



Database and eDNA Records for Freshwater Species of Conservation Interest

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Prepared by

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Introduction

New Zealand, as an isolated island chain, boasts a variety of unique species. Unfortunately, many of these species are listed by the New Zealand Threat Classification System (NZTCS) as being at risk or threatened. The National Policy Statement for Freshwater Management (NPS-FM) (2020) lists Threatened Species as a compulsory value to be managed by regional councils. While the NPS-FM does not identify attributes specific to the threatened species value it states that all ecosystem health components (and attributes) as well as any specialised habitat or conditions needed for only part of a threatened species' life cycle must be managed at a Freshwater Management Unit (FMU) level. The National Objective Framework (NOF) further specifies that the NPS-FM (2020) compulsory value applies to threatened indigenous flora and fauna that rely on freshwater bodies for at least part of their life cycle. From a council perspective, this raises two main issues 1) *what* species occur within the region and 2) *where* do they occur.

Northland Regional Council (NRC) has multiple monitoring programmes that record the presence of freshwater organisms within the region. However, these are not sufficient for assessing the state of threatened species populations because either this was not the programme's intended purpose (e.g., State of Environment (SOE) monitoring) or the focus has been on specific areas/waterbodies. For instance, the annual SOE fish monitoring programme overrepresents wide, low elevation rivers near the coast but collects minimal data (i.e., presence/absence) on lakes and wetlands. As a result, the monitoring network is not able to provide sufficient information on threatened climbing species (i.e., shortjaw kōkopu *Galaxias postvectis* and pouched lamprey *Geotria australis*) often found in small, high elevation streams or those found in lakes and wetlands like the Northland mudfish *Neochanna heleioides*. Likewise, the SOE macroinvertebrate programme, as a result of the metrics (e.g., macroinvertebrate community index (MCI)) calculated for NPS-FM reporting, is insufficient because taxa are not identified to the species level. Assessments have also been conducted at specific lakes and wetlands across Northland (Biodiversity Team – Annual Report, 2023), but these are also not sufficient on their own to assess threatened species populations at a regional level. Plant records are based on herbarium collections and site-based records which go back more than 100 years and can be revisited and checked. For this reason, the conservation status of most vascular freshwater plants can be determined except for a few data Deficient and Taxonomically Indeterminate taxa for which there are insufficient records to make a call. For example, the tiny Threatened - Nationally Critical submerged plant *Trithuria inconspicua* endemic to Northland, has been recorded at 13 dune lakes but since the 1980's has been lost from seven of these and in the remaining five, is searched for and evaluated during SOE lakes ecological monitoring. Lake bird data are derived from bird counts on site for SOE reporting and records are uploaded to NZ Birds Online. So, in the absence of robust, purpose-built monitoring networks, other data sources are needed to build a *region-wide* picture of threatened species distributions.

This exercise will draw data from two sources:

1. Species Occurrence Databases

Other regional councils have sought external advice (e.g., Bay of Plenty – Thorsen (2021) and Otago – Thorsen (2022)) to pull species records from databases, collate the gathered data into a

species list, and then map the occurrences. Most of the databases used for these works are publicly available through the Global Biodiversity Information Facility (GBIF) and as such NRC has decided to complete this exercise internally.

2. Environmental DNA

Environmental DNA (eDNA), i.e., biological material (e.g., scales, hair, waste, etc.) collected from the environment (e.g., water, soil, air, etc.), is emerging as a useful tool surveillance tool for cryptic species. Given species of conservation interest are often inherently rare, and thus difficult to physically encounter, eDNA is an excellent tool for detecting their presence.

Northland Regional Council has begun taking eDNA samples for various purposes, using different methods, and across multiple departments. For simplicity, data collected by the Biodiversity team and the Natural Resources group were collated for this work.

While the NPS-FM (2020) specifies that only species listed as *threatened* by the NZTCS need to be considered for policies and objective setting, this work will include other conservation interest categories (i.e., at risk, data deficient, and taxonomically indistinct). These categories will be included because 1) some species can be regionally rare, 2) these taxa have the potential to be elevated to threatened in future assessments, 3) all the Dune Lake *Galaxias* “Kai Iwi” in the world only occur in two of the Kai Iwi lakes but is listed as “at risk”.

Methodology

Freshwater Dependent Species

A dilemma facing the regional sector is defining a “freshwater dependent species”. For simplicity, we focused on species listed as “freshwater” as well as those that utilise wetlands as key areas of occupancy within Northland but are classed as “terrestrial” in the NZTCS datasets (e.g., banded rail *Gallirallus philippensis assimilis*, mānuka *Leptospermum scoparium*, etc.). An initial list of species was constructed using data available from the NZTCS for vascular plants (de Lange et al., 2018a), non-vascular plants (Rolfe et al., 2016; de Lange et al., 2018b; de Lange et al., 2020), freshwater macroinvertebrates (Grainger et al., 2018), fish (Dunn et al., 2018), birds (Robertson et al., 2021), and amphibians (Burns et al. 2018). From this list, those species with threat categories of Threatened, At Risk, Data Deficient, and Taxonomically Indistinct were selected. All maps generated were done using the *ggmap* package (Kahle and Wickham, 2013).

GBIF Database Search

Occurrence data for freshwater species of conservation interest present, or likely to be present, in the region has been collated using publicly available databases. The list of candidate species was run through external, publicly available occurrence databases via GBIF using the R package *rgbif* (Chamberlain and Boettiger, 2017; Chamberlain et al., 2023). A candidate list of databases was selected based on 1) usage in reports prepared for the Bay of Plenty (Thorsen, 2021) and Otago Regional Councils (Thorsen, 2022) and 2) potential for containing occurrence data in Northland (Table 1). If a database contained continually or routinely updated occurrence data, occurrences from 2000 through 2022 were searched to increase confidence in species identification and continued presence. For the databases that search museum collections, or the equivalent, the full record of occurrences was searched to capture specimens that were collected prior to 2000. The databases were searched for relevant taxa (i.e., birds were searched on eBird; Table 1) specifically within the Northland regional boundary and the results collated into a single species list.

NRC eDNA Data

All samples used for this report were taken and sequenced using Wilderlab NZ Ltd. equipment and methods (Table 2; David et al., 2021). Samples were collected by either actively (i.e., 60ml syringe or a motorised pump (“Wilbebeest”)) or passively (i.e., allowing flow through for a period of time) passing water through a filter that suspends biological material. For actively collected samples, a maximum of 1L of water is passed through a single filter (i.e., 1 sample). In rivers, taking six samples per site increases the likelihood of detecting 95% of species present, and as such makes it more likely to detect rare, conservation interest species (per. comm. Josh Smith, Waikato Regional Council and Shaun Wilkinson, Wilderlab). Once a sample is taken, a preservative (provided by Wilderlab NZ Ltd.) is added directly to the filter and then the sample is sent to Wilderlab for sequencing.

Table 1: Candidate list of occurrence databases available through GBIF.

Database	Publishing Authority	Database Access Key	Taxa Searched	Date Range
Auckland Museum Botany Collection	Auckland War Memorial Museum	83ae84cf-88e4-4b5c-80b2-271a15a3e0fc	Vascular Plants, Non-Vascular Plants, Algae	All Records
Auckland Museum Entomology Collection	Auckland War Memorial Museum	1671ddfb-1f8a-4d24-ab4d-50adb89af001	Insects	All Records
Auckland Museum Land Vertebrates Collection	Auckland War Memorial Museum	aad97542-a068-449d-adb3-a8e937f64cb4	Birds, Amphibians	All Records
Canterbury Museum Mayfly Collection	Canterbury Museum	93e4d24c-92f0-40b7-84e3-ba054886b1c3	Insects	All Records
Cawthron Institute Freshwater Invertebrate Data	Cawthron Institute	18d0270e-899b-4a16-82f2-aa87d93bb1df	Freshwater Invertebrates	2000-2022
CHR Allan Herbarium	Landcare Research/Manaaki Whenua	df582950-3b58-11dc-8c19-b8a03c50a862	Vascular Plants, Non-Vascular Plants, Algae	All Records
eBird	Cornell Lab of Ornithology	4fa7b334-ce0d-4e88-aaae-2e0c138d049e	Birds	2000-2022
iNaturalist	iNaturalist.org	50c9509d-22c7-4a22-a47d-8c48425ef4a7	All	2000-2022
National Vegetation Survey	Landcare Research/Manaaki Whenua	788439f0-3b56-11dc-8c19-b8a03c50a862	Vascular Plants, Non-Vascular Plants, Algae	2000-2022
New Zealand Arthropod Collection	Landcare Research/Manaaki Whenua	6e4b215e-9019-4934-8433-65d80a35c230	Insects, Crustaceans	All Records
NIWA Invertebrate Collection	NIWA	4d0b1b2a-3209-49ce-bb93-7503e4868019	Freshwater Invertebrates	2000-2022
New Zealand Freshwater Fish Database*	NIWA	103cca88-8677-4ab0-9a22-61771ee31af5	Fish, kākahi, koura	2000-2022
Wetland Algae	NIWA	765ff590-b785-4797-adfe-3132689ce917	Algae	2000-2022
Online Zoological Collections of Australian Museums	Atlas of Living Australia	dce8feb0-6c89-11de-8225-b8a03c50a862	Freshwater Invertebrates	All Records

*NRC's fish data up to the 2021/2022 sampling season is included in the database.

Table 2: Sites sampled for eDNA by NRC.

Site Name	IRIS ID	Method	Purpose
Mangahuru at Main Rd	LOC.100237	Syringe – 6rep	National eDNA Method Development
Waipoua at SH12	LOC.103304	Syringe – 6rep Syringe – High Rep	National eDNA Method Development
Ruakaka at Flyger Rd	LOC.105008	Syringe – 6rep Syringe – High Rep	National eDNA Method Development
Waiarohia at 2 nd Ave	LOC.108359	Syringe – 6rep Syringe – High Rep	National eDNA Method Development; Comparison with SOE monitoring
Oruaiti at Windust Rd	LOC.304641	Syringe – 6rep	Threatened and At Risk Freshwater Fish Monitoring
Pukenui at Kanehiana Dr	LOC.312177	Syringe – 6rep	National eDNA Method Development
Tapapa at SH1	LOC.313165	Syringe – 6rep Syringe – High Rep	National eDNA Method Development
Wairau at SH12	LOC.313168	Syringe – 6rep	National eDNA Method Development
Punaruuku at Russell Rd	LOC.313171	Syringe – 6rep	Threatened and At Risk Freshwater Fish Monitoring
Tangowahine at Tangowahine Valley Rd	LOC.322490	Syringe – 6rep Syringe – High Rep	National eDNA Method Development
Tanekaha Track Stream at King Rd	LOC.333761	Syringe – 6rep	Threatened and At Risk Freshwater Fish Monitoring
Ahuroa River Trib		Syringe – 1rep	Hochstetter's frog survey
Lake Kai Iwi		"Wildebeest" – motorised pump	
Lake Kihona	LOC.101907	Syringe – 1rep	Presence/absence for specific species
Lake Ōmāpere	LOC.328575	Syringe – 2rep	NRC eDNA Method Development
Lake Parawanui	LOC.101416	Syringe – 6rep	NRC eDNA Method Development
Lake Rototuna	LOC.324771	Syringe – 3rep	NRC eDNA Method Development
Lake Taharoa	LOC.101442	"Wildebeest" – motorised pump	Koi carp surveillance
Lake Te Riu	LOC.313022	Syringe – 1rep	Presence/absence for specific species
Lake Tutaki	LOC.331162	Syringe – 20rep	Pre- and post-herbicide application monitoring
Lake Waikare	LOC.100448	"Wildebeest" – motorised pump	Koi carp surveillance
Lake Waingata	LOC.312998	Syringe – 10rep	NRC eDNA Method Development and grass carp detection
Lake Wairere	LOC.312966	Syringe – 6rep	Hornwort surveillance
Lake Waro	LOC.325857	Syringe – 4rep	NRC eDNA Method Development
Maxwell Creek		Syringe – 1rep	Hochstetter's frog survey
Mt Taika Stream 1		Syringe – 1rep	Mt Taika Biodiversity Survey
Mt Taika Stream 2		Syringe – 1rep	Mt Taika Biodiversity Survey
Mt Taika Stream 3		Syringe – 1rep	Mt Taika Biodiversity Survey
Mt Taika Stream 4		Syringe – 1rep	Mt Taika Biodiversity Survey
Mt Taika Stream 5		Syringe – 1rep	Mt Taika Biodiversity Survey
Tarakihi Wetland	LOC.335499	Passive Sampler – 24hr x2	Mudfish survey
Unnamed Stream on Northland College Farm		Syringe – 6rep	Threatened and At Risk Freshwater Fish Monitoring
Waihoihoi Stream - Pool		Syringe – 1rep	Hochstetter's frog survey
Waihoihoi Stream - Tributary		Syringe – 1rep	Hochstetter's frog survey
Waikoromiko at AH Reed Park		Syringe – 6rep	Threatened and At Risk Freshwater Fish Monitoring
Waipapa US of Unnamed Tributary		Syringe – 6rep	Threatened and At Risk Freshwater Fish Monitoring
Waipapa Unnamed Tributary		Syringe – 6rep	Threatened and At Risk Freshwater Fish Monitoring
Waipu Pond A	LOC.311630	Syringe – 2rep	NRC eDNA Method Development
Waipu Pond C	LOC.311630	Syringe – 1rep	NRC eDNA Method Development

Land Cover

The New Zealand Land Cover Database (LCDB) was used to approximate habitat usage of conservation interest species. Using the *sf* package in R Programming (R Core Team, 2023), GBIF occurrence and eDNA records were overlaid on the LCDB 2018 shapefile land cover categories (Table 3). The categories were simplified to increase the interpretability of maps and plots. Simplified categories are based on those presented in LAWA with some variation to better differentiate artificial/modified land types from natural ones. Aquatic Herbaceous Vegetation is left as a separate category at the broad level because these can contain both indigenous and exotic plants. Detailed descriptions of land cover categories can be found in Thompson et al. (2003).

Table 3: Land cover categories used for plotting and mapping GBIF occurrence and eDNA data.

Simplified Category		LCDB 2018 Category
Artificial	Artificial Bare	Transport Infrastructure
		Surface Mine or Dump
	Urban	Built-up Area (Settlement)
		Urban Parkland/Open Space
	Cropland	Short-rotation Cropland
		Orchard, Vineyard or Other Perennial Crop
	Exotic Grassland	High Producing Exotic Grassland
		Low Producing Exotic Grassland
		Depleted Grassland
	Exotic Scrub/Shrub	Gorse and/or Broom
		Mixed Exotic Shrubland
	Exotic Forest	Forest - Harvested
Exotic Forest		
Deciduous Hardwoods		
Natural	Natural Bare/Lightly Vegetated	Sand or Gravel
		Landslide
		Gravel or Rock
	Water Bodies	Lake or Pond
		River
		Estuarine Open Water
	Aquatic Herbaceous Vegetation	Herbaceous Freshwater Vegetation
		Herbaceous Saline Vegetation
	Indigenous Forest	Broadleaved Indigenous Hardwoods
		Indigenous Forest
	Flaxland	Flaxland
	Indigenous Scrub/Shrub	Fernland
Manuka and/or Kanuka		
Matagouri or Grey Scrub		
Mangrove		

Results and Discussion

A total of 82 conservation interest taxa have been detected in Northland (Table 4). The GBIF database search returned more taxa than NRC's eDNA samples, but this is likely because the databases are region-wide and not limited to sample location. Environmental DNA data returned 5 species that were not reported in the GBIF databases. Care should be taken when interpreting the data as non-detection, particularly for eDNA, does not necessarily mean a species is absent. Further, some GBIF databases (e.g., iNaturalist and eBird) rely heavily on community reporting, so species identification cannot be validated post hoc. As a result, species records have been taken at face-value for this exercise with some caveats. For instance, records for Dune Lake *Galaxias* "Kai Iwi" get confounded with *Galaxias gracilis* due to the latter being taxonomically accepted and the two taxa being genetically similar. In this case, *G. gracilis* records in the Kai Iwi lakes can be assumed to be Dune Lake *Galaxias* "Kai Iwi". Likewise, the sun orchid *Thelymitra* "Ahipara" was difficult to search on GBIF due to taxonomic ambiguity. As a result, all records returned with just the genus *Thelymitra* were used for species occurrence mapping. This will undoubtedly result in spurious records being included, however we consider this an acceptable risk if the alternative is excluding actual *Thelymitra* "Ahipara" occurrences is the alternative.

Table 4: The number of taxa of each NZTCS threat category detected in Northland according to GBIF databases and NRC's eDNA samples.

NZTCS Threat Category	GBIF Databases Only	NRC eDNA Data Only	Both Data Sources	Total
Threatened	22	1	7	30
At Risk	25	1	13	39
Data Deficient	8	3	1	12
Taxonomically Indistinct			1	1
Total	55	5	22	82

Some species ($n = 19$) have been recorded once and/or only prior to 2000 in Northland (Table 5), of which 18 are either vascular plants or macroinvertebrates. The remaining record is for a black-fronted dotterel *Elseya melanops*, a water bird that often does not occur north of the Auckland region, so it is possible this is a misidentification. However, given it is not possible to validate the report, the highly vagile nature of birds, and the propensity of animals to ignore imaginary lines on a map, *E. melanops* has been left on the list species recorded in Northland (Table 5).

The majority of records from the GBIF database search were birds, fish, and vascular plants (Figure 1; Figure 2). Taxonomic bias in biodiversity surveys is not new and often reflects public interest (Troudet et al., 2017). Globally, birds and vascular plants are the most represented groups in GBIF databases (Troudet et al., 2017), often due to enthusiasts/citizen science, so it is not surprising that there are numerous records in Northland. In contrast, the number of fish records is due to the New Zealand Freshwater Fish Database housing citizen science records as well as data collected by monitoring programmes by organisations such as NRC, Department of Conservation, and Whitebait Connection. Amphibian records are low because only one native species, Hochstetter's frog *Leiopelma hochstetteri*, occurs in the region in a relatively small known area (i.e., the Brynderwyn

Hills), and this group is often underrepresented (Troudet et al. 2017). Likewise, macroinvertebrates are underrepresented compared to their overall diversity (Troudet et al., 2017). This holds true for Northland despite NRC's annual sampling of macroinvertebrate communities because taxa are not identified to species for State of Environment reporting.

Environmental DNA records were fewer and not as widely spread geographically as the GBIF database search (Table 5; Figure 3; Figure 4). Fish records were the most abundant likely because samples were taken directly from the water and that the eDNA methods used were originally developed for fish monitoring. Regardless, the eDNA samples still provided information that would have been missed otherwise. The first record for pouched lamprey *Geotria australis* in almost 20 years was picked up in an eDNA sample in 2021, confirming the species is still present in the region. These samples also provided the only record for the threatened caddisfly *Helicopsyche torino*. Further, eDNA samples determined that the threatened mayfly *Zephelbia* aff. *pirongia* sp. 1, once only known from Pukenui forest, is found throughout the Whangārei area.

There are “hotspots” for threatened species occurrence records on the Poutō peninsula, Waipoua forest, the Aupōuri peninsula, Lake Ōmāpere, Puketi forest, Bay of Islands, Russell Forest, and the east coast in general (Figure 5). Most threatened species records (61.5%) occurred in natural land cover types (Table 3; Figure 6). Fish and macroinvertebrate records occurred most often in indigenous vegetation land types likely reflecting both habitat usage and where sampling efforts are directed. Birds, however, were recorded in a variety of land cover types likely due to their vagility and propensity to be recorded by bird watchers and other members of the community. For vascular plants, the majority of records are in indigenous vegetation types but 40.08% also occur in exotic vegetation land types. It is possible these records are occurring in small patches of unmapped wetland or native bush that is being overshadowed by exotic grassland, forest, and/or shrub/scrub in the LCDB.

Freshwater Management Unit specific maps are in Appendices 1 and 2.

Table 5: Species of conservation interest, i.e., categorised as Threatened, At Risk, Taxonomically Indistinct, and Data Deficient by the NZTCS, that have been recorded in Northland according to GBIF Database search and eDNA data collected by NRC. Metadata is taken from NZTCS.

