North Island and western South Island, but tends to be sparsely distributed through the eastern South Island (Robertson et al. 2007). Its diet consists mainly of large invertebrates (weta (family Stenopelmatidae), stick insects, cicadas, moths and beetles), mice (*Mus musculus*), small rats (*Rattus* spp.) and small birds (Heather & Robertson 2005), suggesting it forages mainly within and about the edges of forests. Two radio-tracking studies of moreporks suggested that adults remain within small home ranges year round, while juveniles disperse to find vacant habitat or mates (Imboden 1975; Stephenson & Minot 2006). Although little is known about the species' propensity to fly above the canopy or between forest patches, the fact that it occupies widely-spaced forest patches in rural areas and has reached inshore islands (e.g. Matiu/Somes in Wellington Harbour) indicates that individuals are quite capable of moving between forest patches.

Risk of wind farm impacts

It is not known how susceptible moreporks would be to flying into turbine rotors at night, but owls have suffered fatal collisions with turbines in other countries (Erickson et al. 2001; Langston & Pullan 2003; Kingsley & Whittam 2005; Percival 2005). Since moreporks feed on moths and other large invertebrates that are attracted to lights, the use of lights on wind farm structures may increase the frequency of morepork collision fatalities; thus, New Zealand wind farms situated in areas occupied by this species should limit bright lighting to that needed for aircraft safety. Wind farm development would result in habitat loss for the morepork if forest clearance was required. The impact of such habitat loss on the local morepork population would depend on the extent of the clearance and the quality of the habitat involved. Given that moreporks inhabit forest patches in urban areas, and occasionally move beyond these patches to forage in treed urban sections, it seems unlikely that the species would be displaced far, if at all, by operational turbines.

2.19 KINGFISHERS (ORDER CORACIIFORMES)

The sacred kingfisher (*Halcyon sancta*) has a threat ranking of Not Threatened, and is widespread through the North Island and the northern and eastern portions of the South Island, but is sparse west of the Southern Alps/Ka Tiritiri o te Moana and in Southland (Robertson et al. 2007). Kingfishers occupy a variety of habitats, including native and exotic forests, farmland with scattered trees, habitat about rivers, streams and lakes, and tidal estuaries and mangrove swamps (Heather & Robertson 2005). There is a seasonal shift in kingfisher distribution, with most birds occupying forests during the breeding season (October–February) but moving to farmland or coastal habitats for winter (Heather & Robertson 2005).

Risk of wind farm impacts

Even though there is no indication from studies in other countries that members of the Coraciiformes are prone to negative impacts from wind farm developments, such as collision fatalities (Erickson et al. 2001; Langston & Pullan 2003; Kingsley & Whittam 2005; Percival 2005), at least one sacred kingfisher has been a collision fatality at a New Zealand wind farm (Clutha District Council 2007). Sacred kingfishers frequently use elevated perches, including artificial structures such as powerlines and posts, to scan the ground for prey. It is not known whether this activity would make them vulnerable to flying into turbine rotors in an attempt to perch on turbines, but it seems unlikely that a perch more than 20 m above the ground would be attractive to them for this purpose. Whether the kingfisher would suffer from significant habitat loss or displacement as a result of wind farm developments within occupied habitat is unknown.

2.20 NEW ZEALAND WRENS (FAMILY ACANTHISITTIDAE)

The rifleman (*Acanthisitta chloris*) has a threat ranking of Declining, despite being widespread through the North and South Islands (Robertson et al. 2007). Riflemen mainly inhabit native forest and older-age stands of scrub in both the North and South Islands (Heather & Robertson 2005), and 'grey shrub' habitats of the eastern South Island (C. O'Donnell, DOC, pers. comm.), and are rarely found in exotic forests (Heather & Robertson 2005). Riflemen are reluctant to disperse across open areas, land or water, and so the species has become patchily distributed (Heather & Robertson 2005).

The rock wren (*Xenicus gilviventris*) (Nationally Vulnerable) inhabits alpine rockfalls and screes, and subalpine scrub along the Southern Alps/Ka Tiritiri o te Moana from the Nelson region to Fiordland (Heather & Robertson 2005; Robertson et al. 2007).

