2020

Identifying the Location of Freshwater Habitats of Threatened Species in New Zealand

A SUMMARY OF CURRENT TOOLS AND RESOURCES

REPORT PREPARED FOR MINISTRY FOR THE ENVIRONMENT

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1 INTRODUCTION

The National Policy Statement for Freshwater Management (NPS-FM) 2020 was gazetted on 5 August 2020 and introduces a compulsory value for threatened species (Policy 9)[1]. There is also a new requirement for regional council's to identify the location of habitats of threatened species in each FMU (Subpart 2, section 3.8) and map wetlands of any size known to contain threatened species (Subpart 3, section 3.23)[2]. Some councils have mapped some of these areas, often based on information available on the New Zealand Freshwater Fish Database (NZFFD) supplemented with their own monitoring programmes. The Department of Conservation (DOC) and potentially other organisations such as Botanical Societies and universities, also holds information about threatened species. Yet, there is no compiled list of all relevant resources.

It is anticipated that regional councils will require better information about threatened species so that they can take a more integrated approach to freshwater management and be more efficient in their interactions with landowners, particularly farmers, who may have threatened species on their land.

Adaptive Environmental Consulting was engaged by the Ministry for the Environment (MfE) to compile a register of existing and potentially available tools, databases and resources relating to the distribution of threatened freshwater species and their habitats in New Zealand. This was primarily undertaken through an online search of available resources in conjunction with a series of interviews with experts, professionals and practitioners in the field of freshwater ecology and biodiversity. Interviewees represented regional councils, research institutes, universities and private sector organisations across New Zealand. This report and the accompanying threatened freshwater species resource spreadsheet summarises and collates the information gathered during this project.

1.1 PROJECT AIM

The purpose of this project is to document and evaluate sources of information on threatened freshwater species habitat, and geospatial information on the occurrence of threatened species. The main output from this project is a database of resources relating to threatened freshwater species habitat. This database and report has been presented to help regional councils and territorial authorities identify what tools are currently available and how they may be applied to help identify and protect threatened freshwater species habitats in their regions.

2 METHODS

This project was undertaken using two complimentary research approaches, 1) an online review of available resources and, 2) a series of interviews with subject matter experts and practitioners, as detailed in the following sections.

[1]Threatened species are defined in the NPS-FM (2020) as any indigenous species of flora or fauna that: (a) relies on water bodies for at least part of its life cycle; and (b) meets the criteria for nationally critical, nationally endangered, or nationally vulnerable species in the New Zealand Threat Classification System Manual.

[2] Click here to access the NPS-FM (2020).

2.1 Review of Current Tools and Resources

A desktop study was undertaken to review and collate information relevant to identifying the distribution of threatened freshwater species (flora and fauna) and/or their habitats. Specific resources sought under this review included, geospatial information, databases, research articles, technical reports, books and other online resources. The following keywords and phrases were used to search for relevant resources using general Google search engine:

- New Zealand (Aquatic) Sites of Significance
- New Zealand Wetland (Habitat & Extent)
- New Zealand (Threatened) Freshwater Fish (Distribution, Habitat &/or Management)
- New Zealand (Threatened) Freshwater Invertebrates (Distribution, Habitat &/or Management)
- New Zealand (Threatened) Wetland and Migratory Birds (Distribution, Habitat &/or Management)
- New Zealand (Threatened) Wetland Plants (Distribution, Habitat &/or Management)
- New Zealand (Threatened) Freshwater Aquatic Plants (Distribution, Habitat &/or Management)
- New Zealand (Threatened) Threatened algae (Distribution, Habitat &/or Management)
- New Zealand (Threatened) Amphibians (Distribution, Habitat &/or Management)

2.2 Interviews

Interviews were undertaken with subject matter experts, practitioners and end users of freshwater databases and biodiversity tools. The interviews were conducted in two rounds. The initial round of interviews was undertaken with key regional council contacts identified by MfE as representatives of the different regions in New Zealand. In addition, individuals who had varying areas of expertise covering different freshwater taxa and habitats found in New Zealand were identified by MfE or Adaptive Environmental Consulting and then contacted for an interview. The second round of interviews was undertaken with subject matter experts recommended by people interviewed during the first round.

All interviewees were initially contacted by email with a brief overview of the project and the interview topic. A subsequent time was then set to run the interview either over the phone or by video conferencing. Interviewees were asked a series of questions applied through a guided conversation technique. Interview questions covered key themes, as follows:

1. What are the main tools or sources of information you use, and/or are aware of, to either document the distribution of threatened freshwater species or map their habitats?
2. Are you aware of any limitations associated with the tools you use?
3. What do you consider to be the important factors to cover to identify potential threatened freshwater species habitat?
4. Are you aware of any gaps in either the tools and resources currently available or their application?
5. Can you recommend any other contacts/subject matter experts you feel would be able to contribute to this project?

Table 1 lists the names and affiliations of those interviewed for this project.

