Manaaki Whenua
Landcare Research

Giving effect to councils' biodiversity obligations for specified highly mobile fauna

Envirolink Grant: 2412-ORC008

Prepared for: Otago Regional Council

December 2024

Giving effect to councils' biodiversity obligations for specified highly mobile fauna

Contract Report: LC4562

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Summary

Project and client

- The National Policy Statement for Indigenous Biodiversity 2023 (NPS-IB) requires regional councils and unitary authorities to identify and manage areas used by threatened or at-risk fauna that are listed as highly mobile in order to maintain their populations across their natural range (categorised as 'specified highly mobile fauna species').
- Most regional councils and unitary authorities do not currently have the capacity, resources or expert knowledge to meet these obligations under the NPS-IB.
- Otago Regional Council (ORC), together with other supporting councils, secured an Envirolink Medium Advice Grant to investigate current knowledge on specified highly mobile species and identify a strategy to fill the knowledge gaps.

Objectives

The objectives of this report are to:

- review available data for specified highly mobile species concerning their distribution, dispersal, habitat use, and pressures
- comment on the feasibility of implementing a landscape-level tool across highly mobile fauna to help improve distribution data and identify priority habitat and actions, across species and regions
- guide regional councils and unitary authorities in developing plans for the protection and restoration of populations of highly mobile species.

Methods

- A workshop was held in May 2024 with representatives from regional authorities and experts in which the councils' concerns regarding their NPS-IB obligations and challenges for implementation were discussed.
- Information needs for specified highly mobile fauna (distribution, dispersal, habitat, and pressure data) to enable councils to meet their NPS-IB obligations were identified.
- Available information was reviewed and current knowledge gaps were identified.
- Recommendations were developed to strategically address these knowledge gaps.

Results

- There are several challenges faced by councils in meeting their NPS-IB obligations.
    - The available data on the distribution of highly mobile fauna and the habitat areas they use are limited.
    - Information about movement across regional boundaries by these taxa is limited.
    - There are few tools available to help councils identify highly mobile fauna habitat.
    - Information on the pressures faced by highly mobile fauna is scarce.

- Some research is underway but it is not widely known about. Data availability and sharing responsibilities, and possible protocols, are not well known.
- Councils would like more guidance on approaches to implementing the policy and its clauses, particularly with regard to identifying mobile fauna areas and managing adverse effects.
- The key outstanding requirements for protecting and managing highly mobile fauna are:
  - distribution and occurrence data
  - the locations of mobile fauna areas and habitats used throughout the year
  - dispersal, movement, and connectivity data
  - information on threats and pressures
  - information on best practice for managing adverse effects, including objectives, policies, and methods.

Conclusions

- Several key outstanding data requirements have been identified for identifying and managing highly mobile fauna areas. The lack of accurate distribution data is a key impediment to implementing NPS-IB requirements.
- For local authorities, a key challenge is lack of a clear definition on what constitutes a highly mobile fauna area, especially given there is a significant temporal component to the distribution of highly mobile fauna.

Recommendations

- Generate accurate distribution models for specified highly mobile fauna as a key step in addressing data requirements.
- Complete species fact sheets for non-forest specified highly mobile fauna.
- Use tools such as species distribution modelling and hierarchical occupancy modelling, with up-to-date occurrence records and high-resolution environmental data, to improve knowledge not only of distribution, but also of key habitat variables associated with specified highly mobile fauna.
- Establish a working group to help communication across regional authorities and with research organisations.
- Implement current management tools to help alleviate some adverse effects at a local scale. Research to develop cost-effective management actions at the landscape scale is still needed to support the management of adverse effects at a scale relevant to highly mobile fauna.
- Adapt existing policy wording in regional plans to include specified highly mobile fauna. Specifically, policy wording that includes ‘foraging, roosting or breeding habitat’ may help to distinguish key areas where adverse effects can be managed.

1 Introduction

The role of regional councils and unitary authorities has recently expanded with the National Policy Statement for Indigenous Biodiversity 2023 (NPS-IB) which came into force on 4 August 4 2023. The NPS-IB requires local authorities to identify and manage areas that support highly mobile fauna to maintain populations across their range. Most regional councils and unitary authorities do not currently have the capacity, resources, or expert knowledge to meet these new requirements effectively.

An Envirolink Medium Advice grant on specified highly mobile fauna was initiated by Otago Regional Council, with the support of other councils, to assess current knowledge, identify remaining gaps that need to be filled, and develop a strategy to help regional authorities to adequately protect mobile species under the new NPS-IB obligations.

2 Background

2.1 Mobile fauna in New Zealand

New Zealand has a high proportion of threatened fauna, with over 80% of extant native terrestrial birds threatened with, or at risk of, extinction (Roberston et al. 2021). Historical habitat clearance and the introduction of mammalian predators have resulted in a depauperate terrestrial faunal assemblage across much of mainland New Zealand (Innes et al. 2010; Ruffell & Didham 2017).

Movement and dispersal are key elements of animal ecology. Habitats are not constant, so movement facilitates the acquisition of resources, range expansion/contraction, mating, genetic mixing, and plasticity, and allows for resilience to environmental change. Animal movement can be categorised into four main types.

1. *Daily foraging movements* – where individuals move to locate resources necessary for survival. Daily foraging movements are often tied to an individual's home range or territory, and can extend across large spatial scales or be highly localised to distinct habitats or ecological units.
2. *One-way dispersal movements* – which are often linked to reproduction. An example of one-way dispersal is natal dispersal, where juvenile individuals leave their parental home range to establish their own breeding territory. The extent to which natal dispersal occurs depends on the ecology and dispersal ability of species. Natal dispersal is particularly prevalent in bird species, and is thought to be a critical factor in maintaining healthy population dynamics.
3. *Predictable, seasonal round-trip movements* – where dispersal (often long-distance movements) occur at predictable times in response to environmental cues. Migration movements are usually highly synched with resource availability across breeding and over-wintering sites.
4. *Less-predictable, nomadic movements* – dispersal with little or no seasonal regularity. Nomadic dispersal results in highly spatially and temporally dynamic distributions, with

individuals tracking resources as they fluctuate throughout the landscape. Nomadism is common in arid systems, where resource pulses are unpredictable.

The NPS-IB lists specific highly mobile fauna taxa, but it does not include a definition of how these taxa were nominated. To assist interpretation in the context of the NPS-IB, highly mobile fauna can be defined as taxa that undertake movements greater than the extent of an ecosystem or species management unit (EMU/SMU), or populations of taxa that use multiple EMUs/SMUs to sustain them throughout their annual life cycle. To supplement the NPS-IB highly mobile fauna policy, the Department of Conservation (DOC) has defined mobile fauna as 'those that use the environment at regional and national landscape scales, moving on a seasonal basis to exploit discontinuous (i.e. patchy) foraging and breeding resources and moving across rohe, takiwā, or territorial authorities jurisdictions'.

The specified highly mobile fauna now listed in the NPS-IB are either avian or native bat taxa. These flighted taxa have variable distributions and dispersal behaviours to accommodate spatial and temporal resource availability across the landscape. For example, New Zealand's braided river ecosystems are resource-rich environments but are highly unstable. They support over 80 species of birds, of which a number have adapted to this unstable environment through high mobility and migratory behaviours (O'Donnell et al. 2016). Wetland habitats can also be highly ephemeral, undergoing constantly changing habitat conditions. As a response, many wetland taxa such as the matuku-hūrepo / Australasian bittern (*Botaurus poiciloptilus*) have developed wide-ranging foraging behaviours to utilise extensive networks of habitat to sustain populations throughout the year (Williams 2024).

Shorebirds undertake annual migrations between breeding and non-breeding habitats across the year. For forest taxa, resource dynamics across the landscape (e.g. mast seeding) result in dispersal throughout the landscape to follow resources (Innes et al. 2022). Historical land clearance and ongoing habitat degradation have required some mobile taxa to move further and more frequently across the landscape to access suitable feeding and breeding habitat.

As a result of their movements, highly mobile fauna are subject to a variety of different pressures across the landscape (summarised in Appendix 1). As much as 97% of areas used by mobile fauna may be on private land in lowland and coastal zones. Protection and management focused on individual sites and on public land will therefore not be enough to halt the decline of these vulnerable taxa.

2.2 National Policy Statement for Indigenous Biodiversity (NPS-IB)

The NPS-IB aims to provide a unified approach for identifying and managing biodiversity across New Zealand. Part of the overall objective of the NPS-IB is to improve guidance first introduced through the RMA to reduce adverse effects on nature. The NPS-IB outlines a series of national policies for 'protecting and restoring indigenous biodiversity as necessary to achieve overall maintenance of indigenous biodiversity' with 'at least no overall loss'.

The policies in the NPS-IB are designed to help agencies and local authorities deliver a consistent approach to implementing, identifying, and managing significant natural areas (SNAs) and other specific requirements for maintaining indigenous biodiversity.

Implementation of SNA-related requirements under the NPS-IB has been suspended by the current government until December 2030.

One of the specific requirements in the NPS-IB has been the introduction of a policy (Policy 15) to help improve protection of ‘specified highly mobile fauna’, particularly outside SNAs. These requirements (Policy 15 and Clause 3.20) are in the NPS-IB because protecting SNAs is not sufficient to ensure the survival of highly mobile fauna across their natural ranges. Mobile fauna can easily be left out of SNA identification because they are often difficult to detect and/or can be absent when surveys occur.

To protect and maintain populations of specified highly mobile fauna, a landscape-level management approach is necessary. To address this, Policy 15 and Subpart 3.2 of the NPS-IB give regional authorities standardised requirements for identifying, maintaining, and protecting specified mobile fauna areas. Policy 15 (p. 14) requires that ‘areas outside significant natural areas (SNAs) that support specified highly mobile fauna are identified and managed to maintain their populations across their natural range, and information and awareness of highly mobile fauna is improved’.

Subpart 3.2 (pp. 27–28) outlines ‘necessary requirements’ that regional authorities ‘must do’ for the implementation of Policy 15:

- ‘record areas outside SNAs that are highly mobile fauna areas’ (3.2.1)
- provide a ‘map and description of each highly mobile fauna area in the region’ (3.2.2)
- supply ‘objectives policies or methods in their policy statements and plans for managing adverse effects of new subdivision, use, and development on highly mobile fauna areas’ (3.2.3)
- provide ‘information to their communities about (a) highly mobile fauna and their habitats and (b) best practice techniques for managing adverse effects’ (3.2.4).

Although this policy is a significant step forward for maintaining populations of highly mobile fauna, there has been some concern expressed by regional authorities about implementation, given the considerable challenges and information gaps associated with these taxa. This report aims to address these challenges, and was initiated by regional councils to be proactive about understanding their responsibilities for protecting highly mobile fauna.

2.3 Specified highly mobile fauna

The NPS-IB identifies 49 taxa of highly mobile fauna. All are (or were, in 2017) classified as ‘Threatened’ or ‘At Risk – Declining, Relict or Recovering’. The taxonomy used was based on the New Zealand Threat Classification System (NZTCS), which operates at a subspecies level. Due to this taxonomic classification, local authorities will be required to manage highly mobile fauna at the subspecies and regional level identified. This report will refer to taxa or a taxon to reflect this subspecies distinction for NPS-IB requirements.

Of the specified highly mobile fauna, 29 (59 %) are classified as ‘Threatened’ under the NZTCS (eight ‘Nationally Critical’, seven ‘Nationally Endangered’, nine ‘Nationally Vulnerable’, and five ‘Nationally Increasing’). The remaining 20 are considered ‘At-Risk’ of extinction (16

‘Declining’, one ‘Relict’, and three ‘Recovering’). Almost a third (27%) of all New Zealand’s Threatened or At-Risk bird taxa are represented, along with all four taxa of native bats.