Aside from juvenile dispersal, both species are thought to be sedentary (Heather & Robertson 2005).

Risk of wind farm impacts

Both the rifleman and rock wren tend to remain within or close to cover, and so would be highly unlikely to be involved in collision fatalities at wind farms. Due to its limited distribution, it is unlikely that the rifleman would be impacted by wind farm developments, unless occupied forest habitat was cleared or fragmented, or the species was displaced from forest edge areas due to turbines being erected close by. In contrast, any wind farm construction and operation in areas inhabited by rock wren along the Southern Alps/Ka Tiritiri o te Moana would probably have detrimental consequences for this species, as a result of habitat destruction, displacement of wrens and/or possible changes in predator dynamics due to improved access along roads in alpine areas.

2.21 SWALLOWS (FAMILY HIRUNDINIDAE)

The welcome swallow (*Hirundo tahitica*) has a threat ranking of Not Threatened. This species is a recent colonist of New Zealand, whose population has undergone rapid expansion since breeding was first recorded in 1958. Welcome swallows are now common through much of the North and South Islands (Robertson et al. 2007). They are especially common in lowland areas and over wetlands, but they are also occasionally seen in the high country, including over forests (Heather & Robertson 2005). Welcome swallows feed on small aerial invertebrates caught during flight, which can often involve quick, sharp turns. This species is suspected of being a partial migrant in New Zealand (Heather & Robertson 2005), but it is not known what routes are taken or whether migration occurs at night as well as by day.

Risk of wind farm impacts

Due to their excellent flight manoeuvrability, welcome swallows may be able to avoid collisions with wind farm structures. Also, given the species' abundance and high reproductive ouput (Heather & Robertson 2005), any mortality that did occur as a result of infrequent collisions with wind turbines would be unlikely to have any impact at the population level. Since welcome swallows occupy a wide variety of habitats, during both the breeding and non-breeding season, in both rural and urban areas, it is unlikely that wind farm development would result in habitat loss or displacement of this species.

2.22 PIPITS (FAMILY MOTACILLIDAE)

The New Zealand pipit (*Anthus novaeseelandiae*), which is Declining, has a widespread distribution through the North and South Islands (Robertson et al. 2007). It is found in open habitats from the coast to alpine areas, including beaches, riverbeds, gravel roads, rough pasture with patches of short sward or bare earth, and herbfields (Heather & Robertson 2005). At least some adults are thought to be territorial year round, but juveniles form loose, transient flocks in autumn and winter (Heather & Robertson 2005).

Risk of wind farm impacts

Typical tower heights for commercial-scale turbines (1–2 MW capacity) are currently 80–100 m, and the blades are usually about half the length of the height of the tower (Ashby 2004). Therefore, because pipits occasionally fly more than 40 m above ground level when involved in courtship flights or long-distance movements during the non-breeding season (T. Beauchamp, Northland Conservancy Office, DOC, pers. comm., 19 February 2009), this species may be at moderate risk of collision with turbine blades. The New Zealand pipit is one species that may benefit from the building of wind farms, at least for a few years immediately after development, because the construction of gravel roads and infrastructure would create bare patches and/or short sward that would likely be suitable habitat for pipits. Given that the species occurs in rural and coastal situations where human disturbance is often frequent, it seems unlikely that the pipit would be displaced from habitat as a result of wind farm developments.

2.23 FERNBIRDS (FAMILY SYLVIIDAE)

The fernbird (*Bowdleria punctata*) is listed as Declining. Although widespread, it has a disjunct and patchy distribution in both the North and South Islands (Robertson et al. 2007). It is locally common in Northland, Auckland, Coromandel Peninsula, central North Island, northern and western South Island, and coastal Otago and Southland (Robertson et al. 2007). Fernbirds tend to be most numerous on land that is unsuitable for farming, particularly swampy areas with relatively short, thick, scrubby vegetation (Heather & Robertson 2005). Although fernbirds are reluctant to fly from cover by day, it seems that some disperse in flight at night, as young stands of exotic trees are occasionally quickly occupied by individuals.

