Mapping the Knowledge of Insect Biodiversity across Northland

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Landcare Research
Manaaki Whenua

Mapping the knowledge of Insect Biodiversity across Northland

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Project and Client

This report forms the output for Envirolink project 'Mapping the state of insect biodiversity knowledge across Northland' (1571-NLRC182), conducted for the Northland Regional Council.

Objectives

The objectives of the project are to

- use mass digitisation of historical provenance records from specimens held in the New Zealand Arthropod Collection to spatially map current knowledge of invertebrate biodiversity across Northland, and
- explore future potential use of digitised records to inform biodiversity management and environmental reporting in Northland.

Methods

Digitised records for the Northland region were obtained and compiled from the New Zealand Arthropod Collection, scientific publications and the Fauna of New Zealand Series. A large number of insect groups were covered, including several iconic groups: native bees, ground beetles, cicadas, landhoppers, weta, and stick insects.

Digitised records were georeferenced and plotted across Northland using topological maps at a background sampling scale of 1:50 000. Relationships were examined between land area, sampling effort and diversity.

Results

Digitised records were obtained for 7523 specimens (covering 1034 species) from 275 locations across Northland.

In general, sampling for invertebrates has occurred widely across the Northland region. However, greater sampling effort has occurred at some locations such as the Poor Knights Islands, Waipoua Forest, Omahuta Forest, Mangamuka Gorge, Te Paki and Whangarei. These top six locations contributed 59.7% of all records from Northland. No records from the Kaipara Heads region were found.

The majority (51%) of sampling was undertaken in the 1970s and 1980s. Only 24% of records originate from 1910-1969, and 25% of records are more recent (since 1990).

The Poor Knights Is. is the region with the best baseline for monitoring environmental change as it has the greatest number of records (>3000) and highest proportion (99%) of records from the 1970s to 1980s. Other regions for this purpose could include Mangamuka and Rawene.

Conclusions

Collection records proved useful in demonstrating important biological relationships: i) the sampling effort-species diversity relationship, and ii) area-diversity relationships for Northland regions.

In general, offshore islands have received greater sampling effort than many mainland locations of comparable area.

The major challenge for linking collection records and environmental assessment is gaining a critical mass of records, especially across all regions. Therefore, more work is needed before these large datasets can be utilised as 'monitoring platforms' to assess environmental quality and change.

Recommendations

Survey invertebrate diversity from the Kaipara Heads region. Currently records from this area are lacking, representing a gap in our knowledge, particularly given the important dune and wetland habitats in this area.

Support initiatives to digitise biological data collections, and to integrate currently fragmented data sources from different collections. This will start to filling some of the spatial gaps in our baseline knowledge of insect biodiversity across Northland, facilitating enhanced environmental management and reporting.

1 Introduction

Primary biodiversity data provide information about a species at a specific time from a specific location. Such data have accumulated over centuries in natural history collections, but have only been converted to digital formats relatively recently (Sousa-Baena et al. 2014). Even more recently, primary biodiversity data have begun to be shared openly online (Graham et al., 2004). Large databases of specimen labels with geographical coordinates are being compiled by an ever-growing number of natural history museums, research and government institutions around the world (Soberon et al. 2000; Ward 2012; Sousa-Baena et al. 2014).

In recent years the increased use of this information is changing the way in which taxonomic knowledge is used for ecology, environmental restoration and environmental reporting for applied purposes (Soberon et al. 2000). Such data are being used to address major environmental themes, such as the spread of invasive species, geographical patterns of environmental representation and diversity, and climate change and other long-term temporal trends (Soberon et al 2000; Ward 2012; Sousa-Baena et al. 2014).

New Zealand is regarded as one of the world's biodiversity hotspots, with an exceptional proportion of endemic species (Myers et al. 2000). The long geographic isolation from Australia of about 80 million years, the changing climate and shorelines, and periods of intense glaciation and vulcanism, have all shaped the composition of the fauna and led to high levels of endemism (Cooper & Millener 1993, McGuiness 2001). In particular, New Zealand has a unique invertebrate biota with a high proportion of endemic species relative to many countries (McGuiness 2001). New Zealand has an estimated 52 000 invertebrate species (SoE 1997). This roughly equates to 34x as many species of invertebrates as vertebrates, and 15x as many species of invertebrates as plants (SoE 1997). Essentially, invertebrates dominate New Zealand's fauna, yet our knowledge of their biodiversity remains rudimentary.

New Zealand's endemic invertebrates face a variety of threats, including reduction of habitat, increased predation and competition from introduced species, and land use changes (McGuiness 2001). It is well known that changes in land use over time threaten endemic biodiversity. Thus, monitoring changes in biodiversity, particularly at over landscape and regional scales, is a vital step in effective biodiversity reporting (Walker et al. 2006; Overton et al. 2015).

The overall aim of this project is to spatially map the knowledge of invertebrate diversity for the Northland region. By examining records of invertebrate diversity from previous sampling events we can assess the current state of our knowledge. We can also better determine how such data could be incorporated into future biodiversity planning and environmental reporting. The focus is on the Northland region because it plays an important role in the biodiversity of New Zealand, both historically and at present. Phylogenetic studies suggest that regional endemism in Northland results from old diversifications associated with isolated islands and changes in sea levels (Buckley et al. 2015). Northland also has a very high proportion (19%) of New Zealand's threatened invertebrate species (McGuinness 2001).

2 Objectives

The objectives of the project are to

1. use mass digitisation of historical provenance records from specimens held in the New Zealand Arthropod Collection to spatially map current knowledge of invertebrate biodiversity across Northland,

2. explore potential use of digitised records to inform biodiversity management and environmental reporting in Northland.