Table 1. Names and affiliations of those interviewed

Full Name	Current Place of Work	Position	Expertise
Alice Baranyovits	Auckland Council	Bio Information Analyst	Bio Information Analyst
Matthew Bloxham	Auckland Council	Senior Regional Advisor (Freshwater)	Fish & Freshwater Ecology
Dave West	Department of Conservation	Science Advisor Freshwater - Kaipūtaiao Tāonga Wai Maori	Fish & Freshwater Ecology
Nicholas Dunn	Department of Conservation	Freshwater Science Advisor / South Island Freshwater Team	Fish, Wetlands & Freshwater Ecology
Duncan Gray	Environment Canterbury	Senior Scientist - Water Quality and Ecology	Fish, Braided Rivers & Freshwater Ecology
Andy Hicks	Hawkes Bay Regional Council	Team Leader Fresh Water & Ecology	Fish & Freshwater Ecology
Iain Maxwell	Hawkes Bay Regional Council	Group Manager – Integrated Catchment Management	Catchment Management
Keiko Hashiba	Hawkes Bay Regional Council	Terrestrial Ecologist	Wetland Birds & Ecology
Bev Clarkson	Landcare Research	Wetland Ecologist, Capability Leader	Wetlands & Wetland Plants
Shona Myers	Myers Ecology	Ecologist	Wetlands & Wetland Plants
Paul Champion	NIWA	Principal Scientist - Freshwater Ecology	Aquatic & Wetland Plants
Brian Smith	NIWA	Freshwater Biologist	Freshwater Invertebrates
Cindy Baker	NIWA	Group Manager - Freshwater Ecology /Principal Scientist - Freshwater Fish	Fish & Freshwater Ecology
Carol Nicholson	Northland Regional Council	Resource Scientist - Freshwater Ecology	Freshwater Ecology
Katrina Hansen	Northland Regional Council	Biodiversity Advisor	Wetlands and Birds
Kim Jones	The Whitebait Connection	Poutokomanawa/Co-Director - Freshwater Lead /	Native Fish Spawning Habitat
Bruno David	Waikato Regional Council	Scientist | Water, Science and Strategy	Fish, Wetlands & Freshwater Ecology
Natasha Grainger	Waikato Regional Council	Freshwater Advisor - Lakes & Wetlands	Fish, Invertebrates & Freshwater Ecology

3 PROJECT LIMITATIONS

This project was not intended to be an exhaustive analysis of all tools and resources relevant to identifying and monitoring threatened freshwater species and their habitats. This report and the accompanying database, summarises and evaluates a range of (but not all) resources currently used

to monitor freshwater taxa and environments in New Zealand. Application of additional, supporting tools and resources, which may be available but not identified here, should also be employed.

4 Summary Statistics on Threatened Freshwater Species

4.1 Conservation Status Reports on NZ Freshwater Species

Under the NPS-FM (2020) threatened species are defined as any indigenous species of flora or fauna that: (a) relies on water bodies for at least part of its life cycle; and (b) meets the criteria for nationally critical, nationally endangered, or nationally vulnerable species in the New Zealand Threat Classification System Manual (Townsend, et al., 2008). The threat classification reports for freshwater fish, invertebrates, birds, vascular plants, macroalgae and amphibians are included in the accompanying threatened freshwater species habitat resources database. While specific information on the threat classification of wetland birds, freshwater macroalgae and aquatic vascular plants, are not presented separately in the respective threat classification series, this data is accessible online through the NZ threat classification system database (Department of Conservation, 2020). Summarised information on the conservation status of freshwater fish, amphibians, invertebrates, birds, vascular plants and macroalgae are presented in Table 2 in accordance with the above definitions and classifications available for each taxonomic group at the time of writing.

Table 2. Summary of threat status of six freshwater taxonomic groups, including at risk-declining and naturally uncommon species, and data deficient species.

Year updated	2016	2017	2018	2018	2019	2017
Category	Freshwater Birds[4] (%)	Freshwater Fish[1] (%)	Freshwater Invertebrates[3] (%)	Freshwater Vascular plants[5] (%)	Freshwater Macroalgae[6] (%)	Freshwater Amphibians[2] (%)
Threatened	11 **(14.5)**	22 **(28)**	78 **(12)**	26 **(13.5)**		
• Nationally Critical	5 **(6.6)**	4 **(5)**	48 **(7)**	12 **(6)**		
• Nationally Endangered	1 **(1)**	6 **(8)**	14 **(2)**	5 **(2.6)**		
• Nationally Vulnerable	5 **(6.6)**	12 **(15.4)**	16 **(2.4)**	9 **(5)**		
At Risk	6 **(8)**	17 **(22)**	99 **(15)**	46 **(24)**		1 **(50)**
• Declining	2 **(2.6)**	11 **(14)**	10 **(1.5)**	18 **(9.4)**		1 **(50)**
• Naturally Uncommon	4 **(5)**	6 **(8)**	89 **(13)**	28 **(14.6)**		
Data Deficient	1 **(1)**	0	178 **(26.4)**	7 **(3.6)**	21 **(100)**	1 **(50)**
Total No. Species	**76**	**78**	**675**	**192**	**21**	**2**