Each of the NPS-IB highly mobile fauna taxa is assigned to one of four terrestrial ecosystem categories (e.g. Figure 1), regardless of whether or not they use areas outside the terrestrial environment for part of their life cycle, such as marine or intertidal zones. Eighteen taxa are mainly found in forest/open ecosystems, 17 mainly in coastal/riverine ecosystems, 13 mainly in wetland/riverine ecosystems, and one is a riverine specialist (Appendix 2).

Figure 1. Examples of New Zealand’s highly mobile fauna and the habitats they occur in. From left to right: kārearea / southern falcon in rātā forest; pīhoihoi / New Zealand pipit foraging on rocky alpine turf; tōrea pango / variable oystercatcher on a coastal sandy beach; and whio / blue duck in an alpine river. (Photos: Zoë Stone)

2.3.1 Mobile forest/open taxa

The highly mobile forest/open taxa (Table 1) are found in predominantly forest habitat across lowland and alpine areas. Although they rely on forest habitats, many of these taxa also disperse across open pasture and exotic habitats. The forest/open taxa are found across both North (eight) and South Islands (ten), and include multiple subspecies (as recognised by the NZTCS). This category includes three taxa of southern kiwi, and four native mammal taxa (pekapeka / short-tailed and long-tailed bats). The karearea / falcon is split into three identified subspecies (bush, eastern, and southern). Kākā are split into North and South Island taxa, despite genetic analysis suggesting they are a single species based on nationwide gene flow (Martini 2022; Sainsbury et al. 2006).

These taxa are more commonly associated with mature native forest habitat, but sometimes they utilise more modified habitats for foraging. Pīwauwau / rock wrens are predominantly found above the treeline in open subalpine and alpine conditions and are split into northern and southern populations based on genetic analysis (Weston et al. 2016). The remaining forest/open taxa are pihoihoi / New Zealand pipit, North Island weka, kea, and kakaruai / South Island robin which can be found in open, regenerating scrub or modified forest habitats, as well as in tall intact forest.

Table 1. Forest/open taxa in the NPS-IB

Scientific name	Species	Threat status
Anthus novaeseelandiae novaeseelandiae	pīhoihoi / New Zealand pipit	At Risk (Declining)
Apteryx australis 'northern Fiordland'	tokoeka / northern Fiordland brown kiwi	Threatened (Nationally Vulnerable)
Apteryx australis australis	tokoeka / southern Fiordland brown kiwi	Threatened (Nationally Endangered)
Apteryx maxima	roroa / reat spotted kiwi	Threatened (Nationally Vulnerable)
Chalinolobus tuberculatus	pekapeka / long-tailed bat	Threatened (Nationally Critical)
Falco novaeseelandiae ferox	kārearea / bush falcon	Threatened (Nationally Increasing)
Falco novaeseelandiae novaeseelandiae	kārearea / eastern falcon	Threatened (Nationally Vulnerable)
Falco novaeseelandiae 'southern'	kārearea / southern falcon	Threatened (Nationally Endangered)
Callirallus australis greyi	North Island weka	At Risk (Relict)
Mystacina tuberculata aupourica	pekapeka / northern short-tailed bat	Threatened (Nationally Endangered)
Mystacina tuberculata rhyacobia	pekapeka / central short-tailed bat	At Risk (Declining)
Mystacina tuberculata tuberculata	pekapeka / southern short-tailed bat	At Risk (Recovering)
Nestor meridionalis meridionalis	kākā / South Island kaka	Threatened (Nationally Vulnerable)
Nestor meridionalis septentrionalis	kākā / North Island kaka	At Risk (Recovering)
Nestor notabilis	kea	Threatened (Nationally Endangered)
Petroica australis australis	kakaruai / South Island robin	At Risk (Declining)
Xenicus gilviventris 'northern'	pīwauwau / northern rock wren	Threatened (Nationally Critical)
Xenicus gilviventris 'southern'	pīwauwau / southern rock wren	Threatened (Nationally Endangered)

2.3.2 Coastal/riverine taxa

The 17 coastal/riverine taxa (Table 2) are found in coastal and estuarine habitats, predominantly linked with intertidal and braided river systems. These taxa have very large migration movements, undertaking some of the longest individual movements of all the specified highly mobile fauna. For instance, several taxa perform annual migrations to international over-wintering sites, including pohowera / banded dotterel and kuaka / eastern bar-tailed godwit. Other taxa spend considerable time foraging offshore in the marine environment, such as tarapirohe / black fronted-tern, tara / white-fronted tern, and the taranui / caspian tern.

Many of these coastal/riverine fauna often aggregate in larger flocks, and multiple taxa share common foraging and breeding habitats. Although these taxa are predominantly associated with coastal regions, several also use inland habitats. For example, the tōrea / South Island pied oystercatcher and pohowera / banded dotterel occasionally use highly modified pastoral environments during winter and can use inland habitats for breeding.

Table 2. Coastal/riverine taxa in the NPS-IB

Scientific name	Species	Threat status
Anarchynchus frontalis	ngutu pare / wrybill	Threatened (Nationally Increasing)
Calidris canutus rogersi	huahou / lesser knot	At Risk (Declining)
Charadrius bicinctus bicinctus	pohowera / banded dotterel	At Risk (Declining)
Charadrius obscurus aquilonius	tūturiwhatu / northern New Zealand dotterel	Threatened (Nationally Increasing)
Charadrius obscurus obscurus	tūturiwhatu / southern New Zealand dotterel	Threatened (Nationally Critical)
Childonias albostriatus	tarapirohe / black-fronted tern	Threatened (Nationally Endangered)
Egretta sacra sacra	matuku moana / reef heron	Threatened (Nationally Endangered)
Haematopus finschi	tōrea / South Island pied oystercatcher	At Risk (Declining)
Haematopus unicolor	tōrea pango / variable oystercatcher	At Risk (Declining)
Hydroprogne caspia	taranui / caspian tern	Threatened (Nationally Vulnerable)
Larus bulleri	tarāpuka / black-billed gull	At Risk (Declining)
Larus novaehollandiae scopulinus	tarāpunga / red-billed gull	At Risk (Declining)
Limosa lapponica baueri	kuaka / eastern bar-tailed godwit	At Risk (Declining)
Phalacrocorax varius varius	kāruhiruhi / pied shag	At Risk (Recovering)
Sterna striata striata	tara / white-fronted tern	At Risk (Declining)
Sternula nereis davisae	tara iti / fairy tern	Threatened (Nationally Critical)
Thinornis novaeseelandiae	tuturuatu New Zealand shore plover	Threatened (Nationally Critical)

2.3.3 Wetland/riverine taxa

Wetland/riverine taxa (Table 3) are associated with freshwater environments, such as wetlands, rivers and lake habitats. This group includes mostly wader taxa, with many reliant on freshwater ecosystems. Because these systems are highly ephemeral, wetland/riverine highly mobile taxa disperse regularly across the landscape. Indeed, a large number of taxa depend on a network of sites throughout the year to support foraging and breeding.

Many of the wetland/riverine taxa can be important indicator species for wetland health, with many requiring a network of high-quality wetland sites for survival. For example, matuku-hūrepo / Australasian bitterns have highly seasonal dispersal patterns, using a large network of foraging habitat throughout the year (Williams 2024). Decline of habitat quality is probably a key pressure for this taxon, with high levels of mortality due to starvation becoming an increasing pressure (Kennard 2022; Williams & Brady 2014; Williams 2024).

Table 3. Wetland/riverine taxa in the NPS-IB

Scientific name	Species	Threat status
Anas chloratis	pāteke / brown teal	Threatened (Nationally Increasing)
Anas superciliosa superciliosa	pārera / grey duck	Threatened (Nationally Vulnerable)
Ardea modesta	white heron / kōtuku	Threatened (Nationally Critical)
Botaurus poiciloptilus	matuku-hūrepo / Australasian bittern	Threatened (Nationally Critical)
Bowdleria punctata stewartiana	mātātā / Stewart Island fernbird	Threatened (Nationally Vulnerable)
Bowdleria punctata punctata	koroātito / South Island fernbird	At Risk (Declining)
Bowdleria punctata vealeae	mātātā / North Island fernbird	At Risk (Declining)
Gallirallus philippensis assimilis	moho pererū / banded rail	At Risk (Declining)
Himantopus novaezealandiae	kakī / black stilt	Threatened (Nationally Critical)
Podiceps cristatus australis	kamana / southern crested grebe	Threatened (Nationally Vulnerable)
Poliocephalus rufopectus	weweia / New Zealand dabchick	Threatened (Nationally Increasing)
Porzana pusilla affinis	kotareke / marsh crake	At Risk (Declining)
Porzana tabuensis	pūweto / spotless crake	At Risk (Declining)

The whio / blue duck is classified as the sole riverine taxon (Table 4). This taxon is now associated with fast-running water in forested, riverine habitats (Whitehead et al. 2022). Whio live permanently in forested headwater catchments, where they mostly disperse along river corridors, but juveniles may also disperse between catchments when establishing territories (Glaser et. al. 2010). This taxon is listed as 'Nationally Vulnerable', and has primarily been affected by forest clearance, habitat degradation, and predation by introduced mammalian predators, particularly stoats (Whitehead et al. 2008).

Table 4. Riverine taxa in the NPS-IB

Scientific name	Species	Threat status
Hymenolaimus malacorhynchos	whio / blue duck	Threatened (Nationally Vulnerable)

2.4 Summary

Following the release of the NPS-IB there is an urgent need to review the available information on highly mobile fauna in New Zealand. This is because local authorities tasked with implementing the NPS-IB need to understand the data requirements for identifying and managing highly mobile fauna areas. Also, local authorities need information on outstanding data requirements to best direct policy, research, and strategic action. Although recent research efforts have made progress towards achieving a better understanding of highly mobile fauna, this information has yet to be collated in a format that is readily accessible to local authorities and relevant to NPS-IB implementation.

3 Aims

The aim of this report is to provide advice and guidance for managing highly mobile fauna in New Zealand, as set out in the NPS-IB. To achieve this, I have:

1. reviewed data requirements and knowledge gaps for highly mobile fauna, and best practices for managing adverse effects, focussing on forest/open taxa
2. provided fact sheets, which are designed to provide local authorities with an overview of the distribution, habitat, use and dispersal patterns of the forest/open taxa, and that can serve as a basis for the development of future fact sheets that encompass all highly mobile fauna
3. investigated the use of spatial models to help identify highly mobile fauna areas, and the remaining information needed to complete these analyses
4. provided recommendations for improving regional policies so they can better manage adverse effects on highly mobile fauna, in accordance with the NPS-IB
5. recommended next steps for implementing the NPS-IB highly mobile fauna policies to improve biodiversity outcomes.

4 Methods

4.1 Workshop

An online workshop was held on 14 May 2024 to provide a starting point for local authorities and experts to discuss highly mobile fauna and the NPS-IB. The aim of the workshop was to present summaries to local authorities of recent research efforts, provide a summary of the potential data available for guiding implementation of NPS-IB highly mobile fauna policies, and briefly review outstanding knowledge gaps. In addition, a key aim of the workshop was to provide an opportunity for local authority representatives to discuss concerns and challenges they face in implementing highly mobile fauna policies.

The workshop was attended by 16 representatives from eight regional or unitary councils. In addition to council representatives, researchers from Manaaki Whenua – Landcare Research, Massey University, and DOC attended. These researchers were invited due to their recent and ongoing research on highly mobile fauna. Given the breadth of attendees, the workshop was able to facilitate communication between local authorities and researchers working on highly mobile fauna.