Species	Common Name (NZTCS)	Te Reo Name (NZTCS)	Taxa Type	NZTCS Report	Category (NZTCS)	Status (NZTCS)	Criteria (NZTCS)	Population State (NZTCS)	Population Size (NZTCS)	Data Source
<i>Nocturama antipodites</i>	red freshwater alga		Algae	Macroalgae 2019 (Nelson et al. 2019)	Data Deficient	Data Deficient				eDNA Only
<i>Nothocladus discors</i>	red freshwater alga		Algae	Macroalgae 2019 (Nelson et al. 2019)	Data Deficient	Data Deficient				eDNA Only
<i>Leiopelma hochstetteri</i>	Hochstetter's frog		Amphibian	Amphibians 2017 (Burns et al. 2018)	At Risk	Declining		UNNATURAL	MATIND>100000	Both Sources
<i>Anarhynchus frontalis</i>	wrybill	ngutu-pare	Bird	Birds 2021 (Robertson et al. 2021)	Threatened	Nationally Increasing		UNNATURAL	MATIND=1000-5000	GBIF Only
<i>Anas chlorotis</i>	brown teal	pāteke	Bird	Birds 2021 (Robertson et al. 2021)	Threatened	Nationally Increasing		UNNATURAL	MATIND=1000-5000	Both Sources
<i>Anas superciliosa</i>	grey duck	pārera	Bird	Birds 2021 (Robertson et al. 2021)	Threatened	Nationally Vulnerable	C(1)	UNNATURAL	MATIND=1000-5000	GBIF Only
<i>Botaurus poiciloptilus</i>	Australasian bittern	matuku hūrepo	Bird	Birds 2021 (Robertson et al. 2021)	Threatened	Nationally Critical	B(1)	UNNATURAL	MATIND=250-1000	GBIF Only
<i>Hydroprogne caspia</i>	Caspian tern	taranui	Bird	Birds 2021 (Robertson et al. 2021)	Threatened	Nationally Critical		UNNATURAL	MATIND<250	GBIF Only
<i>Poliocephalus rufopectus</i>	New Zealand dabchick		Bird	Birds 2021 (Robertson et al. 2021)	Threatened	Nationally Increasing		UNNATURAL	MATIND=1000-5000	Both Sources
<i>Elsayornis melanops*</i>	black-fronted dotterel		Bird	Birds 2021 (Robertson et al. 2021)	At Risk	Naturally Uncommon		NATURAL	MATIND=1000-5000	GBIF Only
<i>Gallirallus philippensis assimilis</i>	banded rail	mioweka	Bird	Birds 2021 (Robertson et al. 2021)	At Risk	Declining		UNNATURAL	MATIND=5000-20000	GBIF Only
<i>Phalacrocorax sulcirostris</i>	little black shag	kawau tuī	Bird	Birds 2021 (Robertson et al. 2021)	At Risk	Naturally Uncommon		NATURAL	MATIND=1000-5000	GBIF Only
<i>Porzana pusilla</i>	marsh crake	koitareke	Bird	Birds 2021 (Robertson et al. 2021)	At Risk	Declining		UNNATURAL	MATIND=5000-20000	GBIF Only
<i>Porzana tabuensis</i>	spotless crake	pūweto	Bird	Birds 2021 (Robertson et al. 2021)	At Risk	Declining		UNNATURAL	MATIND=5000-20000	GBIF Only
<i>Galaxias postvectis</i>	shortjaw kōkopu	kōkopu	Fish	Freshwater fishes 2017 (Dunn et al. 2018)	Threatened	Nationally Vulnerable		UNNATURAL	MATIND=5000-20000	Both Sources
<i>Geotria australis</i>	lamprey	piharau	Fish	Freshwater fishes 2017 (Dunn et al. 2018)	Threatened	Nationally Vulnerable	C(3)	UNNATURAL	AREA<=100	Both Sources
<i>Neochanna heleioides</i>	northland mudfish		Fish	Freshwater fishes 2017 (Dunn et al. 2018)	Threatened	Nationally Vulnerable	C(3)	UNNATURAL	AREA<=100	Both Sources
<i>Anguilla dieffenbachii</i>	longfin eel	tuna	Fish	Freshwater fishes 2017 (Dunn et al. 2018)	At Risk	Declining		UNNATURAL	AREA>10000	Both Sources

<i>Cheimarrichthys fosteri</i>	torrentfish		Fish	Freshwater fishes 2017 (Dunn et al. 2018)	At Risk	Declining	C(2)	UNNATURAL	AREA>10000	Both Sources
<i>Galaxias argenteus</i>	giant kōkopu	kōkopu	Fish	Freshwater fishes 2017 (Dunn et al. 2018)	At Risk	Declining		UNNATURAL	MATIND=20000-100000	Both Sources
<i>Galaxias brevipinnis</i>	kōaro	kōaro	Fish	Freshwater fishes 2017 (Dunn et al. 2018)	At Risk	Declining		UNNATURAL	MATIND>100000	Both Sources
<i>Galaxias maculatus</i>	īnanga	īnanga	Fish	Freshwater fishes 2017 (Dunn et al. 2018)	At Risk	Declining		UNNATURAL	MATIND>100000	Both Sources
<i>Gobiomorphus gobioides</i>	giant bully		Fish	Freshwater fishes 2017 (Dunn et al. 2018)	At Risk	Naturally Uncommon		NATURAL	AREA<=1000	Both Sources
<i>Gobiomorphus hubbsi</i>	bluegill bully		Fish	Freshwater fishes 2017 (Dunn et al. 2018)	At Risk	Declining	C(2)	UNNATURAL	AREA>10000	Both Sources
<i>Neochanna diversus</i>	black mudfish		Fish	Freshwater fishes 2017 (Dunn et al. 2018)	At Risk	Declining	C(2)	UNNATURAL	AREA>10000	GBIF Only
<i>Galaxias gracilis</i> †	dwarf īnanga (North Kaipara Head dune lakes)		Fish	Freshwater fishes 2017 (Dunn et al. 2018)	Taxonomically indistinct	Taxonomically indistinct		UNNATURAL	AREA<=1000	Both Sources
<i>Echyridella aucklandica</i>	freshwater mussel	kākahi	Macroinvertebrate	Freshwater invertebrates 2018	Threatened	Nationally Vulnerable	E(2)	UNNATURAL	AREA<=10000	GBIF Only
<i>Edpercivalia dugdalei</i> †	caddisfly		Macroinvertebrate	Freshwater invertebrates 2018	Threatened	Nationally Critical		UNNATURAL	AREA<=1	GBIF Only
<i>Helicopsyche torino</i>	caddisfly		Macroinvertebrate	Freshwater invertebrates 2018	Threatened	Nationally Vulnerable		UNNATURAL	SUBPOP<=15, MATIND<=500	eDNA Only
<i>Paxillostium nanum</i> *	freshwater snail		Macroinvertebrate	Freshwater invertebrates 2018	Threatened	Nationally Vulnerable		UNNATURAL	AREA<=100	GBIF Only
<i>Zephlebia</i> aff. <i>pirongia</i> sp. 1	mayfly		Macroinvertebrate	Freshwater invertebrates 2018	Threatened	Nationally Critical	A(3)	NATURAL	AREA<=1	eDNA Only
<i>Antipodochlora braueri</i>	dusk dragonfly		Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Naturally Uncommon		NATURAL	AREA<=10000	GBIF Only
<i>Echyridella menziesii</i>	freshwater mussel	kākahi	Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Declining		UNNATURAL	AREA>10000	Both Sources
<i>Isothraulus abditus</i>	Fringed-gill mayfly		Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Declining	A(2)	UNNATURAL	AREA<=1000	GBIF Only
<i>Mauilulus aquilus</i>	mayfly		Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Naturally Uncommon		NATURAL	AREA<=1000	Both Sources
<i>Megaleptoperla grandis</i> *†	stonefly		Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Naturally Uncommon		NATURAL	AREA<=10000	Both Sources
<i>Paranephrops zealandicus</i>	freshwater crayfish	kōura	Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Declining		UNNATURAL	MATIND>100000	eDNA Only
<i>Rakipyrgus gardneri</i> *†	freshwater snail		Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Naturally Uncommon		NATURAL		GBIF Only
<i>Siphlaenigma janae</i>	mayfly		Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Declining	A(2)	UNNATURAL	AREA<=1000	Both Sources

<i>Zephlebia nebulosa</i>	mayfly		Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Naturally Uncommon		NATURAL	AREA<=1000	GBIF Only
<i>Zephlebia pirongia</i>	mayfly		Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Naturally Uncommon		NATURAL	AREA<=1000	GBIF Only
<i>Zephlebia tuberculata</i>	mayfly		Macroinvertebrate	Freshwater invertebrates 2018	At Risk	Naturally Uncommon		NATURAL	AREA<=1000	GBIF Only
<i>Austropeplea tomentosa</i>	freshwater snail		Macroinvertebrate	Freshwater invertebrates 2018	Data Deficient	Data Deficient				GBIF Only
<i>Homalaena dispersa</i> *†	freshwater beetle		Macroinvertebrate	Freshwater invertebrates 2018	Data Deficient	Data Deficient				GBIF Only
<i>Homalaena setosa</i> *†	freshwater beetle		Macroinvertebrate	Freshwater invertebrates 2018	Data Deficient	Data Deficient				GBIF Only
<i>Hyphydrus elegans</i>	Beetle		Macroinvertebrate	Freshwater invertebrates 2018	Data Deficient	Data Deficient				GBIF Only
<i>Limnoxenus zealandicus</i> *†	beetle		Macroinvertebrate	Freshwater invertebrates 2018	Data Deficient	Data Deficient				GBIF Only
<i>Spaniocercoides wattii</i> †	stonefly		Macroinvertebrate	Freshwater invertebrates 2018	Data Deficient	Data Deficient				Both Sources
<i>Zephlebia</i> aff. <i>nebulosa</i> sp. 1	mayfly		Macroinvertebrate	Freshwater invertebrates 2018	Data Deficient	Data Deficient				eDNA Only
<i>Sphagnum perichaetiale</i> †	moss		Non-vascular Plant	Mosses 2014 (Rolfe et al. 2016)	At Risk	Naturally Uncommon		NATURAL	AREA<=10000	GBIF Only
<i>Corybas carsei</i> †§	swamp helmet orchid		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Critical	A(3)	UNNATURAL	AREA<=1	GBIF Only
<i>Hibiscus diversifolius</i> subsp. <i>diversifolius</i>			Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Critical	B(3)	UNNATURAL	AREA<=10	GBIF Only
<i>Isolepis lenticularis</i>	aquatic sedge		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Critical	A(3)	NATURAL	AREA<=1	GBIF Only
<i>Korthalsella salicornioides</i>	Dwarf mistletoe		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Critical	C	UNNATURAL	MATIND>100000	GBIF Only
<i>Kunzea robusta</i>	rawirinui	rawirinui	Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Vulnerable		UNNATURAL	MATIND>100000	GBIF Only
<i>Leptospermum scoparium</i> var. <i>incanum</i>	mānuka		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Vulnerable	E(2)	UNNATURAL	AREA<=10000	GBIF Only
<i>Machaerina complanata</i>			Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Vulnerable	C(2)	UNNATURAL	SUBPOP<=15, MATIND<=500	GBIF Only
<i>Ophioglossum petiolatum</i> †	Stalked adder's tongue		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Critical	A(3)	UNNATURAL	AREA<=1	GBIF Only
<i>Pterostylis micromega</i> §	swamp greenhood		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Endangered	A(3)	UNNATURAL	AREA<=10	GBIF Only
<i>Pterostylis puberula</i>	dwarf greenhood		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Vulnerable	C(3)	UNNATURAL	AREA<=100	GBIF Only
<i>Schoenus carsei</i>			Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Critical	A(3)	UNNATURAL	AREA<=1	GBIF Only
<i>Syzygium maire</i>	swamp maire	maire tawake	Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Critical	C	UNNATURAL	MATIND>100000	GBIF Only
<i>Thelymitra</i> “Ahipara”	sun orchid		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Critical	A(3)	UNNATURAL	AREA<=1	GBIF Only
<i>Todea barbara</i>	royal fern		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Vulnerable	C(1)	UNNATURAL	MATIND=1000-5000	GBIF Only

<i>Trithuria inconspicua</i>	hydatella		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Critical	B(3)	UNNATURAL	AREA<=10	Both Sources
<i>Utricularia australis</i>	yellow bladderwort		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Threatened	Nationally Critical	C	UNNATURAL	AREA<=10	GBIF Only
<i>Carex fascicularis</i> †	sedge		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Declining	B(2)	UNNATURAL	AREA<=10000	GBIF Only
<i>Carex litorosa</i> †	sea sedge		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Declining	A(1)	UNNATURAL	MATIND=5000-20000	GBIF Only
<i>Cyclosorus interruptus</i>			Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Declining	B(2)	UNNATURAL	AREA<=10000	GBIF Only
<i>Eleocharis neozelandica</i> †			Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Declining	A(1)	UNNATURAL	MATIND=5000-20000	GBIF Only
<i>Empodisma robustum</i>	wire rush		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Declining	B(2)	UNNATURAL	AREA<=10000	GBIF Only
<i>Isoetes kirkii</i> ‡	quillwort		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Declining	B(2)	UNNATURAL	AREA<=10000	GBIF Only
<i>Juncus caespiticius</i> *			Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Declining	C(1)	UNNATURAL	MATIND>100000	GBIF Only
<i>Leptospermum scoparium</i>	mānuka	mānuka	Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Declining	C(1)	UNNATURAL	MATIND>100000	Both Sources
<i>Myriophyllum robustum</i> †	stout water milfoil		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Declining	C(1)	UNNATURAL	MATIND>100000	GBIF Only
<i>Sporadanthus ferrugineus</i> †§	bamboo rush		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Relict		UNNATURAL	MATIND=5000-20000, FRMHAB<10%	GBIF Only
<i>Stuckenia pectinata</i>	fennel-leaved pondweed		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Naturally Uncommon		NATURAL	AREA>10000	GBIF Only
<i>Thelypteris confluens</i>	marsh fern		Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Naturally Uncommon		NATURAL	AREA<=10000	GBIF Only
<i>Thyridia repens</i> †			Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	At Risk	Naturally Uncommon	B	UNNATURAL	AREA<=10000	GBIF Only
<i>Lemna disperma</i>	duckweed	kārearea	Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Data Deficient	Data Deficient				GBIF Only
<i>Ranunculus macropus</i>		raoriki	Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Data Deficient	Data Deficient				GBIF Only
<i>Spiranthes novae-zelandiae</i>			Vascular Plant	Vascular plants 2017 (de Lange et al. 2018)	Data Deficient	Data Deficient				GBIF Only

*Only 1 record in Northland according to GBIF databases.

†Records only from before 2000 according to GBIF databases.

‡*G. gracilis* records from GBIF databases and eDNA samples will include Dune Lake *Galaxias* “Kai Iwi” occurrences.

‡*Isoetes* aff. *kirkii* lake Ōmāpere is extinct in wild.

§Extinct

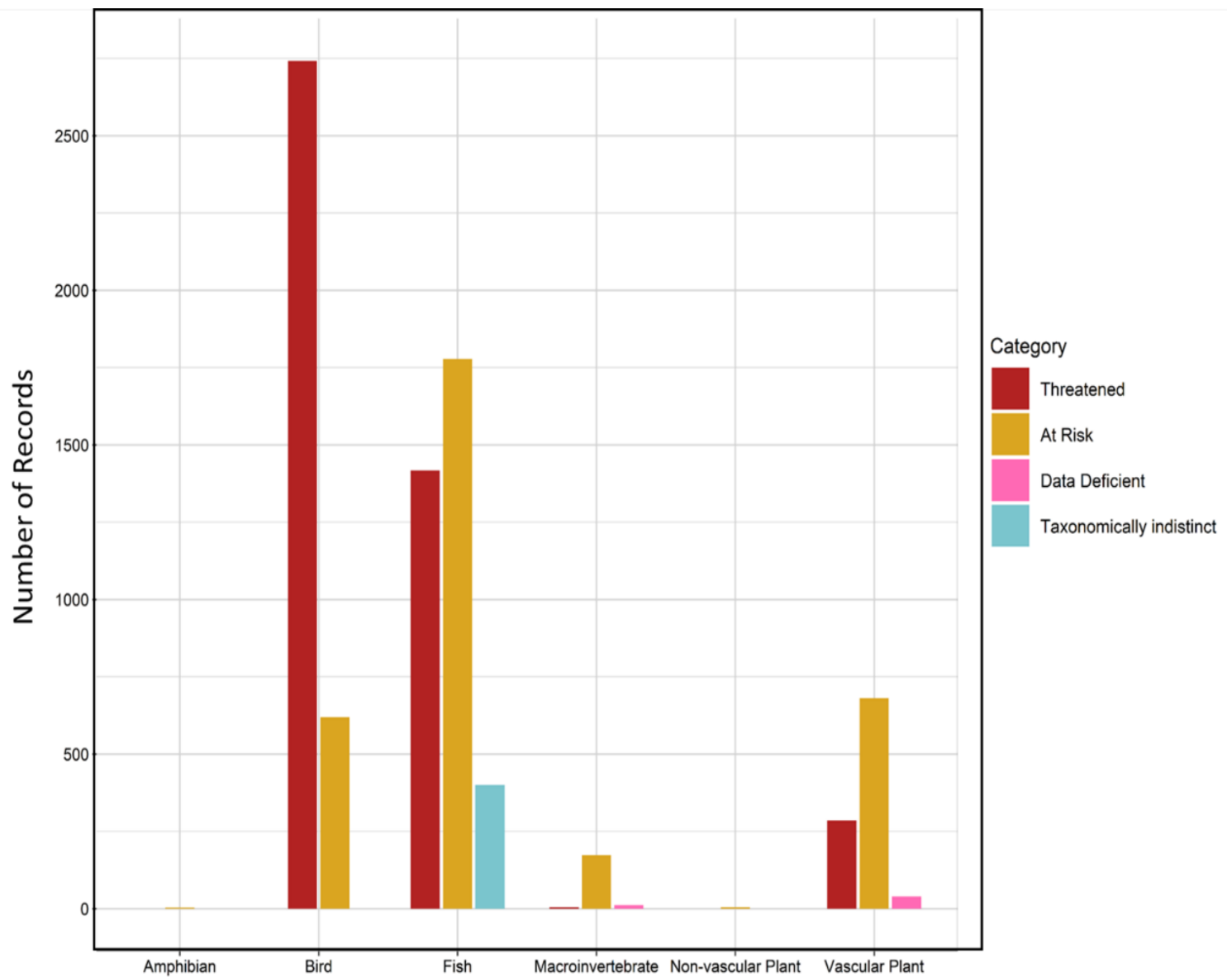


Figure 1: The number of records returned in GBIF database searches for each taxa type and NZTCS threat category.

