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# Using GIS and neural networks to create fish habitat suitability maps

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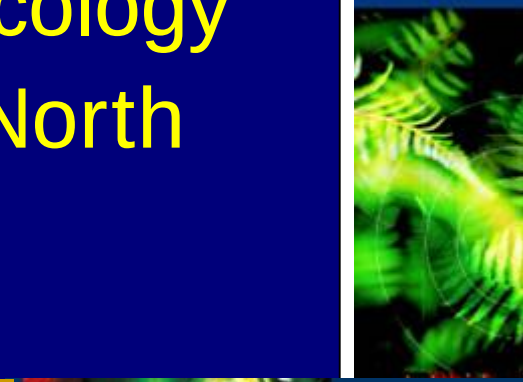

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# Modeling the relationship between species and their environments

Predictive modeling in freshwaters for:

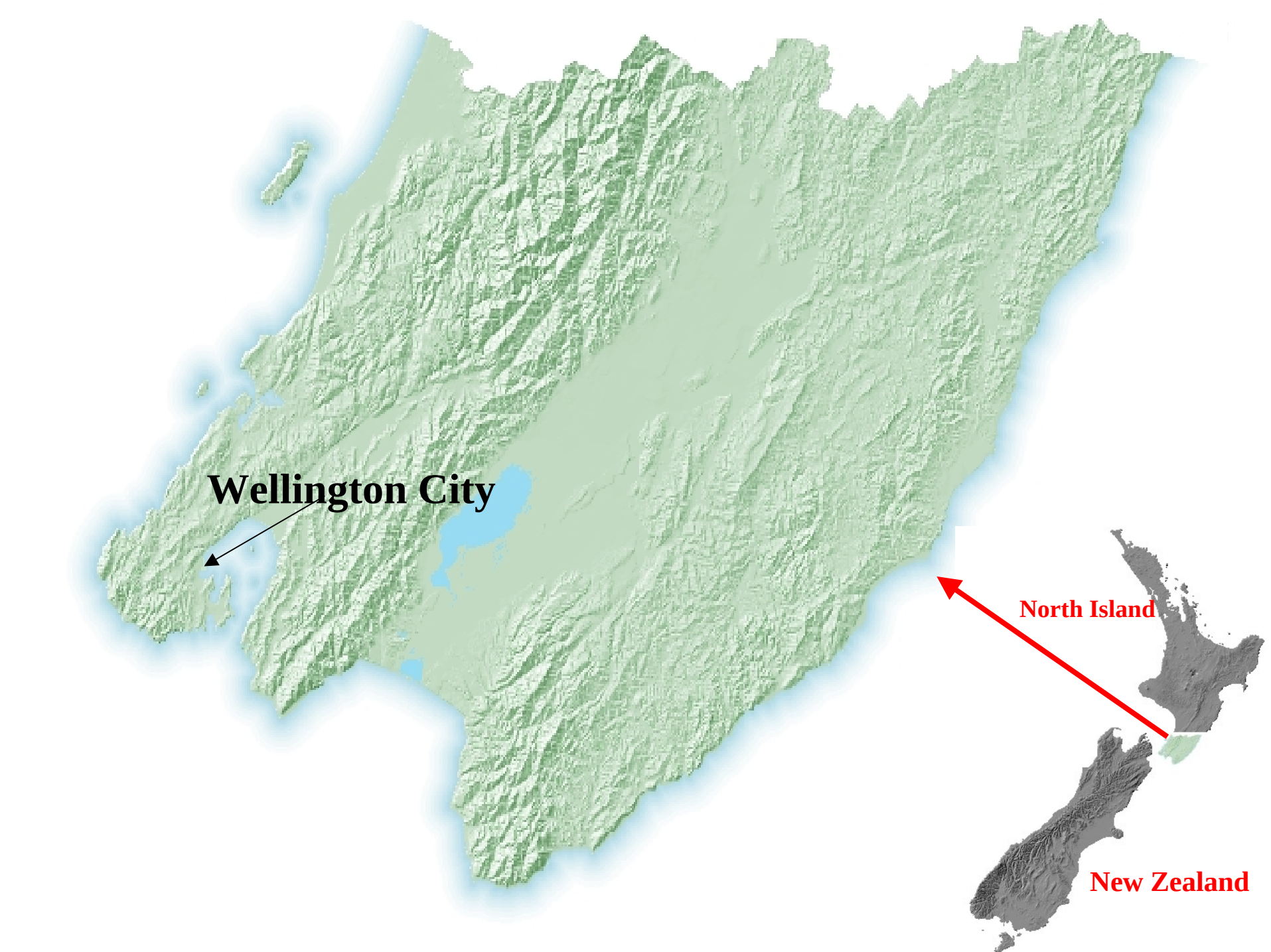
- Bioassessment
- Exotic species invasions
- Algal blooms
- Lake trophic levels…



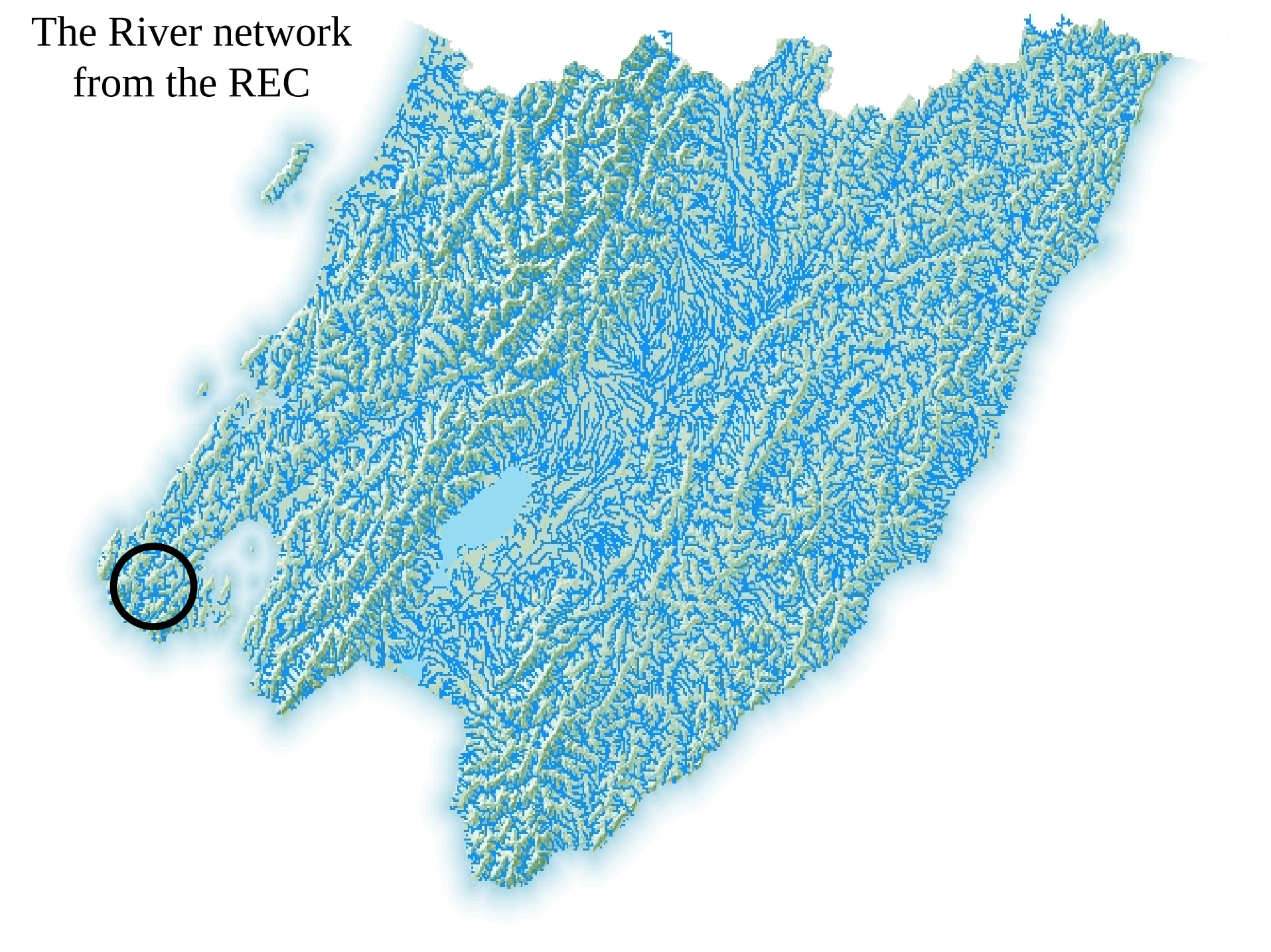
# Advantages of ANNs over traditional modeling methods