[1] (Nicholas R. Dunn, 2018); [2] (Burns, et al., 2018); [3] (Grainger, et al., 2018); [4] (Robertson, et al., 2017); [5] (de Lange, et al., 2018), [6] (Nelson, Neill, D'Archino, & Rolfe, 2019)

Over 14 percent of all native wetland birds are classified as threatened, 8 percent are at-risk and less than 1 percent are considered data deficient. Twenty eight percent of freshwater fish species are classified as threatened, 22 percent are at-risk and none are classified as data deficient. Twelve

percent of freshwater invertebrates are classified as threatened, 15 percent are at-risk and 26.4 percent are classified as data deficient. Over 13 percent of all native vascular plants are classified as threatened, 24 percent are at-risk and over 3 percent are data deficient. All known freshwater macroalgae species are considered data deficient. There are only two described native freshwater amphibian species in New Zealand know to be dependent on freshwater habitats for their survival. These are the Hochstetter's frog (*Leiopelma hochstetteri*) which is classified as at-risk, declining and the Northern Great Barrier Island (NGBI) swimming frog (*Incertae cedis*) which is classified as data deficient and has only been described twice (Burns, et al., 2018).

5 INFORMATION ABOUT NEW ZEALAND'S NATIVE FRESHWATER FLORA AND FAUNA IS INCOMPLETE

The threat classification system was developed with the goal of applying the threat classification report to develop a species recovery plan and identify species management zones. There is currently, however, insufficient data available to do this. For this reason, ecological management units have not, as yet, been identified (N. Grainger 2020, pers. comm., 11 June).

Discrepancies associated with nomenclature and classification systems further complicate our current ability to triage and assign a threat status to New Zealand's freshwater species. For example, the classification of freshwater vascular plants does not encompass all freshwater-dependant plants, that live either in or around freshwater ecosystems. Freshwater-dependant plants include mosses, hornworts, liverworts and green algae, together with vascular plants. Notably, freshwater-dependant plants does not encompass native charophytes, which are a type of macroalgae. There are 537 known native freshwater-dependant plants in New Zealand and, of these, 14% are nationally threatened with extinction and 17% are at risk of extinction (Gerbeaux, Champion, & Dunn, 2016).

Native charophytes are macroalgae, however, they are not included in the New Zealand threat classification system as macroalgae. There are fourteen native freshwater charophyte species (de Winton & Casanova, 2002), of these two species are considered nationally critical (*Nitella opaca* and *Tolypella nidifica*), one species is nationally vulnerable (*Lamprothamnium macropogon*) and five *Nitella* taxa are data deficient (*N. tricellularis, N. masonae, N. claytonii, N. hookeri* and *N. subtillisima*) (P. Champion 2020, pers. comm., 15 July).

5.1.1 Data Deficient Species

A significant proportion of certain freshwater taxonomic groups are classified as data deficient, specifically, all macroalgae species (excluding charophytes) and over a quarter of freshwater invertebrate species. Data deficient species are seldom seen and may be cryptic and/or exceedingly rare. Potentially, data deficient species may already be extinct, but due to a lack of data about the population size and distribution they cannot be categorized as such under the threat classification system (Robertson, et al., 2017; de Lange, et al., 2018). A scarcity of information about these taxa translates into limited understanding of their known range and habitat requirements and thus presents real challenges in identifying and protecting the habitats that support these species.

5.1.2 Naturally Uncommon Species

Species classified as naturally uncommon deserve special mention regarding the classification and consequential management of threatened species. Approximately 13 percent of freshwater invertebrates and over 14 percent of vascular plants are classified as naturally uncommon. Naturally uncommon species are defined according to Townsend, et al. (2008) as "*Taxa whose distribution is*

confined to a specific geographical area or which occur within naturally small and widely scattered populations, where this distribution is not the result of human disturbance." This is further defined for birds as "*Taxa with > 20,000 mature individuals are not considered naturally uncommon unless they occupy an area of < 1,000 km^2"* (Robertson, et al., 2017). Townsend, et al. (2008) defined "Naturally Uncommon" as a separate category to differentiate between species that are biologically scarce and those that are threatened. Yet, species classified as naturally uncommon may also be classified as "threatened" or "at risk" and are potentially more susceptible to impacts due to the inherent restricted and limited nature of their distribution and population size.

6 RESULTS

6.1 SUMMARY OF RESOURCES IN THE THREATENED FRESHWATER SPECIES HABITAT DATABASE

Seventy-five primary resources are documented in the accompanying threatened species database. In addition, a further 27 supporting resources have been identified and included in the database to provide supplementary information on the occurrence and distribution of threatened freshwater species and/or their habitats. Of the primary resources technical reports were the most commonly identified resource accounting for 29 entries in the database, followed by geospatial databases (17 entries), other databases (13 entries), threat classification series publications (5), research articles (4) and archival information (2).