3 Methods

The New Zealand Arthropod Collection (NZAC) is the largest holding of invertebrates in New Zealand (estimated c. 1 million specimens pinned; 5–6 million in ethanol). It was started in Nelson in 1920 as the Cawthron Institute collection, and is currently situated in Auckland at Landcare Research. Digitised records of NZAC specimen information are available via the 'Systematics Collections Data' (SCD) portal [https://scd.landcareresearch.co.nz/].

Digitised records for the Northland region were obtained and compiled from the NZAC, including: i) existing SCD records, ii) existing non-SCD records (occurring in scientific publications: Fauna of New Zealand Series, TFBIS projects, DOC reports on threatened species, and NZAC records yet to be verified and entered in SCD); and iii) newly digitised records specifically for this project.

It should be noted that this project does not include all of the specimen records from Northland. I estimate that this project encompasses approximately one-third of records from Northland held in the NZAC. Records from other institutions are also largely absent, although some information from other institutions was available within the existing non-SCD records.

Digitised records include four main components:

1. **Species.** A large proportion of the dataset is identified to species level. However, I also count "species" for undescribed species with a tag name, or a species identification number (these are not officially recognised species). Specimens identified only to genus are treated as one species, which will underestimate the true number of species.

2. In this report we covered a large number of insect groups (Table 1), including several iconic groups and/or groups with potential value as environmental bioindicators or for public education. These are: native bees, ground beetles, cicadas, landhoppers, weta, and stick insects. Freshwater insects make up a very small proportion (<1%) of the records, because the NZAC mostly holds collections of terrestrial invertebrates.

3. **Locations.** A location is spatially unique (i.e. separated from other locations), but a location can be visited at different times (e.g. months, years), contributing to sampling effort at that location. This is important as some locations have been visited more than others. Information of locations and sampling effort constitute the basic dataset on which analyses and discussion are based.

4. **Georeferenced points**. Georeferenced points (decimal degrees) of sampling locations were either recorded at the time of sampling (from New Zealand Map Grid coordinates, or more recently using global positioning systems) or obtained retrospectively by matching location descriptions to georeferenced maps and databases (MapToaster Topo^{TM}).

To assess the current knowledge of insect biodiversity across Northland, maps and a GIS layer of sampled locations across Northland were created in ArcGIS. The number of records and species on topological maps (scale 1:50,000; Topo50 map series) and the area of each Topo50 map was calculated to assess relationships between land area and sampling effort. The Three Kings Islands are not included as part of this dataset.

Table 1. Invertebrate groups and the number of records used in this study.

Group	Common Name	Order	#Records	%Records
Insect	Wasps/Bees	Hymenoptera	4662	0.620
Insect	Beetles	Coleoptera	1128	0.150
Insect	True Bugs	Hemiptera	593	0.079
Insect	Moths/Butterflies	Lepidoptera	410	0.054
Insect	Flies	Diptera	99	0.013
Insect	Thrips	Thysanoptera	74	0.010
Insect	Stoneflies	Plecoptera	57	0.008
Insect	Lice	Phthiraptera	20	0.003
Insect	Booklice	Psocoptera	15	0.002
Insect	Weta	Orthoptera	13	0.002
Insect	Caddisflies	Trichoptera	5	0.001
Insect	Stick Insects	Phasmatodea	3	0.000
Insect	Mayflies	Ephemeroptera	1	0.000
Invertebrate	Snails/Slugs	Gastropoda	230	0.031
Invertebrate	Spiders	Araneae	165	0.022
Invertebrate	Landhoppers	Amphipoda	29	0.004
Invertebrate	Earthworm	Oligochaeta	13	0.002
Invertebrate	Nematodes	Nematoda	3	0.000
Invertebrate	Pseudoscorpions	Pseudoscorpionida	3	0.000

4 Results

Digitised records were included for 7523 specimens from 275 locations across Northland (Appendix 1). These comprised i) 1142 existing SCD records, ii) 2335 existing non-SCD records, and iii) 4046 records newly digitised specifically for this project.

The total number of species counted was 1034. A large number of insect groups are covered (Table 1) but the dataset is dominated by the insect order Hymenoptera because this group has the greatest number of digitised records available. This group includes native bees and parasitoids, but also introduced wasps and ants.

In general, sampling for invertebrates has occurred widely across the Northland region (Figure 1). However, when number of records is considered on a per location basis (Figure

2), it is clear that greater sampling effort has occurred at some locations. Top locations (and % of total records) were: Poor Knights Islands (41.0%), Waipoua Forest (7.2%), Omahuta Forest (4.9%), Mangamuka Gorge (2.4%), Te Paki (2.1%), and Whangarei (2.1%). These top six locations contributed 59.7% of all records from Northland.

This project also investigated invertebrate diversity at smaller spatial scales using the Topo50 maps as a background scale. Invertebrates records were found for 35 Topo50 map areas in Northland (the Three Kings Islands are not included as part of this dataset). No records of insect diversity were recorded for three areas: Cape Rodney (AY32), Kaipara Harbour (AZ30), and Kaipara Heads (AZ29). Most of the first two areas (Cape Rodney, Kaipara Harbour) overlaps with the Auckland region and it is likely that records in the NZAC for these areas would be labelled as 'Auckland'. However, the lack of records from Kaipara Heads represents a real gap in knowledge.

In general it is expected that a smaller land area would have fewer records and hence a lower number of species. This was confirmed by the generally positive (linear) relationships (Figure 3) showing between Topo50 map area (ha) and sampling variables (i.e. number of locations, records, and species).

There was a strong relationship between area and the number of locations that had been sampled ($R^2 = 0.647$). There were good relationships between area and the number of records, number of species, and the number of years when sampling had occurred (Table 2). However, R^2 values declined when island groups are included. This was largely due to higher sampling rates in the three major island groups (Cavalli Is, Hen and Chickens Is, and Poor Knights Is, see Table 2).