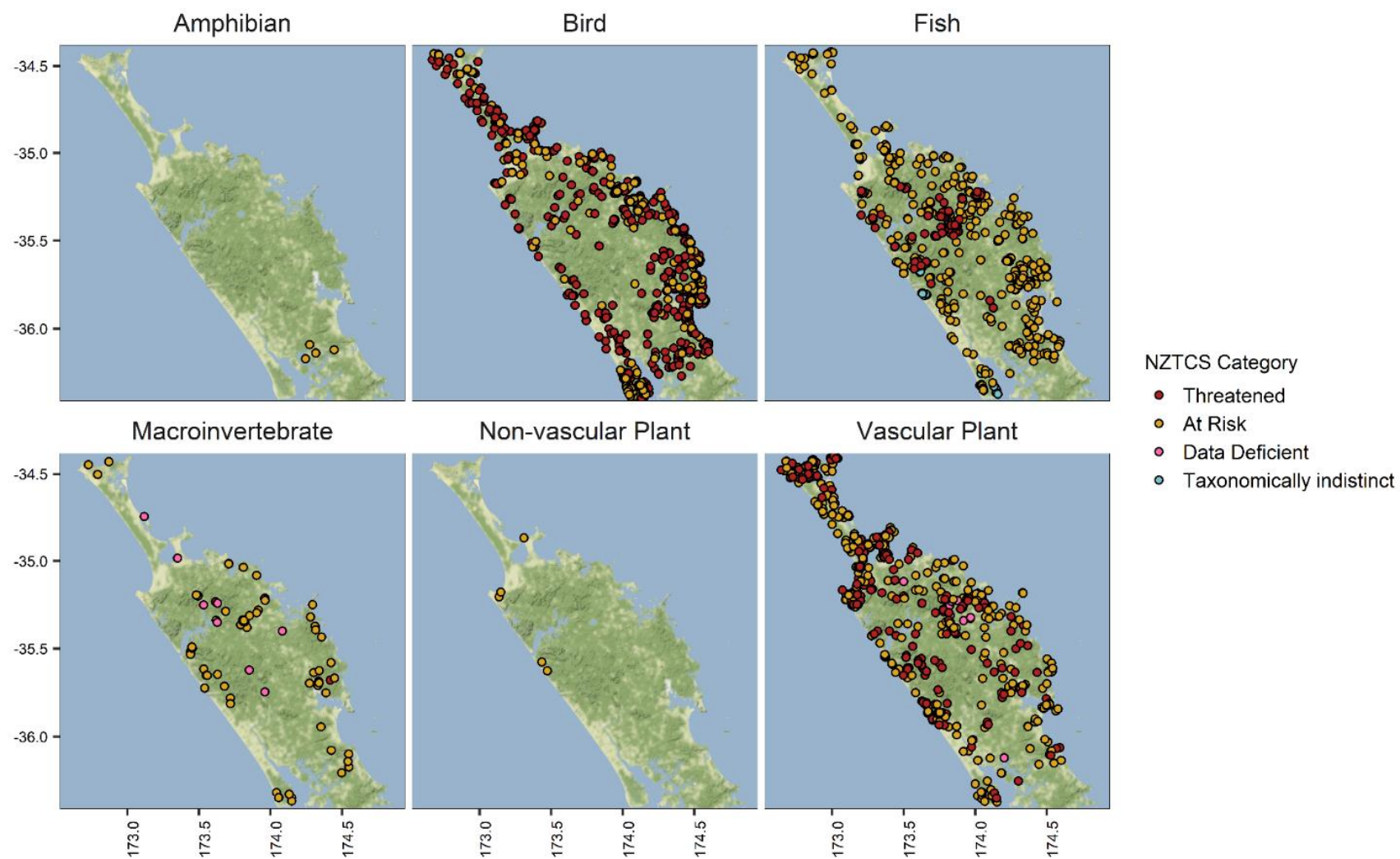


Figure 2: Maps showing occurrence records retrieved from GBIF databases for species classified as threatened, at risk, data deficient, and taxonomically indistinct.

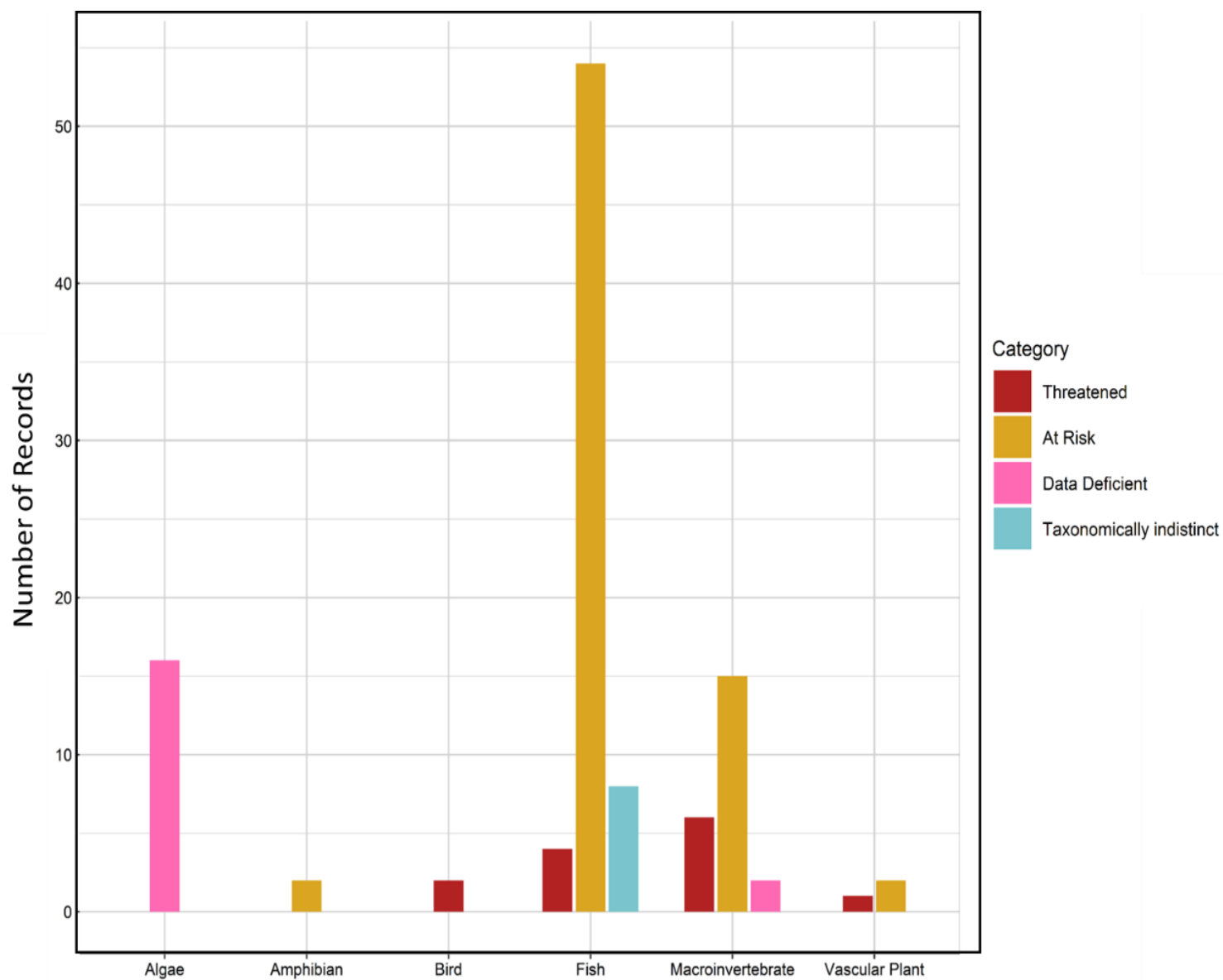


Figure 3: The number of records in NRC's eDNA samples for each taxa type and NZTCS threat category.

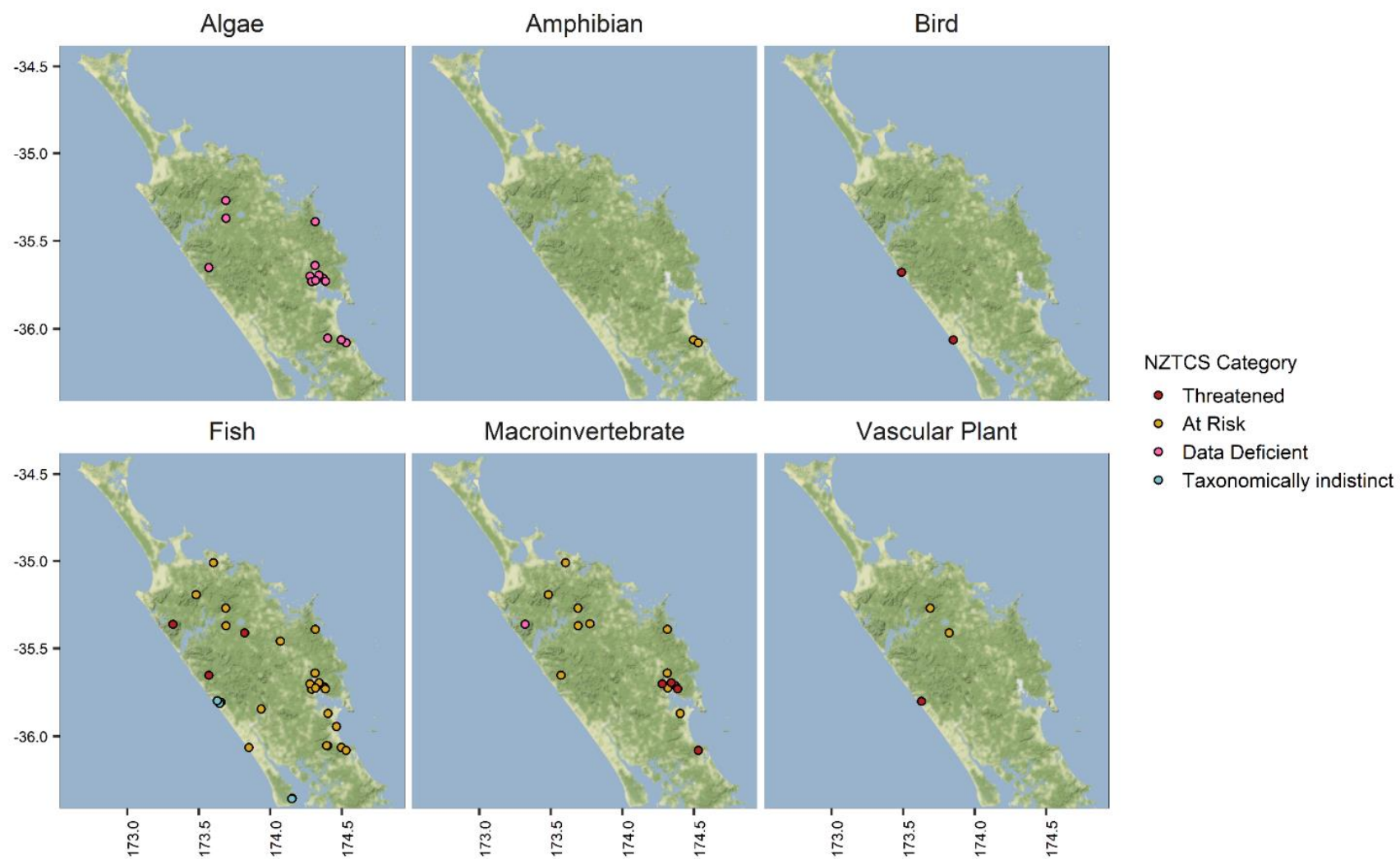


Figure 4: Maps showing eDNA detections collected by NRC for species classified as threatened, at risk, data deficient, and taxonomically indistinct.

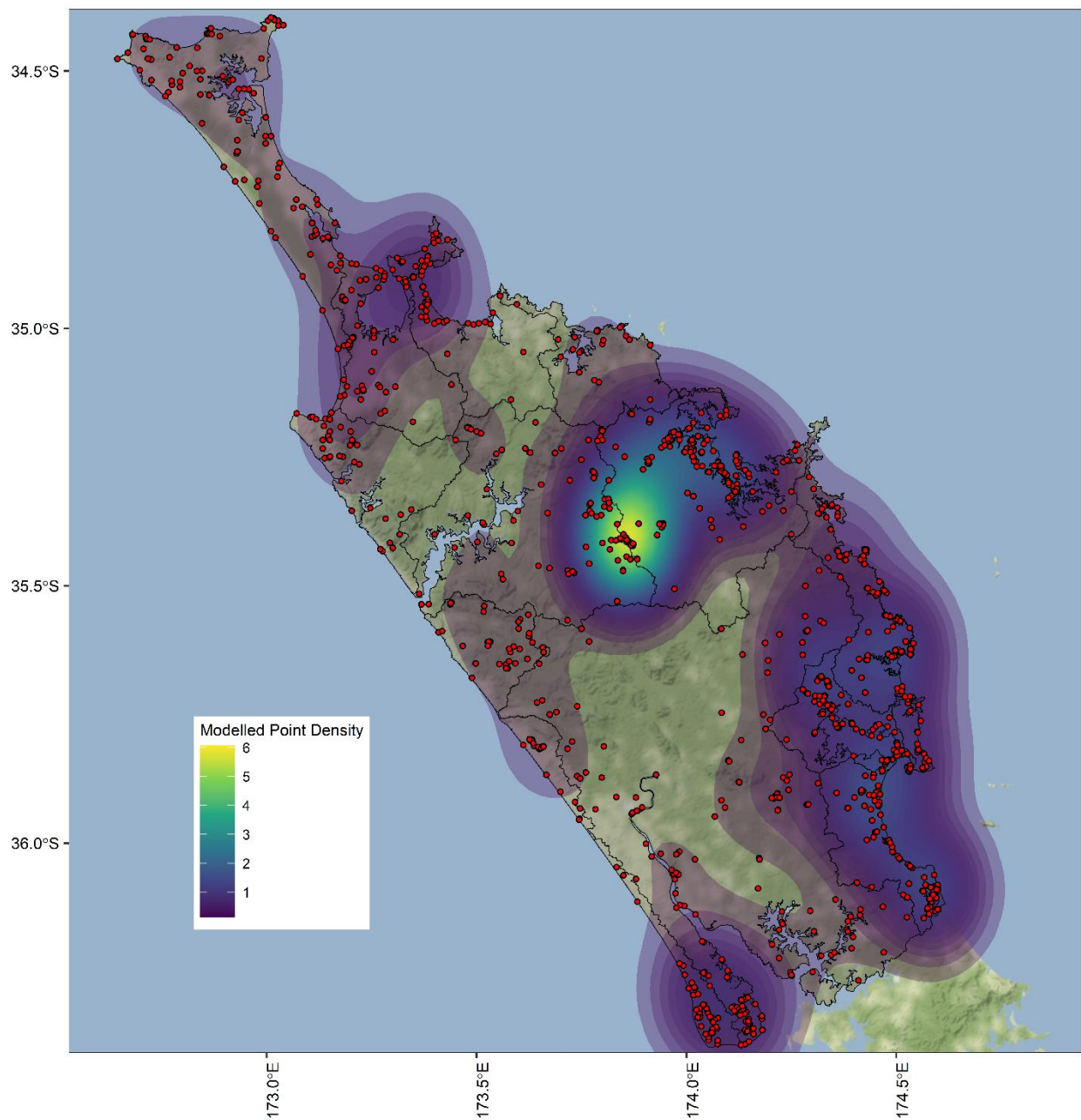


Figure 5: Plot showing modelled kernel density estimates of threatened freshwater species occurrences from NRC's eDNA sampling and GBIF databases across Northland. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 50 for visualisation.

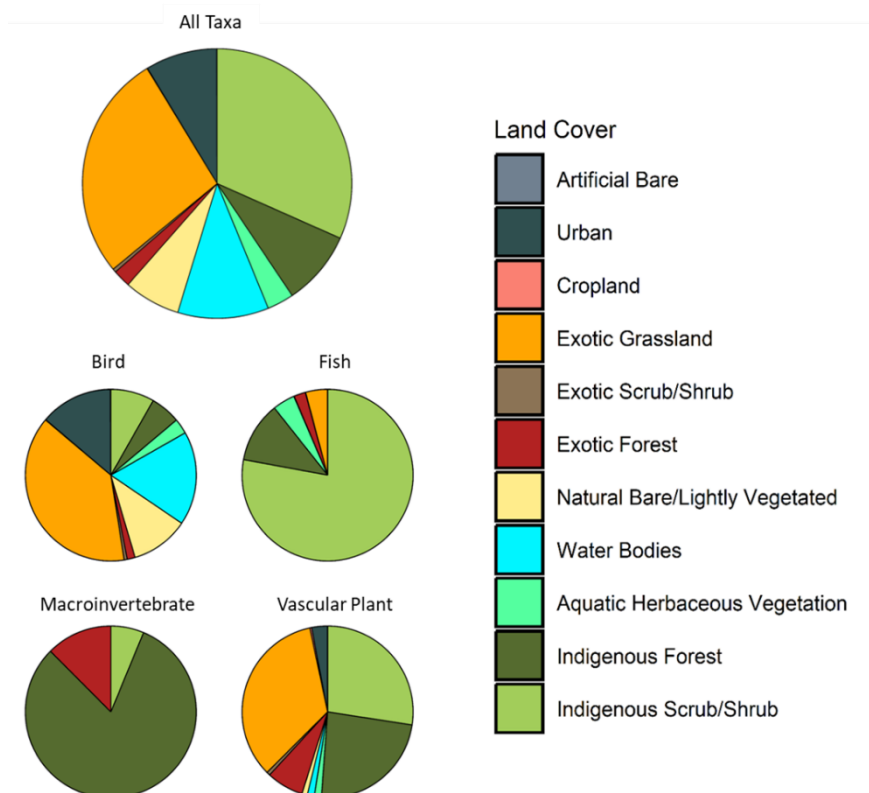


Figure 6: Pie charts showing proportion of NZTCS threatened species records by land cover and taxa type.

Table 6: Percentage of NZTCS threatened species occurrence records by land cover and taxa type.

Land Cover	Birds <i>n</i> = 2739	Fish <i>n</i> = 1421	Macroinvertebrates <i>n</i> = 11	Vascular Plants <i>n</i> = 287	All Taxa <i>n</i> = 4458
Artificial Bare	0.07%	0.00%	0.00%	0.00%	0.04%
Urban	13.73%	0.00%	0.00%	3.14%	8.64%
Cropland	0.07%	0.00%	0.00%	0.00%	0.04%
Exotic Grassland	38.63%	4.15%	0.00%	34.15%	27.25%
Exotic Scrub/Shrub	0.58%	0.07%	0.00%	0.70%	0.43%
Exotic Forest	1.50%	2.18%	9.10%	5.23%	1.97%
Natural Bare/Lightly Vegetated	10.95%	0.00%	0.00%	1.05%	6.80%
Water Bodies	17.67%	0.07%	0.00%	3.84%	11.13%
Aquatic Herbaceous Vegetation	2.88%	4.22%	0.00%	1.39%	3.21%
Indigenous Forest	5.66%	11.40%	81.82%	24.39%	8.88%
Flaxland	0.00%	0.00%	0.00%	0.00%	0.00%
Indigenous Scrub/Shrub	8.25%	77.90%	9.10%	26.13%	31.61%

Conclusions and Recommendations

For this work we considered all conservation interested categories (i.e., threatened, at risk, data deficient, and taxonomically indeterminant) for the sake of collating an exhaustive list of species potentially present in Northland according to online databases and NRC's eDNA records. However, the majority of the recommendations presented below will focus on species listed as threatened due to NPS-FM (2020) requirements. In addition, this work is not intended to provide a definitive list of threatened species in Northland, simply a collation of occurrences recorded in online databases and/or detected by eDNA and should be treated as a starting point not a destination.

Regional councils are tasked with managing ecosystem health components as well as any specialised habitat or conditions needed for only part of a threatened species' life cycle at an FMU level.

However, given threatened species occur throughout the region developing management strategies at an FMU level is not the best way forward; regardless of NPS-FM (2020) requirements.

Management strategies should be robust and constructed on a regional scale otherwise we risk inconsistency of efforts and methods. The majority of threatened species records occur in areas of natural land cover, with some exceptions (Table 6). Birds are recorded mostly from exotic grassland, but this should not be interpreted as "exotic grasslands are good for birds". These are highly vagile animals that likely become more visible to birders when there are fewer visual obstructions (e.g., forest cover). Further, it is possible these occurrences are recorded from small waterbodies (e.g., streams, wetlands, ponds, etc.) that are not picked up by the LCDB 2018. Another possibility is that the geographic location provided in a given record actually occurred in a waterbody but when overlayed with the LCDB 2018 layer the point fell in an adjacent terrestrial land cover. This is not an issue as one should assume that, for example, a fish record in "indigenous forest" occurred in a waterbody, most likely a stream, within that land cover type.

With these points in mind, a key for managing habitats of threatened species in Northland will be to *maintain the current extent and quality of natural land areas* (e.g., indigenous forest and shrub, water bodies, aquatic vegetation, and naturally bare areas) within NRC's area of influence along the shore or edges of waterbodies. Land cover is not necessarily static and some of these areas may have changed since LCDB 2018 was published, or small patches of native bush or wetland were not mapped. So, care should be taken in developing action plans or rules around specific land types but given not all taxa are limited to specific habitat types using broad definitions will provide more robust management.

Other Conservation Interest Species

Other conservation interest species (i.e., at risk, data deficient, and taxonomically indeterminant) do not fall under any NPS-FM requirement. Some of these species, however, are regionally rare (e.g. bluegill bully *Gobiomorphus hubbsi*, giant kōkopu *Galaxias argenteus*, and kōaro *G. brevipinnis*), occur exclusively in the region (e.g. Dune Lake *Galaxias* "Kai Iwi"), and/or are important to communities (e.g. longfin eel *Anguilla dieffenbachii* and kākahi *Echyridella menziesii*). So, while there is no statutory requirement to consider these species, having them listed and occurrence records collated into a dataset will be useful for future endeavours.