Freshwater fish were the most well represented taxonomic group with 12 database entries, followed by invertebrates (6 entries), birds (5), plants (4) and amphibians (2). Regarding specific ecosystem types wetlands accounted for 8 entries, followed by river systems (7), lakes (2) and groundwater (2). The majority of the identified resources had a national coverage (52 entries), followed by the regions of Canterbury (10), Auckland (5), Manawatū-Whanganui (3), Northland (2), and Southland, Nelson and Gisborne all having 1 entry each. Summarised information about the resources documented in the accompanying database are presented in Table 3.

Table 3. Summary of primary resources relating to threatened freshwater species distribution and/or habitat

Subject Matter	Resource Type (N U M B E R)	Geographic Area
Fish (12)	Technical Report (26)	National (55)
Ecosystems (10)	Geospatial Database (21)	Canterbury (6)
Wetlands (8)	Database (other) (13)	Auckland Region (5)
Invertebrates (8)	Threat Classification Series (6)	Manawatū-Whanganui (3)
Biodiversity (8)	Research Article (3)	Northland (3)
Rivers, including braided rivers (6)	Archival Information (2)	Southland (1)
Birds (5)	Other (4)	Nelson Region (1)
Plants (5)		Gisborne (1)
Lakes (4)		
Amphibians (2)		
Other (7)		
Total: (75)	**(75)**	**(75)**

6.2 RESOURCES IDENTIFIED DURING INTERVIEWS

Tools and resources applied by researches, bio-managers and practitioners to record the distribution of threatened freshwater species and/or their habitats are identified in Table 4. The full details of these resources are provided in the accompanying threatened species habitat database. In addition

to the resources listed here a number of technical reports and supporting documents were also identified and are included in the accompanying database.

Table 4. Tools and resources identified during interviews for documenting and detecting threatened freshwater species and/or their habitats. Resources are presented in alphabetical order under subject matter.

Name	Subject Matter	Type	Geo. Area	Reference
Atlas of the amphibians and reptiles of New Zealand	Amphibians	Geospatial database	National	(Department of Conservation, 2020)
BioWeb	Biodiversity	Geospatial Database	National	(Department of Conservation, 2020)
iNaturalist NZ	Biodiversity	Database	National	(New Zealand Bio-recording Network Trust, 2020)
New Zealand Organisms Register	Biodiversity	Database	National	(Landcare Research, 2020)
Open Waters Aotearoa Environmental DNA (eDNA) Portal	Biodiversity	Geospatial Database	National	(Wilkinson, 2020)
Local knowledge (expert and landowner)	Biodiversity	Anecdotal	National	
Monitoring protocols for cryptic wetland bird species	Birds	Technical Report	National	(DOC resource, not currently publicly available)
New Zealand Birds Online	Birds	Database	National	(DOC, Te Papa, Birds New Zealand, 2013)
New Zealand eBird/ New Zealand Bird Atlas	Birds	Database	National	(eBird, 2020)
Auckland Council GEOMAPS - Ecosystem Current Extent	Ecosystems	Geospatial Database	Auckland Region	(Auckland Council, 2014)
Black Maps, Canterbury maps	Ecosystems	Geospatial Database	Canterbury	(Environment Canterbury, 2020)
Mātauranga Māori	Ecosystems	Anecdotal	National	
Fish Passage Assessment Tool	Fish	Geospatial Database	National	(NIWA, 2018)
Fish Spawning Indicator – National Environment Strategy for Plantation Forestry	Fish	Geospatial Database	National	(Ministry for Primary Industries, 2017)
Freshwater Fish Spawning and Migration Periods	Fish	Technical Report	National	(Smith J. , 2015)
Inanga/Whitebait Summary sheet (WBC-1B)	Fish	Educational Resource	National	(The Whitebait Connection & EOS Ecology, 2016)
New Zealand Freshwater Fish Database	Fish	Geospatial Database	National	(NIWA, 2020)
Predicting distributions of New Zealand freshwater fishes	Fish	technical report	National	(Crow, Booker, Sykes, Unwin, & Shankar, 2014)
Freshwater Ecosystems of New Zealand Database (FENZ)	Freshwater Ecosystems	Geospatial Database	National	(Department of Conservation, 2010)
Macroecology of NZ Ephemeroptera	Invertebrates	PhD Thesis	National	(Pohe, 2019)
Mayfly DNA database	Invertebrates	Database	National	(S. Pohe, currently not available)
New Zealand Trichoptera Database	Invertebrates	Database	National	(Ward & Henderson, 2012)
Threatened freshwater invertebrate layer	Invertebrates	Geospatial Database	National	(Department of Conservation, currently not available)
Lake Submerged Plant Indicators (SPI)	Lakes	Geospatial Database	National	(NIWA, 2020)
National Library Cadastral Maps	Landscapes	Archive	National	(The National Library of New Zealand, 2020)