Table 2. Relationships (R^2 values) between Topo50 area (ha) and the number of records, number of species, and the number of years when sampling had occurred. The effect of greater sampling on Island groups (Cavalli, Hen and Chickens, Poor Knights) is shown, as R^2 values improve when Islands groups are removed.

	R^2 values		
	#records	**#species**	**#years**
Island groups included	0.051	0.124	0.353
Island groups excluded	0.399	0.404	0.427

There was also a very strong relationship between the number of species and the number of records ($R^2 = 0.9041$, Figure 3). This is an important biological relationship to consider, where increased sampling effort results in more species diversity. It also indicates that sampling has not yet captured all of the species present in an area, that is, when the curve becomes an asymptote (levels off).

There is an important effect of time in the dataset (Figure 4). The majority (51%) of sampling was undertaken in the 1970s and 1980s. Only 24% of records originate from 1910-1969, and 25% of records are more recent (since 1990). Data from the Poor Knights Is, where almost all (99%) of the sampling occurred in 1980-1981, has a strong biasing effect. When the Poor

Knights Is records are removed the temporal data become more even; although, the 1970s and 1980s periods still dominate.

The potential for regions to contain sufficient baseline information for environmental monitoring was examined (Figure 5). Given the large number of records from the 1970s and 1980s, this period was specifically examined. The Poor Knights Is region provides the best baseline for monitoring environmental change as it has the greatest number of records (>3000) and highest proportion (99%) of records from the 1970s-1980s (it was excluded from Figure 5 for the purposes of clarity). Mangamuka and Rawene Topo50 Map regions also have a high number of records and a high proportion of records from the 1970s-1980s (Figure 5) and these regions may have sufficient records to act as baseline data.

5 Conclusions

The overall aim of this project was to spatially map the knowledge of invertebrate diversity for the Northland region.

The concept of using collection and museum records for biodiversity and environmental reporting is a relatively recent development. It has come about by the increased number of electronically digitised records becoming available through museum digitisation projects.

The rationale of examining records is that they provide information on sampling effort, and this generally equates with knowledge. Collection records can provide specific information on location and date, and also allow information to be generated on coverage of taxonomic groups, regional diversity, and sites of possible use as baselines sites for long-term environmental monitoring of change (e.g. climate change, land use changes).

Invertebrates play important roles in the natural environment, agro-forestry sectors, biosecurity, and as icons of New Zealand biodiversity. However, invertebrate collections generally lag behind in these digitised projects because they typically have many more specimens (>1 million in the NZAC) with poorer taxonomic resolution. Thus, the major challenge for linking collection records and environmental assessment is gaining a critical mass of records (Sousa-Baena et al. 2014).

Consequently, I consider this project a preliminary step in relating terrestrial invertebrate diversity in Northland to environmental monitoring and reporting. Over half the records used here were digitised specifically for this report. I also estimate that the total number of records used in the report is only one-third of records held in the NZAC. Furthermore, records from other institutions are largely absent (although some information from other institutions was available within the ‘existing non-SCD’ records). For example, important records for Northland will be held in the Auckland War Memorial Museum and Northtec. This represents a fragmentation of data sources that limits data collection and subsequently environmental interpretation.

Therefore, more work is needed before these large datasets can be utilised as ‘monitoring platforms’ to assess environmental quality and change, as is currently done in freshwater environments (e.g. Booth et al. 2013; Hughey et al. 2013 for Northland).

Nevertheless, some important findings emerge from the current project. In general there was good coverage of sampling across Northland. Also, important biological relationships were

recovered in the dataset, indicating that collection records can demonstrate ecological relationships. These relationships include: i) the sampling effort-species diversity relationship, and ii) area – diversity relationships.

Sampling in island groups (Cavalli Is, Hen and Chickens Is, and Poor Knights Is) had major effects on area-diversity relationships, and when removed from the dataset, the relationship between area and diversity was strengthened. This indicated that offshore islands have received greater sampling effort than many mainland locations of comparable area. This is not surprising as there is a general focus on islands as sanctuaries for threatened species in New Zealand.

Furthermore, several locations and regions appear to have sufficient records to be used as baselines for long-term environmental monitoring of change (e.g. climate change, land use changes etc.). These include the Poor Knights Is, Mangamuka and Rawene regions.

6 Recommendations

Survey invertebrate diversity from the Kaipara Heads region. Currently there appears to be a lack of records from this area, representing a gap in our knowledge, particularly given the important dune and wetland habitats in the region.

Support initiatives to continue to digitise biological collections and also to integrate currently fragmented data sources from different collections (e.g. NZ Biodata Services Stack, etc.) to enhance environmental management and reporting.