4.2 Data requirements for highly mobile fauna

The workshop identified a set of data requirements that local authorities need in order to protect and manage adverse effects on highly mobile fauna. These data requirements particularly pertain to the identification and management of highly mobile fauna areas to 'protect populations across their natural range' (NPS-IB). Due to differences among highly mobile fauna, each of these data requirements is specific to each taxon. They include the following.

1. *Distribution data* describe the locations of populations and individuals across the landscape. These data are critical for ensuring that highly mobile fauna areas are established in places that safeguard highly mobile fauna. The data can also capture stopover sites and potential seasonal variation in the distributions of highly mobile fauna (e.g. for migratory species).
2. *Dispersal data* describe the movement patterns of highly mobile fauna. These data include home range sizes, dispersal routes, dispersal distances, and gap-crossing abilities. Dispersal data are necessary for maintaining connectivity between highly mobile fauna areas, especially for more gap-limited taxa.
3. *Habitat data* describe the range of habitat types that highly mobile fauna use for breeding, foraging, and roosting. These data allow for the identification of key habitat features necessary for populations of highly mobile fauna to persist. Although indigenous habitats are critical for highly mobile fauna, some taxa use modified environments that are also important to consider.
4. *Pressure data* describe key threatening processes that affect highly mobile fauna. They are important for managing highly mobile fauna areas to ensure adverse effects are effectively managed.

5 *Management data* describe best practices for managing adverse effects. These data serve to inform management actions implemented in highly mobile fauna areas and, in turn, minimise adverse effects.

4.3 Literature review and data compilation

I reviewed published and unpublished literature to summarise available ecological information on highly mobile fauna and identify outstanding data limitations to implementing the NPS-IB. This review has been conducted for the 18 forest/open taxa to represent general data challenges across highly mobile fauna. For many taxa, few scientific studies mean that data are not always readily available. In cases where data were unavailable, or poorly described, I have noted this in the results.

I generated distribution maps to characterise available information on the distribution of select highly mobile fauna. For avian taxa, distribution maps were based on occupancy models generated by Walker and Monks (2018) using 1999–2004 NZ Bird Atlas records. Since these occupancy models do not account for recent updates to the NZ Bird Atlas, these distribution maps were overlaid with observations from the 2019–2024 NZ Bird Atlas survey data. This was particularly important for taxa that have undergone range expansion since 2004 (e.g. North Island kākā establishing in the Wellington Region). While some species have had more recent fine scale distribution modelling (e.g. roroa / great spotted kiwi), I have kept factsheets consistent by using with the same 2018 occupancy modelling and 2019-2024 NZ Bird Atlas data.

For the four bat taxa, occurrence records were obtained from the DOC bat database (26 August 2024). To ensure the distribution maps for bat taxa were not biased by long-extinct populations, the database was filtered to remove records prior to 2000. For these taxa, distribution maps show changes in recent occurrence by comparing records collected between 2000 and 2010, and records collected between 2010 and 2024.

I collated information on the habitat requirements of the select highly mobile fauna and identified three habitat types that are critical for highly mobile fauna: breeding habitat, foraging habitat, and roosting habitat. We then compiled information on each of these habitat types, for each taxon. This information was obtained through published peer-reviewed publications in the scientific literature and the unpublished grey literature, such as reports by species experts, recovery groups, and research organisations.

I also reviewed dispersal information for the select highly mobile fauna, obtained through published peer-reviewed publications in the scientific literature and the unpublished grey literature. Although available dispersal data were limited, I collected as many sources of information as possible to help inform the identification of highly mobile fauna areas. These metrics included:

- core home range (HR_C), which measures the area where most activity occurs, typically represented as a 95% home range kernel estimate
- foraging home range (HR_F), which measures the area across which foraging occurs, generally representing a maximum convex polygon of all dispersal within a territory

- foraging dispersal (D_F), which measures the total dispersal distance travelled during foraging events
- home range dispersal (D_{HR}), which measures the maximum straight-line dispersal distances recorded from roost or nest location
- natal dispersal (D_N), which measures the dispersal distance by juvenile individuals from natal (hatching) territory to establish a new territory
- seasonal dispersal (D_S), which measures the dispersal distance between seasonally used breeding and over-wintering areas
- gap-crossing distance (D_{GC}), which measures the non-habitat dispersal distance that individuals are willing to cross (e.g. urban land cover, cleared pasture, water).

Where appropriate, metrics are reported as average or maximum recorded distances. It is important to note that these metrics are based on only a few studies that typically comprise a small sample size. This means dispersal metrics are probably biased by the individual behaviour of tracked animals and methodological or technological limitations. When dispersal data were unavailable or unconfirmed, metrics were reported as unknown.

I reviewed pressures and management information for the select highly mobile fauna. Based on available data, the key pressures and threats were summarised for each forest/open taxon.

4.4 Highly mobile fauna fact sheets

I developed fact sheets for 18 highly mobile fauna. These fact sheets aim to provide an up-to-date summary of existing knowledge on highly mobile fauna. They were based on the results of the literature review and describe the distribution, pressures, habitat requirements, and best practices for managing adverse effects on highly mobile fauna. The fact sheets also detail any outstanding data requirements that impede identification and management of highly mobile fauna areas for particular taxa.

To ensure the fact sheets meet the needs of local authorities, I initially drafted fact sheets for three highly mobile fauna and had them reviewed by species experts, representatives of local authorities, and DOC. Based on this feedback, the three fact sheets were revised and used to craft the remaining 15. After completing each fact sheet, it was reviewed by a species expert.

5 Results

5.1 Workshop

The workshop included presentations aimed at providing an update of recent research on highly mobile fauna (summarised in Appendix 2). Following the presentations, an open forum discussion session was held. Overall, defining what constitutes a 'highly mobile fauna area' was a particular challenge that was raised multiple times throughout the discussion. Specifically, attendees called for clarity on what defines a highly mobile fauna area, particularly regarding the temporal nature of highly mobile fauna distribution and habitat use. Attendees felt there are multiple outstanding data requirements needed to identify and manage these areas. In particular, attendees felt that limited knowledge on distribution habitat and limited dispersal data were the main barriers to identifying highly mobile fauna areas. Also, inconsistent pressure and management data limit their ability to manage adverse effects.

For distribution data, attendees felt that variability in cross-regional highly mobile fauna distributions make it difficult to define policies at the regional level for identifying highly mobile fauna areas. There was common agreement that the absence of fine-scale range maps limits councils' ability to identify highly mobile fauna areas, with many councils uncertain about which taxa are found (and when) in their region. This led to questions regarding what level of occupancy is needed to classify sites as 'used intermittently by specified highly mobile fauna' under the NPS-IB. In particular, what extent and frequency of habitat use are necessary to warrant classification as a highly mobile fauna area?

For habitat data, attendees felt there was uncertainty about how to identify habitat, especially if exotic or modified habitats are used by highly mobile fauna. For example, there were questions about whether hedgerows or wastewater treatment areas should be considered as highly mobile fauna areas. Given the challenges of regulating these modified environments – particularly if on private land – attendees found it difficult to understand their NPS-IB obligations if highly modified habitat is used by highly mobile fauna.

Another point raised consistently during the discussion session was the limited availability of data on non-breeding habitat use by highly mobile fauna, particularly for the migratory taxa. Many attendees were apprehensive about identifying and protecting breeding habitat if key pressures at unknown over-wintering and foraging habitats remained unmanaged. From the discussion it was clear there was a need for detailed information on different habitat types used by highly mobile fauna throughout the year; most notably, habitat information across the key requirements of breeding, foraging, and roosting habitat.

Dispersal data were also identified as a key limitation to NPS-IB implementation by most attendees. Limited awareness of – or access to – recent or ongoing research on highly mobile fauna contributed to this feeling. For example, many attendees were unaware of the DOC highly mobile fauna work stream and its recent research efforts to fill data gaps for highly mobile fauna. Following the presentations, attendees were appreciative of the research updates, and suggested that continued communication with local authorities might help reduce accessibility issues to dispersal data.

The presentations themselves also highlighted missing dispersal data for many taxa, particularly regarding temporal spatial variability in habitat use. Studies are improving dispersal information, but they are still based on only a few projects, in specific regions, and involving only a few individuals. Therefore, the applicability of new dispersal information across populations may well be restricted. In terms of identifying highly mobile fauna areas, attendees considered that dispersal thresholds (such as maximum dispersal distances from roost sites, natal territory or habitat gaps) are still lacking and are a key data requirement for mapping highly mobile fauna areas. These dispersal thresholds were considered crucial to improving the connectivity of habitat and populations.

Workshop attendees agreed that accessibility of pressure data was a challenge for local authorities, particularly with regard to variability across habitat types and regions.

Management data are often spread across multiple sources and can be difficult for local authorities to access and collate when developing up-to-date best practice management plans for taxa. It was felt that best practice guides that synthesise key management actions are needed.

It was agreed that councils have an important role to play in protecting and managing highly mobile fauna, especially given that some taxa spend very minimal time on Crown-managed land. For example, tracking of tōrea / South Island pied oystercatchers showed that they only spend 2% of their time within the Crown estate (A. Schlesselmann, MWLR, unpublished data). Improved collaboration and communication between DOC and councils were suggested as ways to mitigate these concerns.

Finally, attendees felt there were limited tools available to councils for identifying and managing highly mobile fauna areas. This was particularly with regard to NPS-IB obligations to map highly mobile fauna areas. Attendees suggested some guidance for local authorities on structuring and wording highly mobile fauna policies within their regional plans would also be welcomed.

From the discussion a series of outputs were suggested that would be useful for local authorities in implementing NPS-IB policy for highly mobile fauna. These included fact sheets that provide a starting point for information on distribution, habitat, dispersal, pressures, and management. In addition, a review of outstanding data requirements for identifying and managing highly mobile fauna areas was needed. Attendees also requested recommendations for how local authorities can develop and improve policy relating to highly mobile fauna.

To summarise, key concerns from the workshop attendees in relation to developing policies included the following.

- Lack of *distribution* data was considered a fundamental limitation for implementing NPS-IB highly mobile fauna requirements.
- Identification of highly mobile fauna areas is challenging given current *habitat* and *dispersal* information, especially when taxa use modified habitats intermittently.
- Seasonal variation in distribution, especially for migratory taxa, creates complications for understanding the *pressures* affecting highly mobile fauna.
- Clarity on *best practice* protocols for managing pressures is needed, because much of this information is spread across multiple sources and is difficult to interpret.

Collaboration among local authorities, researchers, and government agencies will be critical for protecting and managing highly mobile fauna. The workshop discussion provided an opportunity to bring together these different stakeholder groups and reveal similarities and discrepancies in their shared perceptions and experiences. Identifying these similarities and discrepancies is a key step towards effective landscape-scale outcomes for highly mobile fauna.

Although there are genuine limitations in the available data, some of the concerns raised by workshop attendees result from knowledge lags, unfamiliarity with available resources, or the fact that available information is inconsistent and fragmented across multiple platforms with varying completeness. Due to recent advances in academic research and management techniques, enough information is available – despite some remaining data requirements – for many taxa to begin implementing NPS-IB highly mobile fauna policies. Indeed, many councils are already beginning to incorporate landscape-scale approaches to threatened species obligations (e.g. the Waikato Regional Bat Strategy). To help resolve outstanding data requirements, the following sections summarise the requirements and discuss strategies for resolving them.