Name	Subject Matter	Type	Geo. Area	Reference
Google Earth Pro	Landscapes	Geospatial Database	National	(Google, 2020)
Retrolens - Historical Imagery Resources	Landscapes	Archive	National	(Local Government Geospatial Alliance & Land Information New Zealand, 2020)
NIWA Aquatic Plant Database	Plants	Database	National	(NIWA internal DB, data available on request)
NZ Plant Conservation Network	Plants	Database	National	(National Council of the New Zealand Plant Conservation Network, 2020)
The Australasian Virtual Herbarium (AVH)	Plants	Database	National	(Australian and New Zealand Herbaria, 2020)
NZ River Maps: An interactive online tool for mapping predicted freshwater variables across New Zealand	Rivers	Geospatial Database	National	(Booker & Whitehead, 2017)
River Environment Classification Tool	Rivers	Geospatial Database	National	(NIWA, 2016)
A vegetation tool for wetland delineation in New Zealand	Wetlands	Technical Report	National	(Clarkson B. , 2013)
Handbook of Monitoring Wetland Condition	Wetlands	Technical Report	National	(Clarkson B. R., et al., 2003)
Wetland Types in New Zealand	Wetlands	Technical Report	National	(Johnson & Gerbeaux, Wetland Types in New Zealand, 2004)
Wetlands Database	Wetlands	Database	National	(Landcare Research, available on request)

6.3 Important Considerations for Identifying Freshwater Habitat of Threatened Species

The key factors identified by subject matter experts as important for identifying threatened species habitat are broadly grouped into two main categories; **1) habitat characteristics**, including temporal dynamics, connectivity, degree of intactness and rarity (both regionally and nationally); and **2) species specific factors**, including life-history strategies, working with local experts and mana whenua to locate species and identifying and applying appropriate monitoring techniques, the latter being particularly important for detecting the presence of rare or cryptic species.

6.3.1 Habitat Characteristics

West and Neale (2016) identified consistency in the attributes environmental managers and researchers used to assess the significance of ecological value. These include:

- Representativeness,
- Ecosystem rarity and/or uniqueness,
- Naturalness,
- Degree of modification (physical and hydrological),
- Diversity and pattern of habitats and species,
- Presence of native species, in particular rare and/or unique species,
- Connectivity within and between ecosystems,
- Presence of exotic species, and
- Current extent of protection.

Waterbodies are characterised by their habitats and the species that reside within them. They are subject to temporal and spatial dynamic shifts, coinciding with seasonal changes, weather events and biological life-cycles. For these reasons, effective management of threatened species habitat will be best supported through a holistic and integrated approach, rather than reducing waterbodies to their individual components and considering them isolation, e.g. delineating habitats and taxon groups (West & Neale, 2016).

Ephemeral and discrete habitats

Many rare and threatened species are associated with ephemeral and/or discrete habitats. Important habitats for threatened freshwater species may include seeps, wet gullies, cave systems, small streams, springs, and small, forested streams (S. Myers 2020, pers. comm, 18 June; B. Smith 2020, pers. comm, 17 July).

Habitat connectivity and temporal dynamics

Protecting threatened species habitat requires an integrated catchment management approach. Aquatic habitats are interconnected and cannot be easily delineated. For example, hydrological connectivity allows riverine species to adapt to flood and drought conditions by facilitating species movement to 'safe' areas during periods of disturbance and then their re-establishment from refugia when the event is over (Fuller & Death, 2018). Maintaining habitat continuity and connectivity is, therefore, fundamental to facilitating species movement and migration. Similarly, disturbance regime processes may promote diversity, increasing the likelihood for threatened species to occur. For example, natural fluctuations in water level and/or browsing pressure by herbivores can create open habitat in lakes, allowing threatened shoreline turf plants or submerged native aquatic plants to take hold (P. Champion 2020, pers. comm, 15 July).

Naturalness

The more natural the hydrology and less impacted the site the greater the likelihood the habitat will support threatened flora and/or fauna (S. Myers 2020, pers. comm., 18 June; B. Clarkson 2020, pers. comm., 22 July). Indicators for naturalness are based on unique characteristics specific to each aquatic habitat type, as outlined below:

Riverine habitats – faunal and floral community composition, hydrological connectivity, decomposition rates of organic matter and water quality (Schallenberg, et al., 2011).

Braided rivers – presence of constraints to braidplain breadth, occurrence of structures and/or human modifications, proportion of native vegetation cover versus exotic vegetation, degree of flow regime modification from impoundments or large diversions of flows, extent of change to active surface channel shape, water and habitat quality, exotic aquatic flora and fauna and extent of land use intensification adjacent to braidplain (Gray, 2018).

Lakes – faunal and floral community composition or nativeness, sediment anoxia, trophic status, hydrological connectedness and depth range (Schallenberg, et al., 2011).

Wetlands - hydrological integrity, physicochemical parameters (e.g. nutrients), reduction of original wetland extent, browsing by domestic or feral animals, predation pressure on native wildlife, harvesting of native vegetation and plant community composition (Clarkson B. , et al., 2004).