Risk of wind farm impacts

The implications of a wind farm being built within or close to habitat occupied by fernbirds are unknown. The risk of collision fatalities seems low as long as fernbirds fly within or just above the vegetation during dispersal. However, if a wind farm was built within or adjacent to fernbird habitat, it would likely result in loss of this habitat (as a result of road and building construction, and/or changed hydrology). It is not known whether the species would be displaced by the development of an operational wind farm close to occupied habitat.

2.24 WHITEHEAD AND ALLIES (SUBFAMILY MOHOUINAE)

The whitehead (*Mohoua albicilla*) is confined to the North Island, and the brown creeper (*M. novaeseelandiae*) to the South Island (Robertson et al. 2007). Both species have a threat ranking of Not Threatened and have widespread distributions, occurring in native and exotic forest and scrub from sea level to near the bush line (Heather & Robertson 2005).

The yellowhead (*Mohoua ochrocephala*) has a threat ranking of Nationally Vulnerable. This species has a disjunct distribution in the South Island only, and its range is continuing to contract (Robertson et al. 2007). It is well established in Fiordland and Mount Aspiring National Parks, with moderate numbers occurring in and near Arthur's Pass National Park, the Catlins, Blue Mountains and Landsborough Valley (Heather & Robertson 2005). Yellowheads inhabit mainly mature stands of beech forest.

Risk of wind farm impacts

All three species appear reluctant to make short movements (> 100 m) across open areas to reach nearby forest patches. Thus, it is unlikely that any of these species would be involved in collision fatalities as long as turbines were sited some distance from forest and scrub margins. Each of these species would be likely to suffer habitat loss if occupied forest or scrub habitats were cleared for turbines and other wind farm infrastructures. It is not known whether the operation of a wind farm adjacent to habitat occupied by any of these three species would result in the displacement of birds.

2.25 AUSTRALASIAN WARBLERS (FAMILY ACANTHIZIDAE)

The grey warbler (*Gerygone igata*) (Not Threatened) is widely distributed through the North and South Islands (Heather & Robertson 2005; Robertson et al. 2007). Warblers inhabit most forest and scrub habitats, including exotic plantations and hedgerows, and are especially common in seral habitats, such as manuka (*Leptospermum scoparium*), kanuka (*Kunzea ericoides*) and gorse (*Ulex europaeus*) scrub (Heather & Robertson 2005). The species is territorial during the breeding season, and territories then expand into overlapping home ranges during the non-breeding season, such that adults do not move far from their core area. In contrast, juveniles are quite mobile, and may disperse several kilometres from their natal territory before locating vacant and suitable habitat (Heather & Robertson 2005).

Risk of wind farm impacts

Given the size of grey warblers (10 cm long) and the fact that they rarely fly above the canopy, the chance of individuals being involved in collision fatalities seems low. Forest or scrub clearance for the development of a wind farm could result in habitat loss for the species, but the risk of displacement as a result of the presence of operational turbines seems minimal given the species occurs in suburban gardens where a variety of artificial structures, noises and activities (e.g. fireworks displays) occur. Thus, it seems unlikely that a wind farm development would have a significant impact on a local grey warbler population.

2.26 MONARCH FLYCATCHERS (FAMILY MONARCHIDAE)

The New Zealand fantail (*Rhipidura fuliginosa*) is the only member of this family on the North and South Islands. It is Not Threatened, and is widely distributed through both islands (Robertson et al. 2007). Like the grey warbler, it commonly occurs in a variety of forest and scrub habitats from sea level to the bush line, including modified environments where there are scattered trees, such as farmland, golf courses, orchards and suburban gardens (Heather & Robertson 2005). Adults are territorial during the breeding season but, like juveniles, may wander widely during the non-breeding season.

Risk of wind farm impacts

Given the fantail's small size (16 cm long), highly manoeuvrable flight ability and the fact that it rarely flies above the canopy, the chance of this species being involved in collision fatalities at wind farms seems low. The clearance of forest or scrub for a wind farm could result in habitat loss for the species, but the risk of displacement seems minimal given the species occurs in suburban gardens where a variety of artificial structures, noises and activities occur. Thus, it seems unlikely that a wind farm development would have a significant impact on a local fantail population.

2.27 AUSTRALASIAN ROBINS (FAMILY EOPSALTRIIDAE)

Two species are considered in this grouping, the New Zealand tomtit (*Petroica macrocephala*) and New Zealand robin (*P. australis*), both of which are Not Threatened.