5.2 Remaining data requirements

This report has highlighted five key areas of data deficiency, or knowledge gaps, specific to highly mobile fauna: distribution, dispersal, habitat, pressures, and best practice management. Sixteen of the 39 highly mobile fauna (41 %) have been classified with some level of data deficiency by the New Zealand Threat Classification system (Robertson et al. 2021). Many of these data deficiencies reflect limited information to assess population trends (‘trend data poor’), but many of the highly mobile fauna are also ‘size data poor’. These classifications reflect the fact that many highly mobile fauna are difficult to detect and monitor, making basic predictions about the status of populations difficult.

Forest/open taxa have generally received greater scientific attention and public engagement. For example, recent, large-scale research projects such as the MBIE-funded ‘More birds in the bush’ have resulted in new research on forest bird responses to rodent pressures, management, habitat dynamics, and landscape-level dispersal. These research outputs are already being used to inform management, such as *in situ* pest control or conservation translocations.

Despite this research, there is still uncertainty about the key knowledge gaps identified (Table 5). Specifically, variability in distribution of many taxa is still unknown, and there are limited data on taxonomic distinctions between geographical forms (e.g. eastern and southern falcon, and northern and southern rock wren). However, any remaining taxonomic uncertainty should have little impact on local authorities if they are expected to manage these populations regardless. Although some forest taxa (e.g. kākā) are less dependent on forest habitat for dispersal and can readily cross deforested areas, others are largely restricted to native, intact forest habitats. This means that dispersal patterns, particularly gap-crossing ability and natal dispersal, are tied to fragmentation and habitat availability (e.g. forest corridors), making management requirements slightly more predictable.

Table 5. Data availability for the forest/open category of the NPS-IB specific highly mobile fauna. Data requirements where adequate information (black) and limited information (grey) is available for informing NPS-IB obligations are presented.

Ecosystem	Taxa	Distribution	Dispersal	Habitat	Pressure	Management
Forest/open	Pīhoihoi / New Zealand pipit	✓		✓	✓	✓
Forest/open	Tokoeka / northern Fiordland brown kiwi	✓	✓	✓	✓	✓
Forest/open	Tokoeka / southern Fiordland brown kiwi	✓	✓	✓	✓	✓
Forest/open	Roroa / great spotted kiwi	✓	✓	✓	✓	✓
Forest/open	Pekapeka / long-tailed bat	✓	✓	✓	✓	✓
Forest/open	Kārearea / bush falcon	✓	✓	✓	✓	✓
Forest/open	Kārearea / eastern falcon	✓	✓	✓	✓	✓
Forest/open	Kārearea / southern falcon	✓			?	?
Forest/open	North Island weka	✓			✓	✓
Forest/open	Pekapeka / northern short-tailed bat	✓		✓		?
Forest/open	Pekapeka / central short-tailed bat	✓	✓	✓	✓	✓
Forest/open	Pekapeka / southern short-tailed bat	✓		✓	✓	✓
Forest/open	Kākā / South Island kaka	✓	✓	✓	✓	✓
Forest/open	Kākā / North Island kaka	✓	✓	✓	✓	✓
Forest/open	Kea	✓	✓	✓	✓	✓
Forest/open	Kakaruai / South Island robin	✓	✓	✓	✓	✓
Forest/open	Pīwauwau / northern rock wren	✓	✓	✓	✓	✓
Forest/open	Pīwauwau / southern rock wren	✓	✓	✓	✓	✓

Compared to the forest/open taxa, other taxa still have considerable outstanding knowledge gaps. Most wetland/riverine taxa are data deficient, comprising half of the highly mobile fauna listed as data poor by Roberston et al. (2021). The extreme loss of wetland and riverine habitats, the cryptic nature of many of these taxa, and high temporal variability in habitat contributes to this data deficiency. Migratory patterns of many coastal/riverine taxa also mean these taxa are difficult to survey, and there are significant data deficiencies regarding distribution, habitat, and management.

5.2.1 Knowledge gap 1 – distribution data

Distribution data were identified as a key knowledge gap during the workshop. Although considerable efforts in recent years have increased occurrence data, especially for avian taxa (e.g. NZ Bird Atlas), these data have yet to be analysed to provide high-resolution distribution maps for highly mobile fauna. The 2019–2024 NZ Bird Atlas team made a concerted effort to increase survey coverage and representation, which resulted in over 440,000 checklists across 97% of mainland New Zealand, and records for 309 species. The NZ Bird Atlas now also includes DOC Tier 1 monitoring, resulting in improved remote area coverage and seasonal occurrence data, and a fairly comprehensive occurrence data set for most highly mobile fauna. However, some taxa remain under-represented.

Based on previous atlas data (1999–2004), hierarchical occupancy models were able to be created by Walker and Monks (2018) and Walker et al. (2020) for 38 of the listed avian taxa. These occupancy models provide valuable predictions of recent patterns of distribution. Updating these occupancy models with new data (e.g. from the 2019–2024 NZ Bird Atlas) and, in particular, at higher spatial resolution will be critical to improved identification of highly mobile fauna areas. Occupancy models can provide good predictive ability for identifying distribution and density. However, they have been limited by their reliance on presence *and* absence data, a tendency towards single species, and a reduced capacity to account for temporal–spatial variability (Devarajan et al. 2020). This could have implications for identifying highly mobile fauna areas. However, updated methodologies, such as multi-species occupancy models, could reduce these limitations.

Given the paucity of habitat data (see 'Knowledge gap 3'), alternative methods for modelling species distributions could also be used to improve knowledge, not only of distribution but also of habitat, which will be highly relevant to regional authorities for NPS-IB implementation (see section 7.3). Such tools have already been developed for some highly mobile fauna (e.g. whio / blue duck), showing the potential for fine-scale distribution mapping to inform management (e.g. Whitehead et al. 2022).

The quality of distribution data now available for many avian highly mobile fauna means that distribution modelling, once undertaken, may adequately address distribution knowledge gaps. However, for some taxa, additional distribution data are sorely needed. Seven taxa (three coastal/riverine and four wetland/riverine) had too few records for occupancy models to be fitted using the 1999–2004 data). Observation records for highly cryptic wetland/riverine taxa, such as koitareke / marsh crake (*Porzana pusilla affinis*) and pūweto / spotless crake (*Porzana tabuensis*), are still extremely rare, meaning there may be a limited ability to produce informative distribution models, even with the 2019–2024 data.

In addition, occurrence records of the four bat taxa are biased towards large, intact Crown estate forests, with fewer records from private land across the wider rural landscape. Concerted efforts to improve bat distribution data across regional authorities would greatly improve the predictive power of any future modelling of highly mobile fauna areas.

5.2.2 Knowledge gap 2 – dispersal data

Another outstanding knowledge gap for identifying and managing highly mobile fauna areas is the scarcity of dispersal data. In particular, the lack of information on individual movement patterns within and between habitats makes it difficult to determine where, and what type of, management is necessary throughout the year. For example, of the forest/open taxa that were reviewed for this report, most species have some level of information on territory sizes (core home range) and territory-related dispersal such as foraging home range and home range dispersal (Table 6). However, foraging dispersal is completely unknown for 10 out of 18 taxa, natal dispersal is unknown for 9 out of 18 taxa, and seasonal dispersal and gap crossing abilities are unknown for 6 out of 18 taxa. For those with information, most of these are estimates based on small sample sizes or from studies on other geographical populations (see fact sheets for more information).

Table 6. Summary of dispersal metrics for the forest/open category of the NPS-IB specific highly mobile fauna

Taxa	HR_C	HR_F	D_F	D_{HR}	D_N	D_S	D_{GC}
Pīhoihoi / New Zealand pipit	3-4 ha	unknown	unknown	unknown	unknown	unknown	800 km
Tokoeka / northern Fiordland brown kiwi	mean: 51 ha	unknown	unknown	800 m	min: 5 km (?)	NA	unknown
Tokoeka / southern Fiordland brown kiwi	mean: 51 ha	unknown	unknown	800 m	min: 5 km (?)	NA	unknown
Roroa / great spotted kiwi	mean: 23-29 ha	max: 120 ha	1,050-1,250 m	357-722 m	unknown	NA	unknown
Pekapeka / long-tailed bat	230-2,000 ha	max: 6,000 ha	unknown	max: 25 km	unknown	unknown	min: 1 km
Kārearea / bush falcon	900-1,500 ha	4,000-60,000 ha	mean: 4 km	max: 10 km	1-35 km	NA	500 km
Kārearea / eastern falcon	900-1,400 ha	4,000-60,000 ha	mean: 4 km	max: 10 km	1-35 km	NA	500 km
Kārearea / southern falcon	unknown	unknown	unknown	unknown	unknown	unknown	unknown
North Island weka	0.65-1 ha	mean: 3-10 ha	max: 940 m	6-10 km	min: 1.5-5 km	90 km	min: 1 km (water)
Pekapeka / northern short-tailed bat	150 ha (?)	10,000 ha	unknown	< 5 km(?)	unknown	unknown	< 1 km (?)
Pekapeka / central short-tailed bat	150 ha (?)	10,000 ha	unknown	10-11 km (?)	unknown	unknown	< 1 km (?)
Pekapeka / southern short-tailed bat	60 ha	max: 4,300 ha	6-41 km	< 5 km (?)	unknown	unknown	< 1 km (?)
Kākā / South Island kaka	30-1,000 ha	1600 ha	20-25 km	max: 400 km	unknown	180 km	min: 25 km
Kākā / North Island kaka	15-50 ha	125 ha	40-45 km	max: 400 km	unknown	180 km	min: 25 km
Kea	300-1,000 ha (?)	unknown	5 km	unknown	max: 500 km	NA	unknown
Kakaruai / South Island robin	0.2-6 ha	0.2-6 ha	unknown	250 m	max: 16 km	NA	max: 1.7 km
Pīwauwau / northern rock wren	0.6-4.2 ha	unknown	unknown	unknown	500 m	NA	unknown
Pīwauwau / southern rock wren	0.6-4.2 ha	unknown	unknown	unknown	500 m	NA	unknown

Notes: Estimates for core home range (HR_C), foraging home range (HR_F), foraging dispersal (D_F), home range dispersal (D_{HR}), natal dispersal (D_N), seasonal dispersal (D_S) and gap-crossing dispersal (D_{GC}) based on literature are given. Metrics with no information are greyed.

Dispersal studies require high investment, and the very nature of highly mobile fauna (i.e. rarity, high mobility, seasonal variability) makes completing these studies challenging. The resulting 'movement shortfall' is not unique to New Zealand, and has arisen due to difficulties in the detection, tracking, and estimation of population trends for mobile fauna globally (Cottee-Jones et al. 2016; Scarpignato et al. 2023). For instance, the NPS-IB specified that highly mobile fauna include extremely rare (e.g. eight nationally critical taxa), highly cryptic, nocturnal, cavity roosting, and migratory taxa. Also, some of New Zealand's highly mobile fauna could be considered dispersive or semi-nomadic, where dispersal from breeding locations occurs without fixed migratory routes, or in response to resource fluctuations (Cottee-Jones et al. 2016; Innes et al. 2022; Williams et. al. 2006). Councils can have significant influence on the protection of small and neglected habitat types (e.g. scrub, marginal wetlands). Being able to predict whether such habitats are used by highly mobile fauna, especially by less gap-limited taxa, could have a considerable impact on populations.

The features of highly mobile fauna described above mean that technological limitations are a considerable barrier to acquiring dispersal data. For example, only in the last decade have tracking devices become small and lightweight enough for small, mobile bird species (Bridge et al. 2011; McKinnon & Love 2018). For smaller taxa (<100 g), tracking options that provide fine-scale movement data are still limited, but they are improving. For example, miniature geolocators and GPS tags can now weigh <1 g (McKinnon & Love 2018). However, there are still considerable challenges to using such small devices, such as their inability to recharge though solar panels in dense forest habitats and their low data storage capabilities, which necessitates frequent downloads.