Unique and Rare Habitats

Applying the factsheet descriptions of New Zealand's naturally uncommon wetland ecosystems can assist in the initial identification of nationally unique habitats which may harbour rare species (Wiser, et al., 2013; Manaaki Whenua - Landcare Research, 2020). Consider those habitats which are regionally rare or discrete for example, floodplain wetlands are rare habitats with high biodiversity values (Davis, Head, Myers, & Moore, 2016). Regionally distinct characteristics will correlate with regionally unique ecosystems (S. Myers 2020, pers. comm., 18 June), for example dune lakes in Northland, domed bogs in northern Waikato and tarns in mountainous regions.

Remnant Habitats

Consider the landscape as a whole and prioritise the protection and restoration of remnant indigenous habitats. Even impacted wetlands or small seepage areas can provide significant habitat. For example, drainage ditches can harbour rare species as they can represent remnant wetland habitat (B. David 2020, pers. comm., 12 June). Historic wetlands may be identifiable based on soil types, ground water depth maps or historic aerial photos, maps or plans. Practitioners and decision makers must identify what the starting point is and how far back in time to look for evidence of remnant habitat, to determine if a particular resource is going to be useful for a given project. (N. Dunn 2020, pers. comm., 17 June).

Summary of Recommendations for Identifying Threatened Species Habitats

Identify key distinguishing characteristic of the region of interest, including topography, geology, soil types, historic land cover and current remaining remnant native habitats. Apply river environment classification (REC) maps to assess larger tributaries. Smaller or intermittent streams, water courses and wetlands can be identified and mapped using a combination of aerial photographs, satellite imagery and/or LiDAR.

Review past and present data on wetland extent and type, consider how well represented different wetland types are in the region and whether they contain unusual habitat or regionally rare species. If available, use maps on alluvial groundwater aquifers and springs to help locate historic wetlands. Consider the proximity and type of wetland in relation to current wetlands known to contain threatened species in the region.

Gather information from Mana Whenua, interview local universities and anecdotal evidence from locals. Ground truthing is always necessary.

6.3.2 Taxa Specific Considerations

Fish

Understanding species life-history strategies is just as important as identifying species occurrence. For example, non-migratory galaxiids do not share all the same drivers as diadromous species. Water quality and presence or absence of certain species can determine habitat suitability and must be taken into consideration. For example, the success of relocations of threatened mudfish (*Neochanna* spp.) will improve if translocation sites have good water and habitat quality and do not harbour invasive mosquito fish (*Gambusia affinis*) (McDonald, 2007).

For particular species of fish the main issues are not necessarily loss of habitat but rather habitat connectivity, for example short jaw kōkopu and torrent fish (McDowall, 1978). Consider locally discrete or naturally uncommon species, such as landlocked kōaro populations in Canterbury and dwarf inanga in Northland.

Approach older NZFFD records (e.g. over ten years) with caution and tap into wider knowledge networks to identify important habitats, particularly spawning habitat.

Invertebrates

Forest cover and lowland bush remnants containing small headwater streams, rich in organic matter and leaf litter are hotspots for threatened invertebrate species. Lateral habitat gradients, wetted margins, near waterfalls, seeps and habitats free from fish are also important sites for rare or threatened invertebrate species (B. Smith 2020, pers. comm., 17 July).

Review the threat classification and look at the species which are data deficient as they are likely to be rare and potentially threatened (N. Grainger 2020, pers. comm., 11 June; B. Smith 2020, pers. comm., 17 July). It is not only aquatic habitat that is required for threatened invertebrates to complete their life-cycles; of equal importance is the protection of wetted margins, including banks, emergent vegetation and surrounding riparian vegetation which provides essential resources for many native invertebrate species (Collier, et al., 1995). Life-history strategies, such as oviposition requirements of Ephemeroptera, Plecoptera and Trichoptera species (EPT) can be linked to morphological adaptations of larvae relating to their habitat requirements and their distribution (Smith & Storey, 2018).

Using the right trapping method is important. Capturing and, therefore, identifying certain species requires targeted sampling to collect the right life-history stage at the right time of year. For example, light trapping is a commonly used method for collecting flying adult insects, however, some species of stonefly are not attracted to light, and some species of caddisflies are not nocturnal. In addition, overnight temperature dictates what will be active and what will be captured by light trapping (B. Smith 2020, pers. comm., 17 July).

Introduced species can pose significant risks to threatened native invertebrate species and the impacts may not always be as obvious as the visible effects of koi carp bioturbation and feeding activity. For example, the introduced mollusc *Pseudosuccinea antipodarum* were found to consume a large number of native caddisfly eggs (Hydrobiosidae and Hydropsychidae), while native *Potamophyrgus* snails did not consume caddisfly eggs (Smith & Reid, 2016).

Plants

Turf plants account for the majority of threatened freshwater dependant species (P. Champion 2020, pers. comm., 15 July). Plant life-history strategies must be considered an assessment at one moment and time may miss certain species. It is important to have an understanding about the biology of the plants and the environmental/climate cues that relate to germination and flowering of the specific plant communities (Johnson & Rogers, Ephemeral wetlands and their turfs in New Zealand, 2003).

Birds

Engage local experts and mana whenua to help map out where species have been located or are likely to be (K. Hashiba 2020, pers. comm., 14 July).