The tomtit occurs as separate subspecies in the North Island (*P. m. toitoi*) and South Island (*P. m. macrocephala*), and is widely distributed through both islands where suitable forest and scrub (native and exotic) habitats occur (Heather & Robertson 2005; Robertson et al. 2007).

The robin also occurs as separate subspecies in the two islands (*P. a. longipes* in the North Island and *P. a. australis* in the South Island), but has a much more restricted distribution than the tomtit. In the North Island, the robin is restricted to native and exotic forests of the central North Island from inland Taranaki east to Hawke's Bay and the Bay of Plenty (Heather & Robertson 2005; Robertson et al. 2007). In the South Island, robins occur mainly north of Arthur's Pass National Park, in Buller, Nelson and coastal Marlborough, and in Fiordland (Heather & Robertson 2005; Robertson et al. 2007).

Adults of both species are territorial year round (Heather & Robertson 2005). In contrast, juveniles leave their natal territories soon after independence, with some dispersing several kilometres, mainly through forest and open scrub habitats, before becoming established on a territory.

Risk of wind farm impacts

Robins rarely fly above the canopy or over gaps of greater than 100 m between vegetation patches (Richard 2007). While tomtits seem to frequent forest edge habitats more frequently than robins (pers. obs.), their dispersal is also usually prevented by wide expanses of open ground. Therefore, the chance of either species being involved in collision fatalities at wind farms seems low. Both species could suffer habitat loss during wind farm development if forest or scrub clearance was required for the construction of roads or turbines. Since both species are confined mainly to large tracts of forest and scrub, especially during the breeding season, it is unknown whether they would be displaced some distance from operational turbines if the latter were sited within or adjacent to forest or scrub habitat.

2.28 WHITE-EYES (FAMILY ZOSTEROPIDAE)

The silvereye (*Zosterops lateralis*), which is Not Threatened, is widely distributed through both the North and South Islands (Robertson et al. 2007). Among the most abundant of New Zealand birds, the silvereye occurs in a variety of habitats (native and exotic forests, scrub, orchards, shelterbelts, suburban gardens) from sea level to the bush line (Heather & Robertson 2005). Habitats where the species is scarce include tussockland and pasture. While silvereyes are sedentary during the breeding season, there is considerable local movement of small flocks from autumn to early spring as they seek out patchily distributed food resources, particularly fruit and nectar. In addition, flocks have been reported flying up the South Island at night in autumn and winter, and at Farewell Spit flocks have been seen flying very high towards the northeast during the day, as though heading for Taranaki (Heather & Robertson 2005).

Risk of wind farm impacts

During the non-breeding season, flocks of silvereyes making local or long-distance movements occasionally fly well above the canopy and so are potentially vulnerable to collision with turbines. It is not known whether the species has regular migration routes through New Zealand or how high silvereyes fly during such movements, particularly at night. Even so, given the species' abundance, widespread distribution and high fecundity (pairs can potentially rear 2–3 broods of 2–5 chicks in a breeding season), some losses as a result of collision fatalities at wind farms would be unlikely to impact at the population level. Likewise, habitat loss as a result of wind farm development would be unlikely to significantly affect silvereye abundance. Given that silvereyes occur in highly modified habitats (e.g. suburban gardens, orchards, central business areas of towns where scattered trees occur) throughout the year in close association with people, it is unlikely that the species would be displaced from habitat within or adjacent to a wind farm.

2.29 STITCHBIRD (FAMILY NOTIOMYSTIDAE)

The stitchbird or hihi (*Notiomystis cincta*) is a forest-dwelling species that has a threat ranking of Nationally Endangered. It has a very restricted distribution, occurring on only three offshore islands (Hauturu/Little Barrier, Tiritiri Matangi and Kapiti) and at two mainland sites (Karori Sanctuary, Wellington, and Ark in the Park, Waitakere Ranges, Auckland). At Karori Sanctuary, the species is sedentary during September–March (breeding season), but local movements to seasonal food resources occur during April–August (R. Empson, pers. comm., 19 February 2009).