Of the 49 NPS-IB highly mobile fauna, 18 (36%) are under 100 g, while only 10 (20%) weigh over 1 kg (sex dependent). Many of New Zealand's larger, highly mobile fauna are either nocturnal, highly intelligent, or undertake considerable large-scale migrations, which adds additional challenges for available technology. For small taxa, reliable GPS units that provide fine-scale habitat information may have limited battery life if appropriate tag weights are used to reduce adverse effects on individuals (Geen et al. 2019). This means dispersal studies for small taxa are often limited to short time periods, or VHF devices that provide coarser information.

Dispersal data can contribute to improved knowledge of population dynamics and hence adverse effects that need managing. For example, the recruitment of juveniles into the breeding population is critical for population growth, but knowledge of natal dispersal is limited. Innes et al. (2022) found that natal dispersal was unknown for almost half (44%) of all forest birds in New Zealand.

Natal dispersal information for wetland/riverine and coastal/riverine taxa is even more limited, yet acquiring such data is crucial for understanding what adverse effects are acting on dispersing individuals; for example, tracking studies of matuku-hūrepo / Australasian bittern have revealed starvation as a key cause of juvenile mortality. Dispersal data are also vital for improving the connectivity of safe, high-quality habitats of highly mobile fauna. Many highly mobile fauna require large networks of habitat patches to successfully forage and breed (e.g. matuku-hūrepo / Australasian bittern, pekapeka / bat species). A lack of data on foraging dispersal, seasonal dispersal, and home ranges estimates limits the ability of local authorities to identify, protect, and manage such large habitat networks and support highly mobile fauna.

5.2.3 Knowledge gap 3 – habitat data

The availability of habitat data is highly variable among highly mobile fauna. Forest/open taxa generally have a greater availability of habitat data, partly due to their stronger reliance on intact, forest habitats, and a strong prior research focus on forest ecosystems. In comparison, taxa that occupy open, modified habitats tend to have received far less attention. Within the forest/open taxa, pīhoihoi / New Zealand pipit and North Island weka can persist in highly modified habitats, but this has resulted in limited information on key habitat features associated with successful breeding and foraging. For example, only six of the forest/open taxa have adequate information on breeding, non-breeding, roosting, and foraging habitat requirements, which can be used to inform management (Table 5).

Coastal/riverine and wetland/riverine taxa occur in a range of modified habitats. Habitat preferences within such modified environments are less well understood, particularly with regard to the frequent temporal variability in habitat quality. Information on what habitat thresholds (e.g. quality, extent) are necessary to ensure that modified habitats can support healthy populations is poorly understood for many taxa. Most wetland habitats are already highly degraded from historical habitat clearance and modification. This loss means that the current spatial distribution and patterns of habitat use by particular taxa may not reflect their ideal habitat requirements. For example, moho pererū / banded rail mostly occur in saltmarsh and mangrove habitats, but observations around freshwater habitats and rural agricultural settings suggest these taxa may, in fact, use a wider range of habitats (Beauchamp 2015).

Coastal and riverine environments also undergo significant natural temporal variation and are highly sensitive to human activity, such as pollution and runoff from agriculture or urban areas. For many coastal taxa, seasonal migrations within New Zealand are generally made in response to changing habitat dynamics. While there is some information on critical breeding and foraging sites for migratory coastal taxa, detailed spatial information is lacking for many of the sites that support smaller populations during breeding and non-breeding seasons. Without this information there is limited ability to identify mobile fauna areas and characterise the adverse effects that may occur inside them.

In the past, ecological research in New Zealand has often necessitated a conservation intervention focus. This has resulted in reduced attention given to core ecological research, such as dispersal and habitat requirements for many fauna (Perry & McGlone 2021). In particular, there are still substantial knowledge gaps on habitat requirements for highly mobile fauna that are less threatened by extinction (e.g. those 'At Risk'). These taxa have received far less research and monitoring because of their less immediate need for conservation intervention. Reduced data availability for such 'At Risk' species can have significant consequences if legislative requirements are lessened for these taxa (e.g. Simmonds et al. 2020). Monitoring of and research on the habitat requirements of all highly mobile fauna that do not exclude taxa because of their apparent commonness should be undertaken to help fill this knowledge gap.

5.2.4 Knowledge gap 4 – pressures

Considerable progress has been made in identifying the individual pressures that affect highly mobile fauna. For example, some of the main pressures with adverse effects for highly mobile fauna include ecosystem change, conflict with humans, development, and climate change (DOC 2020a). Predation by introduced mammalian predators is a key pressure for most highly mobile fauna. There is considerable evidence demonstrating the negative impact that various introduced mammalian predators have on highly mobile fauna (Appendix 1). For example, mustelids are a key predation pressure for all forest/open taxa listed as highly mobile fauna (Appendix 1). Predation has been responsible for significant population declines, high mortality, poor breeding success, poor recruitment, and local extinctions. While this pressure has been well documented in some ecosystems, the long-term impacts of predation pressures on wetland taxa are less well understood (O'Donnell et al. 2015).

Historically, habitat destruction and modification were also significant pressures for most highly mobile fauna. These pressures have resulted in the current reduced and highly fragmented distribution of many key habitats, and are responsible for much of the range contraction experienced by highly mobile fauna. Today, ongoing habitat clearance and degradation are key pressures affecting some taxa.

For example, wetlands and freshwater habitats have been reduced to 10% of their original extent and still experience ongoing decline. Despite such severe declines, high-resolution wetland maps are lacking across much of New Zealand (Dymond et al. 2021) and, in turn, contribute to a significant knowledge gap on the pressures on wetland/riverine taxa. The National Policy Statement for Freshwater Management (NPS-FM) attempts to address this, with requirements for higher-resolution mapping of wetlands across the regions. However, wetland mapping associated with the NPS-FM may not capture all wetland and riverine habitats associated with highly mobile fauna.

For other pressures there is limited information available. Although increasing variability in environmental conditions is a likely pressure for many taxa, detailed information on how such environmental variability will affect survival, breeding, and habitat quality is lacking. For example, North Island weka have been shown to be highly sensitive to drought (Beauchamp 1997; Beauchamp et al. 2009). The core mainland population has experienced a range shift between the Gisborne and Bay of Plenty regions in response to drier conditions on the East Cape (AJ Beauchamp, pers. comm. Oct 2024; Appendix 3 – North Island weka fact sheet), but the extent to which drought is affecting New Zealand weka has yet to be determined.

Pressure data are particularly limited for highly mobile fauna classified as 'At Risk', which, while still facing an extinction risk and are declining in numbers, are not as severely threatened as the other listed taxa. For instance, the 'At Risk' taxa include relatively widespread and abundant coastal taxa, such as tarāpunga / red-billed gull and tara / white-fronted tern. Due to their extinction risk not being as high as those in the 'Threatened' category, these taxa have received less conservation attention, which has, in turn, often resulted in a deficiency of pressure information.

Although recent studies are beginning to shed light on the pressures affecting these taxa (e.g. Mills et al. 2018; Weston & Fraser 2020), most of the information has been gleaned from the pressures known to affect their coastal habitats. For example, some coastal pressures include ongoing habitat loss and degradation from urban development, invasive weeds, and pollution. Pressures associated with conflict with humans are also increasing in coastal habitats, with increasing mortality associated with vehicle strike and nesting disturbance. For species that occupy habitats closely associated with human activity (such as beaches), councils have the potential to contribute to managing adverse effects through local policies and regulations. Therefore, identifying the types of pressures in these habitats could greatly improve outcomes for some highly mobile fauna.

The interactions between multiple pressures can have enormous impacts on highly mobile fauna. This is because some pressures can have synergistic interactions, whereby the presence of one pressure amplifies the adverse effects of another pressure. Alternatively, some pressures can have antagonistic interactions, whereby the presence of one pressure may partially suppress the adverse effects of another pressure. For example, predation and climate change are both pressures that, in isolation, have adverse effects on kea and in combination may have an antagonistic interaction. When rat densities fall following a mast seed year, there is a residual high abundance of stoats, which results in heightened predation on kea (Kemp et al. 2022). Since climate change is expected to increase the frequency and intensity of irruptive mast dynamics, kea are likely to experience the heightened adverse effects of predation on a more regular basis.

Despite the importance for management of understanding such interactions, the interactions between different combinations of pressures are poorly understood for most taxa. DOC and research agencies are currently working to understand some of these interactions for some pressures, particularly in relation to predator dynamics (e.g. Carpenter et al. 2022; Kemp et al. 2022; Sweetapple & Nugent 2007). Councils have the ability to contribute to this knowledge gap, particularly for urban and development pressures, which are often within councils' jurisdictions. To do so, councils should ensure outcome monitoring is integrated into their policies. Outcome monitoring can be seen as unnecessary, or a lower priority when funding is limited, but it is crucial to determining how changes in management or pressures will affect highly mobile fauna, thereby improving knowledge of key interactions in local contexts.

The potential impact of future pressures also represents a key knowledge gap for managing highly mobile fauna. One example is the impending pressure of highly pathogenic avian influenza (HPAI), which will probably have considerable consequences for New Zealand's avian fauna. Migratory species have been identified as a main vector and could be the main source of introduction to New Zealand (Gartrell et al. 2024). Although evidence from international sources suggests that many highly mobile fauna could experience adverse effects from this disease, high uncertainty remains regarding the particular taxa that will experience adverse effects and the severity of these effects.

Another considerable knowledge gap is the extent to which climate change will affect highly mobile fauna. Although research has shown that climate change pressures will have adverse effects on biodiversity, the severity of these effects on particular taxa is poorly understood. There is also exceptionally high uncertainty about how climate change will alter threat dynamics (Keegan et al. 2022).

5.2.5 Knowledge gap 5 – management

Management data for highly mobile faunal areas are sparse and poorly documented. Like pressure data, these data are spread across a range of resources, so existing management data require collation and synthesis to inform the effective management of adverse effects. Also, the key thresholds necessary for effectively managing the adverse effects of pressures are unknown for many taxa.

Without key thresholds it will be challenging to design cost-effective plans for managing adverse effects. This is because key thresholds are important for accurately predicting the outcomes associated with alternative management options. Also, for some pressures there are simply no available management tools available for managing their adverse effects. For example, although hybridisation is a pressure affecting highly mobile fauna such as pārera / grey duck and kakī / black stilt, there are very limited effective tools available for managing hybridisation.

These limitations are present for many of the pressures affecting highly mobile fauna, but substantial progress has been made with regard to predation by introduced mammals, which is one of the main pressures affecting highly mobile fauna. When managing predation, a range of management tools are recognised as being highly effective at the site level. For example, predator-proof fences, aerial 1080 operations, and intensive trapping networks have been successful in controlling predation pressures and improving outcomes for some highly mobile fauna (Bombaci et al. 2018; O'Donnell et al. 2017; Rawlence 2019; Tansell et al 2016). These successes show that predator control is often a crucial management tool, but is more effective for taxa with sedentary home ranges or where breeding sites are well defined.

For more mobile taxa that are vulnerable throughout their life-cycle, further research is needed to allow cost-effective predator control across large areas. Existing tools are often either prohibitively expensive or suffer technical limitations that prevent their implementation across such large areas (e.g. tools for controlling rodents; Murphy et al. 2019). For example, although self-resetting traps can substantially reduce predator populations, they have high production costs and may not be as effective in particular habitats occupied by highly mobile fauna (e.g. wetland environments). Also, several management tools are associated with social and ethical considerations that prevent their implementation in urban habitats (e.g. cat control and 1080 operations).