Summary of Taxonomic Considerations

Prioritise protection of habitats under native forest cover, particularly remnant lowland forest. Lateral habitats, situated 10 meters out from the waterways, may also be particularly important for invertebrate oviposition and fish spawning requirements. These habitats are also the most vulnerable to cattle damage and/or impacts from water extraction (The Whitebait Connection & EOS Ecology, 2016; Collier, et al., 1995).

Compile a database of the current population structure and apply modelling to rank ecological value, including threat ranking, taxonomic uniqueness, and habitat constraints (P. Champion 2020, pers. comm., 15 July). Consider the biogeographic range of species and look at areas which may be data deficient (D. Gray 2020, pers. comm., 17 June).

Field surveys are essential to find out where threatened freshwater species are in each region. Engage local experts and mana whenua to help map out where species have been located or are likely to be (K. Jones 2020, pers. comm., 17 June). Molecular tools such as eDNA and lamprey pheromone sampling have the potential to be applied in conjunction with standard monitoring to narrow down where particular species, particularly cryptic species, are located (B. David 2020, pers. comm., 12 June; A. Hicks 2020, pers. comm., 19 June; S. Pohe 2020, pers. comm., 22 July) (Stewart & Baker, 2012).

Biotic interactions can be just as or more important than habitat constraints. The presence of an invasive species or pathogen may exclude species from an otherwise suitable habitat, e.g. Gambusia and mudfish. Conversely, the absence of key species may limit the survival of another species for its survival or, e.g. the dependence of kakahi on native fish to complete their life-cycle (Allibone & Gray, 2018).

6.4 Mātauranga Māori

Mātauranga Māori is a key part of identifying and monitoring New Zealand's threatened freshwater species and their ecosystems. Engaging mana whenua, kaumatua and marae communities not only reveals new information about species distribution, both historic and present day; it also facilitates a deeper understanding of the connection between people and threatened freshwater species and their habitats. In acknowledgment of this, Te Mana o te Wai is presented as a fundamental concept in the NPS-FM (2020) that encompasses six principles, including whakahaere, kaitiakitanga, manaakitanga, governance, stewardship, and care and respect[3].

Co-development of cultural health indicators is one approached to integrating Māori and western ecological monitoring techniques. For example, Tipa & Teirney (2006) outlined a cultural health index for streams and waterways by quantifying Māori freshwater values. The main components of cultural health index were; 1) Sites traditionally used for food gathering and those that would be useful in the future, 2) Past, present and the likely future state of wild food (mahinga kai) resources at the site, and 3) The current health of the stream at the site as evaluated by members of the Māori community (Tipa & Teirney, 2006).

6.5 Identified Limitations of Resources and Gaps

6.5.1 Monitoring Protocols and Data Handling

All databases contain inherent errors to some extent. There are some inconsistencies in how information on New Zealand threatened freshwater species is currently collected and subsequently managed by organisations across the country. Notably, State of the Environment monitoring is not

[3] The 6 principles as described in the policy are: (a) Mana whakahaere: the power, authority, and obligations of tangata whenua to make decisions that maintain, protect, and sustain the health and well-being of, and their relationship with, freshwater (b) Kaitiakitanga: the obligation of tangata whenua to preserve, restore, enhance, and sustainably use freshwater for the benefit of present and future generations (c) Manaakitanga: the process by which tangata whenua show respect, generosity, and care for freshwater and for others (d) Governance: the responsibility of those with authority for making decisions about freshwater to do so in a way that prioritises the health and well-being of freshwater now and into the future (e) Stewardship: the obligation of all New Zealanders to manage freshwater in a way that ensures it sustains present and future generations (f) Care and respect: the responsibility of all New Zealanders to care for freshwater in providing for the health of the nation.

standardised across regions, leading to a lack of suitable long-term monitoring data (C. Baker 2020, pers. comm., 17 July).

There are also differences in sampling efforts and thus the amount of information available for different habitat types. For example, there is less information available on lakes compared to river systems. Moreover, while the major drivers of biological communities in rivers are fairly well described, these processes are not so well understood for wetland and lake communities. Such discrepancies are reflected in the greater number of predictive models available for river systems with fewer tools being available for lakes and wetlands.

Inconsistencies in threatened species data collection and management are problematic because they reduce the universal applicability of data. For example, differences in approaches to wetland habitat monitoring between organisations leads to discrepancies between important tools used to derive current wetland extent (Newsome, 2017). These inconsistencies create both inefficiencies within current approaches to freshwater monitoring and potential barriers to the effective management of some of New Zealand's most threatened, unique and rare freshwater habitats and species.