7 Acknowledgements

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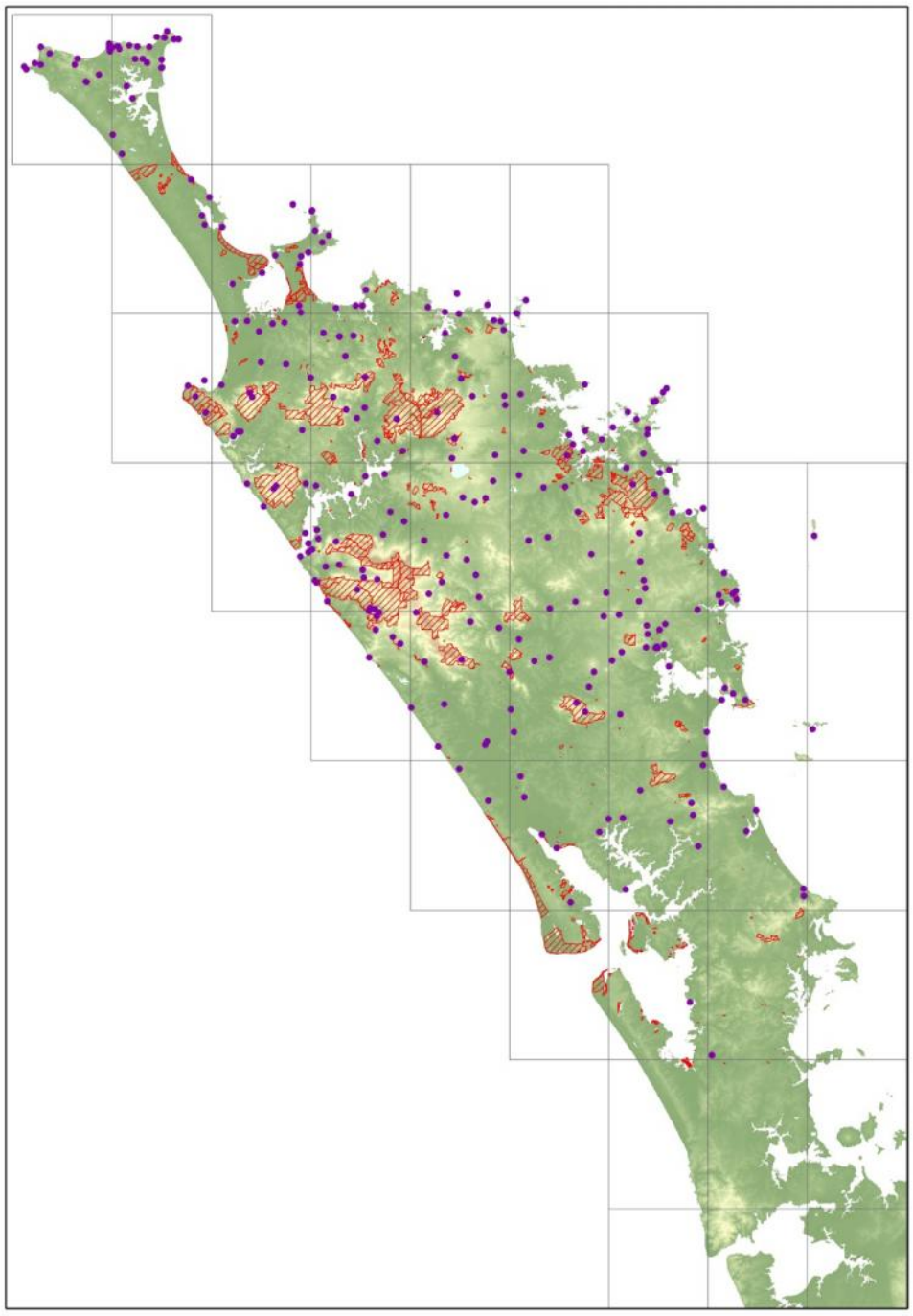

Figure 1. Locations in Northland were invertebrates held in the New Zealand Arthropod Collection have been recorded. Striped areas represent conservation land. Rectangular grid represents TopoMap grids.