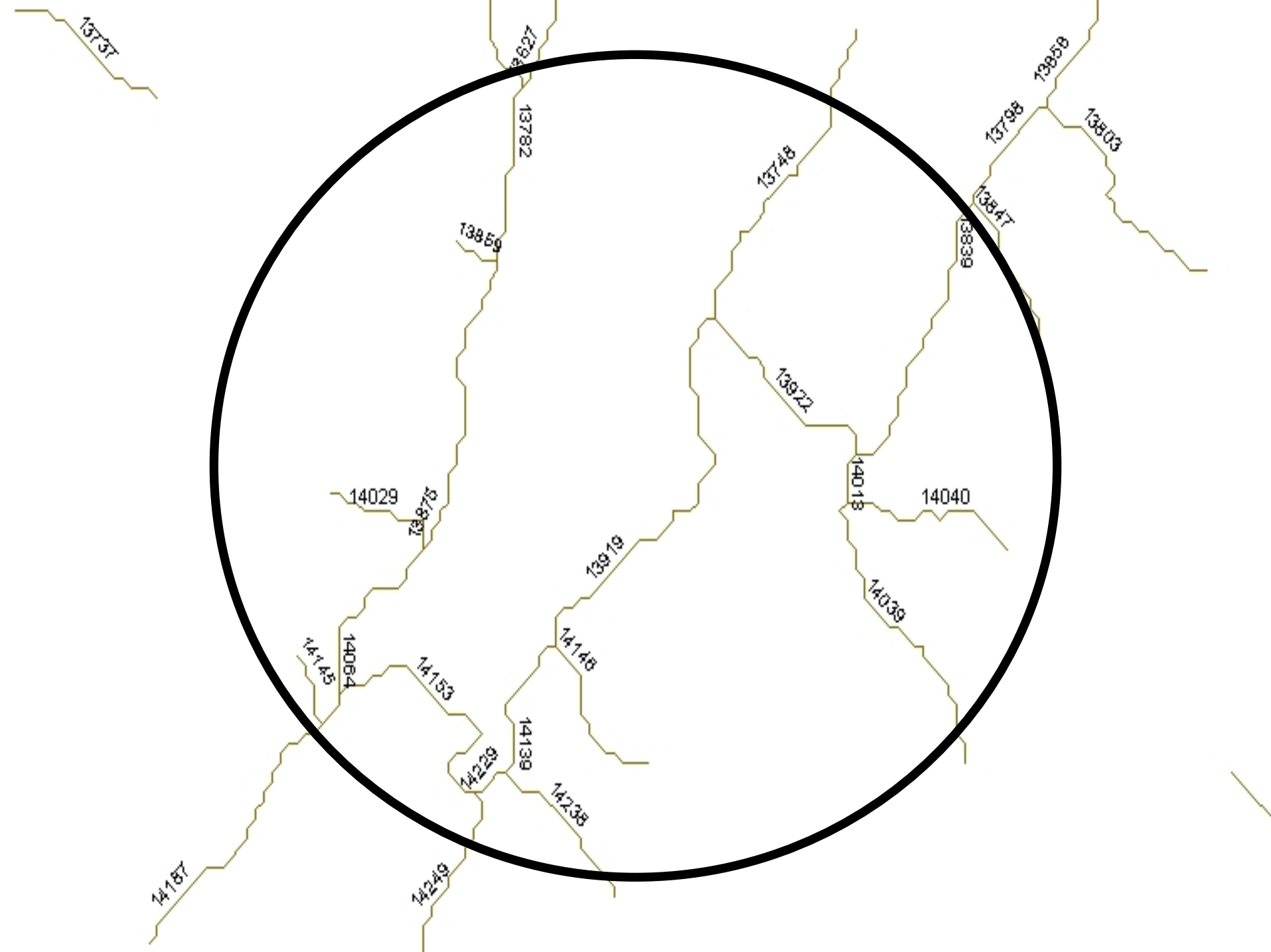
- Not dependant on particular relationships between independent and dependant variables i.e. linear relationships
- No assumptions about underlying data distributions
- The ability to model the entire assemblage not just single species




Wellington City
North Island
New Zealand

The River network from the REC




13737
13627
13782
13859
13748
13798
13858
13803
13847
13839
13922
14018
14040
14029
13875
13919
14039
14064
14145
14153
14148
14139
14229
14238
14187
14249

# Predictor variables

Spatial data:

- e.g. Latitude

Stream size/network position:

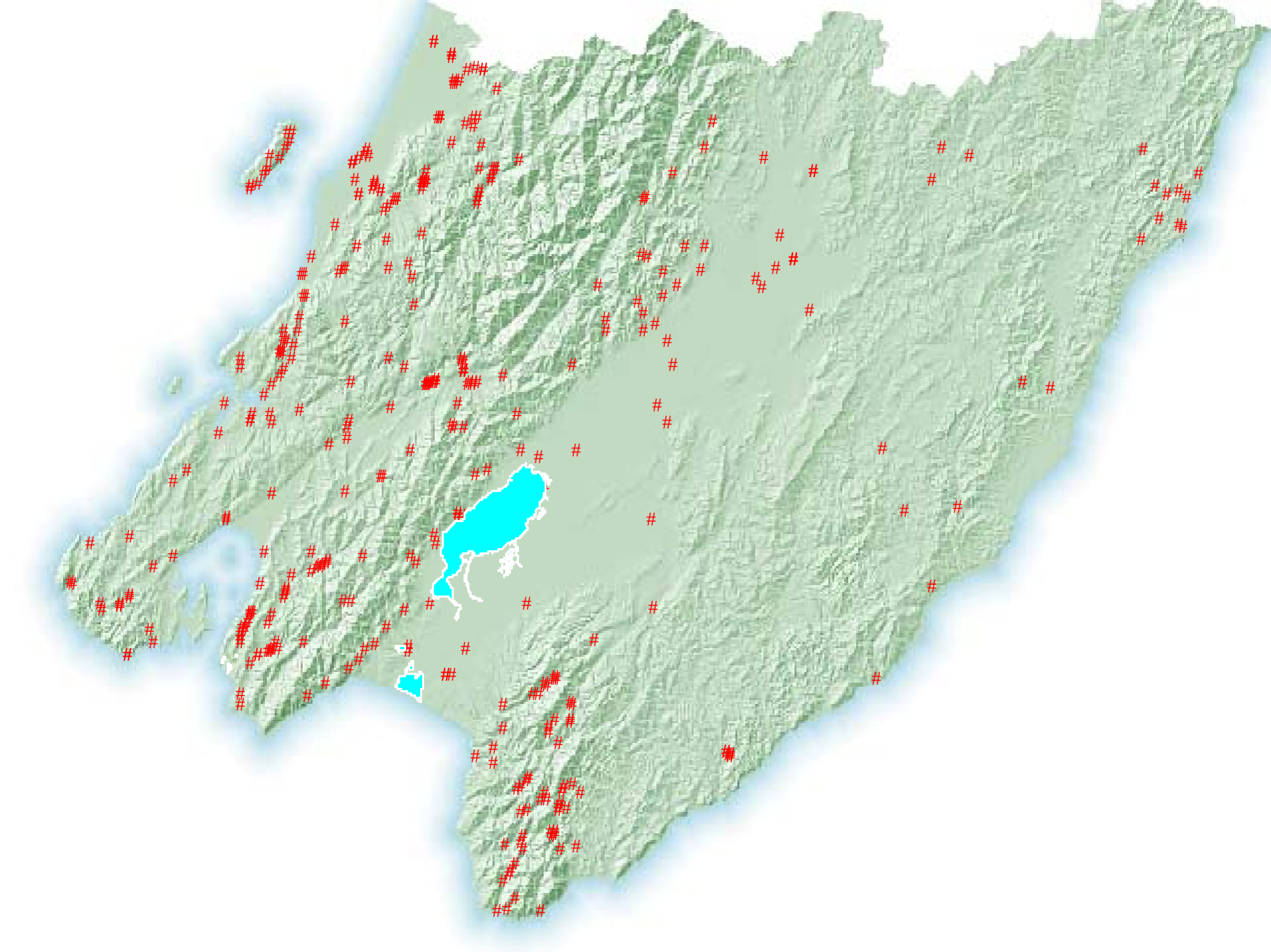
- e.g. order, catchment area flow

Climate:
e.g. rainfall, temperature

Landuse:
e.g. pastoral, native, urban

Geology:
e.g. alluvium, calcareous, mudstone





| Scientific name | Common name |
|---|---|
| *Anguilla australis* | Shortfin eel |
| *Anguilla dieffenbachii* | Longfin eel |
| *Cheimarrichthys fosteri* | Torrentfish |
| *Galaxias brevipinnis* | Koaro |
| *Galaxias divergens* | Dwarf galaxiid |
| *Galaxias fasciatus* | Banded kokopu |
| *Galaxias maculatus* | Inanga |
| *Galaxias postvectis* | Shortjaw kokopu |
| *Gobiomorphus cotidianus* | Common bully |
| *Gobiomorphus hubbsi* | Bluegill bully |
| *Gobiomorphus huttoni* | Redfin bully |
| *Gobiomorphus breviceps* or *G. basalis* | Cran's or upland bully |
| *Paranephrops planifrons* | Koura |
| *Salmo trutta* | Brown Trout |

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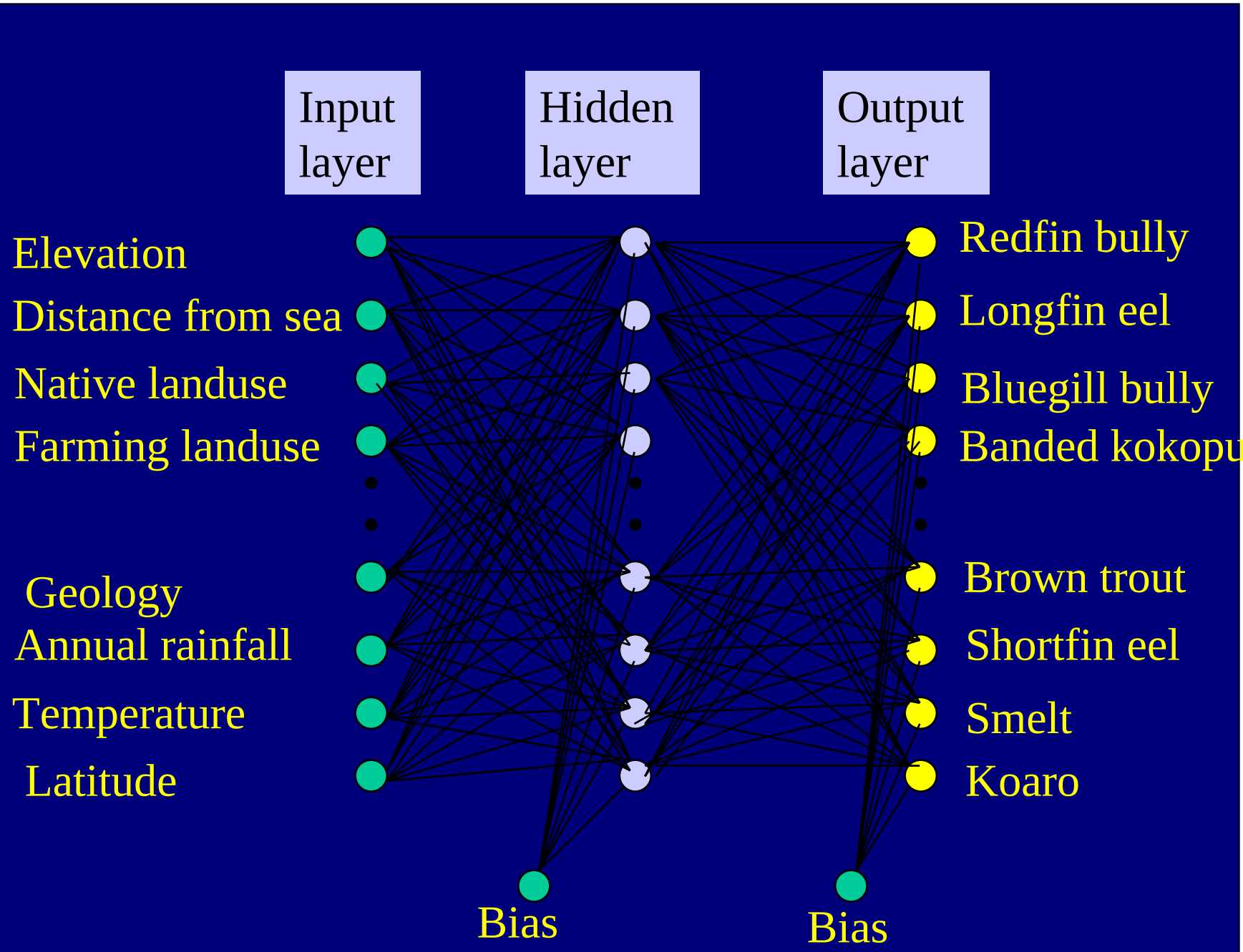
# Building the predictive model

- 380 sites
- 31 environmental variables from GIS

Neural network

- Predicting 13 fish and 1 decapod taxa



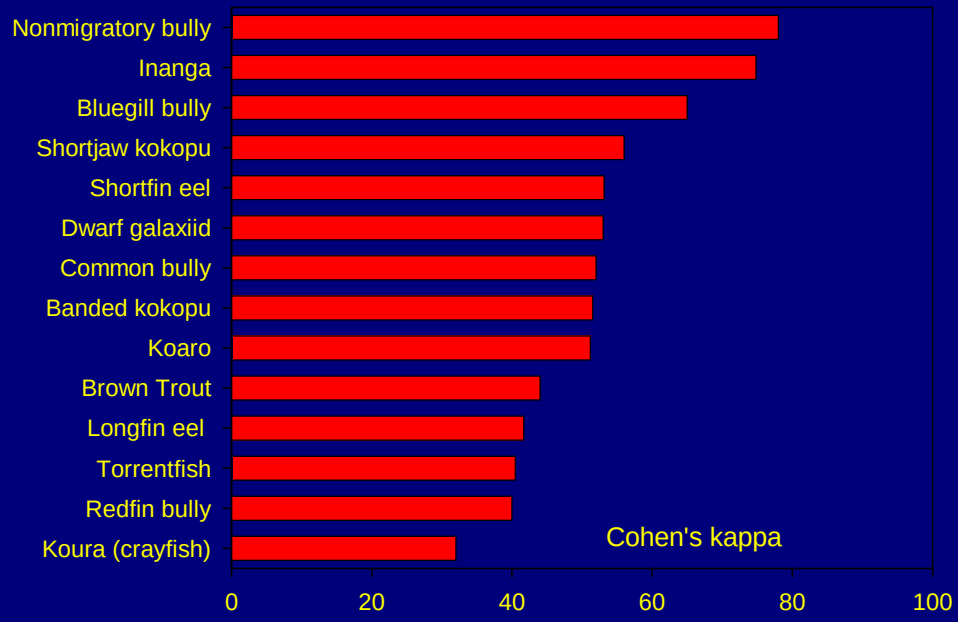

Input layer
Hidden layer
Output layer
Elevation
Distance from sea
Native landuse
Farming landuse
Geology
Annual rainfall
Temperature
Latitude
Bias
Redfin bully
Longfin eel
Bluegill bully
Banded kokopu
Brown trout
Shortfin eel
Smelt
Koaro
Bias