Risk of wind farm impacts

Although the Brooklyn wind turbine is situated adjacent to Karori Sanctuary, it does not appear to be a physical threat to the stitchbird population nearby, as most birds remain within the sanctuary and below the forest canopy. Similarly, stitchbirds at Ark in the Park remain within forest habitat. Therefore, it seems unlikely that the species would be involved in collision fatalities with turbines if at some future time turbines were situated within forest clearings or adjacent to forest occupied by stitchbirds. At present, habitat loss for the species as a result of wind farm development would only occur if forest was cleared at either site for the installation of turbines and other infrastructure. It is not known whether stitchbirds are being disturbed from habitat by the Brooklyn turbine situated just beyond the sanctuary fence.

2.30 HONEYEATERS (FAMILY MELIPHAGIDAE)

New Zealand has two native honeyeaters, the bellbird (*Anthornis melanura*) and tui (*Prosthemadera novaeseelandiae*), both of which are Not Threatened.

The bellbird is widely distributed through the North and South Islands, with the exception of Northland and Auckland provinces (Robertson et al. 2007). It occurs in native and exotic forest and scrub habitats from sea level to near the bush line, as well as in some shelterbelts, and well-treed parks and gardens of rural and suburban areas (Heather & Robertson 2005). Bellbirds are territorial during the breeding season (September–February), but become nomadic and are usually solitary during the non-breeding season (Heather & Robertson 2005).

The tui is widely distributed in the North Island and western and southern South Island, but is sparsely distributed through much of eastern South Island (Robertson et al. 2007). Tui occur in a variety of habitat types, particularly native forest and scrub, but they also occur in native and exotic forest patches and well-treed gardens in rural and urban areas. Pairs of tui confine most of their activities to territories during the breeding season (September–February). Male tui make display flights involving much song during the breeding season, flying well above the canopy and then making near-vertical dives back to it (Higgins et al. 2001). During the non-breeding season, tui can be highly mobile, travelling more than 20 km a day in search of fruit and nectar (Heather & Robertson 2005). When travelling long distances, they often form into loose flocks, and occasionally fly in excess of 100 m above ground level when travelling over open ground or water (pers. obs.).

Risk of wind farm impacts

Bellbirds usually fly within or just above the vegetation when travelling in forest or scrub habitats, and at a similar height when flying over open ground between forest patches. Thus, this species would probably be less likely to be at risk of collisions with turbines than the tui, which occasionally flies at heights within and above the rotor-sweep zone of commercial turbines (50–150 m a.g.l.). The clearance of forest or scrub habitats for a wind farm would likely result in habitat loss for both species, especially if it involved species that provided important seasonal food sources (e.g. kowhai *Sophora* spp.). However, given the abundance and widespread distribution of both species, habitat clearance, unless particularly extensive, would be unlikely to result in significant population declines, even on a local scale. Bellbirds and particularly tui occur in highly modified rural and urban environments, and so it is unlikely that they would be displaced by wind farm developments within or close to forest or scrub habitats.

2.31 WATTLEBIRDS (FAMILY CALLAEIDAE)

The North Island kokako (*Callaeas cinerea*) has a threat ranking of Nationally Vulnerable and a total population of about 1400 birds (Heather & Robertson 2005). As well as being present on a few offshore islands, kokako occur in the following native forests: Raetea, Waipoua, Mataraua and Waima (Northland); Hunua Ranges (Auckland); Pureora and Mapara Forests (King Country); Mamaku, Horohoro and Rotoehu Forests (Bay of Plenty); and the northern Urewera Ranges (East Cape) (Heather & Robertson 2005). Kokako inhabit mainly tall, mixed podocarp-hardwood forests, where pairs defend territories year round. Although kokako have weak flight, they are able to move through their territories rapidly by bounding from branch to branch and by flapping-assisted glides from high launch points, including across gullies (Higgins et al. 2006).

Risk of wind farm impacts

Since kokako are unable to fly far across open country and struggle to gain height when making short flights within forest (Heather & Robertson 2005; Higgins et al. 2006), it is unlikely that any turbines erected near forests or within clear patches would pose a direct threat to the birds from collision fatalities. However, any clearance of forest inhabited by kokako would result in habitat loss, and this would possibly be significant given the species' restricted distribution. In addition, construction of roads for access to and about wind farms in kokako-inhabited forests may increase the access of mammalian predators and competitors (e.g. stoats (*Mustela erminea*), possums) to such areas, and so have detrimental impacts on kokako populations. It is not known whether turbines operated just beyond the forest edge or in clearings would displace neighbouring kokako.