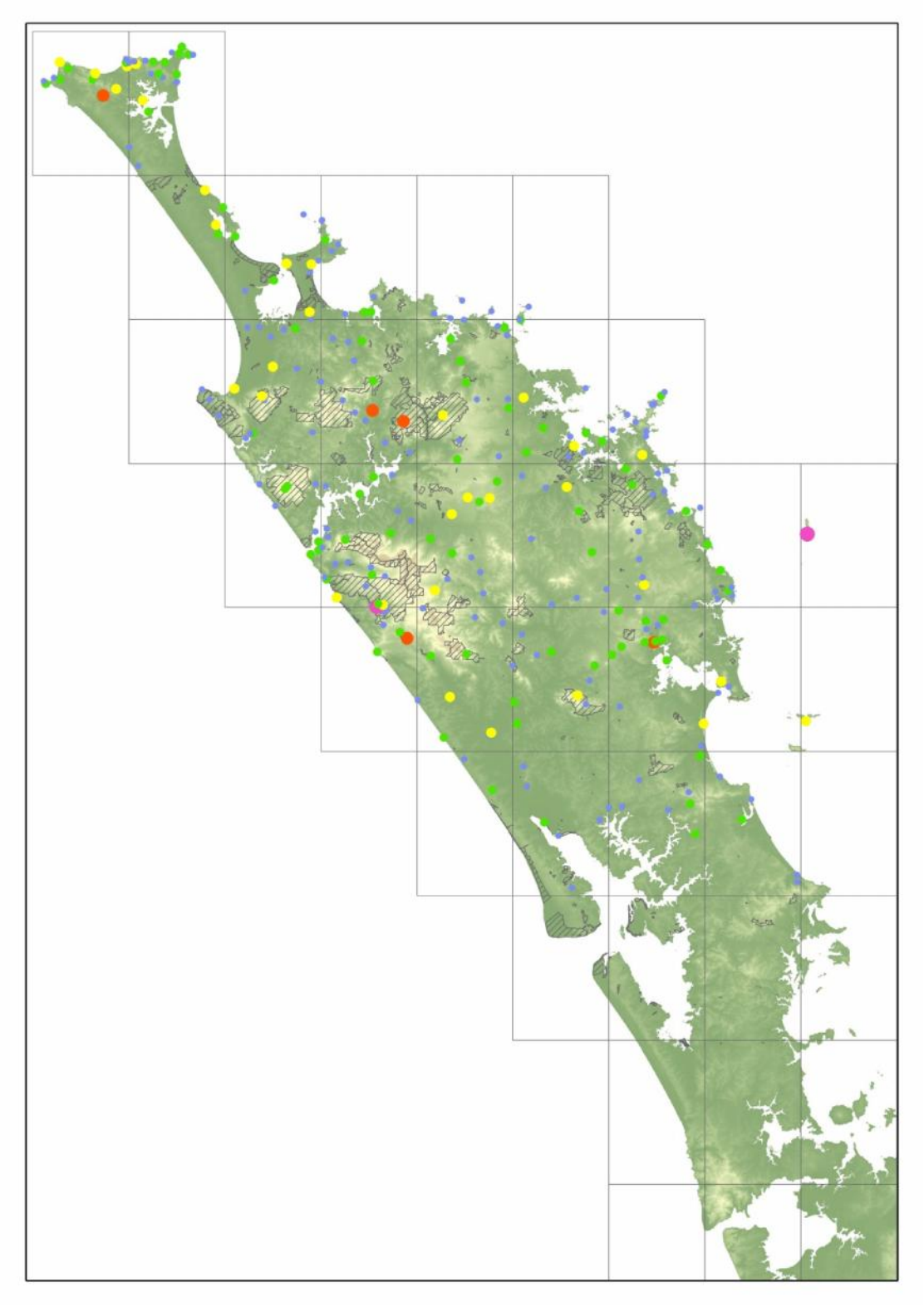

Figure 2. Locations in Northland with sampling effort (number of records) for invertebrates held in the New Zealand Arthropod Collection. Size of bubble is a geometric scale indicative of the number of records: size 1 = 1-4 records (blue), size 2 = 5-24 records (green), size 3 = 25-124 records (yellow), size 4 = 125-624 records (red), size 5 = 625->3000 records (pink). Striped areas represent conservation land. Rectangular grid represents TopoMap grids.

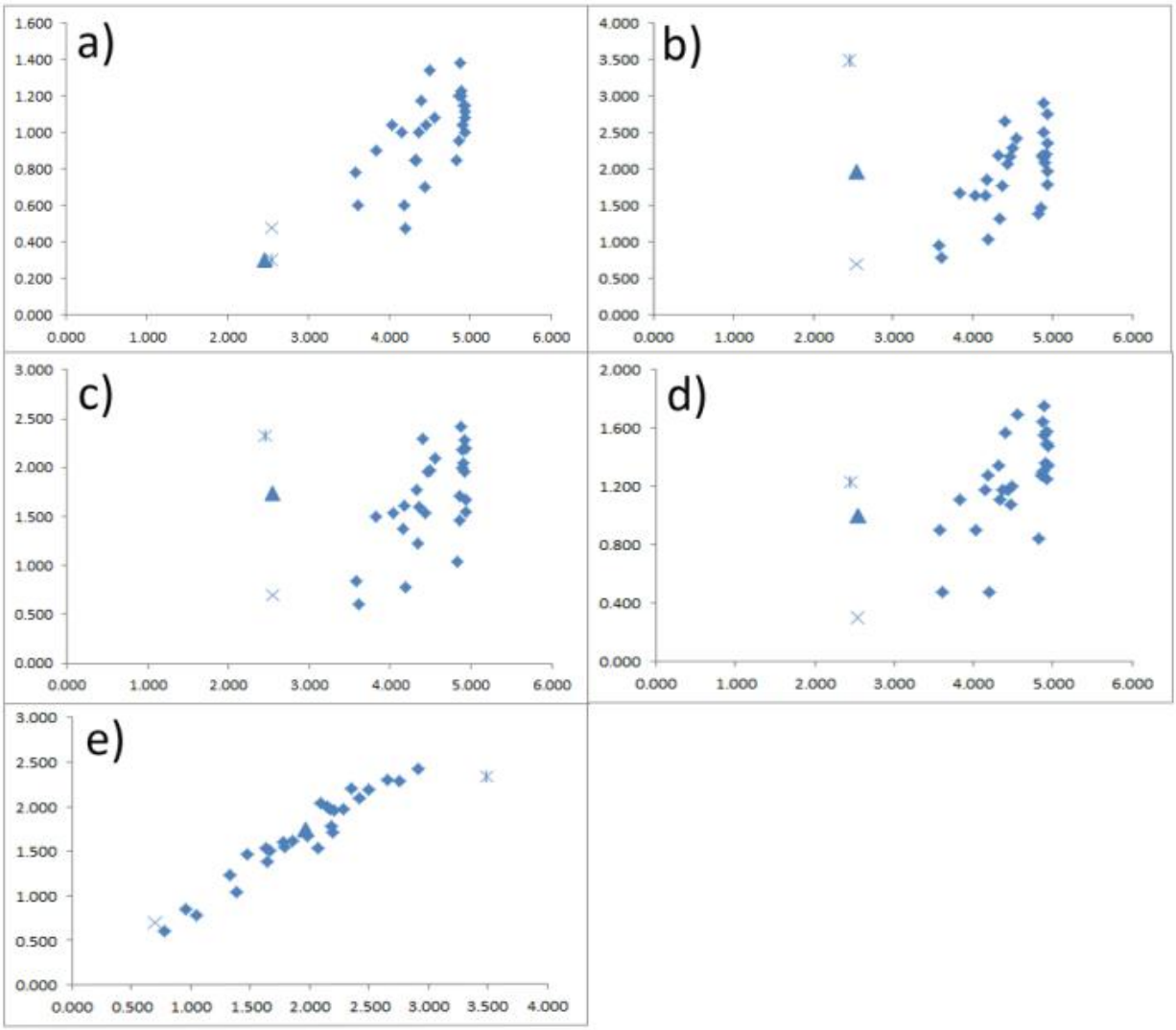

Figure 3. Relationships between Topo50 map area (ha) and sampling effort. a) area and the number of locations, b) area and the number of records, c) area and the number of species, d) area and the number of years when sampling had occurred. X-axis is area ($log_{10}x+1$) and Y-axes are sampling variables ($log_{10}x+1$), e) the number of records (X-axis) and number of species (Y-axis) both transformed ($log_{10}x+1$) to get a linear relationship. Island groups are shown: Cavalli Is. (cross), Hen and Chickens Is. (triangle), and Poor Knights Is. (star).