# Evaluating and tuning the neural network model

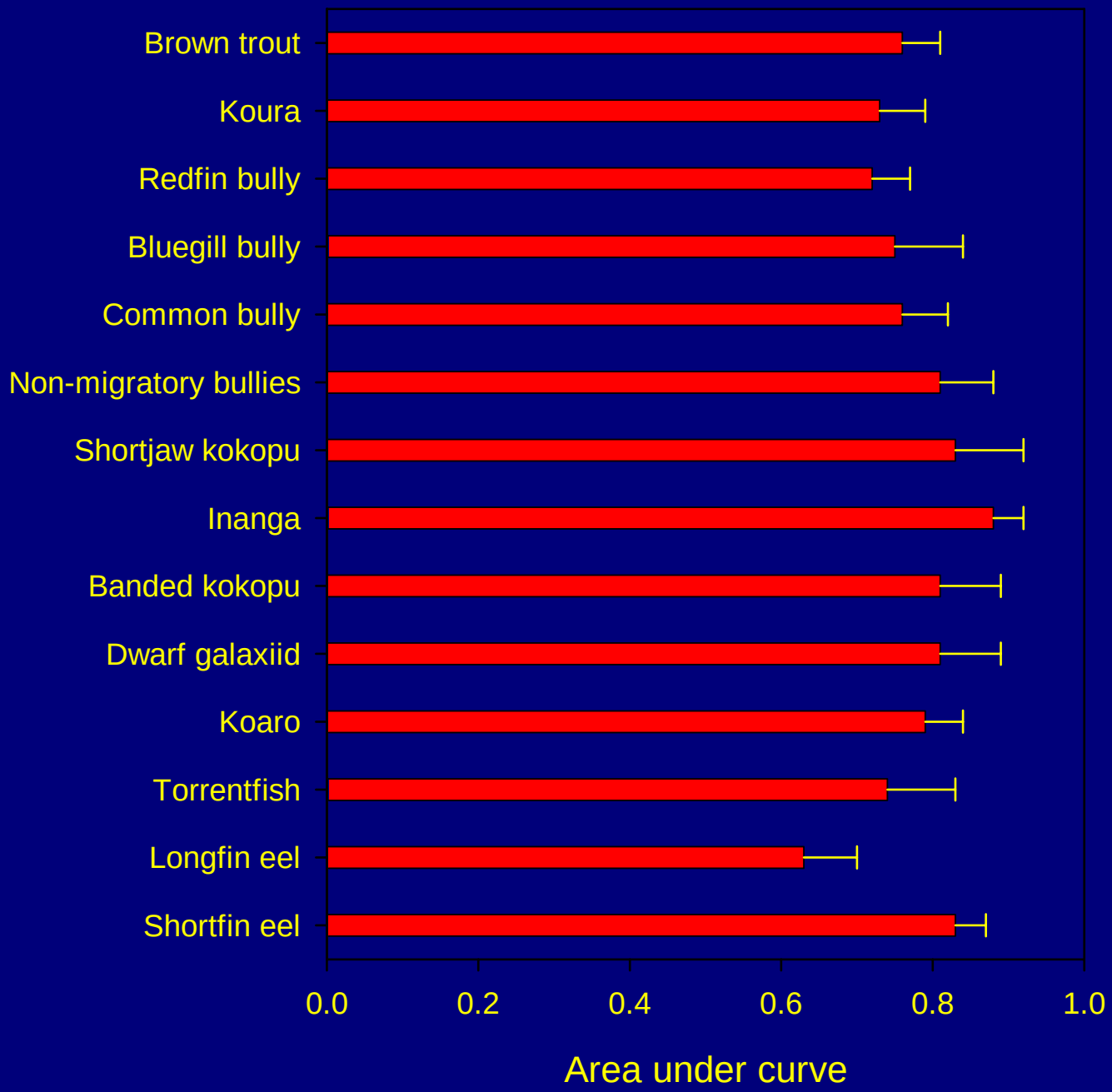
Jack-knife (leave one out)

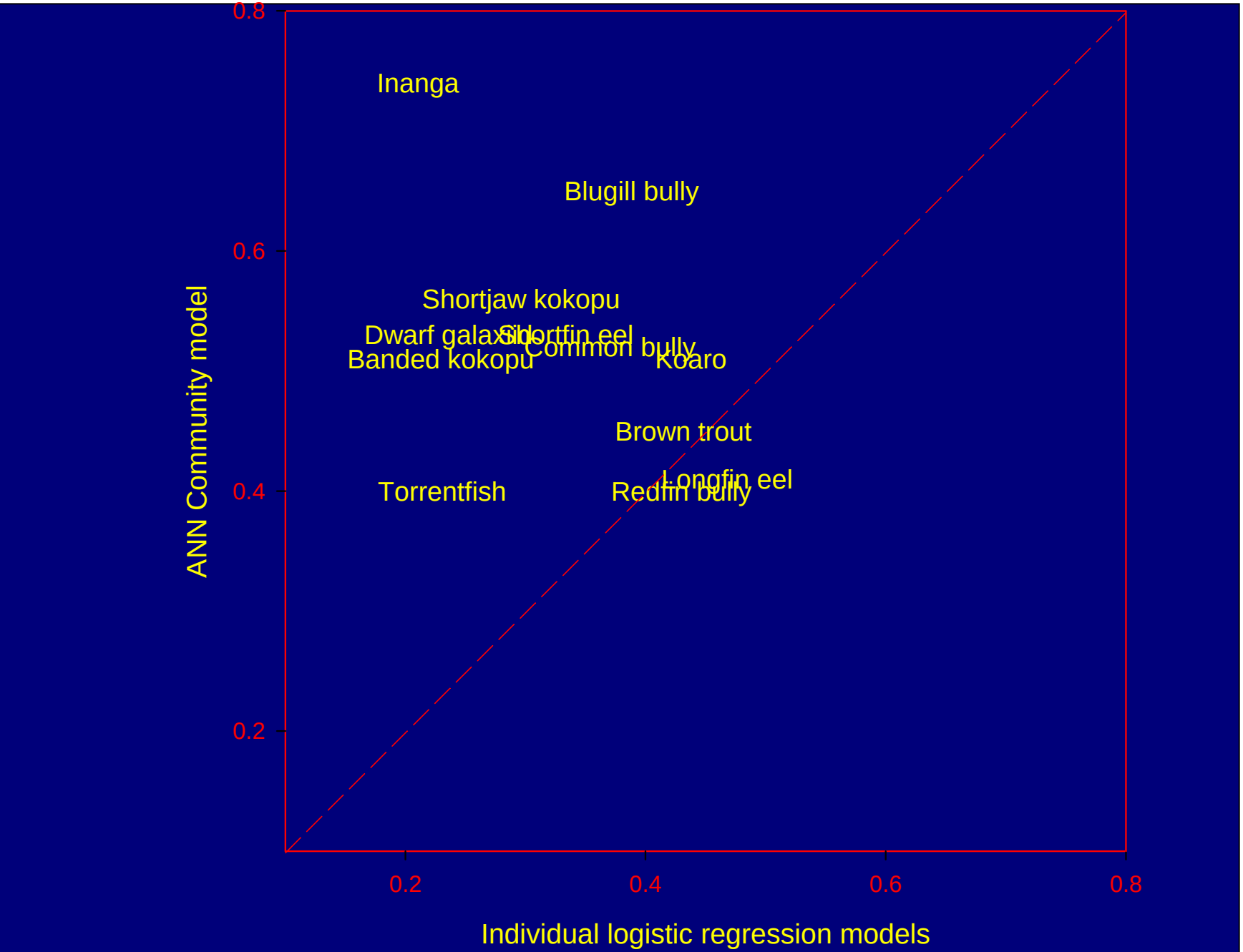
- Optimize model architecture
- Model evaluation
- Chance corrected evaluation
  Cohen's kappa