Dune Lake Galaxias “Kai Iwi”

Despite only occurring in the Kai Iwi dune lakes Taharoa and Waikere (Pingram, 2005; Rowe, 2016), the Dune Lake *Galaxias* “Kai Iwi” is listed by the NZTCS as “at risk – naturally uncommon” and entirely overlooked by established databases in GBIF and those that inform eDNA identification. This is partially due to the taxon being genetically similar to dwarf īnanga *Galaxias gracilis*. The situation is problematic because in addition to being geographically isolated *Galaxias* “Kai Iwi” is under threat from habitat loss and competition with introduced fish. Water levels in Taharoa have markedly decreased in recent years, due in large part to climate change, reducing vegetated littoral habitat available to the galaxiids. The mosquitofish *Gambusia affinis*, a native of the Southeastern United States, is present in large numbers in all three Kai Iwi lakes. *Gambusia* are live-bearing fish (i.e., give birth to “live” young) that reproduce prolifically and will occupy the same littoral habitat as *Galaxias* “Kai Iwi”, forcing competition for space and resources, as well as feeding on their eggs (Pingram, 2005; Rowe, 2016). Additionally, rainbow trout *Oncorhynchus mykiss*, native to the Pacific drainages of North America, had been historically introduced to the lakes for a recreational fishery. There has been debate as to the direct impact of trout on galaxiid populations in the lakes (Rowe and Chisnall, 1997; Rowe, 1998), but a recent study at NorthTec has shown direct predation on *Galaxias* “Kai Iwi” (Heyns et al. unpublished). Trout likely spend more time out of the littoral zone (Pingram, 2005), so *Galaxias* “Kai Iwi” are potentially being pushed into more direct contact with an introduced predator. With all this in mind, *Galaxias* “Kai Iwi” should be treated as “Regionally Threatened” by NRC in order to give greater priority to management.

Recommendations

- The results of this work are to be used as a “first step” towards determining what freshwater conservation interest species occur within Northland.
- Further investigation that engages regional and/or national experts is needed to determine a complete list of conservation interest species in Northland.
- Threatened species actions, at a high level, should be applied broadly to habitat types.
- More specific actions can be applied to certain species or locations as needed (e.g., Dune Lake *Galaxias* “Kai Iwi”).
- Environmental DNA can be an invaluable surveillance tool.

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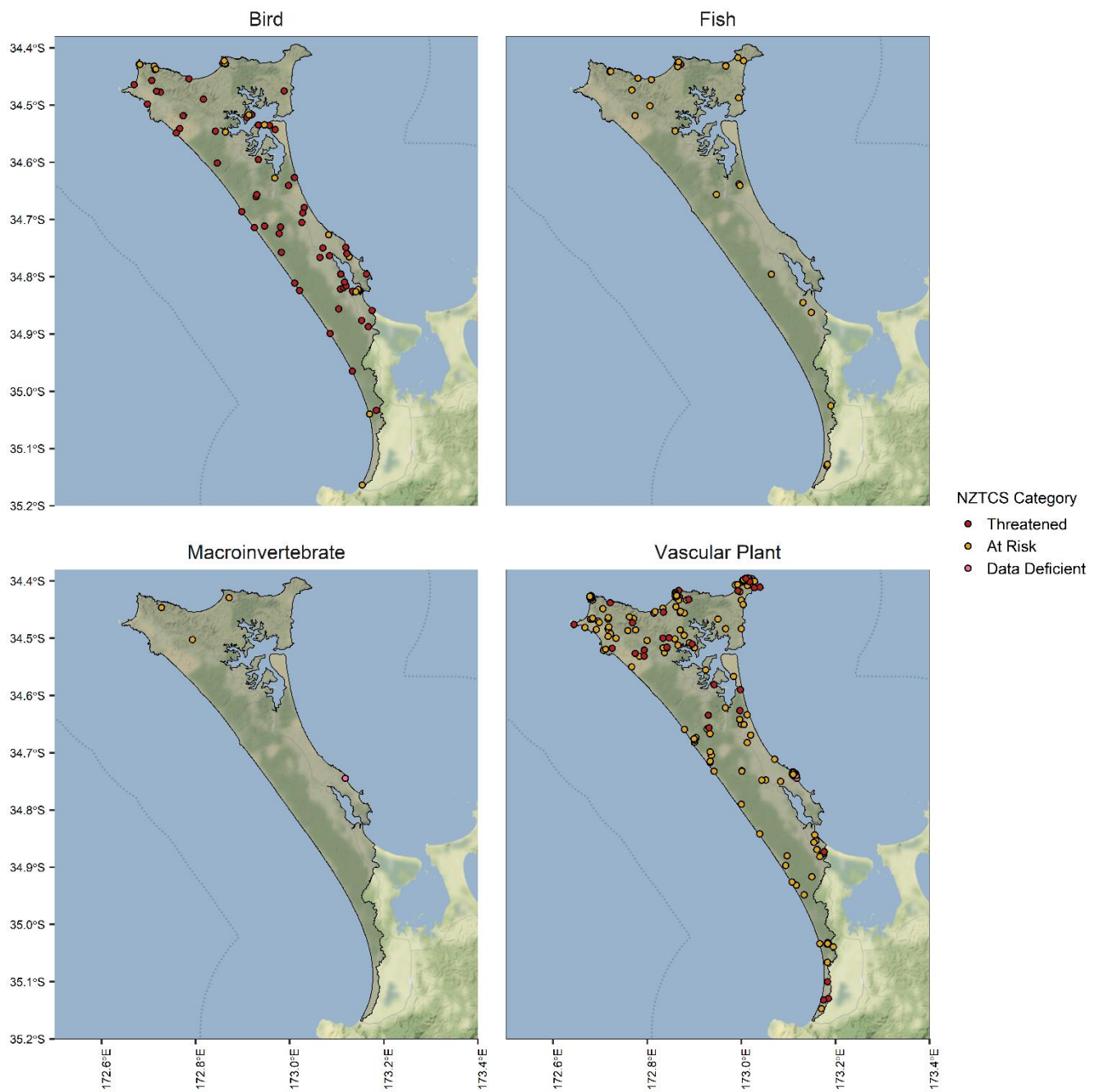
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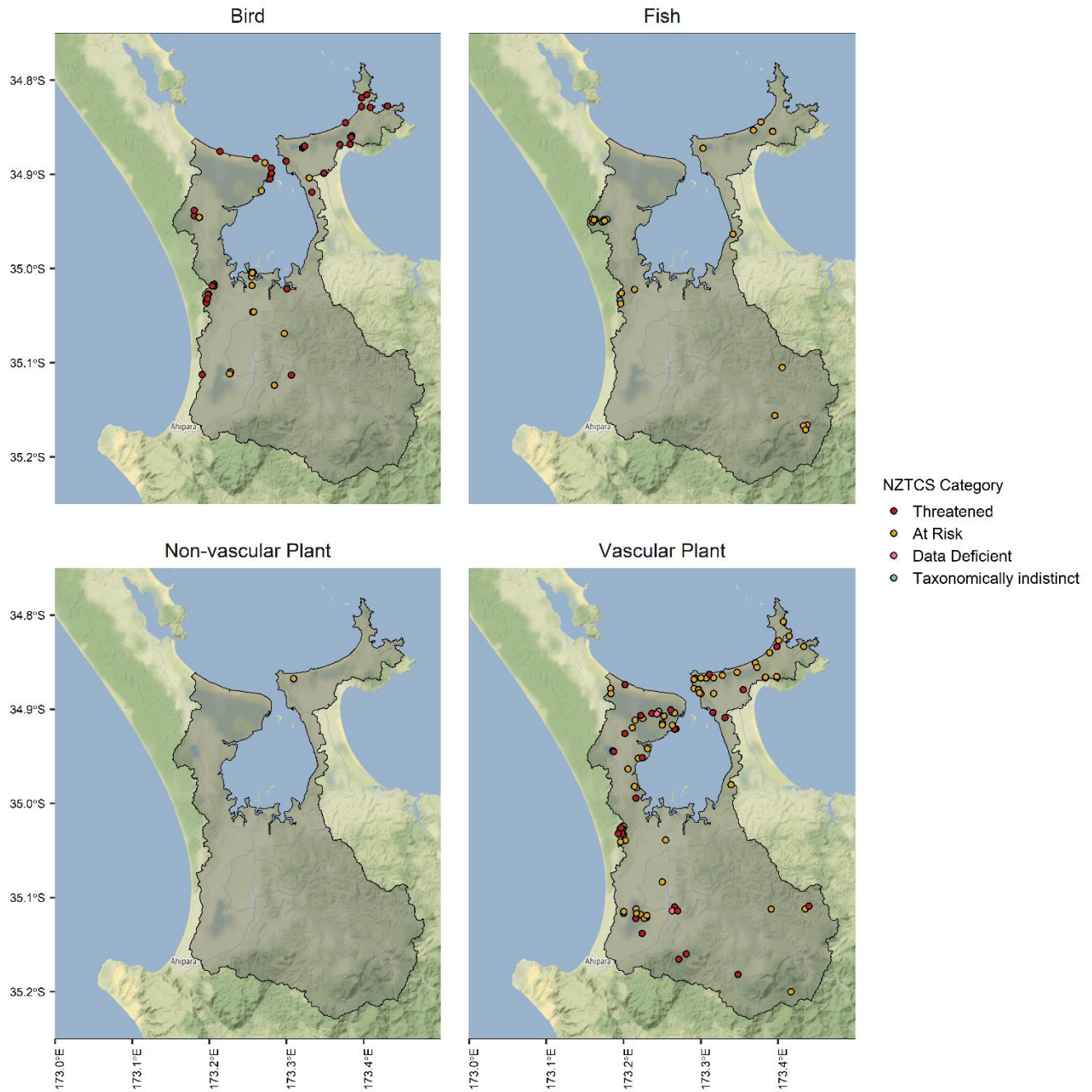
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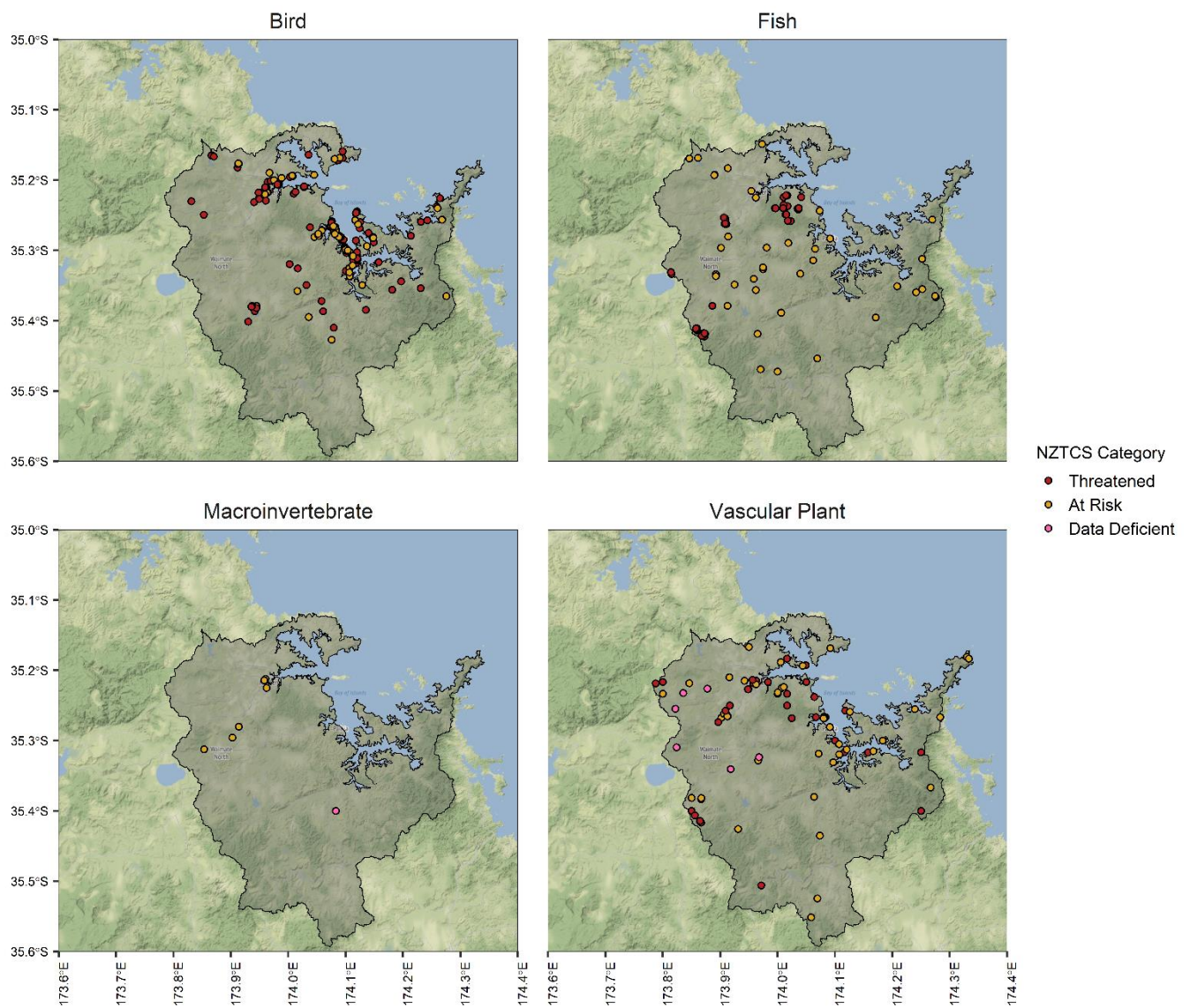
Appendix 1



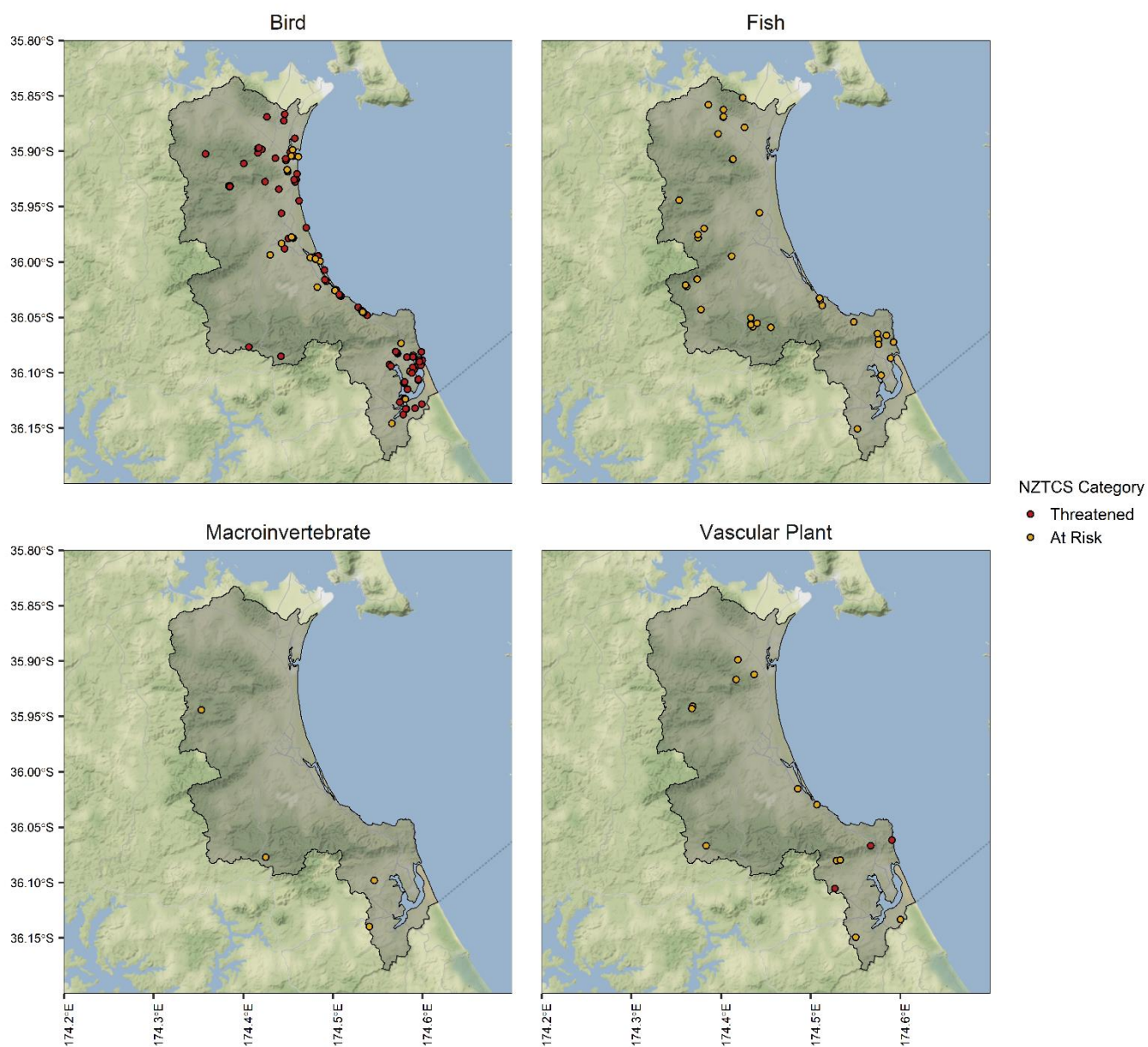
Appendix 1.1 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened, at risk, and data deficient for the Aupōuri FMU.



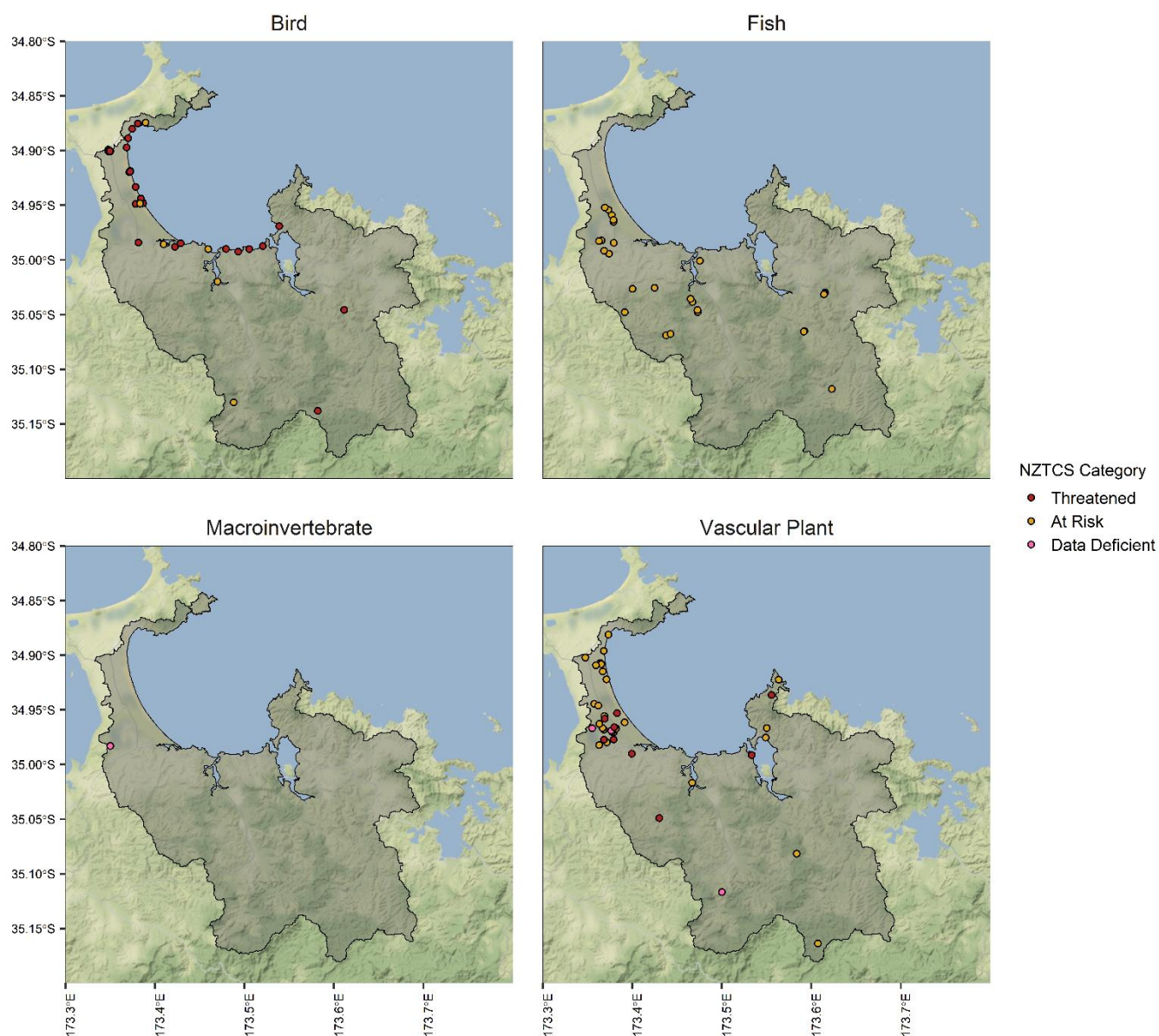
Appendix 1.2 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened, at risk, data deficient, and taxonomically indistinct for the Awanui FMU.