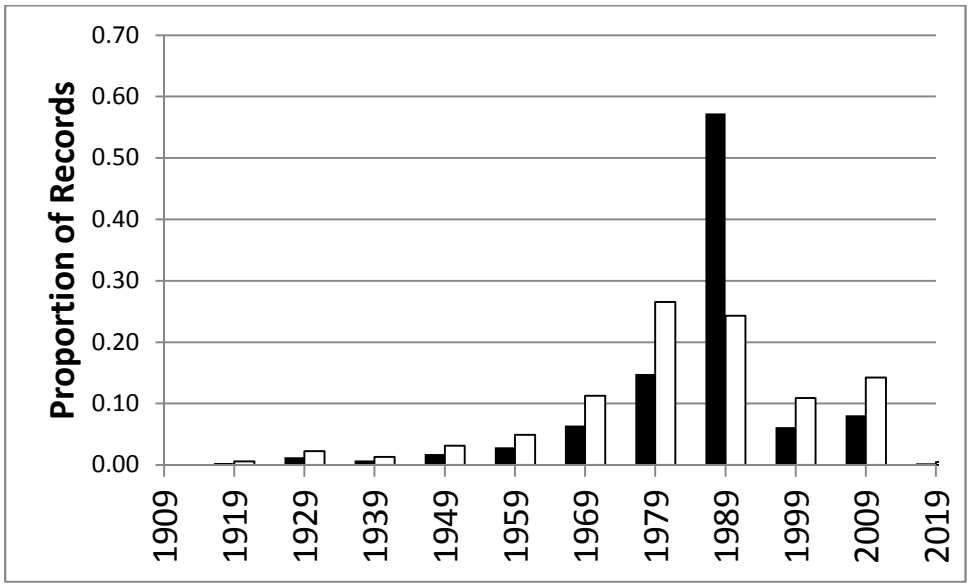

Figure 4. Temporal patterns of sampling for invertebrates in Northland. Full dataset (black), and with Poor Knights Is., records removed (white).

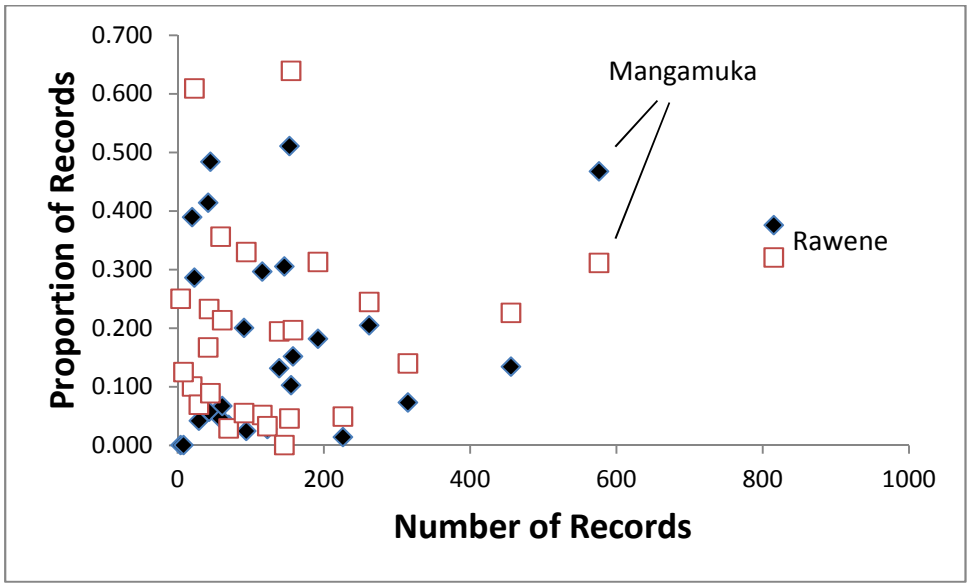

Figure 5. Relationship between number a proportion of records from the 1970s (white square) and the 1980s (black diamond) for each Topo50 Map region. Mangamuka and Rawene are indicated with a high number of records and proportion of records. Note: Poor Knights Is data is excluded for clarity, but it has the greatest number of records (>3000) and highest proportion (99%) from the 1970s-1980s.

Appendix 1

List of locations (n=275) in Northland with specimens from the New Zealand Arthropod Collection. Georeferenced co-ordinates are retrospectively determined.