3. Conclusions

Table 1 provides a summary of the level of protection, threat ranking, and the potential risk of collision fatalities, habitat loss and displacement as a result of wind farm developments for each taxon considered in this report.

Using information about the impacts of wind farms on various groups of birds in other countries, particularly in Europe and North America (Powlesland 2009), and the accounts given here for each native New Zealand species found in the North or South Islands, New Zealand 'species of concern' can be identified. These are species that warrant particular consideration when either present as residents at a proposed wind farm site or likely to be moving through it on migration or during local movements. Identified species of concern and possible risks to them are summarised below:

- Kiwi species
  - —Falls into holes and trenches during construction
  - —Increased mortality from dog attacks as a result of improved public access to kiwi habitat via wind farm roads
  - —Displacement from habitat close to turbines
- Australasian crested grebe
  - —Collision fatalities during nocturnal movements (non-breeding season flocking), particularly in stormy or foggy weather
  - —Displacement from wetland habitat close to turbines
- Penguins
  - —Falls into holes and trenches during construction
  - —Displacement of wary species (e.g. yellow-eyed penguin) from nesting habitat if a wind farm was established close by
- Threatened species of herons and allies
  - —Collision fatalities during strong winds when involved in migration or local movements (may be vulnerable as a result of poor flight manoeuvrability)
- Blue duck and brown teal
  - —Collision fatalities or displacement if wind farm was sited close to an occupied wetland, especially flocking sites of brown teal
- New Zealand falcon
  - —Collision fatalities, particularly when pursuing prey
- Waders
  - —Collision fatalities and displacement if wind farm was sited adjacent to foraging or breeding wetland habitat
  - —Collision fatalities of migrating waders, including both threatened and non-threatened species, due to limited knowledge about flight characteristics (e.g. altitude, flock size, collision avoidance) and migration routes through New Zealand

TABLE 1. POTENTIAL RISK OF WIND FARM DEVELOPMENTS TO NATIVE BIRD TAXA FOUND ON THE NORTH AND SOUTH ISLANDS OF NEW ZEALAND.

Level of protection, threat status, and potential risk of collision fatalities, habitat loss and displacement as a result of wind farm developments are provided: – = no risk, * = low, ** = moderate, *** = high, ? = unknown.