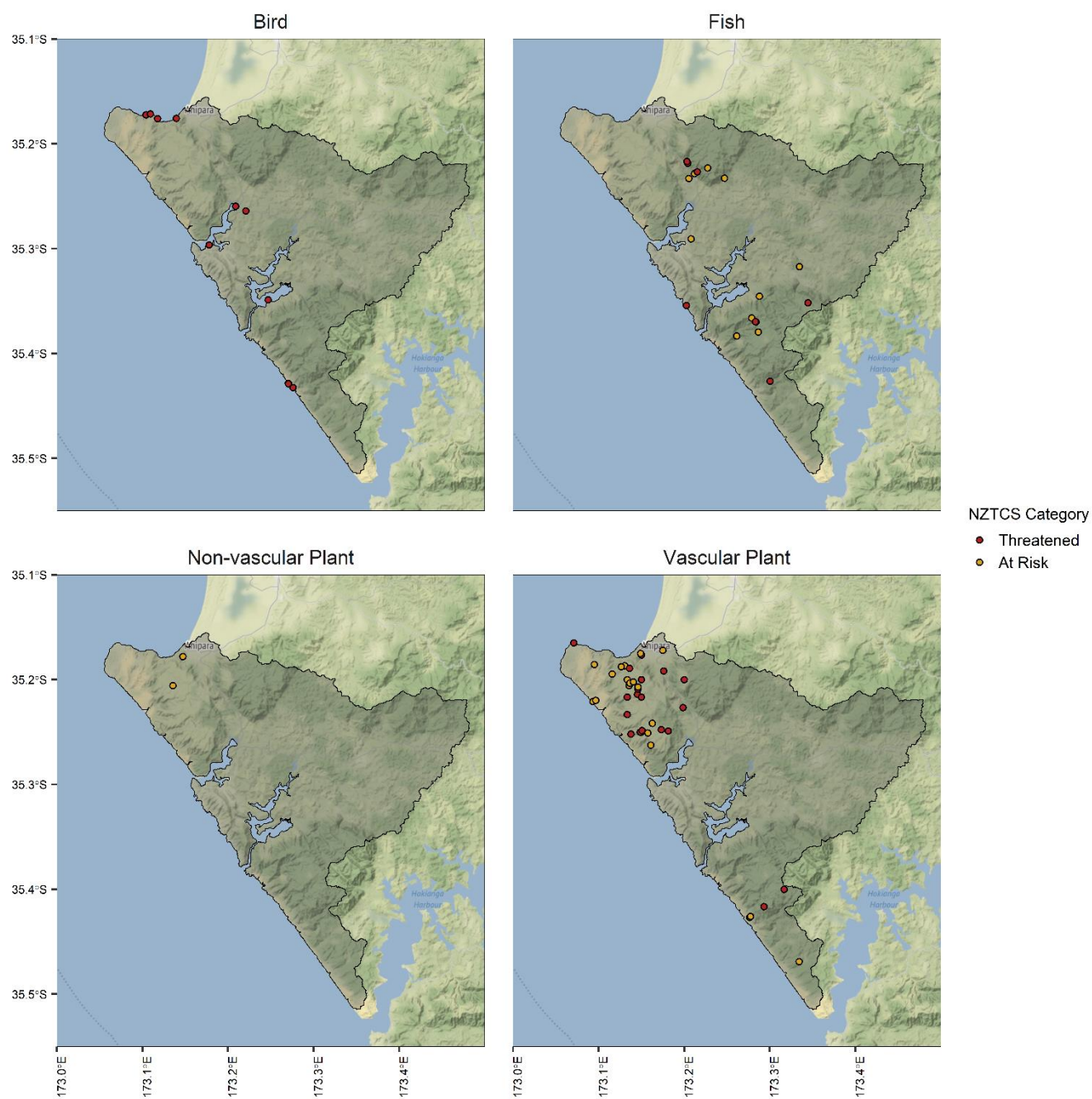
Appendix 1.3 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened, at risk, and data deficient for the Bay of Islands FMU.



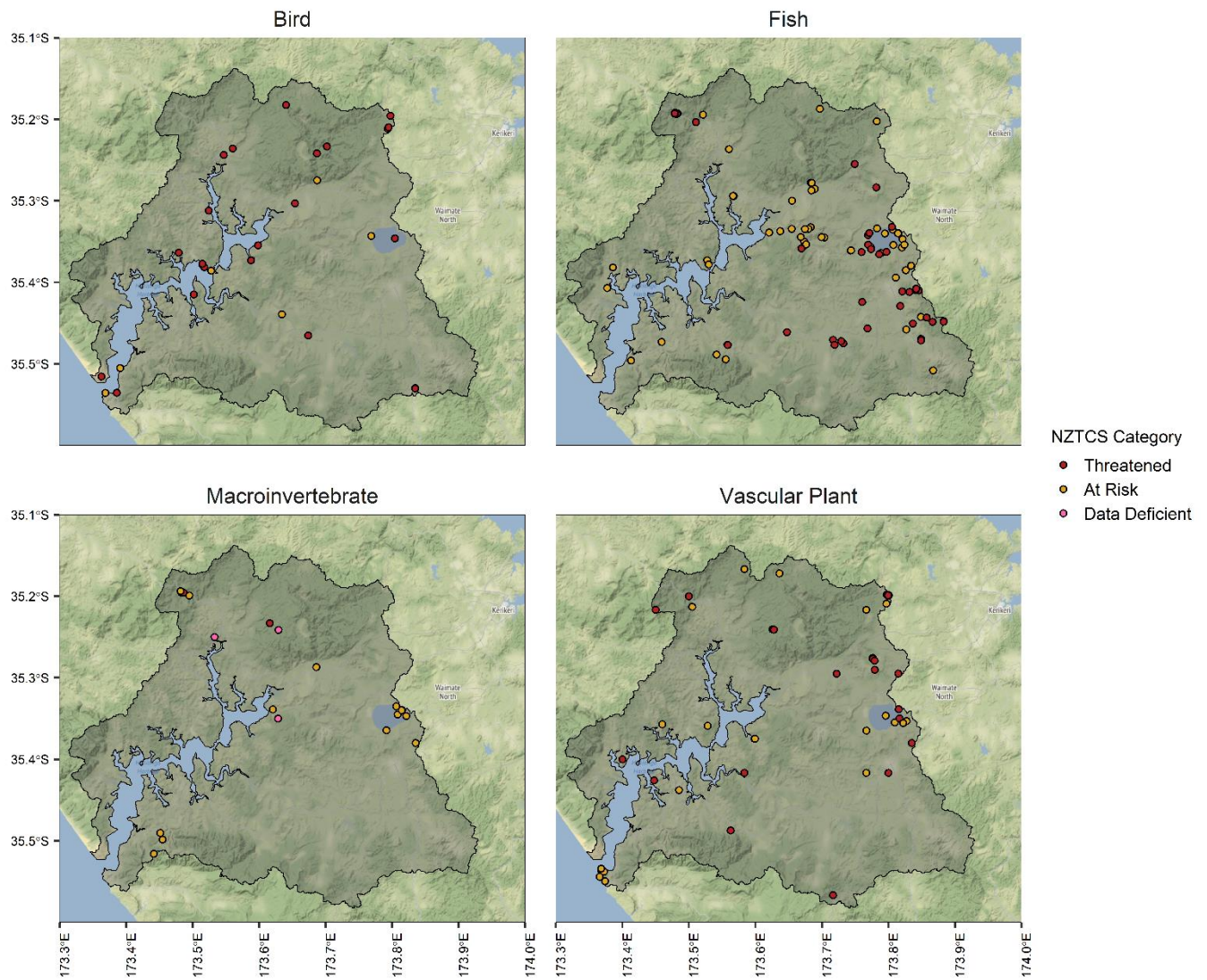
Appendix 1.4 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened and at risk for the Bream Bay FMU.



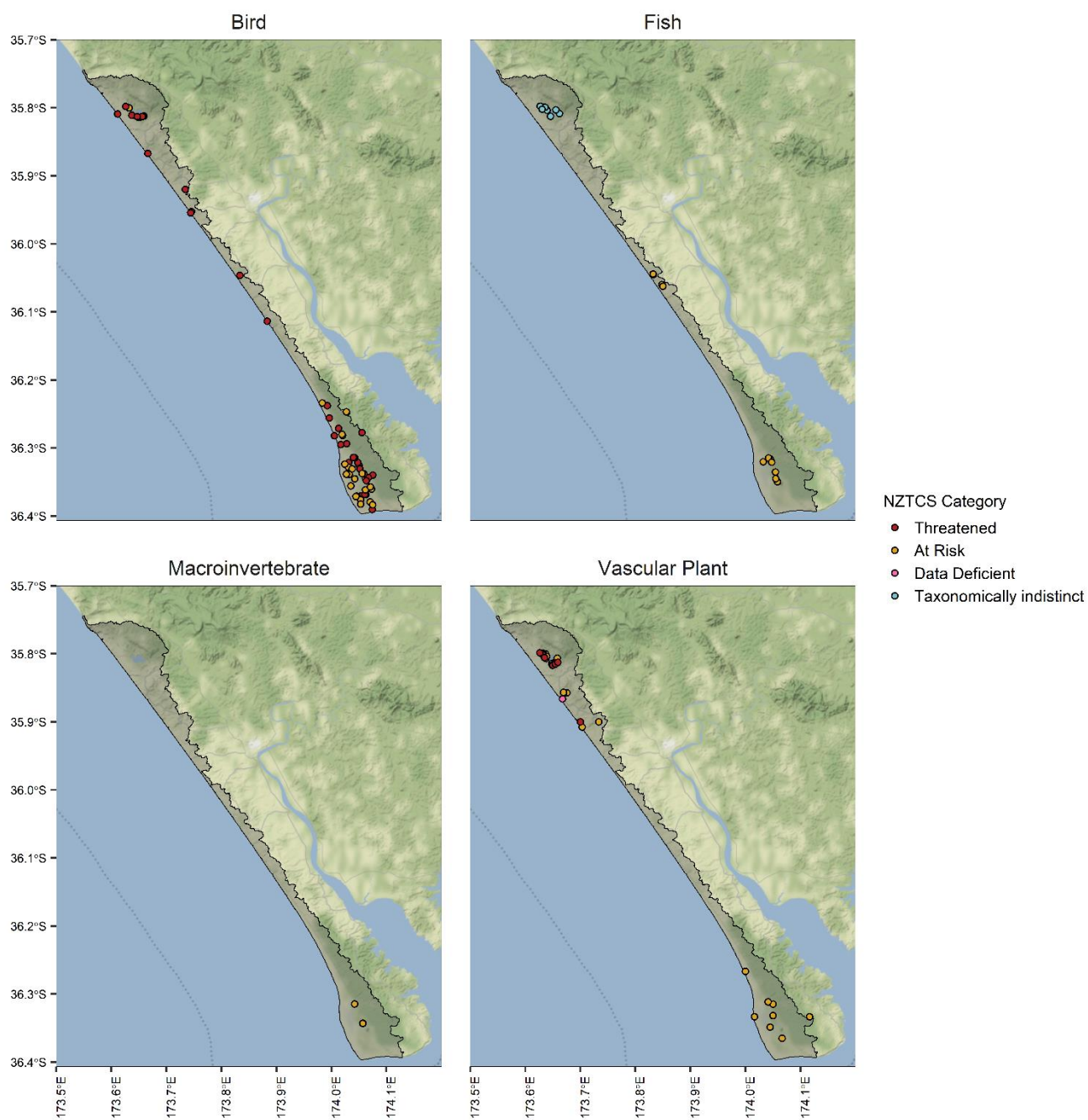
Appendix 1.5 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened, at risk, and data deficient for the Doubtless Bay FMU.



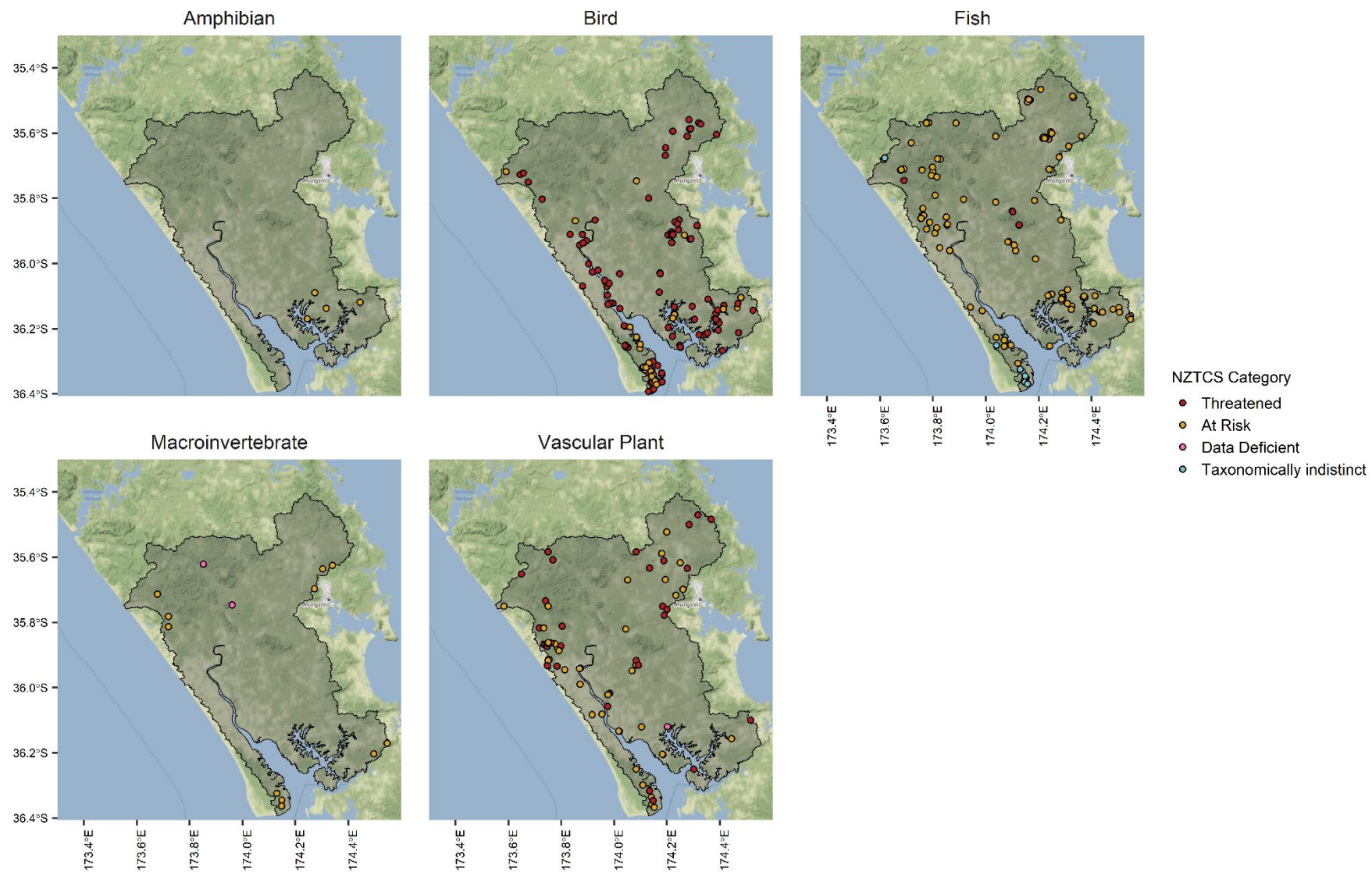
Appendix 1.6 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened and at risk for the Herekino and Whāngāpē FMU.



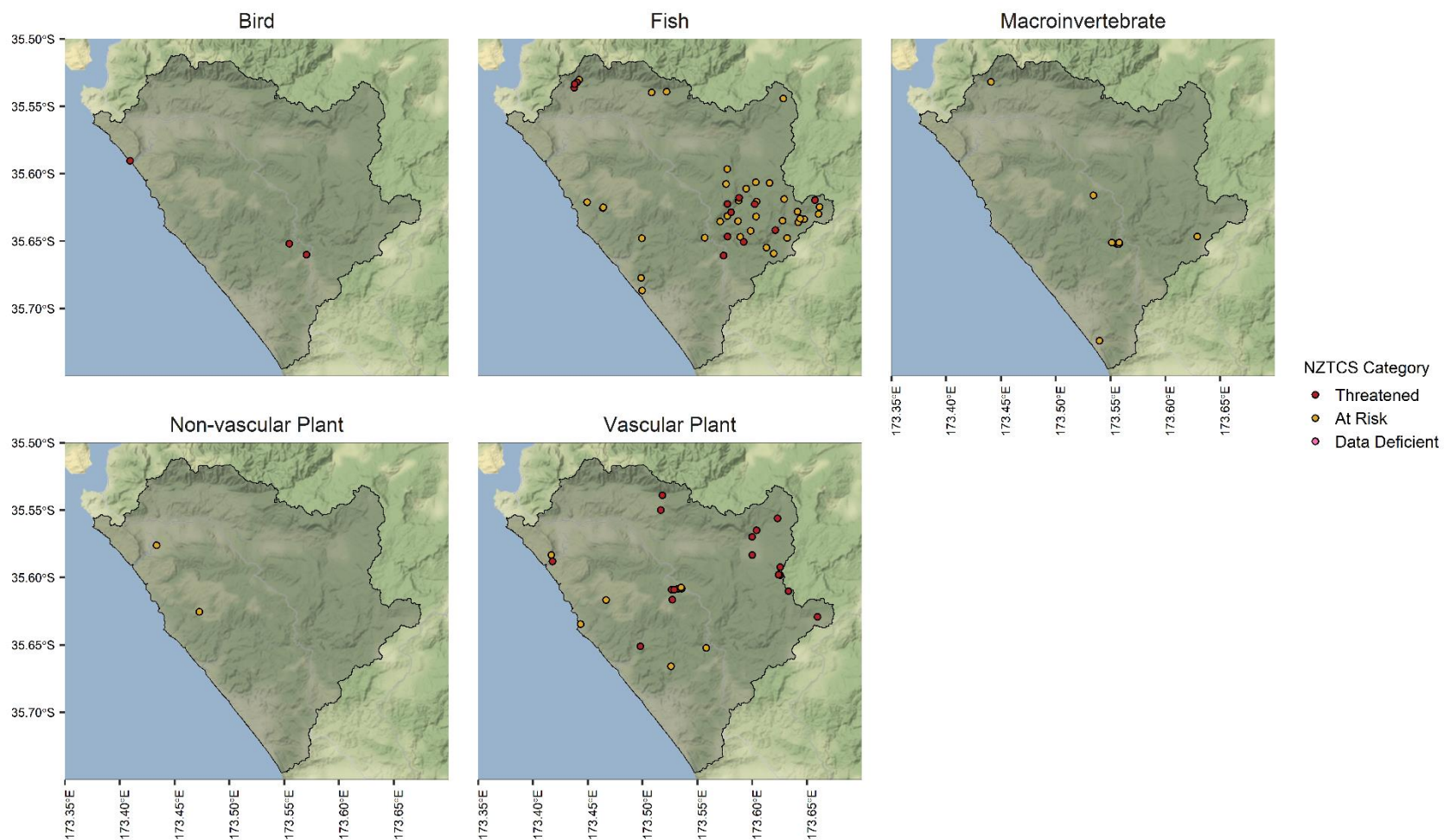
Appendix 1.7 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened, at risk, and data deficient for the Hokianga FMU.