Nonmigratory bully
Inanga
Bluegill bully
Shortjaw kokopu
Shortfin eel
Dwarf galaxiid
Common bully
Banded kokopu
Koaro
Brown Trout
Longfin eel
Torrentfish
Redfin bully
Koura (crayfish)
Cohen's kappa
0
20
40
60
80
100

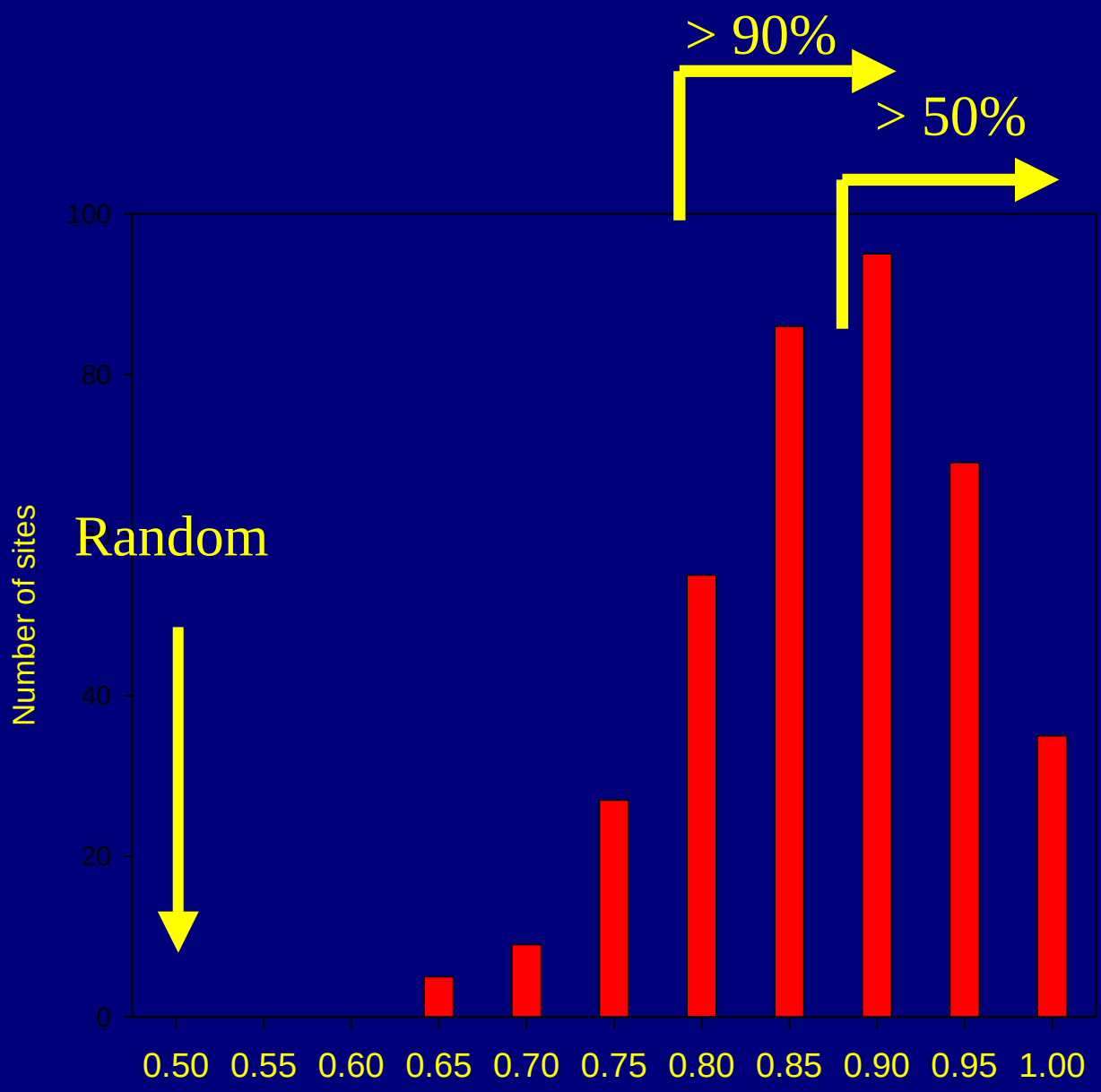

Shortjaw kokopu
Dwarf galaxid
Bluegill bully
Torrentfish
Nonmigratory bully
Inanga
Banded kokopu
Common bully
Koaro
Shortfin eel
Longfin eel
Koura (crayfish)
Brown trout
Redfin bully
0
20
40
60
80
100
Correct classification


Brown trout
Koura
Redfin bully
Bluegill bully
Common bully
Non-migratory bullies
Shortjaw kokopu
Inanga
Banded kokopu
Dwarf galaxiid
Koaro
Torrentfish
Longfin eel
Shortfin eel
0.0
0.2
0.4
0.6
0.8
1.0
Area under curve


0.8
0.6
0.4
0.2
ANN Community model
Inanga
Blugill bully
Shortjaw kokopu
Dwarf galaxias
Shortfin eel
Common bully
Banded kokopu
Koaro
Brown trout
Longfin eel
Torrentfish
Redfin bully
0.2
0.4
0.6
0.8
Individual logistic regression models

# Validation

- Comparing observed and expected taxa lists:
- species by species
- or site by site (assemblage by assemblage)


> 90%
> 50%
Random
Number of sites
100
80
40
20
0
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
1.00
Simple matching coefficient (percentage similarity) between observed and expected assemblages