Considerable progress by local groups and on-the-ground practitioners who adapt existing and new pest control tools to their local conditions is continually improving the effectiveness of pest control. However, this information can be difficult to collate into updated protocols because it is constantly developing and often unpublished. Networks such as Sanctuaries of New Zealand (SONZi) that provide forums for practitioners to connect and share developments have been an important step in spreading new information, and increased efforts to collate and store such information would greatly benefit management.

Management data and tools are especially lacking for pressures related to climate change. This stems from the fact that there is extremely high uncertainty about the adverse effects of climate change on highly mobile fauna. For example, coastal nesting taxa are vulnerable to pressures such as coastal erosion, storms, and flooding. Because climate change is predicted to increase the frequency and severity of such extreme weather events, these pressures will probably have greater adverse effects on coastal nesting taxa in the future. Yet effective management of these pressures is challenging because:

- limited information is available on their timing and spatial extent (although land use, sea-level rise, and climate change projections may help to predict when and where flooding events will occur)
- limited tools are available for managing or mitigating these pressures (e.g. how to preserve a nest during a flooding event).

Although there are few management tools available, halting and reversing urban modification and habitat clearance can reduce the vulnerability of coastal nesting taxa to these pressures. However, effective implementation of management tools such as habitat protection and restoration is complicated by the fact that highly mobile fauna often use highly modified areas, such as hedgerows, water treatment plants, and grazed pastures.

Interactions between pressures creates further challenges for effective management. As mentioned earlier, interactions between pressures can have synergistic or antagonistic adverse effects on individual highly mobile fauna. Therefore, simply managing a single pressure when multiple pressures are affecting a taxon may result in the remaining pressures having a greater adverse effect on the taxon. To avoid this situation, management plans will need to strategically account for multiple pressures.

This is especially pertinent because many highly mobile fauna are affected by a wide variety of pressures. For example, management plans may need to schedule the deployment of tools for different pressures in a simultaneous (e.g. control of mice and rats) or sequential manner. Also, when scheduling the deployment of management tools, research has shown that it may be important to account for environmental or seasonal conditions (e.g. mast seed).

In summary, the key outstanding knowledge gap for management is the lack of cost-effective tools that can be deployed across large spatial scales. Although many tools are available for managing predation at site-level scales (e.g. self-resetting traps and fencing), these tools are prohibitively expensive to deploy across the large areas needed for highly mobile fauna. Similarly, although habitat protection and restoration may help to reduce the adverse effects of extreme weather events, this is challenging to implement across large spatial scales given competing land-use requirements (e.g. housing and agriculture). Also, pressures (e.g. hybridisation) may lack even a single known effective management tool. Finally, there is a communication and skill gap for management data. This was highlighted at the workshop, where many council representatives were unaware of currently available management tools, the effectiveness of existing tools, or necessary operational data for effectively deploying existing tools.

5.3 Fact sheets

Fact sheets were created for all 18 forest/open highly mobile fauna (Appendix 3). The fact sheets were mostly targeted at local authority staff and other ecological practitioners disseminating highly mobile fauna information. The fact sheets provide a brief summary (three pages) on the distribution, key habitat types (breeding, foraging and roosting), dispersal, pressures, and best practices for managing adverse effects for each taxon

(Figure 2). They are based on data available as at September 2024 and have been peer-reviewed by species experts. A list of key references that are relevant to dispersal, habitat use, threats, and management are provided to help trace more detailed information.

Since available data are limited for some taxa, the fact sheets also describe limitations and outstanding knowledge gaps. For example, the information presented in most fact sheets is based on only a few studies comprising relatively small sample sizes. Indeed, limited data were available even when considering more common taxa, such as the pīhoihoi / New Zealand pipit.

Figure 2. Example fact sheet (for North Island kaka) for highly mobile fauna. The fact sheets provide information on the distribution, ecology, pressures, dispersal, habitats, key management, and outstanding data limitations, which is required for implementing the NPS-IB (see Appendix 3).

6 Conclusions

The workshop provided research updates on highly mobile fauna and an open forum for workshop attendees to discuss concerns about their NPS-IB obligations and implementation challenges. A key barrier to implementation is the fact that available information on highly mobile fauna is incomplete and fragmented across a wide range of sources.

I have reviewed and synthesised the available information on highly mobile fauna to inform management and reveal outstanding data requirements. Although detailed distribution, dispersal, habitat, pressure, and management data are lacking for many mobile fauna (see, for example, Table 1), existing data can provide some guidance for meeting NPS-IB obligations.

Finally, to help support effective management, available information and knowledge gaps for all 18 forest/open highly mobile fauna have been distilled into fact sheets.

7 Recommendations

The below section outlines a series of recommendations that are necessary for effective protection and management of highly mobile fauna. Within this section I provide recommendations for how local authorities can contribute towards filling remaining knowledge gaps in collaboration with other research organisations. I also recommend ongoing work to complete remaining factsheets, a potential modelling tool that could be used to help identify highly mobile fauna areas, and a working group to share knowledge and new information as it is acquired. I also provide some suggestions on how currently available management information can be used to begin implementing NPS-IB requirements, and what additional information may still be necessary. Finally, I provide a series of policy recommendations that could be adopted or modified by local authorities to improve protection and management of highly mobile fauna. This is not a definitive list, but a starting point for agencies working on highly mobile fauna to develop NPS-IB policies and improve biodiversity outcomes for highly mobile fauna.

7.1 Data requirements

As discussed above, additional data are needed for councils to fulfil their NPS-IB obligations for highly mobile fauna. In particular, distribution and habitat data are critical shortfalls for identifying highly mobile fauna areas. More data on dispersal, pressures, and management will help to improve the effectiveness of actions to manage adverse effects. Councils have a role to play in addressing these data limitations, and below I provide a list of recommendations for how they can assist in data collection, data accessibility, occupancy modelling, acquisition of spatial data, testing and improving monitoring methodologies, and collaborative funding for long-term research projects.

1. **Data collection:** Councils can play a key role in resolving distribution and habitat data requirements by contributing high-resolution occurrence data across their regions. Regional monitoring of taxa will help improve the quality of distribution data, particularly across private land, and will increase habitat data.

   For example, a comprehensive nesting shorebird survey in October/November 2024 covering 490 km of riverine habitat in the Manawatū-Whanganui Region contributed significant new distribution data for South Island pied oystercatchers / tōrea and identified the Manawatū as a key North Island locality, which will contribute to identifying highly mobile fauna areas in the region.

   National-scale monitoring of habitats (e.g. DOC Tier 1 monitoring) is highly biased towards public land, with limited sites monitored across privately owned land (Bellingham et al. 2020). Regional councils could reduce this bias by aligning regional monitoring sites (e.g. state of environment) with the national Tier 1 grid to improve coverage across deficient areas. Councils could also conduct consistent and regular monitoring of sites and taxa. For highly mobile fauna, this could be as simple as supporting staff to record and upload observations during ongoing regional biodiversity work. For example, monitoring data could be submitted to the eBird community science platform (Sullivan et al. 2014) to help improve long-term distribution data.

2. **Data accessibility:** I recommend that councils adopt community science tools for archiving survey data to help improve data accessibility. Councils routinely collect valuable data on the distribution of, management of, and pressures on highly mobile fauna as part of their legislative obligations. Uploading these data to readily accessible online databases – such as the Global Biodiversity Information Facility (GBIF), iNaturalist, or eBird – would greatly contribute to addressing remaining data requirements (see Wilton et al. 2023 for data sharing recommendations).

   For avian data, eBird is an online platform for recording species occurrence data in the field. It is already used by a range of New Zealand organisations and institutes, and is the current repository for NZ Bird Atlas data. For bat taxa, regular uploads of bat monitoring data should be undertaken to the national bat repository, currently maintained by DOC. Private land is currently under-represented in the bat database, so council data will be invaluable for improving the spatio-temporal resolution of distribution data. A template spreadsheet can be requested from batdatabase@govt.nz to submit standardised monitoring data to the bat database.

   Regardless of the community science platform or data repository used to archive data, it is important to ensure that data collection methods are consistent with standard practices for the platform or data repository. These data could be readily collected during state of environment monitoring, specific SNA or priority habitat monitoring, and site assessments.

   In addition to providing data, councils could better use these databases to help improve knowledge. For instance, the DOC bat database has a large number of locations where taxa are unidentified (n = 250). Targeted monitoring at these locations, when they are within councils' jurisdictions, would be valuable for improving distribution data.

3. **Occupancy modelling:** I recommend using occupancy models to improve distribution data for highly mobile fauna (see section 7.3 for more detail). To aid in this process, the 2019–2024 NZ Bird Atlas data may be useful (available on request from the NZ Bird Atlas team, www.ebird.org/atlasnz/home). Also, an up-to-date version of the bat database can be requested from DOC (batdatabase@doc.govt.nz).

4. **Spatial data:** I recommend improving available environmental data to help with characterising distribution and habitat data for highly mobile fauna. For instance, high-resolution LiDAR (light detection and ranging) data may be extremely useful for generating accurate, informative occupancy models (e.g. following a similar rationale as Acebes et al. 2021 and Rechsteiner et al. 2017). High-resolution data improve predictions of future environmental conditions, which is necessary for the effective, long-term management of pressures (e.g. for coastal systems; Runting et al. 2013).

   Complete LiDAR data are especially helpful for identifying habitat use patterns of highly mobile fauna across the landscape. They are crucial for accurate modelling tools, and also allow for more accurate remote-sensing analyses. For example, such data can be used to map important habitat variables such as terrain, water catchment attributes, wetland and stream habitats, vegetation height and composition, tree crown diameter (i.e. potential roosting trees), and variability in dynamic habitats such as braided rivers.

However, existing LiDAR coverage is incomplete across New Zealand. The Provincial Growth Fund (PGF) LiDAR Elevation Data Capture Project aims to improve coverage to 80% of the country, but plans for LiDAR survey data collection are biased towards key centres, and some rural regions do not yet have any plans for LiDAR surveys. In particular, key regions with incomplete LiDAR data coverage include Manawatū-Whanganui, Otago, and Southland. Gaps in LiDAR make it difficult to complete regional and national-level mapping of habitat and inform modelling of potential mobile fauna areas. I recommend that, where possible, councils contribute to filling in remaining gaps of high-resolution LiDAR data across their regions.

5. **Developing methodologies:** I recommend councils progress developing consistent monitoring methodologies that are relevant to regional scales. Given the breadth of habitats and sites that councils manage, there is a good opportunity to test monitoring methodologies across sites of varying sizes, condition, and complexity. The development of such methodologies could be completed in collaboration with academic institutes, or directly through science programmes within councils.

   Specifically, regional councils need monitoring methods that are designed for small sites. Current national standards are well suited to large-scale monitoring of public land, but may not be appropriate for small scales because the standard transect lengths and plot sizes are often too large. This is especially pertinent for wetland sites, which are often too small for standard protocols. Indeed, some councils are currently developing suitable monitoring methods for such small sites. The lack of clear, consistent methods for monitoring has already been highlighted by regional councils, and I recommend that standardised monitoring protocols be a priority work stream.

6. **Funding:** I recommend that councils continue to fund projects that can contribute to the remaining data requirements for highly mobile fauna. While limited, funding within councils can be relatively stable compared to that for research organisations that rely on central government funding. Councils have the ability to partner with research organisations to support the kind of long-term studies needed to address outstanding habitat, dispersal, and pressure data requirements.