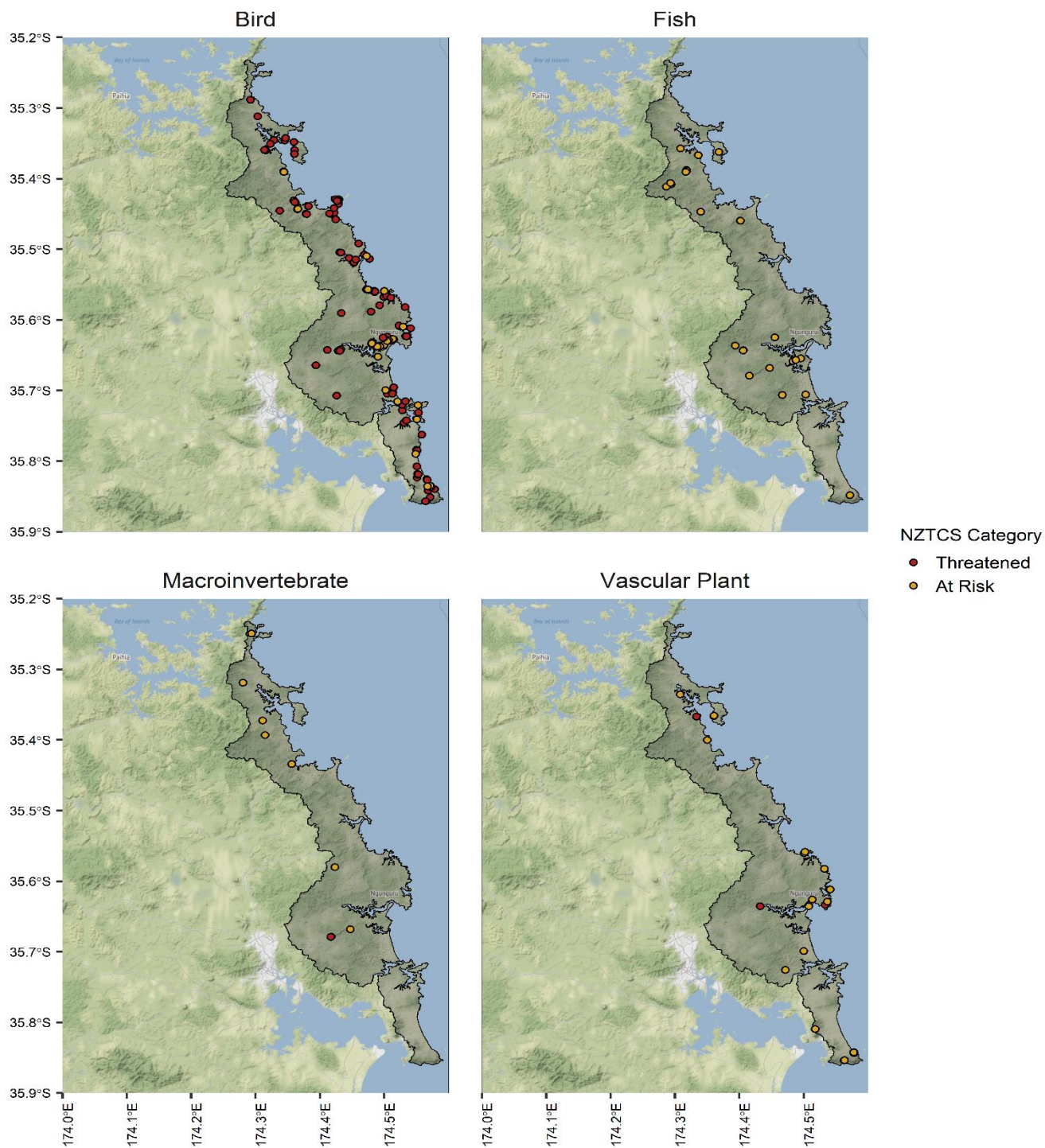
Appendix 1.8 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened, at risk, data deficient, and taxonomically indistinct for the Poutō FMU.



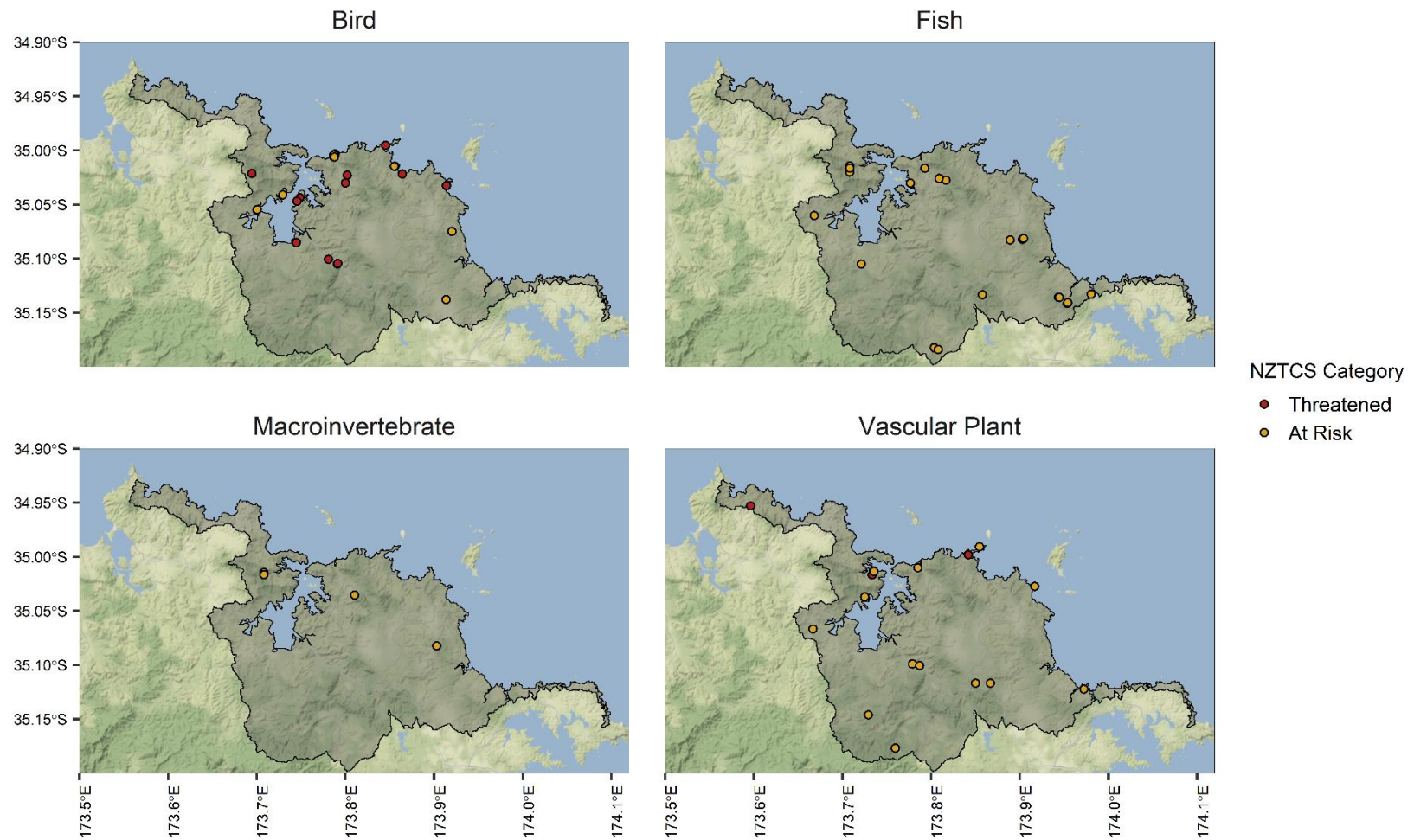
Appendix 1.9 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened, at risk, data deficient, and taxonomically indistinct for the Northern Wairoa FMU.



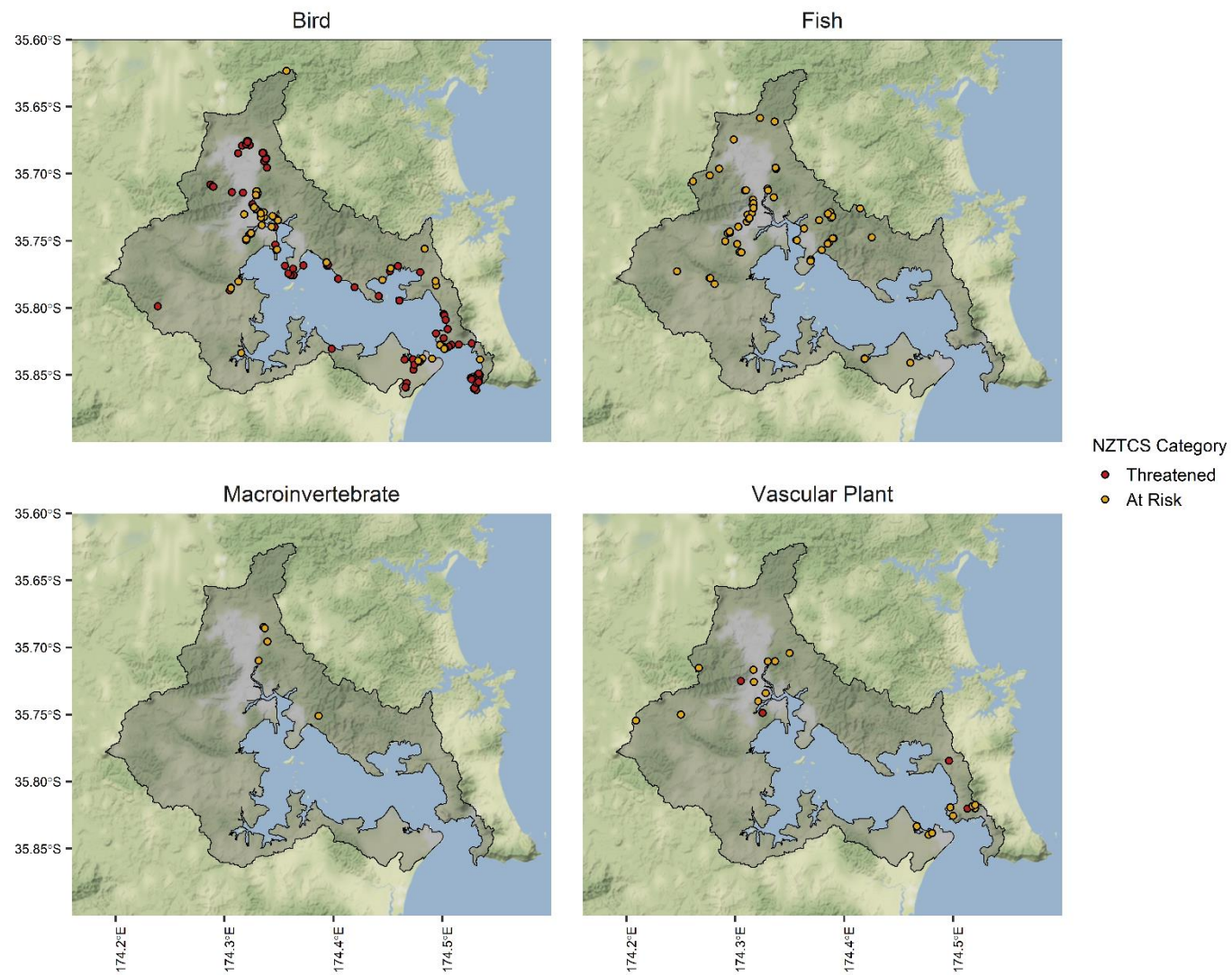
Appendix 1.10 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened, at risk, and data deficient for the Waipoua FMU.



Appendix 1.11 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened and at risk for the Whananaki Coast FMU.

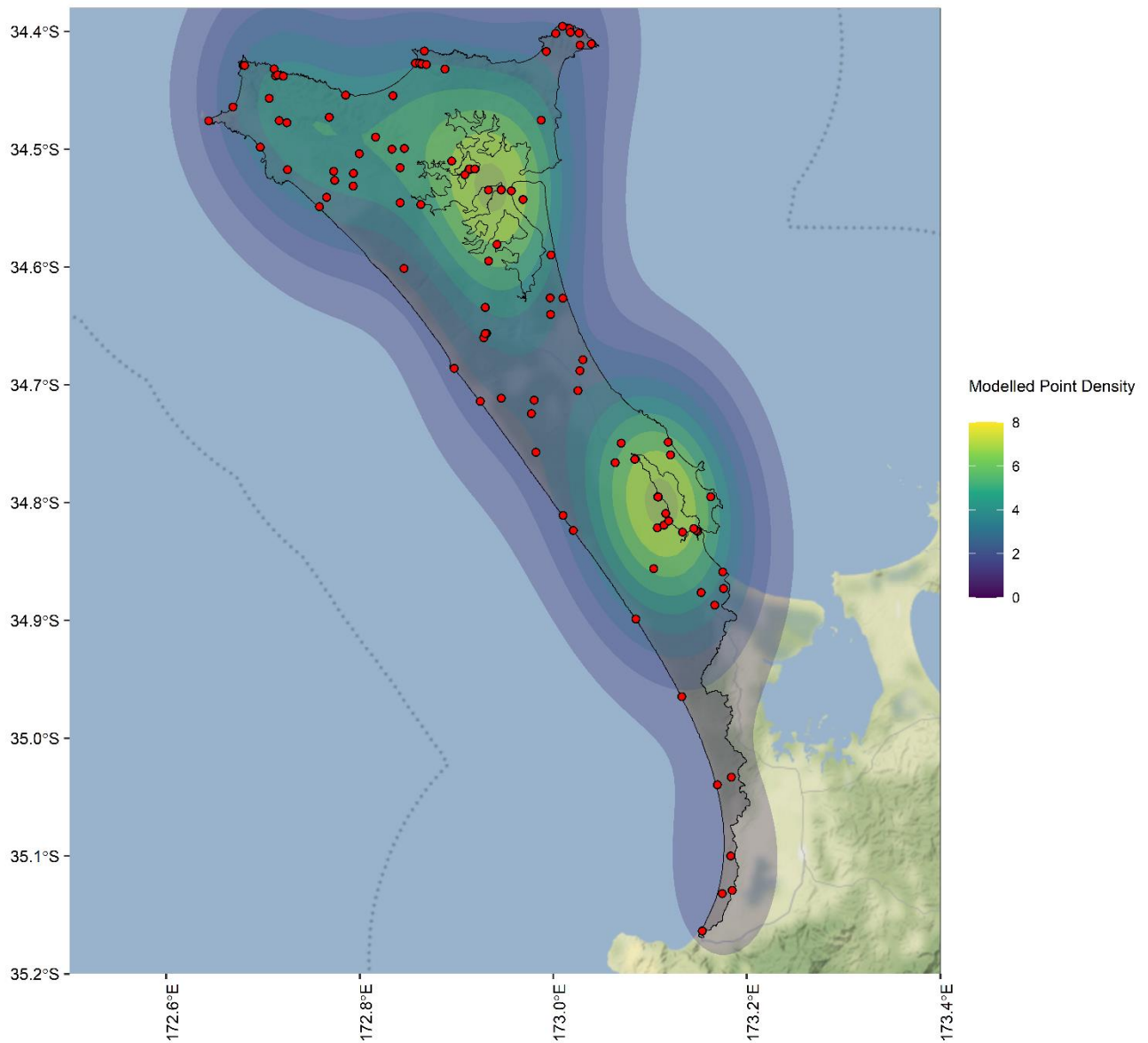


Appendix 1.12 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened and at risk for the Whangaroa FMU.

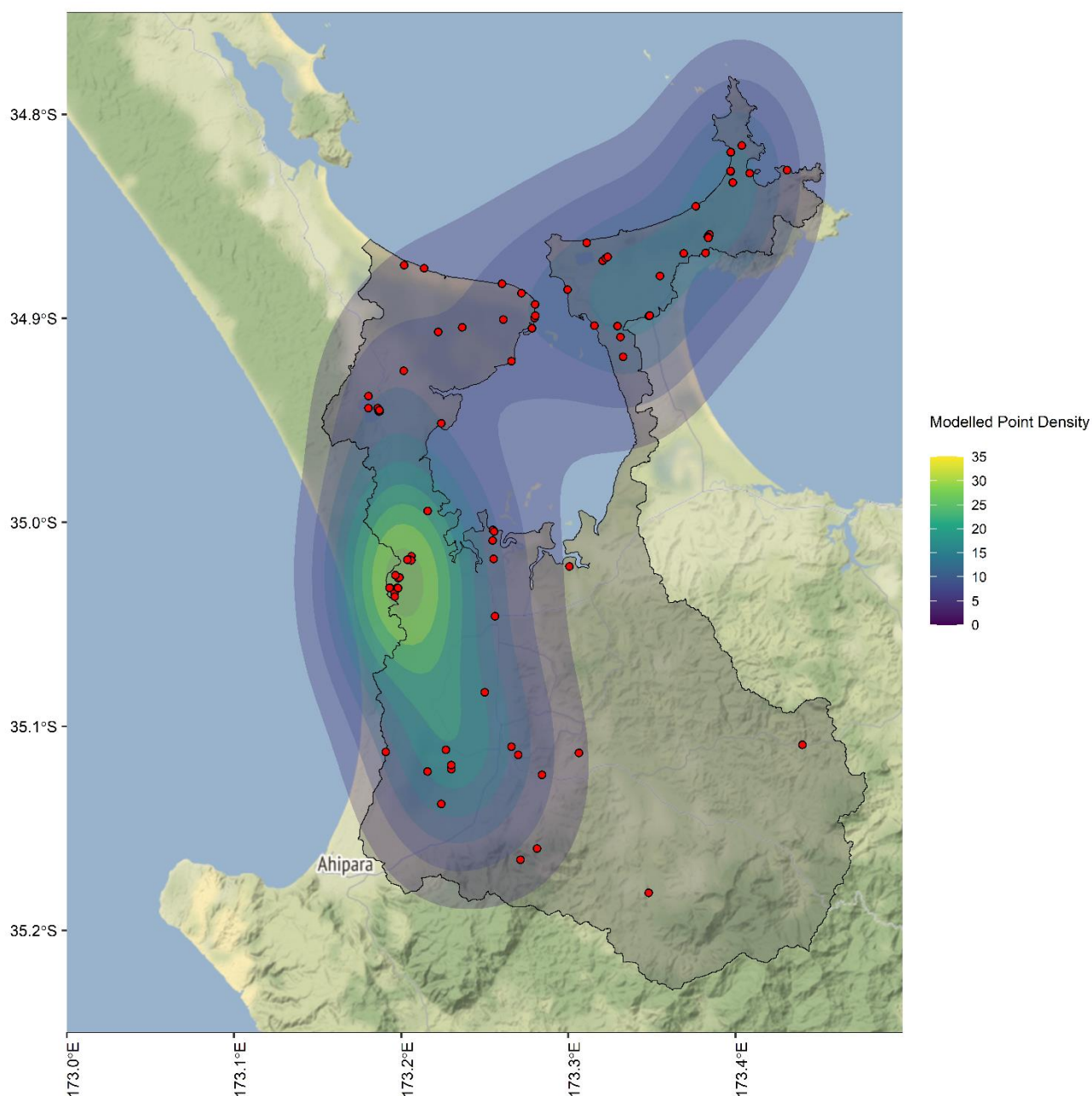


Appendix 1.13 Maps showing occurrence records retrieved from GBIF databases for species classified as threatened and at risk for the Whangārei FMU.