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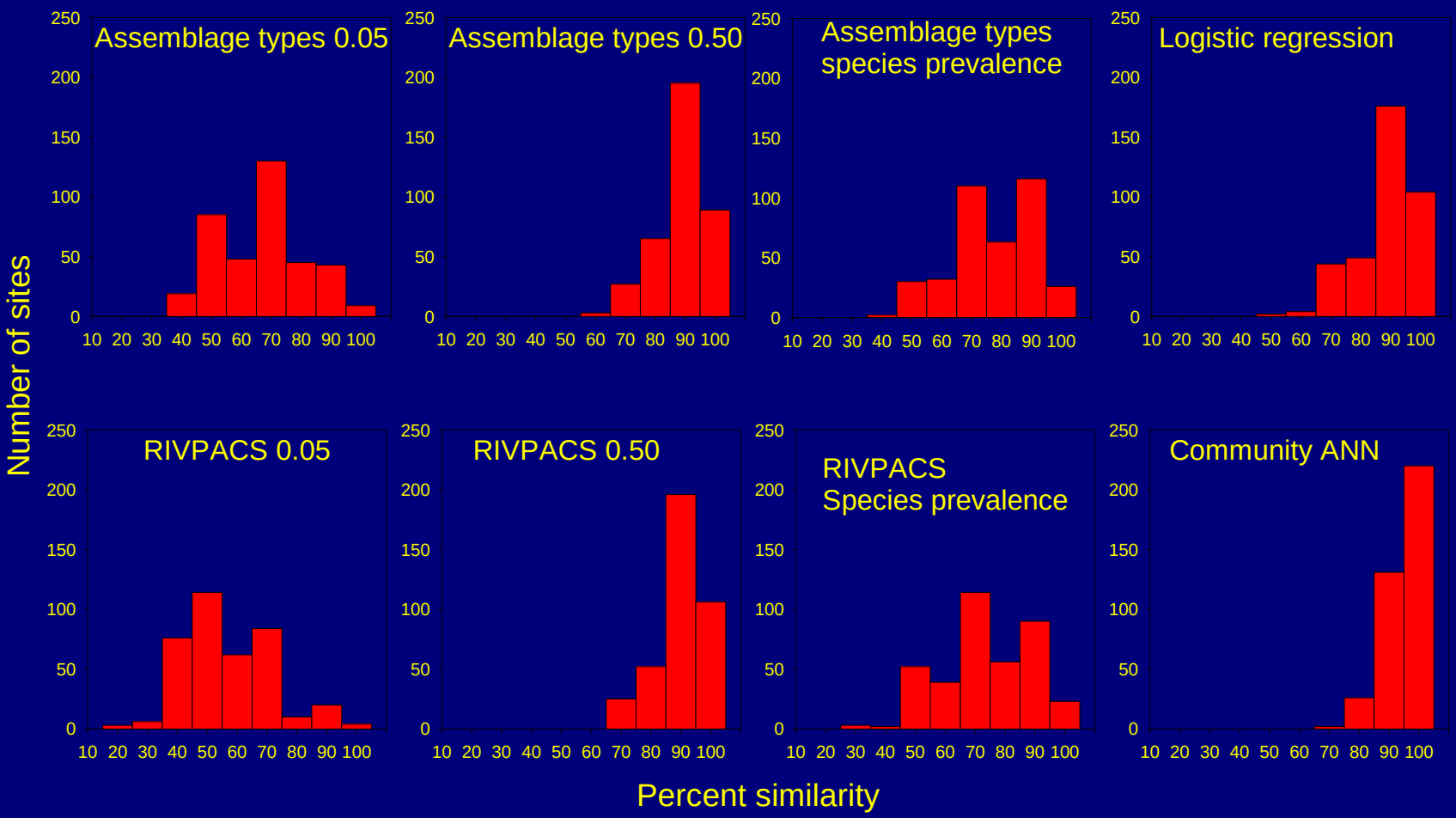


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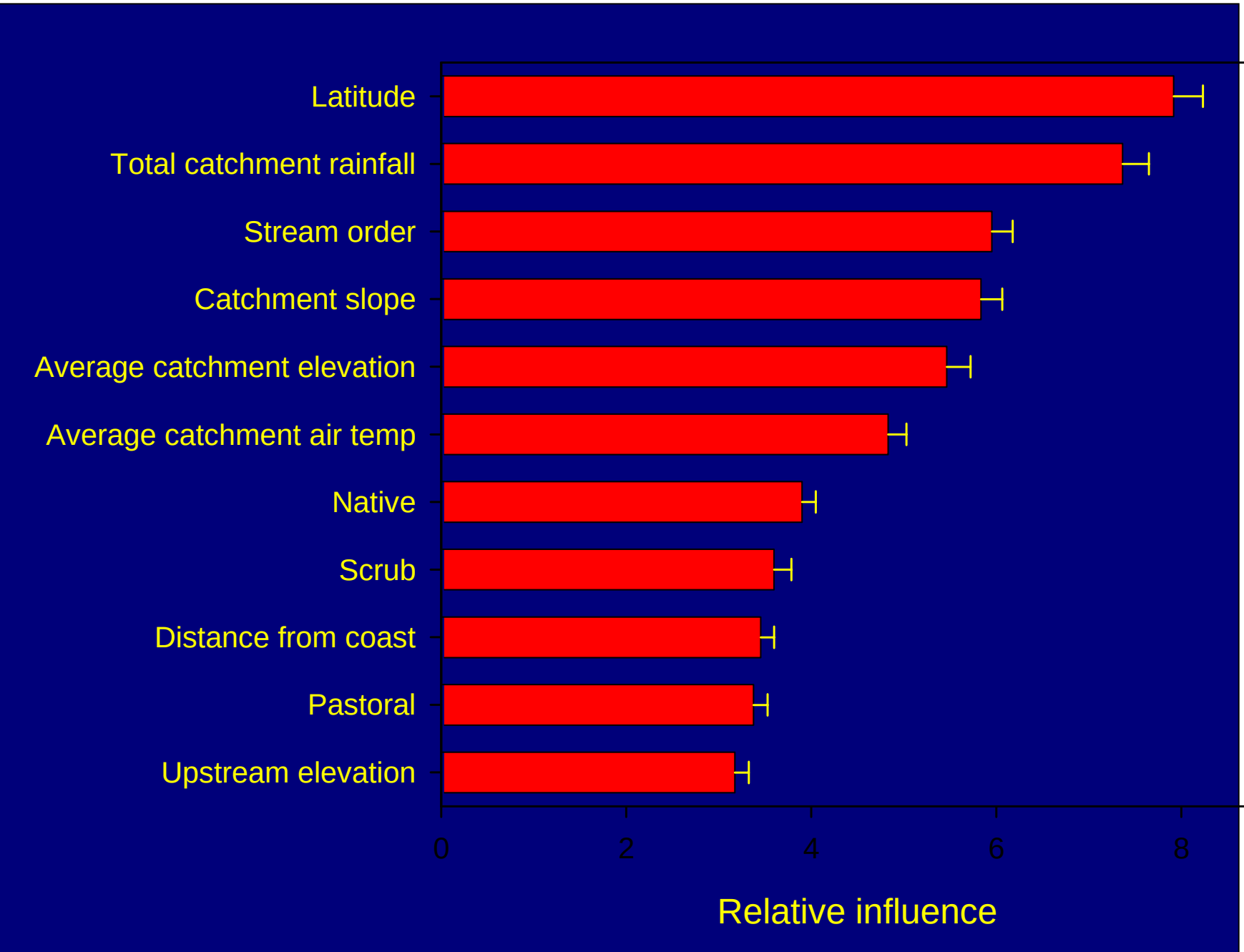
# Important predictor variables

- The connection weights between variables and layer weights indicate the strength of its influence
- The variables with the most influence on predicting the whole assemblage