   Funding is undeniably limited, but one key knowledge gap that councils can contribute to is dispersal data. Dispersal studies often require high investment and long-term commitments, especially for highly mobile fauna. This is often challenging for researchers, for whom unstable funding sources make it difficult to conduct long-term tracking studies. Key outcomes for collecting individual movement data will be to:

- inform the dispersal abilities of gap-limited fauna, to ensure management maintains connectivity between sites
- identify migratory/nomadic species flight paths to determine the management actions necessary for protecting airspaces.

These data can be modelled with high-resolution spatial data to improve connectivity and corridor restoration. Given the complexities of this type of research, I recommend councils partner with appropriate research organisations and groups to support studies on highly mobile fauna dispersal. It is increasingly clear that there is a national need for dispersal-focused research to fill outstanding knowledge gaps on highly mobile fauna. I recommend investigating the development of collaborative research programmes through funding sources such as the MBIE Endeavour Fund.

7.2 Fact sheets

I have provided 18 fact sheets for the forest/open highly mobile fauna (Appendix 3), and I recommend that Councils commission fact sheets for the remaining highly mobile fauna (31 coastal/riverine, wetland/riverine, and riverine taxa). Although these fact sheets reflect up-to-date knowledge, there are still many uncertainties regarding some of the information provided. I therefore recommend care when interpretating the fact sheets: they are not designed to provide a definitive resource.

For instance, the dispersal, habitat use, and pressures that are relevant for each taxon may differ in certain local contexts from those reported. This is especially pertinent given the limited sources of information available for developing the fact sheets. The fact sheets aim to provide a starting point for practitioners to identify highly mobile fauna areas, and should be supplemented by site-specific monitoring to inform identification and management. The fact sheets have been designed to collate information from recent research, grey literature and other expert sources that may not have been easily accessible. Hence, they are presented in such a way to allow councils and council staff to modify them as needed, and as appropriate to their local communities. As new information becomes available, I strongly recommend updating the fact sheets where needed.

7.3 Landscape tool

Occupancy models will be valuable to local authorities for NPS-IB implementation. For a given taxon these statistical models are fitted with detection data at multiple sampling sites, as well as environmental data (MacKenzie et al. 2002). After fitting them, these models can be used to predict the probability that a given taxon inhabits various locations across a broader landscape.

Occupancy models have already been used to characterise the spatial distribution of New Zealand bird species (e.g. Walker & Monks 2018), but advances in methodologies and updated data sets will greatly improve their use for NPS-IB obligations. Occupancy models require high-quality data to provide accurate predictions (Banks-Leite et al. 2014), generally requiring multiple sampling events per site locality (MacKenzie & Royle 2005). As such, it will be important to address the outstanding data requirements discussed previously.

The 2019–2024 NZ Bird Atlas survey was designed to reduce biases in occurrence data, and so it will be valuable for updating occupancy models. However, despite efforts to improve data collection, these survey data may still be insufficient for some avian taxa, such as the kotareke / marsh crake, which are still extremely data restricted and data will need to be acquired from additional sources. Also, to better characterise terrestrial environments, high-resolution LiDAR data could be used along with occupancy modelling to help identify smaller areas of breeding or foraging habitats that may be too fine-scale for occupancy modelling alone.

Occupancy models for highly mobile fauna should, ideally, consider spatial constraints to allow for accurate predictions of species range limits and intra-annual variation (e.g. following Cardador et al. 2013). Although methodological approaches to account for such spatial constraints have typically been developed for species distribution models (SDMs) – which are another modelling technique for predicting landscape occupancy – such approaches could also be applied to an occupancy model tool. For example, taxa-specific dispersal data have been used to improve predictive power for mobile species (e.g. Brotons et al. 2012; Cardador et al. 2013; Di Musciano et al. 2020).

Integration of dispersal data also improves predictions of range shifts associated with climate change pressures (e.g. Huang et al. 2020; Uribe-Rivera et al. 2017). Dispersal data to create such spatially constrained SDMs can be derived from a range of dispersal metrics, including maximum dispersal distances, kernel densities, connectivity and cost-path surfaces. In New Zealand, connectivity analyses based on known dispersal metrics and landscape resistance of highly mobile fauna could be used for such modelling (e.g. for kākā; Moore 2022).

Temporal resolution of detection data also influences the quality of an occupancy model (Manocci et al. 2017). For highly mobile fauna, contemporaneous data (i.e. collected *in situ* at a monthly scale) will be necessary to capture the ephemeral and intra-annual variation nature of distribution (Manocci et al. 2017). Therefore, addressing dispersal and habitat data requirements will be vital to producing informative SDMs for the effective identification and management of highly mobile fauna areas in New Zealand.

7.4 Working group

It is recommended that councils establish a working group on highly mobile fauna to support implementation of the NPS-IB. The working group could be organised like other council working groups that meet periodically, and could be arranged by either a council lead or by DOC's mobile fauna unit. Because this research on highly mobile fauna can take longer periods, I suggest annual or biennial meetings may be an appropriate schedule initially. If the future of the NPS-IB is confirmed, more regular meetings may be needed to help ensure local authorities can work together towards cross-regional policies and implementation. I recommend that relevant researchers and DOC representatives participate in this working group, if possible.

As highlighted during the workshop, many councils were unaware of the range of research on highly mobile fauna occurring across New Zealand. A working group that consists of council, academic and DOC representatives would facilitate data sharing, knowledge transfer, and research updates, and would help to foster a collaborative approach across organisations to inform protection and management for the highly mobile fauna. Meetings could invite short presentations from key researchers or research organisations that summarise progress on relevant research. Presentations could be organised by the DOC mobile fauna unit or research organisations such as Manaaki Whenua – Landcare Research that are well informed on current research projects.

A working group would provide an opportunity for council representatives to share and collaborate on monitoring, policy, and management. I recommend that local authorities continue their proactive work towards a collaborative approach to managing habitats for highly mobile fauna.

7.5 Best practice management

Pressure and management data, though incomplete, may be adequate in their current state to guide conservation actions for many highly mobile fauna. There is often a desire to collect data in order to make the best-informed decision, but research globally has shown that improved knowledge does not necessarily lead to better conservation decisions, particularly when funds are limited (Grantham et al. 2009). This is especially so when reducing uncertainty through research and monitoring is unlikely to affect the management action taken (Canessa et al. 2015).

Many of New Zealand's highly mobile fauna share common features, making them vulnerable to a familiar set of pressures with known management interventions. These core pressures have been identified in national strategies such as Te Mana o Te Taiao – Aotearoa New Zealand Biodiversity Strategy 2020, with specific goals aimed at reducing their impacts on biodiversity (DOC 2020a, 2020b). These national strategies already outline the national objectives and joint responsibility to address the impact of overarching pressures on indigenous biodiversity.

For example, given the extent of historical habitat loss for coastal, wetland, and lowland systems, any further habitat clearance from developments or land-use changes will place significant pressures on already reduced populations. In addition, almost all highly mobile fauna are vulnerable to predation by introduced mammalian predators. There has been considerable research showing the impacts of introduced mammalian predators and the positive responses of native fauna to predator control throughout New Zealand.

In designing effective predator control operations, the degree to which predation affects different life stages of highly mobile fauna will make a considerable difference. For example, many highly mobile fauna are more vulnerable to predation during breeding, with low nest, chick or fledgling survival. For some taxa, 'knockdown' pest control operations during the breeding season can reduce predation pressures for successful breeding (e.g. South Island robin / kakaruai), while others may require more sustained control over longer periods to reduce pressure (e.g. kākā). Pest control operations strategically timed to follow masts can have a greater benefit on taxa in mast-dominated systems (e.g. Kemp et al. 2022). Given the mobility of many taxa, non-breeding adults are often less sensitive, which means blanket prescriptions for predator control throughout the year may be unnecessary and could shift focus from other key pressures during different life phases.

For some highly mobile fauna, predator management may not always be the most effective action, especially for taxa that utilise a range of small, scattered habitat patches. For example, kākā are highly vulnerable to predation during the breeding season, so targeted pest control at breeding sites is a crucial management tool for increasing populations. However, their wide-roaming dispersal and use of scattered vegetation can be a challenge for predator control. Predator control may also not be necessary in such habitats used by non-breeding dispersing individuals.

In braided river systems, taxa are subject to a range of pressures, which appear to have strong temporal/spatial dynamics. The benefits of predator trapping were found to vary across coastal/riverine taxa and between sites in Canterbury (Dowding et al. 2020). Predator control had positive outcomes for kaki / black stilt and pohowhera / banded dotterel, but ngutu pare / wrybill in the same braided river system showed little response to predator trapping, even though predation is a threat for this species (Dowding et al. 2020). For taxa that nest in braided river systems, flooding and changes in river flow can result in complete nesting failure of a population.

Individual tree clearance is also a considerable threat to some native fauna. For example, the loss of important roosting trees is a key ongoing threat to all four bat taxa. Protection of old-growth forest and large individual roosting trees during development or tree felling is a key action that councils can implement. Best practice protocols for minimising impact to roost trees have already been developed and should be incorporated into development plans (DOC 2021). For species that can do well in highly modified habitats, well-considered habitat management practices may protect populations and improve breeding outcomes. For instance, falcons / karearea may benefit from managing the harvesting of exotic forest to deliberately create a mosaic of small open patches, standing trees and edge habitat, in combination with protecting nesting sites.

Human-conflict pressures that cause habitat destruction or modification affect a range of highly mobile fauna. For example, kāmana / southern crested grebe has lost much of its breeding habitat due to wetland loss, agricultural conversion, and urban development. As a result, they rely heavily on artificial nesting platforms in modified habitats ('mariners'). Installation of such platforms and protection from boat traffic has led to increasing breeding success and persistence of this taxon in a highly modified habitat.

I have provided a summary of key pressures affecting forest/open highly mobile fauna in New Zealand in Appendix 1. The fact sheets provided in Appendix 3 expand on this and provide species-specific best practice management options for known pressures of the forest/open taxa.

These examples highlight the fact that many adverse effects on highly mobile fauna are known and can be appropriately managed when detected. Adverse effects can also often be managed in conjunction with human activity, development, and agricultural practises. To do this, accurate predictions of where and when highly mobile fauna are in the landscape is essential. Without a good understanding of where taxa are, when they occupy habitats, and how they move between them, site-specific pressures will be difficult to identify and manage.

Improvements in regional-scale monitoring to improve distribution and dispersal data will help identify where highly mobile fauna are, what habitats they are using across the landscape, and therefore which management is needed. Monitoring and mapping at a regional scale will be a critical part of effective management of highly mobile fauna. Previous Envirolink reports have provided guidance to councils on how to manage and monitor the ecological integrity of habitats (Bellingham et al. 2021), pest control (Clayton & Cowan 2009; Cowan 2010), and site-specific strategies (e.g. Latham et al. 2017). These reports may provide some guidance for operational and monitoring methods.

Also, DOC and other agencies provide multiple resources on best practice protocols for animal pest control (e.g. *Practical Guide to Trapping*, DOC 2023), which are applicable to most highly mobile fauna. Using available resources provides a good starting point for managing adverse effects. In conjunction with site/taxon-specific monitoring, local authorities will be able to employ an adaptive management approach to highly mobile fauna within their regions as new data become available.

7.6 Policy

Regional councils must establish, implement, and review objectives, policies, and methods for maintaining indigenous biological diversity in their regions, and the NPS-IB has brought into focus the need for regional-level initiatives to improve outcomes for highly mobile fauna. Below I provide some preliminary recommendations on how regional authorities could better give effect to their responsibilities for highly mobile fauna in their policies.