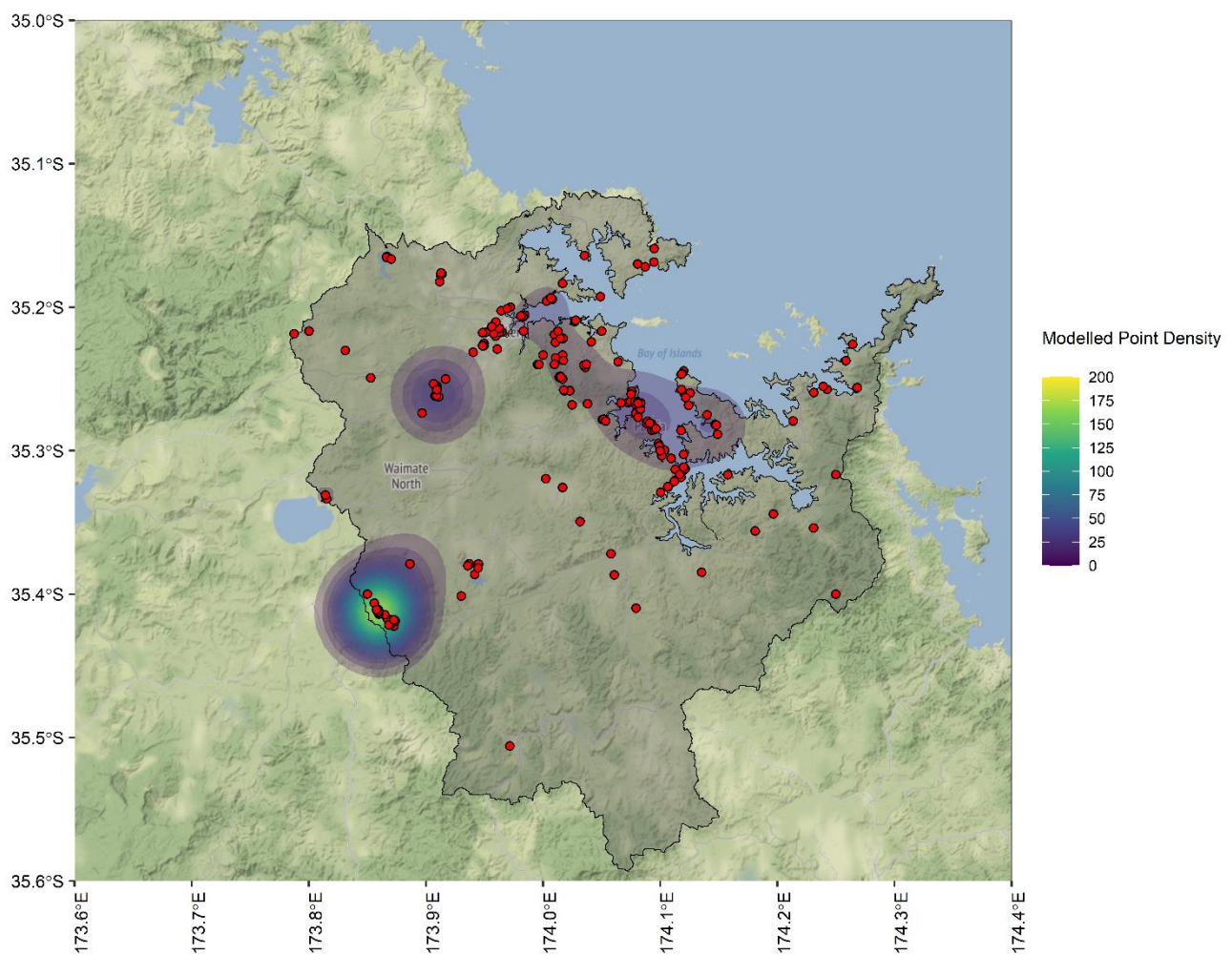
Appendix 2



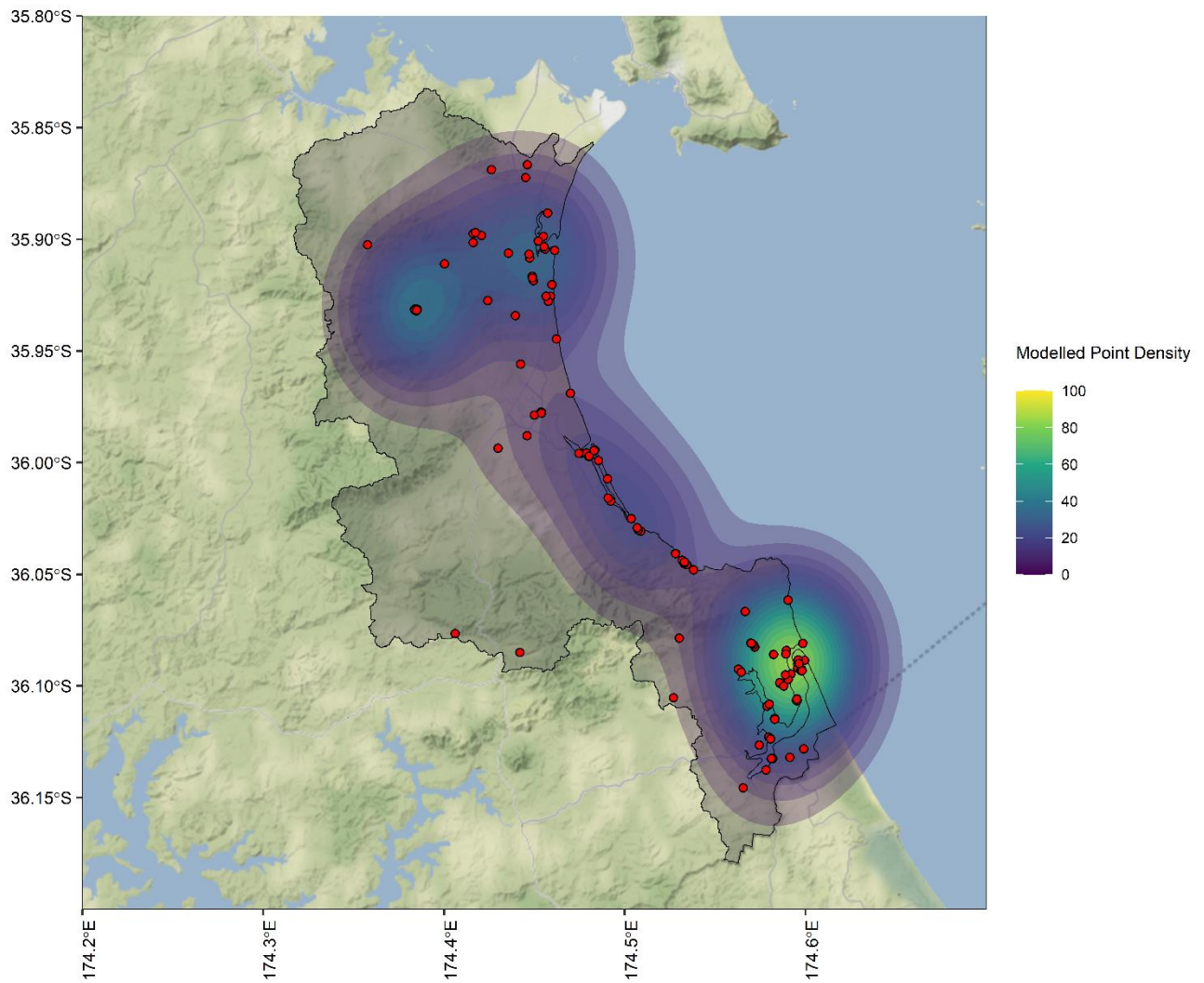
Appendix 2.1 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Aupōuri FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 10 for visualisation.



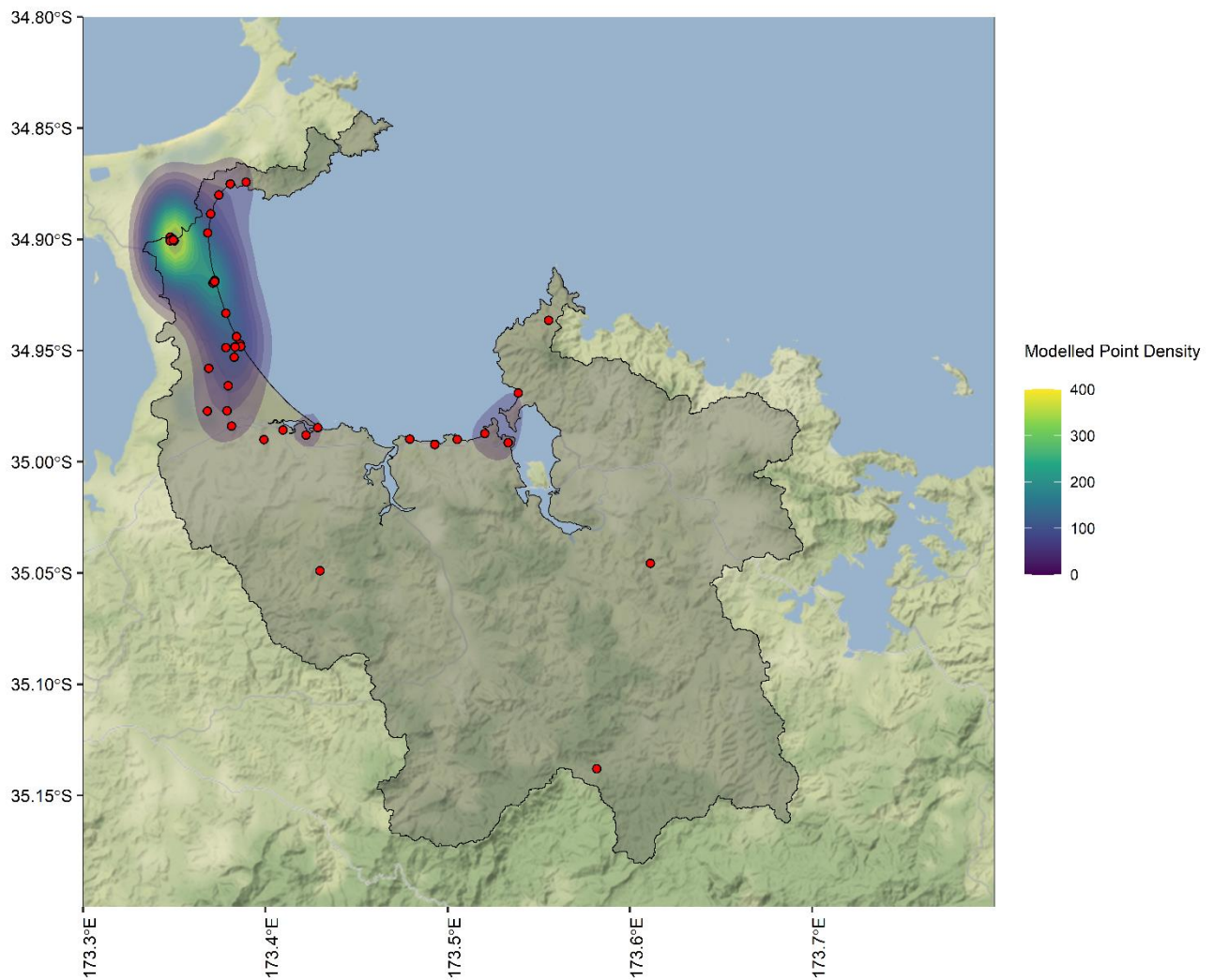
Appendix 2.2 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Awanui FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 10 for visualisation.



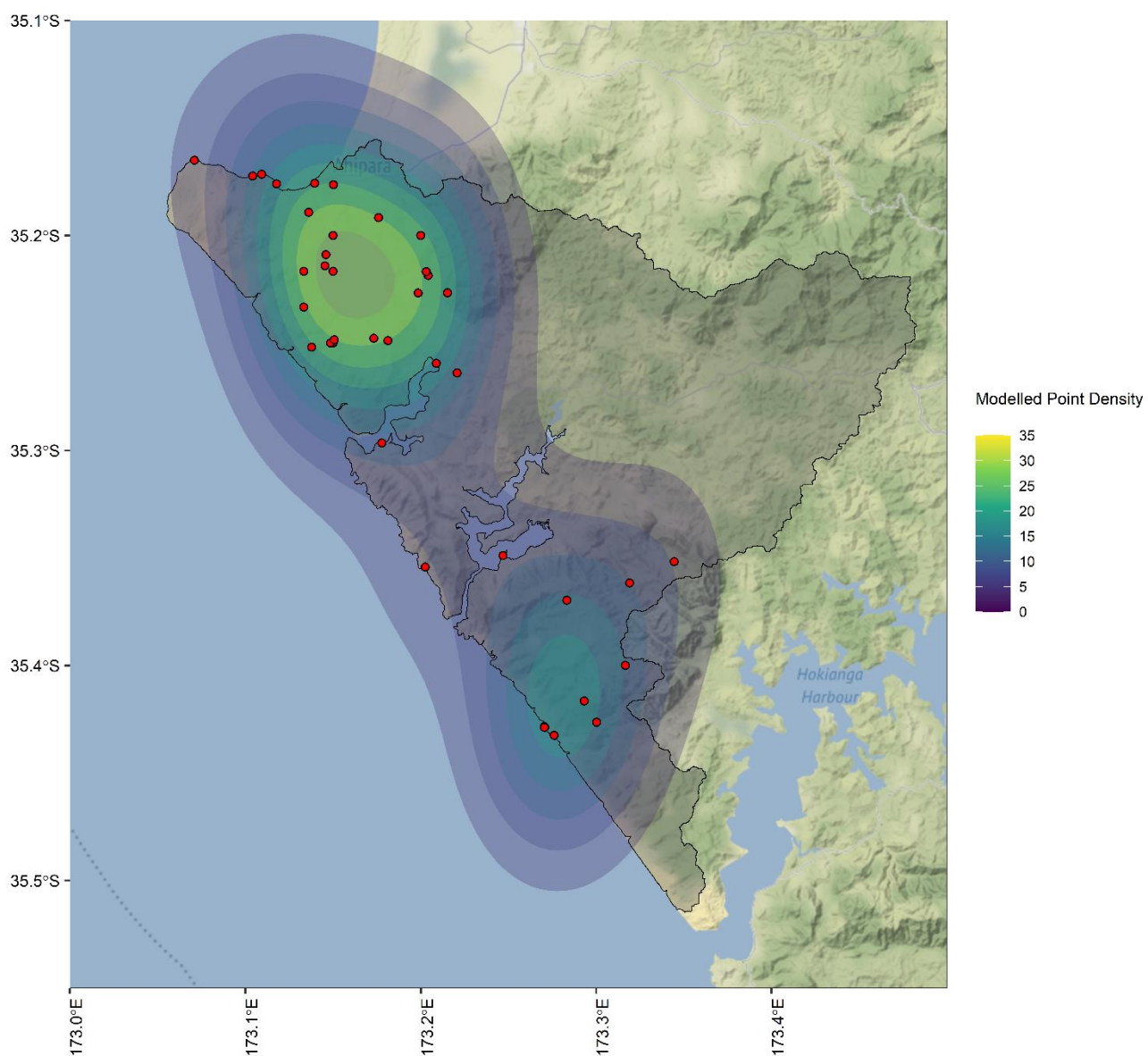
Appendix 2.3 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Bay of Islands FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 20 for visualisation.



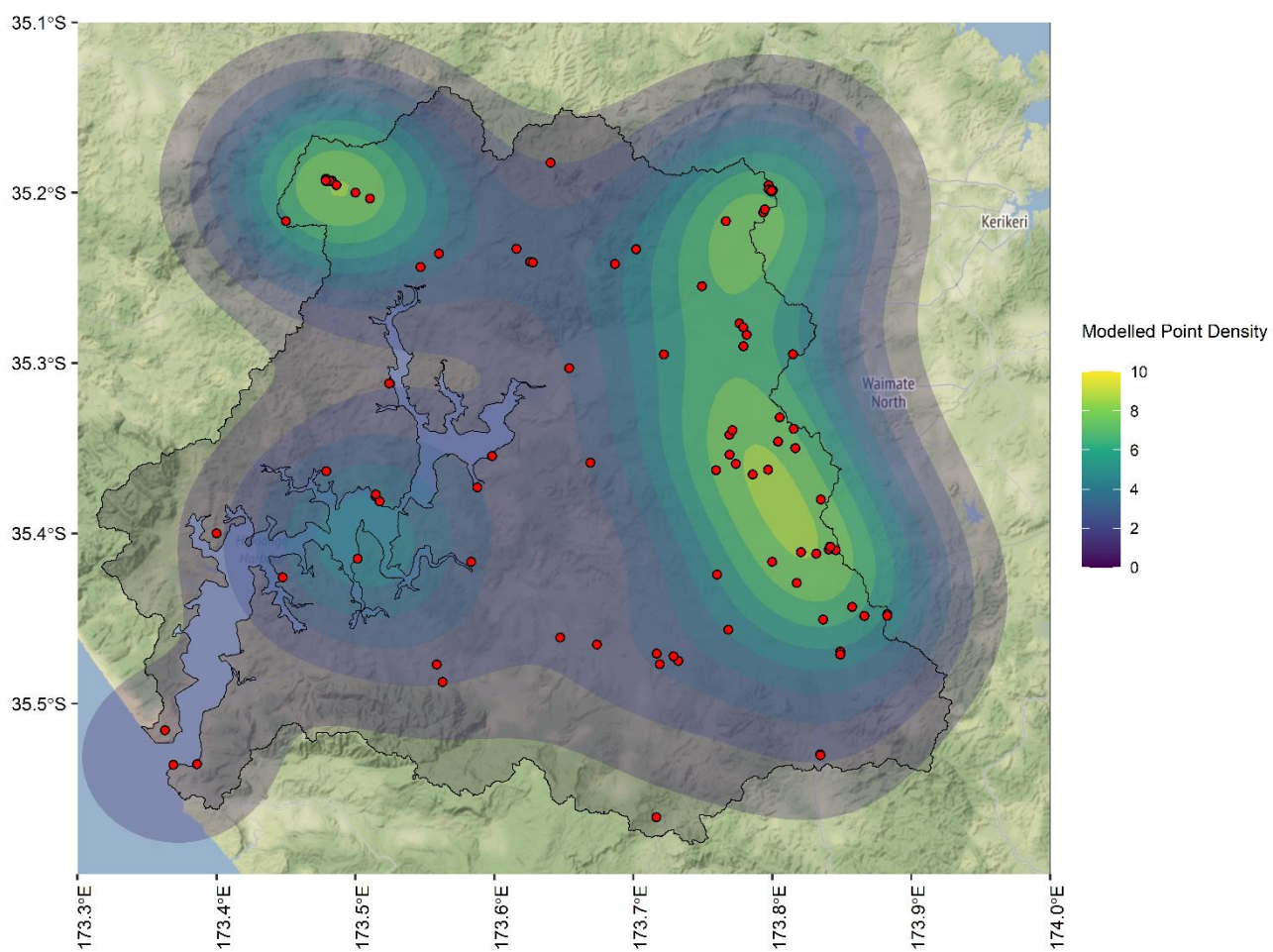
Appendix 2.4 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Bream Bay FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 20 for visualisation.



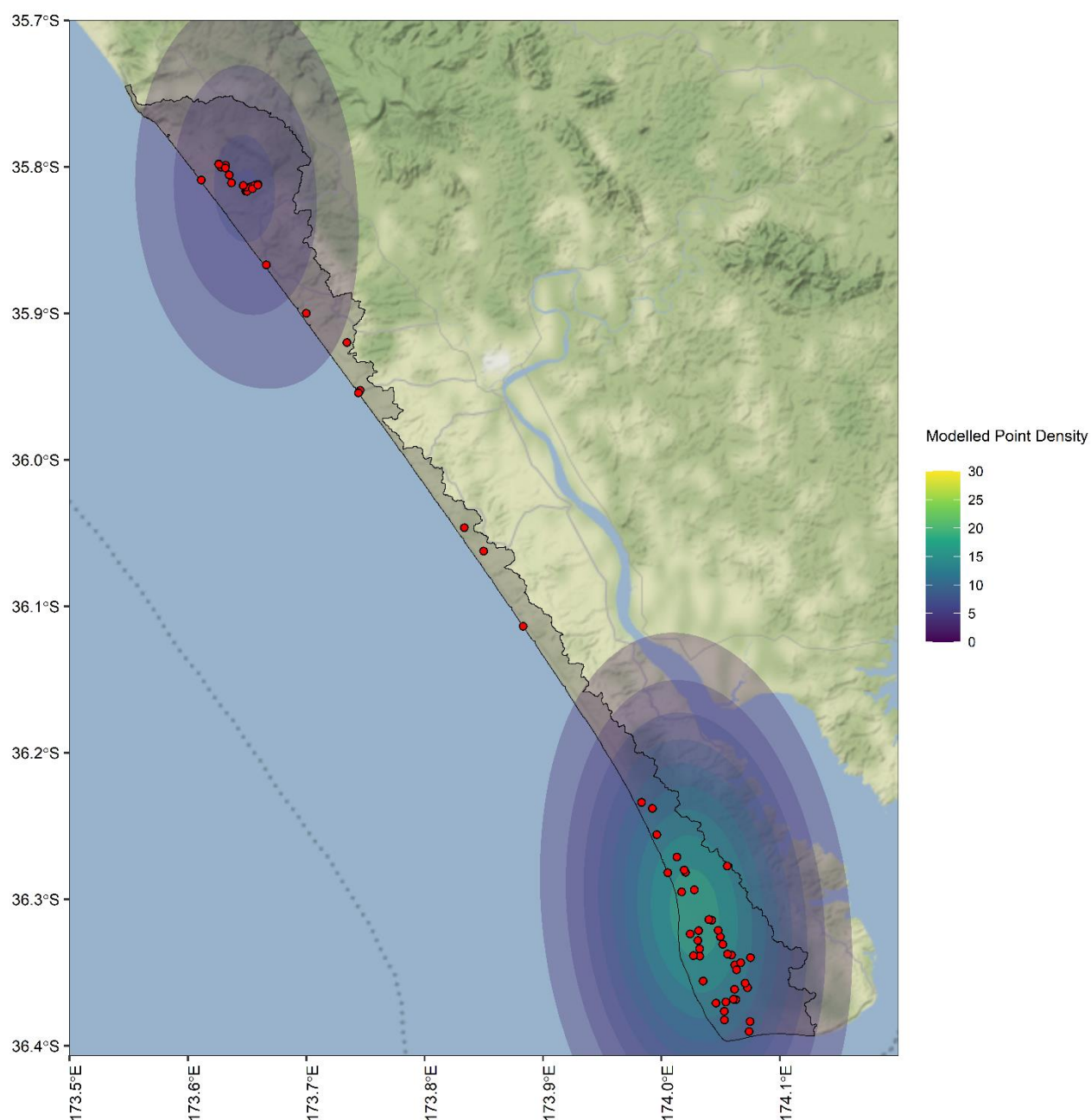
Appendix 2.5 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Doubtless Bay FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 20 for visualisation.