Ahipara -35.163, 173.158; Ahipara Plateau -35.180, 173.233; Herekino Forest -35.189, 173.240; Apotu -35.627, 174.274; Aratoro Stream Bush -35.278, 173.778; Aupouri -34.661, 172.895; Awanui -35.047, 173.257; Awapokanui Stream -35.498, 173.417; Awarua -35.575, 173.837; Baylys Beach -35.948, 173.740; Bland Bay -35.341, 174.349; Brattys Bush Scenic Reserve -35.612, 174.486; Brynderwyn -36.091, 174.426; Burgess Island -36.166, 174.06; Cape Brett -35.172, 174.331; Cape Karikari -34.788, 173.398; Cape Maria van Diemen -34.475, 172.643; Cape Reinga -34.427, 172.681; Cape Wiwiki -35.157, 174.122; Cavalli Islands -35.005, 173.942; Coopers Beach -34.991, 173.523; Dargaville -35.936, 173.871; Deep Water Cove -35.192, 174.305; Donnelly's Crossing -35.711, 173.617; Doubtless Bay -34.900, 173.365; East Herekino -35.26, 173.203; Glenbervie -35.677, 174.345; Haupatoto -34.462, 172.961; Helena Bay -35.434, 174.360; Hen & Chicken Islands -35.889, 174.733; Henderson Bay -34.755, 173.125; Herekino -35.265, 173.209; Herekino Head -35.275, 173.189; Hikurangi -35.599, 174.290; Hokianga Harbour -35.537, 173.369; Horahora Bush -35.728, 174.294; Horeke -35.356, 173.593; Houhora -34.795, 173.106; Houto -35.760, 173.996; Houto Mountain -35.784, 173.930; Kaeo -35.099, 173.77851; Kaihu Bush -35.764, 173.703; Kaikai beach -35.588, 173.409; Kaikohe -35.406, 173.801; Kaimaumau -34.919, 173.265; Kaingaroa -35.027, 173.325; Kaitaia -35.113, 173.263; Kaitui State Forest -35.695, 173.571; Kaiwaka -36.159, 174.442; Kaiwhetu -34.955, 173.540; Kamo -35.681, 174.296; Kapiro -35.184206, 173.90963; Kapowairua -34.428884, 172.86254; Kara -35.727022, 174.324085; Karikari Peninsula -34.853057, 173.424439; Kawaka Stream -35.541227, 173.813368; Kawakawa -35.381228, 174.073455; Kawerua -35.634407, 173.442005; Kerikeri -35.180585, 173.952586; Kerr Point -34.406505, 172.986508; Kiripaka -35.644843, 174.430638; Kohukohu -35.36143, 173.541448; Kohuronaki -34.48828, 172.83467; Kopai Stream -35.657983, 173.580452; Koutu Beach -35.479335, 173.413045; Lake Ngatu -35.025608, 173.193481; Lake Ohia -34.990273, 173.364169; Lake Waiparera -34.943468, 173.187594; Mahuta -35.996724, 173.798715; Maitahi Scientific Reserve -35.856622, 173.75633; Maitai Bay -34.82805, 173.406485; Mangakahia -35.753192, 174.036841; Mangamuka Gorge -35.212301, 173.539137; Manganui -35.915699, 173.944087; Manganuiowae Stream -35.261348, 173.373018; Manganuka -35.189333, 173.456276; Mangaroa Rock -35.943416, 173.867251; Mangataipa Scenic Reserve -35.234931, 173.519065; Mangawhai -36.124815, 174.570861; Mangawhai Heads -36.079456, 174.595833; Mangonui -34.99024, 173.531979; Mareretu -36.039208, 174.284116; Marsden Point -35.839998, 174.499569; Matakohe Maungaturoto -36.130738, 174.176254; Matapouri -35.564469, 174.501038; Matarau -35.65789, 174.22197; Mataraua -35.532924, 173.759236; Matauri Bay -35.040411, 173.906389; Maukins Nook -34.472609, 173.000871; Maungakaramea -35.816321, 174.144147; Maunganui Bluff -35.756156, 173.554617; Maungapiko Hill -34.421172, 172.861791; Maungataniwha Range -35.145486, 173.538971; Maungatapere -35.758387, 174.204926; Maungaturato -35.370243, 173.882211; Maungaturoto -36.106544, 174.36631; Maunu -35.739062, 174.230345; Mimiwhangata -35.444211, 174.394907; Mirowharara Stream -35.666538, 173.573332; Mitimiti -35.42816, 173.271719; Moehau -35.43856, 173.609391; Moengawahine -35.646177, 174.03634; Moerawa -35.38343, 174.01695; Montgomery's Bush -36.011928, 173.96271; Motuekaiti Island -34.986401, 173.862844; Motukawanui Island -35.004532, 173.940842; Motukokako -35.164572, 174.339444; Motuopao Island -34.47018, 172.638214; Moturoa Island -