TAXON	PROTECTION	THREAT STATUS	COLLISION FATALITY	HABITAT LOSS	DISPLACEMENT
North Island brown kiwi	Absolutely protected	Nationally vulnerable	–	*	*
Haast tokoeka	Absolutely protected	Nationally critical	–	**	*
Rowi, Okarito brown kiwi	Absolutely protected	Nationally critical	–	**	*
Fiordland tokoeka	Absolutely protected	Nationally vulnerable	–	*	*
Great spotted kiwi	Absolutely protected	Nationally vulnerable	–	*	*
Southern crested grebe	Absolutely protected	Nationally vulnerable	**	*	***
New Zealand dabchick	Absolutely protected	Nationally vulnerable	**	*	*
Australasian little grebe	Absolutely protected	Coloniser	?	*	?
Northern royal albatross	Absolutely protected	Naturally uncommon	***	***	***
Sooty shearwater	Absolutely protected	Declining	***	***	?
Hutton's shearwater	Absolutely protected	Declining	***	***	?
Westland petrel	Absolutely protected	Naturally uncommon	***	***	?
Mottled petrel	Absolutely protected	Relict	***	***	?
Grey-faced petrel	Absolutely protected	Not threatened	***	***	?
Yellow-eyed penguin	Absolutely protected	Nationally vulnerable	***	***	***
Blue penguin	Absolutely protected	Declining	–	**	*
White-flippered blue penguin	Absolutely protected	Nationally vulnerable	–	**	*
Fiordland crested penguin	Absolutely protected	Nationally vulnerable	–	**	***
Australasian gannet	Absolutely protected	Not threatened	***	**	*
Black shag	Partially protected	Naturally uncommon	*	*	*
Pied shag	Partially protected	Nationally vulnerable	*	*	*
Little black shag	Absolutely protected	Naturally uncommon	*	*	*
Little shag	Partially protected	Naturally uncommon	*	*	*
New Zealand king shag	Absolutely protected	Nationally endangered	*	*	*
Stewart Island shag	Absolutely protected	Nationally vulnerable	*	*	*
Spotted shag	Absolutely protected	Not threatened	*	*	*
White-faced heron	Absolutely protected	Not threatened	**	*	*
White heron	Absolutely protected	Nationally critical	**	*	*
Reef heron	Absolutely protected	Nationally vulnerable	*	*	*
Cattle egret	Absolutely protected	Migrant	*	*	*
Nankeen night heron	Absolutely protected	Coloniser	*	*	?
Australasian bittern	Absolutely protected	Nationally endangered	**	*	?
Royal spoonbill	Absolutely protected	Naturally uncommon	**	*	*
Black swan	Game	Not threatened	**	*	?
Canada goose	Game	Introduced and naturalised	**	*	?
Paradise shelduck	Game	Not threatened	*	*	*
Blue duck	Absolutely protected	Nationally vulnerable	*	?	?
Mallard	Game	Introduced and naturalised	**	*	*
Grey duck	Absolutely protected	Nationally critical	**	*	?
Grey teal	Game	Not threatened	**	*	?
North Island brown teal	Absolutely protected	Recovering	*	?	?
South Island brown teal	Absolutely protected	Nationally critical	*	?	?
Australasian shoveler	Game	Not threatened	**	?	?
New Zealand scaup	Absolutely protected	Not threatened	**	*	*
Swamp harrier	Partially protected	Not threatened	*	*	*
Bush falcon	Absolutely protected	Nationally vulnerable	?	*	*
Eastern falcon	Absolutely protected	Nationally vulnerable	?	*	*
Southern falcon	Absolutely protected	Nationally endangered	?	*	*
Banded rail	Absolutely protected	Naturally uncommon	*	?	?
North Island weka	Absolutely protected	Nationally vulnerable	–	*	*

Continued on next page

Table 1—continued

TAXON	PROTECTION	THREAT STATUS	COLLISION FATALITY	HABITAT LOSS	DISPLACEMENT
Western weka	Absolutely protected	Declining	–	*	*
Spotless crake	Absolutely protected	Relict	*	?	?
Marsh crake	Absolutely protected	Relict	*	?	?
Pukeko	Game	Not threatened	*	*	–
Australian coot	Absolutely protected	Coloniser	*	?	?
New Zealand pied oystercatcher	Absolutely protected	Declining	?	*	?
Variable oystercatcher	Absolutely protected	Recovering	?	*	?
Pied stilt	Absolutely protected	Declining	?	*	?
Black stilt	Absolutely protected	Nationally critical	?	*	?
Northern New Zealand dotterel	Absolutely protected	Nationally vulnerable	*	*	?
Southern New Zealand dotterel	Absolutely protected	Nationally critical	*	*	?
Banded dotterel	Absolutely protected	Nationally vulnerable	?	*	?
Black-fronted dotterel	Absolutely protected	Coloniser	?	*	?
Wrybill	Absolutely protected	Nationally vulnerable	?	*	?
Pacific golden plover	Absolutely protected	Migrant	?	*	?
Spur-winged plover	Absolutely protected	Not threatened	*	*	*
Turnstone	Absolutely protected	Migrant	?	*	?
Lesser knot	Absolutely protected	Migrant	?	*	?
Eastern bar-tailed godwit	Absolutely protected	Migrant	?	*	?
Black-backed gull	Partially protected	Not threatened	*	*	*
Red-billed gull	Absolutely protected	Nationally vulnerable	*	*	*
Black-billed gull	Absolutely protected	Nationally endangered	*	*	?
Black-fronted tern	Absolutely protected	Nationally endangered	?	*	?
Caspian tern	Absolutely protected	Nationally vulnerable	?	*	?
White-fronted tern	Absolutely protected	Declining	?	*	*
New Zealand fairy tern	Absolutely protected	Nationally critical	?	*	?
Kereru, New Zealand pigeon	Absolutely protected	Not threatened	**	*	*
North Island kaka	Absolutely protected	Nationally vulnerable	*	*	*
South Island kaka	Absolutely protected	Nationally endangered	*	*	*
Kea	Absolutely protected	Naturally uncommon	*	*	*
Red-crowned parakeet	Absolutely protected	Relict	?	*	?
Yellow-crowned parakeet	Absolutely protected	Not threatened	?	*	?
Shining cuckoo	Absolutely protected	Not threatened	?	*	?
Long-tailed cuckoo	Absolutely protected	Naturally uncommon	?	*	?
Morepork	Absolutely protected	Not threatened	?	*	*
Sacred kingfisher	Absolutely protected	Not threatened	?	*	*
Rifleman	Absolutely protected	Declining	*	*	?
Rock wren	Absolutely protected	Nationally vulnerable	*	**	?
Welcome swallow	Absolutely protected	Not threatened	*	*	*
New Zealand pipit	Absolutely protected	Declining	?	*	*
Fernbird	Absolutely protected	Declining	*	**	?
Whitehead	Absolutely protected	Not threatened	*	*	?
Yellowhead	Absolutely protected	Nationally vulnerable	*	*	?
Brown creeper	Absolutely protected	Not threatened	*	*	?
Grey warbler	Absolutely protected	Not threatened	*	*	*
New Zealand fantail	Absolutely protected	Not threatened	*	*	*
New Zealand tomtit	Absolutely protected	Not threatened	*	*	?
New Zealand robin	Absolutely protected	Not threatened	*	*	?
Silvereye	Absolutely protected	Not threatened	*	*	*
Stitchbird	Absolutely protected	Nationally endangered	*	*	?
Bellbird	Absolutely protected	Not threatened	*	*	*
Tui	Absolutely protected	Not threatened	?	*	*
North Island kokako	Absolutely protected	Nationally vulnerable	*	*	?