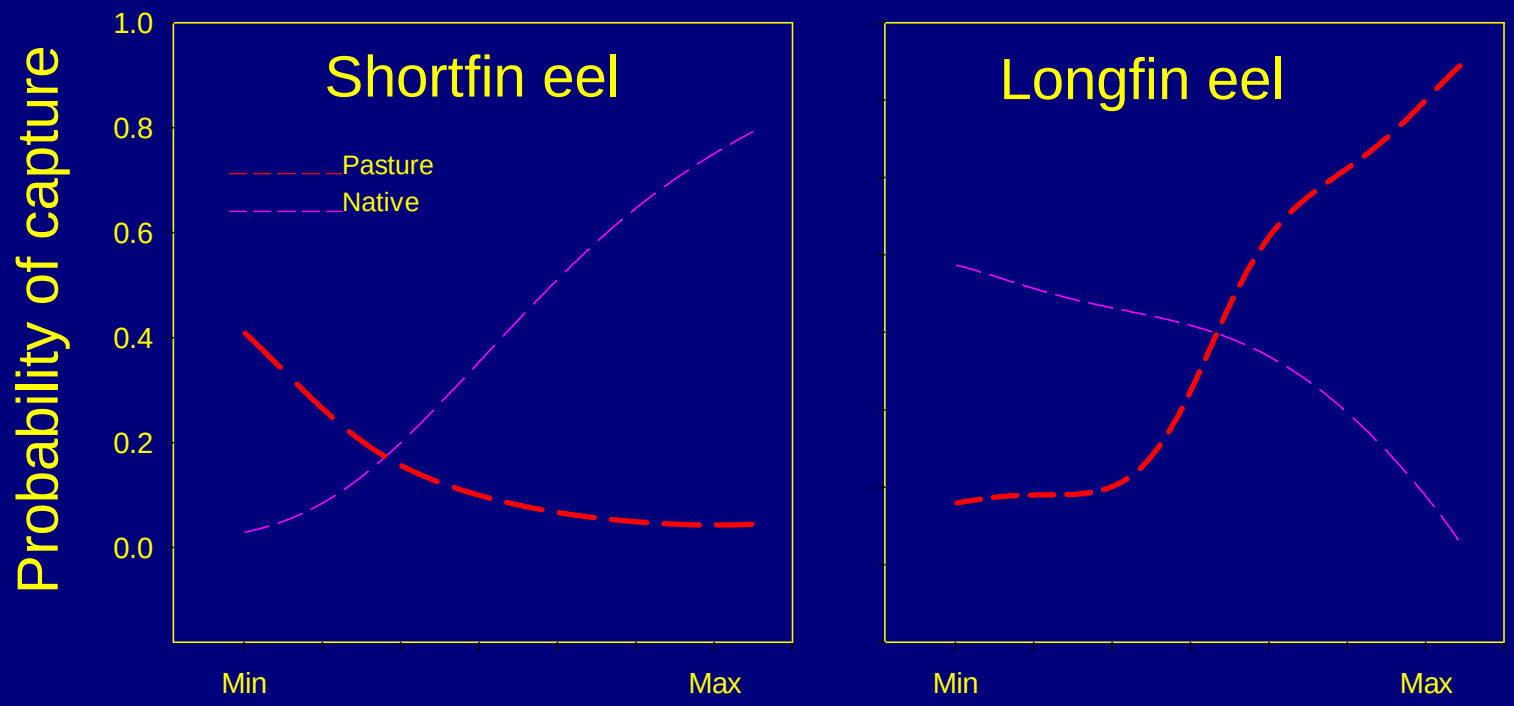

Latitude
Total catchment rainfall
Stream order
Catchment slope
Average catchment elevation
Average catchment air temp
Native
Scrub
Distance from coast
Pastoral
Upstream elevation
0
2
4
6
8
Relative influence

# Important predictor variables

- Sensitivity analysis is used to measure how any variable of influence influences any of the taxa
- Hold all variables except x at their mean values and then vary x through its full range and plot the response



# Influence of landuse from sensitivity analysis



# Extending predictions

- Data from a new site can be entered into model and predictions made about the expected fauna
- Or do the lot in one hit …>18,000 reaches



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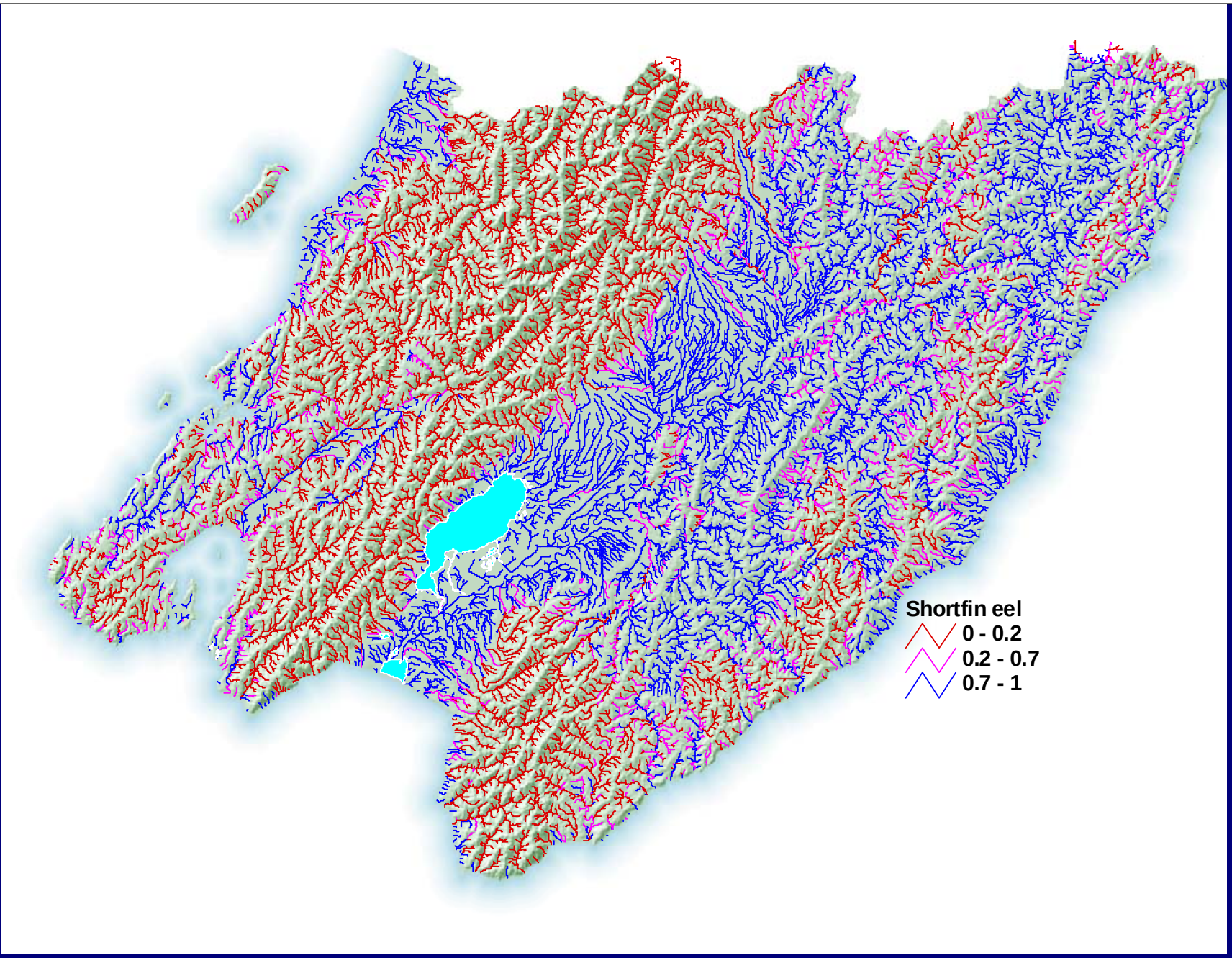