34.770475, 173.347191; Motuti River -35.383316, 173.410408; Mount Camel -34.820328, 173.159485; Mount Horokaka -35.870011, 174.134395; Mount Mangamuka -35.216658, 173.490051; Mount Orowhana -35.590702, 173.747528; Ngaiotonga -35.306858, 174.280356; Ngaroku Stream -34.411371, 173.0321; Ngaruariki Stream -34.424693, 172.915003; Ngawha Springs -35.408075, 173.862359; Ngungaru -35.628105, 174.494939; Ninety Mile Beach -34.618905, 172.870518; North Cape -34.407768, 173.00729; Nukutaunga Island -34.975488, 173.964939; Oakura Bay -35.388276, 174.342417; Ohaewai -35.320684, 173.771989; Okara -35.729469, 174.327056; Omahuta State Forest -35.236059, 173.623919; Omamari Beach -35.865081, 173.667911; Omapare -35.528007, 173.391234; Onerahi -35.768995, 174.355976; Opononi -35.50817, 173.391358; Opua -35.303448, 174.119722; Opua State Forest -35.313201, 174.078276; Orokawa Bay -35.250394, 174.1989; Oruru -35.055717, 173.508388; Otakairangi -35.610797, 174.186921; Otaua Valley -35.500012, 173.700048; Pacific Bay -35.62102, 174.534998; Pahi Bay -35.264599, 174.290464; Paiaka -35.526804, 174.145978; Paihia -35.288273, 174.093121; Pairatahi Road -35.030185, 173.29391; Pakaraka -35.356738, 173.950853; Pakiri -36.263677, 174.72825; Pakiri Beach -36.247289, 174.726998; Pakohu Hill -34.426201, 172.884746; Pakotai -35.68937, 173.901074; Pandora -34.45311, 172.778454; Panguru -35.378355, 173.383464; Paparoa -36.099994, 174.239115; Parahaki -35.722572, 174.343359; Parakao -35.713841, 173.954745; Paranui Hill -35.058118, 173.471995; Paranui Scenic Reserve -35.057757, 173.471993; Parataiko Range -35.585515, 173.575624; Parengarenga -34.539139, 172.922407; Paroa Bay -35.2793, 174.1691; Parua -35.02243, 173.899285; Pekerau -35.005815, 173.368676; Peria -35.10044, 173.486831; Pilbrow Hill -36.065417, 174.422115; Poor Knights Islands -35.479857, 174.739412; Poroiki -34.454283, 172.930215; Puhi puhi -35.479723, 174.273612; Pukenui -34.815689, 173.114372; Puketi Forest -35.221124, 173.730938; Puketona -35.30363, 173.96244; Purua -35.630966, 174.104504; Radar Bush -34.504058, 172.801904; Rakautao Bush -35.416484, 173.83326; Ranfurly Bay Scenic Reserve -35.002924, 173.751129; Rangi Point -35.486017, 173.382762; Rangiahua -35.305673, 173.640512; Rangiora Bay -34.473331, 172.999238; Rangiputa Reserve -34.881291, 173.300492; Rangitihi -35.118552, 173.330224; Rarawa Beach -34.71669, 173.0769; Rawene -35.400453, 173.504266; Rawhiti Bay -35.232268, 174.261271; Red Hill -36.065514, 173.876029; Reef Point -35.1656, 173.069838; Rimariki Island -35.423729, 174.442358; Riwaka -36.10247, 174.20011; Rocky Bay -35.603206, 174.532119; Ruakaka -35.906998, 174.446756; Ruatangata -35.6618, 174.180494; Ruawai -36.137289, 174.022422; Russel Forest, Punaruku Stream -35.395196, 174.311591; Russell -35.25831, 174.125696; Russell Forest -35.373942, 174.254225; Spirits Bay -34.437453, 172.864267; Stephenson Island -34.962468, 173.781867; Surville Cliffs -34.400372, 173.016864; Taheke -35.45973, 173.64597; Taipa -34.995217, 173.461662; Takapau -35.498617, 173.978322; Takitu Stream -35.676301, 173.825013; Tangihua Forest -35.850273, 174.109641; Tangowahine -35.867173, 173.935315; Tapotupotu -34.44183, 172.7046; Taumataroa -34.453842, 172.950683; Taupo Bay -34.992693, 173.705343; Tauranga Bay -35.006076, 173.787213; Tauraroa -35.874185, 174.227945; Taurikura -35.82674, 174.528655; Tauroa Peninsula -35.189393, 173.08974; Te Hapua -34.513788, 172.907831; Te Huka -34.427411, 172.936169; Te Kopuru -36.284259, 174.101055; Te Paki -34.503197, 172.799782; Te Paki, Kauri bush -34.466353, 172.771342; Te Werahi Track -34.461499, 172.677992; Tikipunga -35.689987, 174.330546; Titirangi Point -34.411277, 173.044178; Toatoa Track, Waipoua Forest -35.050254, 173.428527; Tokatoka -36.057546, 173.97398; Tokerau -34.882817, 173.368673; Tom Bowling Bay -34.427875, 172.967567; Trounson Kauri Park -35.72514, 173.63794; Tutamoe -35.759859, 173.80154; Tutukaka -35.609488, 174.523738; Twin Bridges -35.622506, 173.846546; Umawera -35.28452, 173.57311; Unuwhao -34.431796,

172.888112; Upper Pungaere Road -35.185983, 173.825299; Uretiti -35.959991, 174.455484; Urupukapuka Island -35.216276, 174.238281; Victoria Valley, Fryer Road -35.147303, 173.395112; Waiare -35.147231, 173.795157; Waiarohia Stream -32.5215, 173.4011; Waikare -35.338374, 174.23662; Waikohatu Stream -35.648182, 173.555748; Waima -35.488519, 173.589704; Waima Forest -35.504302, 173.464998; Waimamaku -35.554401, 173.473507; Waimamaku Beach -35.592853, 173.413296; Waimate North -35.313405, 173.886764; Waimatenui -35.61692, 173.713598; Waiokumurau Stream -35.657374, 173.679544; Waiomio Cave Stream -35.435372, 174.108215; Waiotemarama -35.558323, 173.437945; Waipapa -35.204022, 173.912488; Waipapakauri -35.024649, 173.226694; Waipoua River -35.650643, 173.569242; Waipoua State Forest -35.65464, 173.553196; Waipu -35.982754, 174.451798; Waipu Beach -35.979287, 174.46998; Waipu Caves -35.938545, 174.350608; Wairau River -35.608929, 173.522464; Wairau summit -35.58273, 173.53945; Waitaha Stream -35.224446, 173.116811; Waitangi -35.267177, 174.082778; Waitangi State Forest -35.248352, 174.007401; Waitanoni Stream -34.428531, 172.87005; Waitui Stream -35.191234, 174.313027; Warawara Forest -35.38399, 173.304327; Waro -35.582909, 174.286391; Warra Warra -35.389326, 173.298181; Wekaweka -35.566133, 173.535648; Werahi Stream -34.465791, 172.681297; Whakapara -35.541721, 174.276577; Whakapouaka -34.782991, 173.39763; Whakaruangangana -35.444753, 173.757746; Whananaki -35.506588, 174.464456; Whangamumu -35.252597, 174.291483; Whangape Harbour -35.37893, 173.22713; Whangarei -35.729132, 174.320803; Whangarei Heads -35.815473, 174.507077; Whangaroa -35.049137, 173.751113; Whangaruru -35.347, 174.325; Whangatupere Bay -34.837, 173.442; Whareana -34.455, 172.999; Whatitiri -35.782, 174.157; Whatuwhiwhi -34.874, 173.388; Whau Bay -35.019, 173.880; Whau Valley -35.698, 174.298.