1. This report has demonstrated the use of modified habitats by a range of highly mobile fauna. In particular, large exotic trees can provide important foraging and roosting habitat, especially in areas where indigenous habitat is reduced. Integration of highly mobile fauna into policy, based on fundamental habitat requirements (foraging, roosting, and breeding), would allow for core habitat vital for survival to be identified and managed accordingly, while allowing for other habitat to be omitted.
2. Many regional plans already include polices for the protection of 'notable trees'. Criteria for identifying notable trees could be updated to include 'used as foraging, roosting or breeding habitat for specified highly mobile fauna'. This would improve protection of important roosting or foraging trees used by taxa such as pekapeka / bats or kākā.
3. A concern raised by attendees at the workshop was what to do regarding highly modified environments such as wastewater treatment areas. These areas can be used for foraging and roosting by highly mobile fauna, which is in conflict with other polices that exclude such infrastructure. For example, the Horizons Regional Council (HRC) *One Plan* states that wetland habitat types are not considered rare or threatened if '5. …specifically designed, installed or maintained for… d) wastewater treatment' (HRC 2024 – Table 47; RP – SCHED6, 5–207). I recommend these policy statements include a clause along the lines of: 'if used as foraging, roosting or breeding habitat by specified highly mobile fauna, protection and enhancement of alternative indigenous biodiversity within the accessible area will be undertaken', where 'accessible' is defined by taxa-specific dispersal data.
4. Both Otago Regional Council (ORC) and Greater Wellington Regional Council (GWRC) include policies for the 'management' (ORC) or 'maintenance and restoration' (GWRC) of areas of 'high' (ORC) or 'significant' (GWRC) biodiversity value. These areas are not restricted to indigenous habitat and can include 'high value' exotic vegetation. I recommend these policies be refined to include 'foraging, roosting or breeding habitat' for highly mobile fauna (e.g. ORC Focus Area 3, Action 3.1, and GWC Policy 23).

5 Under obligations to identify SNAs, councils are required to identify at-risk and threatened habitat. Some councils have already added clauses to their policies to include taxa of regional importance. For instance, HRC's *One Plan* states that an area can be classed as at risk, threatened, or rare for the purposes of biodiversity protection if it meets the criteria 'indigenous vegetation of any size containing *Powelliphanta* snails (HRC 2024 – Table 46, RP – SCHED6, 5-206). Therefore, I recommend that policy criteria for identifying rare, at-risk, and threatened habitats include 'any area of habitat used by highly mobile fauna for foraging, roosting or breeding activity.' For freshwater specific policies (i.e. NPS-FM), similar clauses could be included for the wetland/riverine taxa.

6 Some regional councils already consider connectivity an important component of biodiversity to protect (e.g. GWC policy 47, Southland Operative plan Policy Bio 2). Additional policies within the NPS-IB will require consideration of connectivity (e.g. 3.21 Restoration). However, there is often little directive as to how connectivity can be managed. As demonstrated in this report, data on connectivity of highly mobile fauna are limited. I recommend that future polices that account for connectivity be based on relevant dispersal data and apply to foraging, roosting, and breeding habitat to ensure connectivity is maintained throughout the life cycle of highly mobile fauna.

Connectivity polices will also need to account for both spatial and temporal patterns of distribution and habitat use; for example, 'managing adverse effects on foraging, roosting or breeding habitat that maintains seasonal connectivity'. It is important that connectivity not be solely based on restoring vegetation corridors, as is often the case (e.g. riparian planting). Connectivity of safe habitat is necessary, particularly for taxa that are more vulnerable during foraging and dispersal activities. Supplementary management within corridors/stepping stones may therefore be needed to provide safe habitat.

7 Councils should continue developing policies that allow for adaptability of habitats. For example, recent extreme weather events have prompted calls for policies that 'make room for rivers'.[1] These types of policies apply to many highly mobile fauna habitats. Incorporating policy statements that give highly dynamic environments such as wetlands, rivers, and coastal areas space is needed to ensure these highly mobile fauna areas are resilient to future disturbances (e.g. Brower et al. 2024). For instance, extending statutory requirements for SNAs or identified highly mobile fauna areas to account for buffer zones would be beneficial. This already exists for some freshwater policies such as riparian planting requirements.

[1] https://www.forestandbird.org.nz/sites/default/files/2022-11/F%26B_Room-For-Rivers_Report_online_0.pdf.

8 Acknowledgements

This report provides a summary of research on highly mobile fauna, and as a result relies on the work of multiple researchers in monitoring and studying these taxa. I thank all researchers working on highly mobile fauna for their dedication to monitoring these taxa to inform conservation action.

I thank all the council representatives that were involved in this work, particularly Scott Jarvie, Roger Uys, Matt Moss, Annabel Beattie, Liz Overdyck, Alastair Jamieson, Jeff, Anne, Yanbin Deng, Ben Fenselau, Katrina Hansen, and Paul Dutton, for joining the workshop and providing valuable discussion and feedback.

I also thank Neil Fitzgerald and Emma Williams for presenting their research to the workshop and providing feedback on this report and the species fact sheets.

The fact sheets have been peer-reviewed by species experts. Specifically, I would like to thank Neil Fitzgerald, Tony Greene, Manaia Pearmain-Fenton, Colin O'Donnell, Moira Pryde, Robert Schadewinkel, Ron Moorhouse, Caitlin Lavery, Tony Beauchamp, Josh Kemp, Kerry Wilson, Sandy Toy, Robin Toy, Kevin Parker, Emily King and other experts for their time and effort in reviewing the species fact sheets. I also thank Helen Sharpe and Kate Lancaster from the Ministry for the Environment for their feedback on the fact sheets.

I thank MWLR editor Ray Prebble for his excellent editing and Kate Boardman for formatting.

Finally thank you to Susan Walker and Anne Schlesselmann for providing valuable discussion and review of this report and Kevin Parker for reviewing a draft version of this report and providing valuable input into the final draft.

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Appendix 1 – Pressures affecting forest/open highly mobile fauna

		Ecosystem change						Predation/Introduced species							Human conflict					Development					Climate change			
Ecosystem	Taxa	Habitat clearance	Grazing practices	Browsing (deer)	Tree felling	Fragmentation	Degradation	Mustelids	Rodents	Cats	Possums	Other	Hybridisation	Competition	Vehicles/Boats	Hunting	Poisoning	Urban light	Trap/net bycatch	Forestry practises	Power lines	Urban development	Wind turbines	Hydrodams	Drought	Extreme weather	Flooding	Mast dynamics
Forest /open	NZ Pipit / pīhoihoi	✓	✓				✓	✓	✓	✓	✓	✓ Hedgehogs ?			✓							✓			✓			
Forest /open	Northern Fiordland kiwi / tokoeka							✓		✓																?		✓
Forest /open	Southern Fiordland kiwi / tokoeka							✓		✓																?		✓
Forest /open	Great Spotted kiwi / roroa							✓		✓		✓ Dogs														?		✓
Forest /open	Long-tailed bat / pekapeka	✓			✓		✓	✓	✓	✓							✓	✓		✓					✓			✓
Forest /open	Bush falcon / kārearea	✓			✓			✓		✓	✓	✓ Pigs, hedgehogs				✓	✓			✓	✓		✓					?
Forest /open	Eastern falcon / kārearea	✓			✓			✓		✓	✓	✓ Pigs, hedgehogs				✓	✓			✓	✓		✓					?
Forest /open	Southern falcon / kārearea				?			✓		✓	✓	✓ Pigs, hedgehogs				?	✓				?		?					?
Forest /open	North Island weka	✓	✓				✓	✓		✓		✓ Dogs		✓	✓	✓	✓		✓						✓			
Forest /open	Northern pekapeka / short-tailed bat	✓			✓			✓		✓							✓	✓		✓			✓					

		Ecosystem change						Predation/Introduced species							Human conflict					Development					Climate change			
Ecosystem	Taxa	Habitat clearance	Grazing practices	Browsing (deer)	Tree felling	Fragmentation	Degradation	Mustelids	Rodents	Cats	Possums	Other	Hybridisation	Competition	Vehicles/Boats	Hunting	Poisoning	Urban light	Trap/net bycatch	Forestry practises	Power lines	Urban development	Wind turbines	Hydrodams	Drought	Extreme weather	Flooding	Mast dynamics
Forest /open	Central pekapeka / short-tailed bat	✓			✓			✓		✓							✓	✓		✓			✓					
Forest /open	Southern pekapeka / short-tailed bat	✓			✓			✓		✓							✓	✓		✓			✓					
Forest /open	South Island kākā	✓			✓			✓			✓			✓			✓								✓			✓
Forest /open	North Island kākā	✓			✓			✓			✓						✓								✓			✓
Forest /open	Kea							✓		✓	✓				✓	✓	✓		✓									✓
Forest /open	South Island robin / kakaruai	✓		✓		✓		✓	✓	✓	✓														✓			
Forest /open	Northern Rock wren / pīwauwau			✓		✓	✓	✓	✓																?	✓		✓
Forest /open	Southern Rock wren / pīwauwau			✓		✓	✓	✓	✓																?	✓		✓

Appendix 2 – Workshop summary

There were four presentations from researchers at the workshop.

1 Dr Zoë Stone from Massey University presented research from the 'More birds in the bush' project. This research showed how dispersal and breeding data could be used to develop species distribution models (SDMs) to predict habitat use of species. The presentation highlighted the need for high-quality data to support accurate model predictions. For instance, SDMs were generated using comprehensive distribution data and high-resolution LIDAR and environmental data. If these data are available, SDMs can be very effective for informing the management of adverse effects on populations, such as where to focus predator control.

2 Neil Fitzgerald from Manaaki Whenua – Landcare Research (MWLR) presented research from tracking the dispersal of kākā in the Waikato region. Tracking kākā revealed highly seasonal movement patterns. During winter months, kākā were relatively sedentary in Waikato with little dispersal. They were found foraging on a range of indigenous and exotic habitats, including exotic hedgerows and mixed garden areas. In summer, kākā undertook considerable seasonal dispersal to northern regions, where multiple individuals dispersed to high-quality breeding habitat sites, such as Hauturu-o-toi / Little Barrier Island and Great Barrier Island (Aotea Island). This research is ongoing, but it has highlighted the role of seasonal food supply in dispersal in highly mobile fauna.

3 Dr Anne Schlesselmann from MWLR presented research on five shorebirds listed as highly mobile fauna. The presentation discussed data availability for these species. In particular, there are some long-term distribution data from braided river surveys, Birds New Zealand winter surveys, and aerial surveys (e.g. tarāpuka / black-billed gulls). Despite this, there are few data available on adult survival, natal dispersal, connectivity, and flyways between breeding and wintering sites. Advances in tracking technology and statistical tools have allowed for a collaborative research programme between DOC, MWLR, and Birds New Zealand. MWLR is currently developing a full annual-cycle population model by integrating different existing data to inform when and where management is most effective.

4 Dr Emma Williams from DOC presented work from the Mobile Terrestrial Threatened Species work stream. The presentation provided an overview of research being conducted to fill knowledge gaps for highly mobile fauna. Research has focused on improving dispersal and habitat data. For example, tracking studies of matuku-hūrepo / Australasian bittern have revealed high seasonal variation in the large-scale spatial habitat networks used. Research has also identified potential adverse effects of renewable energy infrastructure on highly mobile fauna due to flyways and flight paths directly through wind turbine farms. The presentation also discussed the value of a collaborative approach for protecting highly mobile fauna, due to the considerable time taxa spend outside protected Crown land. Background information was also presented on the how the specified highly mobile fauna list was defined.

Appendix 3 – Forest/open taxa fact sheets