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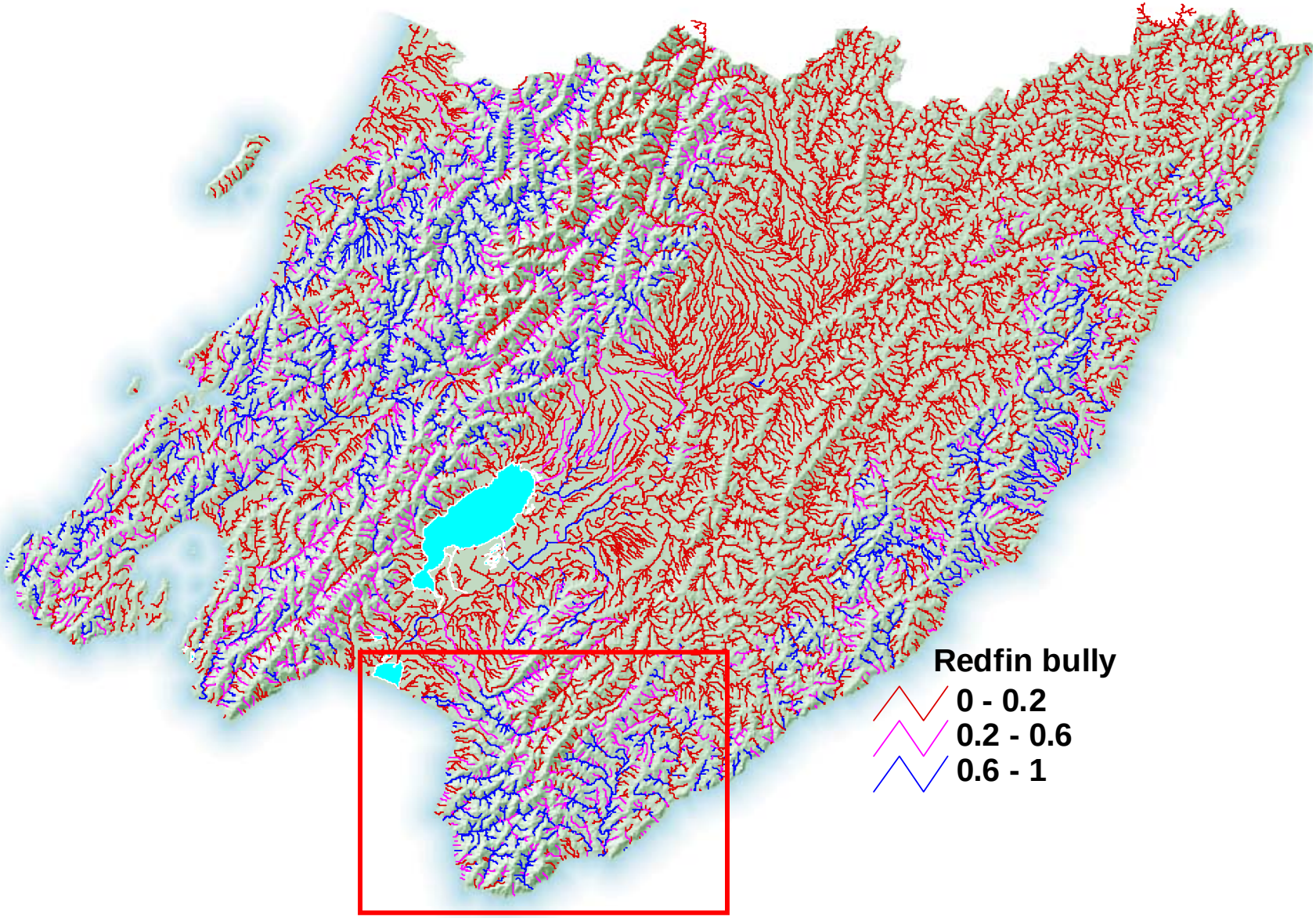
Redfin bully
0 - 0.2
0.2 - 0.6
0.6 - 1

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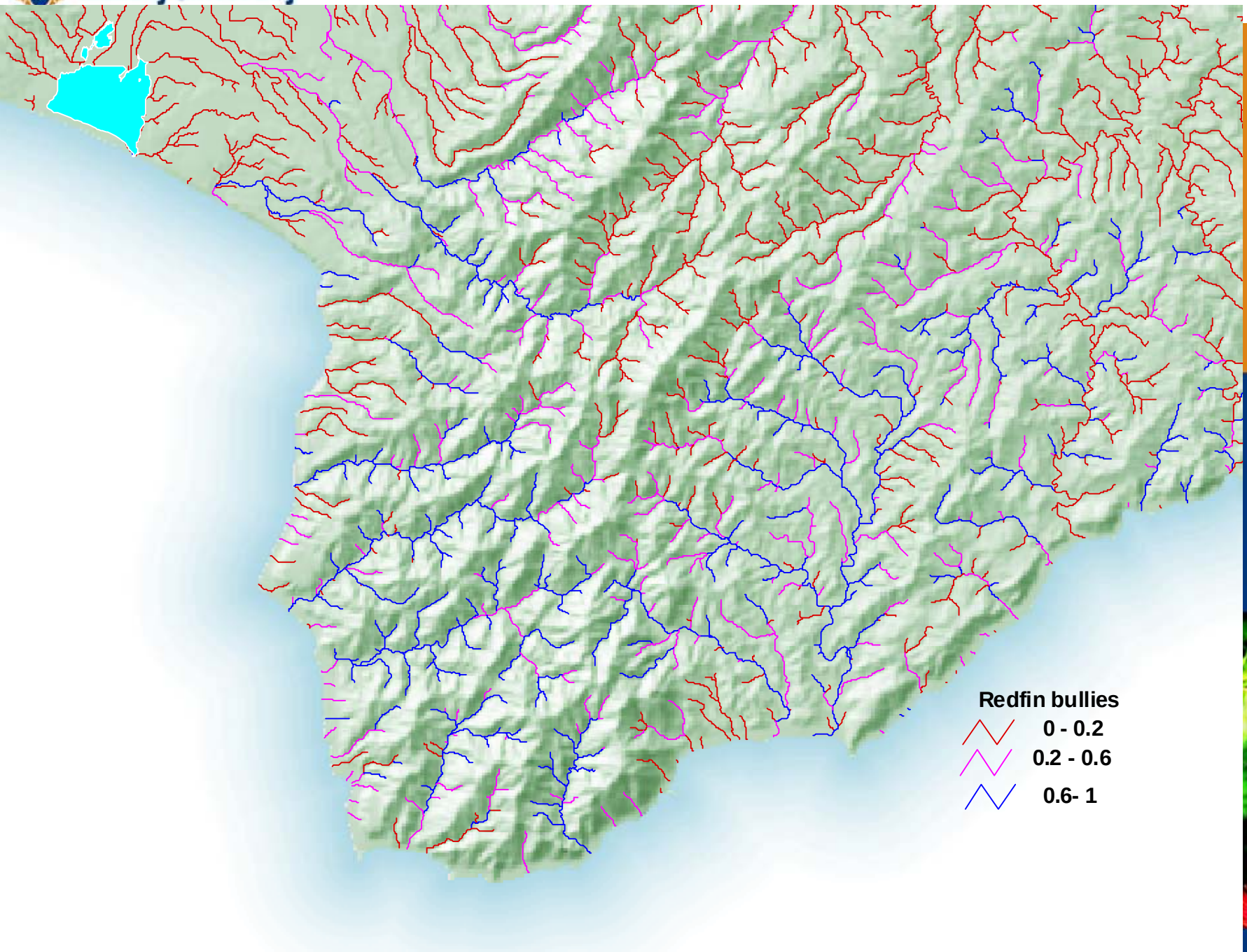


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# Potential for prediction maps

- used as a resource management tool by three regional councils in New Zealand
- conservation tool: finding gaps in species distribution; locating sites for potential releases
- Predicting expansion of exotic species ranges
- Bioassessment



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Quality for Life

greater WELLINGTON THE REGIONAL COUNCIL | Environment

# Greater Wellington's freshwater fish favourites

## Inanga

Twenty two native freshwater fish species live in the rivers, lakes, and wetlands of the Greater Wellington Region. They are among the hidden treasures of New Zealand's plant and animal life because they are seldom seen and we know very little about most of them. The more we find out, the more New Zealander's are realising what a valuable part of our heritage they are.

This information sheet is one of a series about freshwater fish found in the Greater Wellington Region. To find out more, we recommend you go to our website www.gw.govt.nz or the website for the National Institute of Water and Atmospheric Research www.niwa.cri.nz.

### Inanga – more than a fritter

Inanga are well known to New Zealanders' in their juvenile form as whitebait. There are other native species in the whitebait run but Inanga make up most of the catch – up to 95%. The adults grow to around 100mm and can be easily distinguished from the adults of other native fish in the whitebait run by their silver bellies and forked tail.

### Where do Inanga live?

Inanga are found throughout New Zealand and its offshore islands, and they occur in South America and Australia. They inhabit open rivers, streams, lakes, and wetlands and can often be seen shoaling in open water, especially at breeding time.

In Greater Wellington we have found Inanga in larger rivers of the Region like the Ruamahanga, Pahoa, Hutt, Otaki and Waikanae.


Rivers and streams of Greater Wellington with suitable habitat for Inanga

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# Acknowledgements


- Murray McLea (Wellington Regional Council)
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