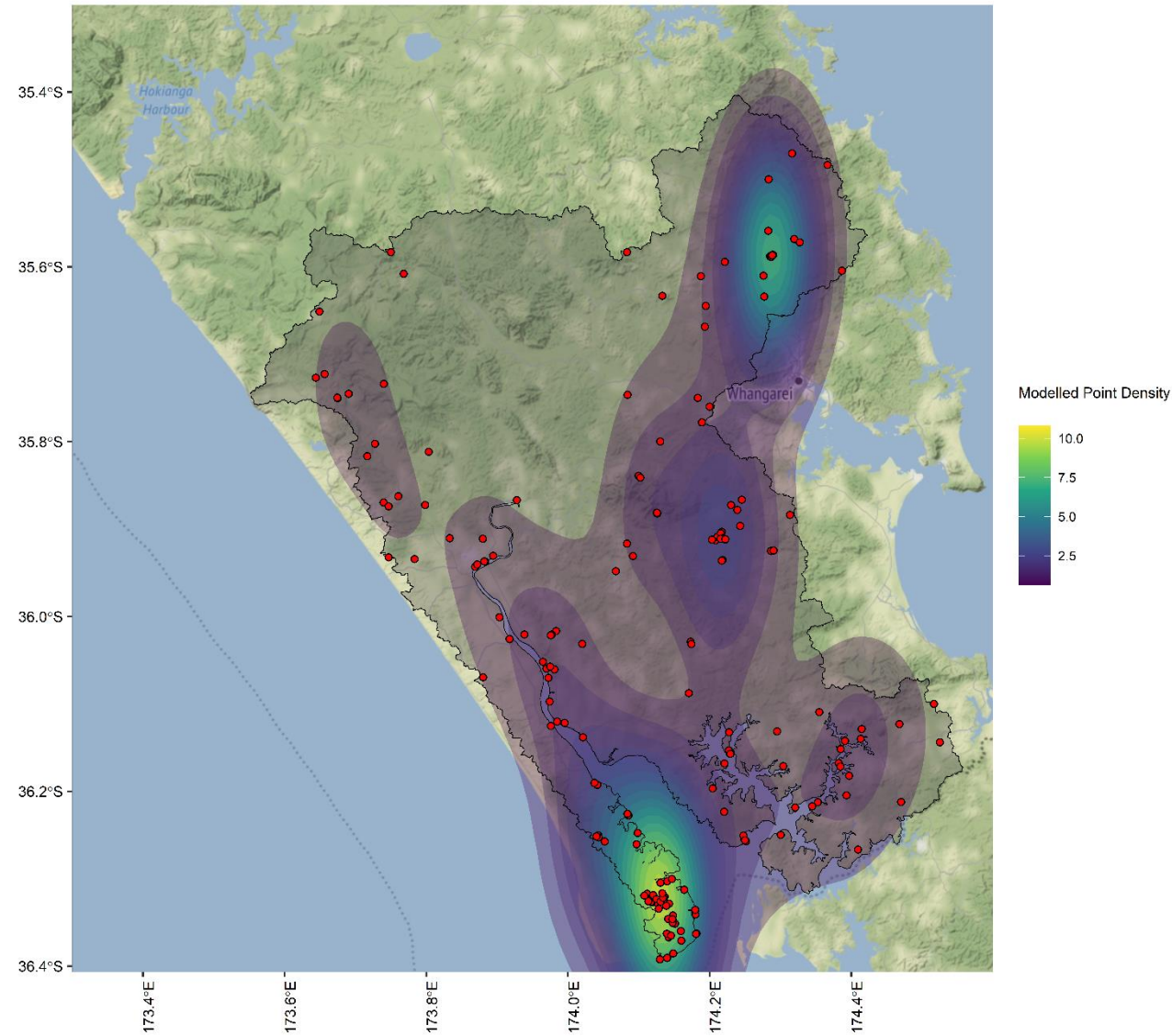
Appendix 2.6 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Herekino and Whāngāpē FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 10 for visualisation.



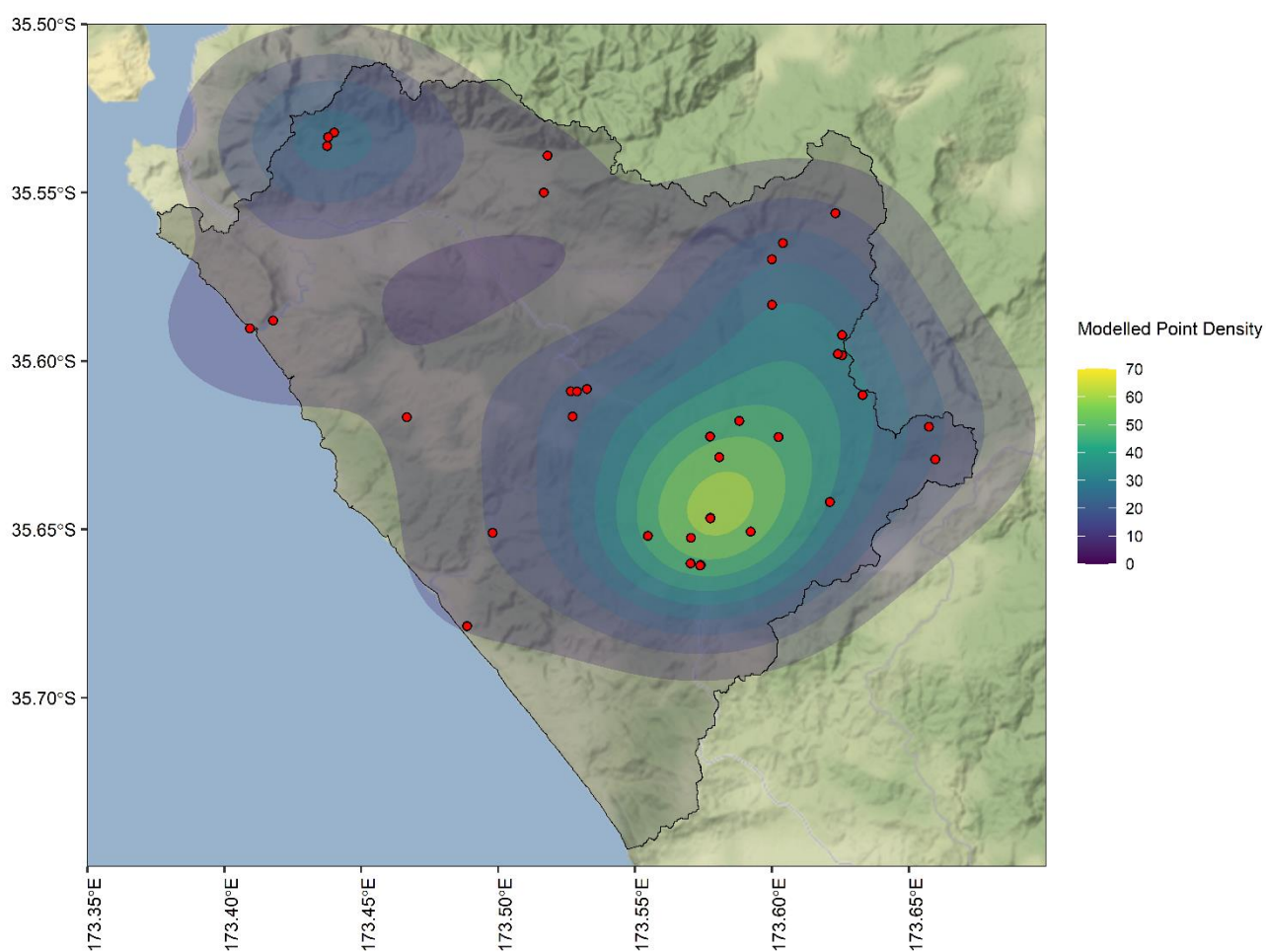
Appendix 2.7 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Hokianga FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 10 for visualisation.



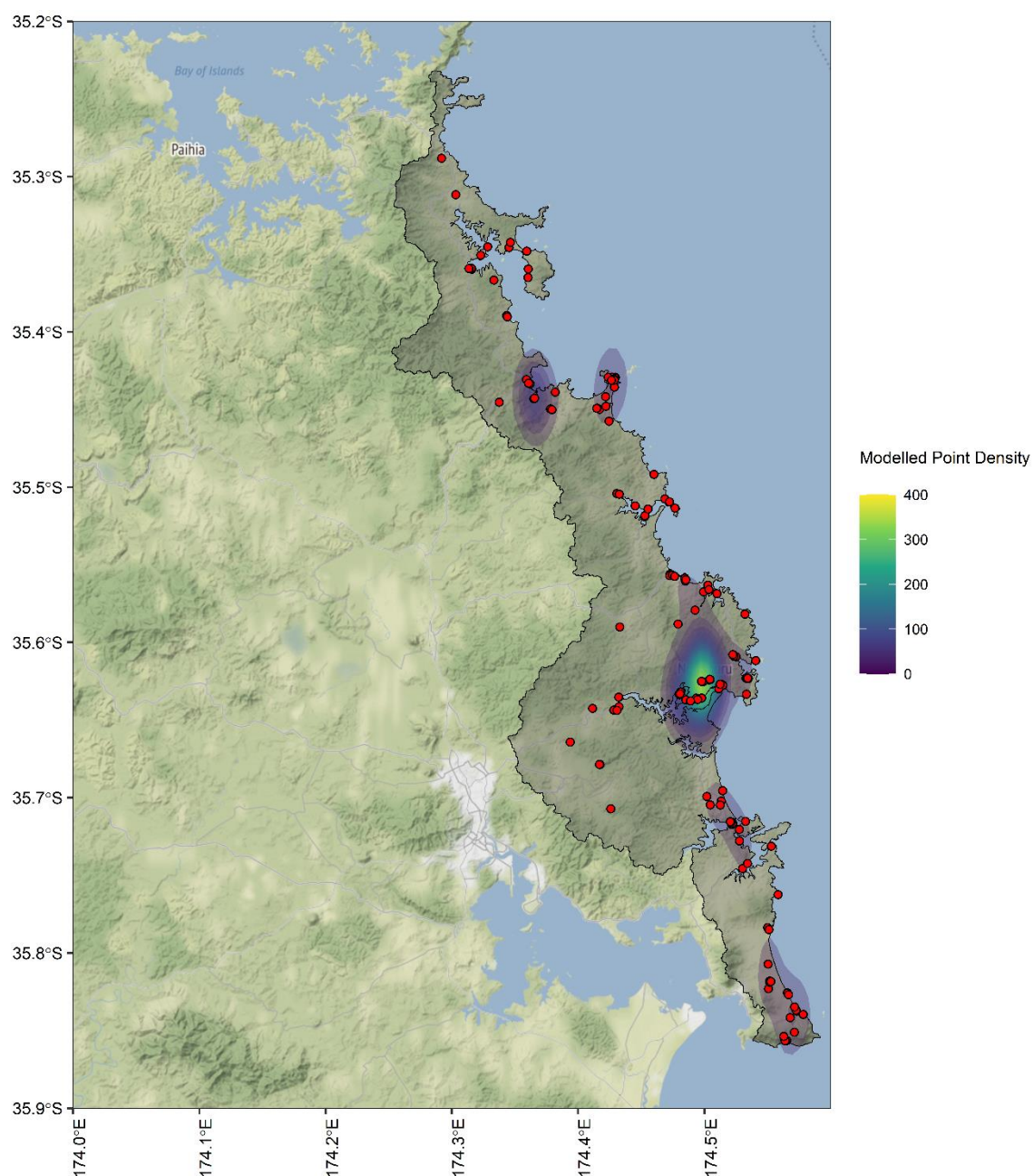
Appendix 2.8 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Poutō FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 10 for visualisation.



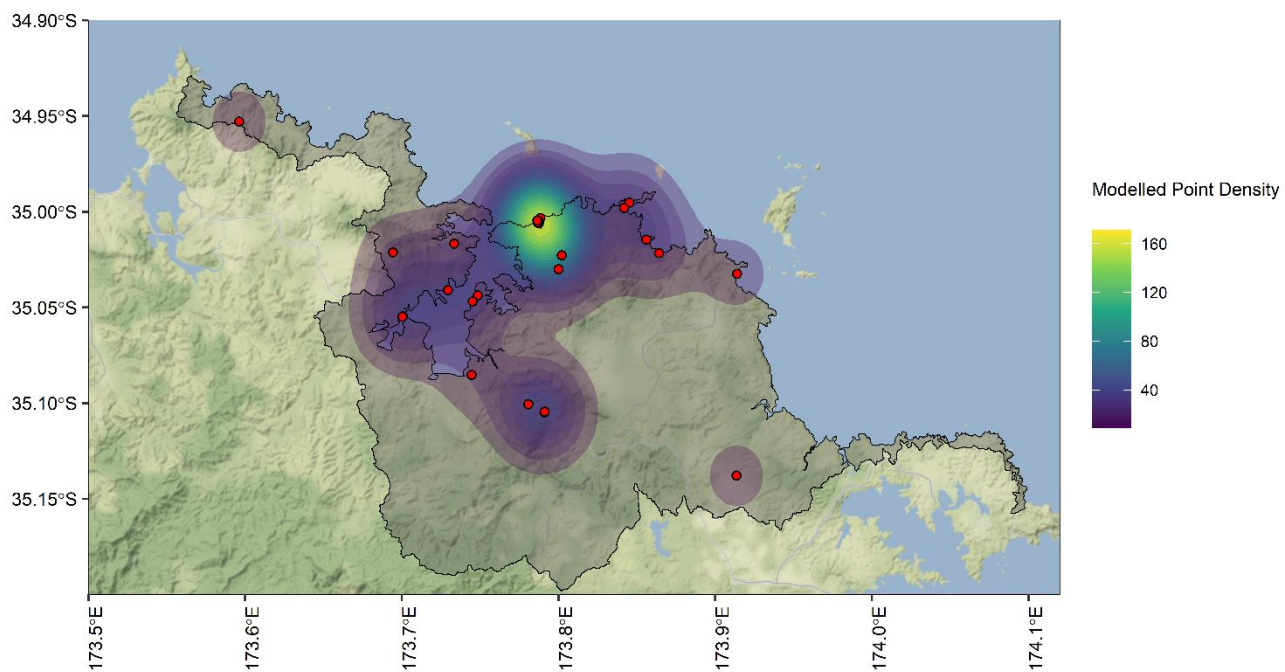
Appendix 2.9 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Northern Wairoa FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 20 for visualisation.



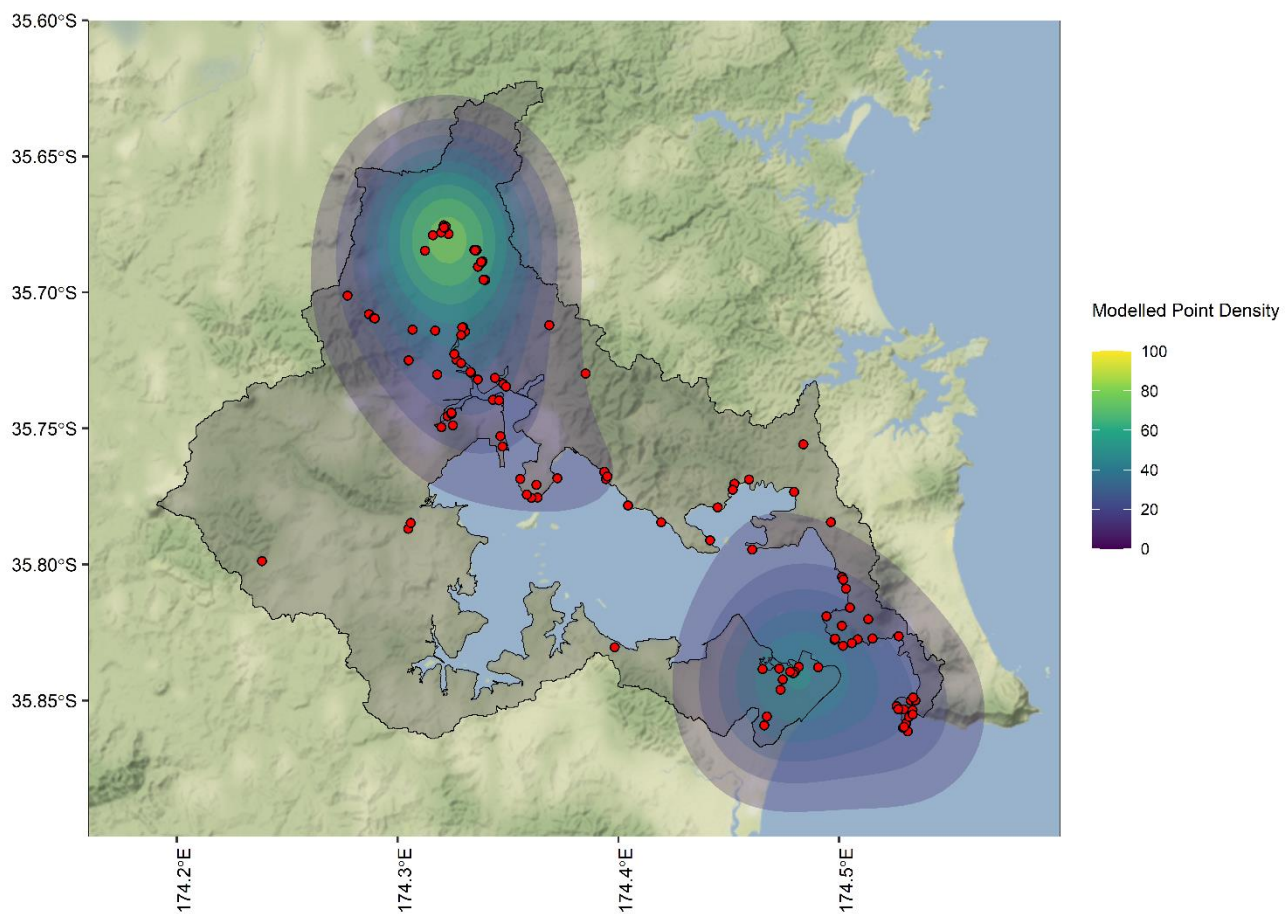
Appendix 2.10 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Waipoua FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 10 for visualisation.



Appendix 2.11 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Whananaki Coast FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 20 for visualisation.



Appendix 2.12 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Whangaroa FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 20 for visualisation.



Appendix 2.13 Plot showing modelled kernel density estimates of threatened freshwater species occurrences for the Whangārei FMU. Points indicate occurrence records for threatened freshwater species. Bins for density estimate set to 10 for visualisation.

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