The New Zealand Freshwater Fish Database

The New Zealand Freshwater Fish Database (NZFFD) warrants special mention as it is the primary resource used and applied by researchers and practitioners nationally to both document and identify freshwater fish occurrence and predict patterns of species distribution. Because other desktop tools are developed using information derived from the NZFFD it is crucial to be aware of the inherent errors in the NZFFD. During interviews identified limitations specifically associated with the NZFFD included:

- The database presents a combination of current and historical observations of species but does not necessary reflect the current distribution of species.
- It contains some misidentifications.
- The database is dependent on regular inputs from the wider scientific community and thus may be of variable quality and reliability.
- There is currently no standardised sampling protocol for fish, therefore individual data entry points in the NZFFD may not be directly comparable with one another.
- There are gaps in sampling effort, fish diversity decreases the further inland you travel, therefore more monitoring sites are required in waterways nearer the coastline in order to improve the representativeness of information on New Zealand freshwater fish distribution and biomass (A. Hicks 2020, pers. comm., 19 June).

6.5.2 Lack of Information and/or sampling issues for freshwater taxa

Gaps in information specific to individual taxonomic groups were identified by interviewees and are summarised here.

Fish

- There are gaps in data and/or knowledge about species distribution or habitat use during critical times of their lifecycles, especially during spawning (M. Bloxham 2020, pers. comm., 11 June; K. Jones 2020, pers. comm., 17 June) (Smith J. , 2015).
- As populations decline there may be loss of pheromone biochemical cues used by fish and some species may no longer recruit to the same areas (C. Baker 2020, pers. comm., 17 July).
- Fish communities in lakes are not regularly monitored (C. Nicholson 2020, pers. comm., 21 July).

- There are issues relating to sampling bias, for example, a lot of electric fishing is carried out in streams near roads, where sites are more accessible, and less monitoring is undertaken on private land (D. West 2020, pers. comm., 20 July).

Invertebrates

- The typical biomonitoring technique focuses on sampling run and riffle habitats to collect benthic invertebrates to calculate Macroinvertebrate Community Index (MCI) scores. This approach limits the types of habitats sampled and the level of taxonomic identification undertaken. This inherent sampling bias makes it exceedingly difficult to determine the abundance of invertebrate species and therefore evaluate their threat status (Death, 2015).
- At present there is no adequate invertebrate monitoring methodology for deep, soft-bottom streams.
- There remain many undescribed New Zealand invertebrate species and a general lack of data on aquatic invertebrates. There is currently not enough information to make meaningful suggestions about threatened species habitat at a farm or even a sub catchment scale (N. Grainger 2020, pers. comm., 11 June; D. Gray 2020, pers. comm., 17 June; B. Smith 2020, pers. comm., 17 July).
- There is a lack of taxonomic expertise in New Zealand, for example, there are currently no stonefly experts (B. Smith 2020, pers. comm., 17 July).

Plants

- There are few skilled and experienced practitioners in the country with expertise in the field of plant identification. There is also a lack of quality plant identification resources, particularly for impacted systems, such as urban and agricultural landscapes.
- Key information on the habitat preferences and life-history strategies of some plants may not be well captured through current monitoring approaches. For example, turf plants are not quite obligate, however this information is often not recorded (P. Champion 2020, pers. comm., 15 July).
- There is a lack of experienced wetland ecologists in New Zealand.
- There is currently no national database on wetland plants. A lot of botanical information sits with consultants, regional council archives, museums, district and city councils (S. Myers 2020, pers. comm., 18 June; B. Clarkson 2020, pers. comm., 22 July).

7 RECOMMENDATIONS

General

- Continue development of nationally coordinated protocols for monitoring, managing and reporting information on threatened freshwater species and their habitats. Include methodology, criteria, minimum standards, and optional additional measure which can be tailored to each region. Coordinate through the National Environmental Monitoring Standards (NEMS) steering group (http://www.nems.org.nz/documents/).
- Draw on the strengths of different regional councils and those organisations monitoring freshwater environments to assist with the development of national protocols and avoid reinventing the wheel.
- Develop a user-friendly system for capturing data that all councils, researchers and practitioners can access via a shared portal.
- Where appropriate use molecular monitoring techniques such as eDNA and pheromone sampling, alongside conventional monitoring techniques.
- Incorporate information on species life-history traits to better understand the habitat requirements of rare and threatened species.
- Incorporate Mātauranga Māori to enrich current and future databases and monitoring methods.
- Undertake field surveys to verify model outputs and desktop exercises and determine actual habitat type, condition and presence of threatened species.
- Develop a red list of NZ freshwater ecosystems, in line with IUCN red list of ecosystems.

Fish

- Undertake continuous and consistent national monitoring and records of freshwater fish spawning habitats and migration periods.
- Assign sampling effort to NZFFD records.
- Include information derived from Mātauranga Māori and citizen science to NZFFD entries, where practical.

Invertebrates

- Adopt a diverse approach to sampling to encompass a range of habitats, particularly those which are underrepresented by current State of the Environment monitoring programmes.
- Develop invertebrate monitoring tools for deep, soft-bottom streams.
- Target sampling to capture data deficient species.

Plants

- Compile relevant information on threatened freshwater-dependent flora, including turf species, aquatic plants and macroalgae, to facilitate the development of effective conservation management strategies for these species.

Wetlands

- Utilise skilled and experienced wetland ecologists to undertake wetland monitoring.

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