- Fairy tern
  —Collision fatalities if wind farm was sited in southern Northland, due to a lack of knowledge about flight characteristics and migration routes across Northland between east coast breeding sites and wintering grounds in Kaipara Harbour
- Cuckoos
  —Collision fatalities with wind turbines during their nocturnal migration flights through New Zealand because flight characteristics and routes are unknown

While other species, such as the black-fronted tern, are potentially at risk of collision fatalities and/or disturbance, population impacts are unlikely to be significant as long as wind farms are not sited near sensitive habitats, such as wetlands, or where concentrations of populations occur, such as at traditional major roosting or colonial nesting sites.

4. Future research

Recommendations for future research into wind farm impacts on bird populations in New Zealand were discussed in Powlesland (2009). There are three main issues of concern: the lack of detailed information about avian migration routes through New Zealand in relation to present and likely future wind farm locations; the lack of data on collision fatalities at New Zealand wind farms obtained using internationally accepted protocols that take into account searcher efficiency and scavenger activity; and the lack of information about New Zealand species' abilities to avoid collisions with wind farm structures, particularly moving rotors during various weather conditions and at night.

While most operational wind farms in New Zealand are presently situated at inland sites on hill-country farmland, some of those that have been consented or are being investigated (Powlesland 2009) would involve coastal sites, or sites within or adjacent to forest following some vegetation clearance for roads and turbines. Wind farms at such sites are more likely to result in interactions with native bird species than those in pastoral situations. Given that there is little published information about how New Zealand wind farms potentially (Fuller et al. 2009) or actually (Rodgers 2006) impact on native bird species, opportunities to investigate such situations need to be taken whenever possible, particularly at potentially sensitive sites (i.e. coastal, adjacent to wetlands or on migration routes). Studies at sites where species of concern are present (e.g. kiwi, penguin), or where the impact on a variety of species can be investigated (e.g. forest birds, wetland birds), would be of particular value.

While it is ideal to carry out both pre- and post-development monitoring of impacts using the Before-After/Control-Impact study design (McDonald et al. 2000) with replication, valuable information can still be obtained if studies start once turbines are operational. Protocols that have been developed for evaluating risks to birds at proposed or operational wind farms in other countries (e.g. Anderson et al. 1999; Australian Wind Energy Association 2006; Scottish Natural Heritage 2005) should be used and modified to the New Zealand situation, as appropriate.

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