LAND & WATER SCIENCE

Physiographic Environments of New Zealand:

"The missing link to better target on-farm practices to address water quality?"

CLINT RISSMANN, LISA PEARSON, JESSIE LINDSAY & MATT COULDREY

OUR LAND AND WATER
Toitū te Whenua, Toiora te Wai
National SCIENCE Challenges
Lincoln University
UC University of Canterbury
Waterways Centre for Freshwater Management

Paradigm shift(?): Linking Water to the Landscape, not the Landscape to Water

"Letting the water tell the story – source of truth"

Why?

“Why, given similar land use pressures does water quality vary significantly in space (stream, aquifer, catchment, region)?”

*Landscape most important

*State and Trend

*Limitations of numerical models

*One size does not fit all

* Land use change

National and International Research

Unfavourable water quality outcomes are caused by anthropogenic land use

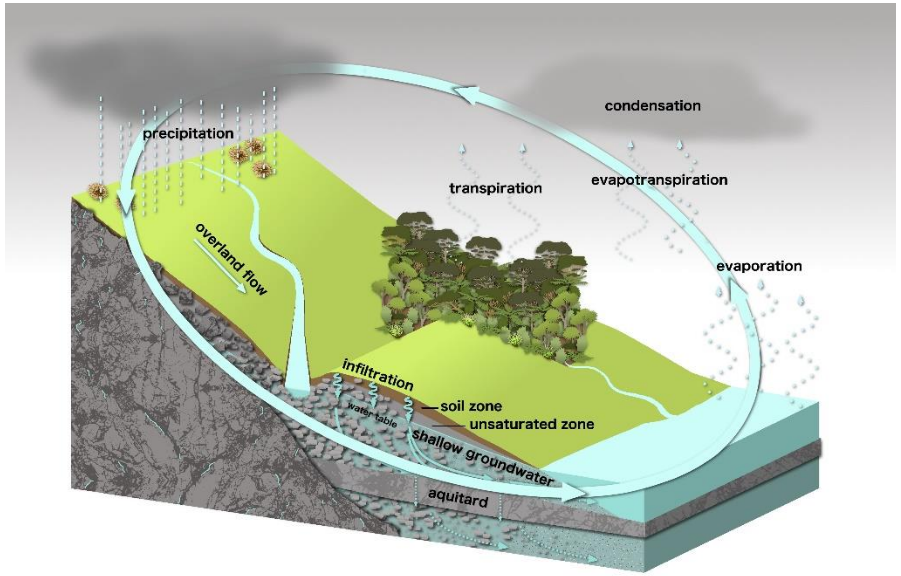
<u>However</u>:

Majority of variation (>2 times) in water quality outcomes within space is driven by landscape attributes

- Outcome type
- Magnitude of outcome
- Especially true of New Zealand
  - Hard vs soft rock

Water Quality Outcomes Strongly Influenced by Landscape Attributes and Processes

Landscape **attributes** control the variation in **processes** that determine water composition:



All about the processes that determine water quality outcomes:

- **Atmospheric**
- **Hydrological**
- **Redox**
- **Weathering**

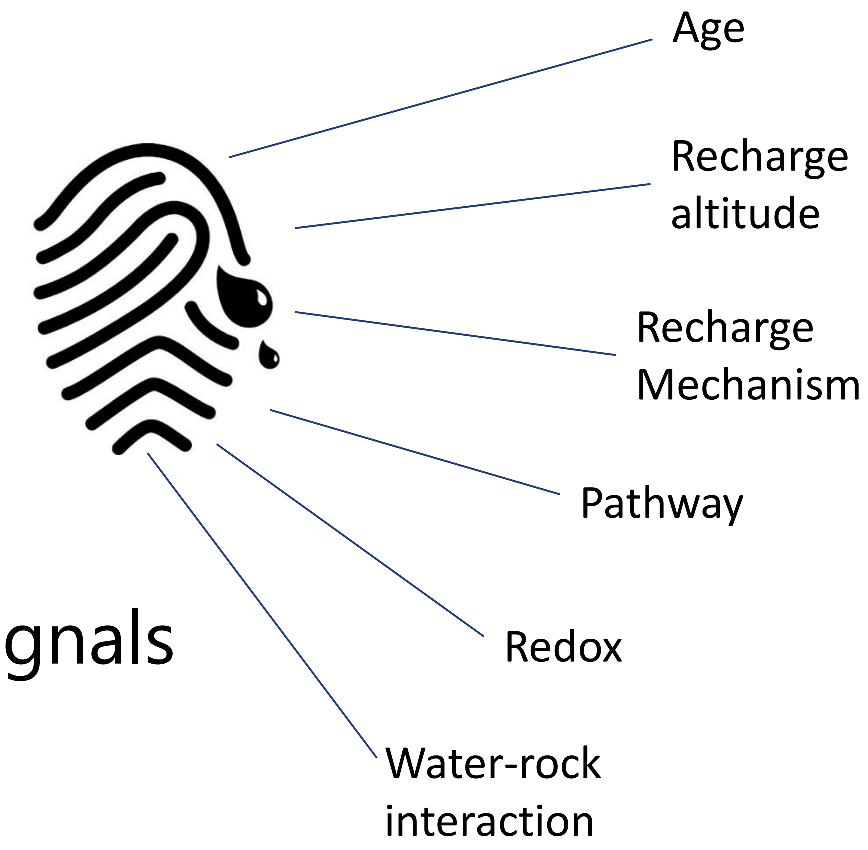
These processes occur in both natural state and areas of intensive land use.

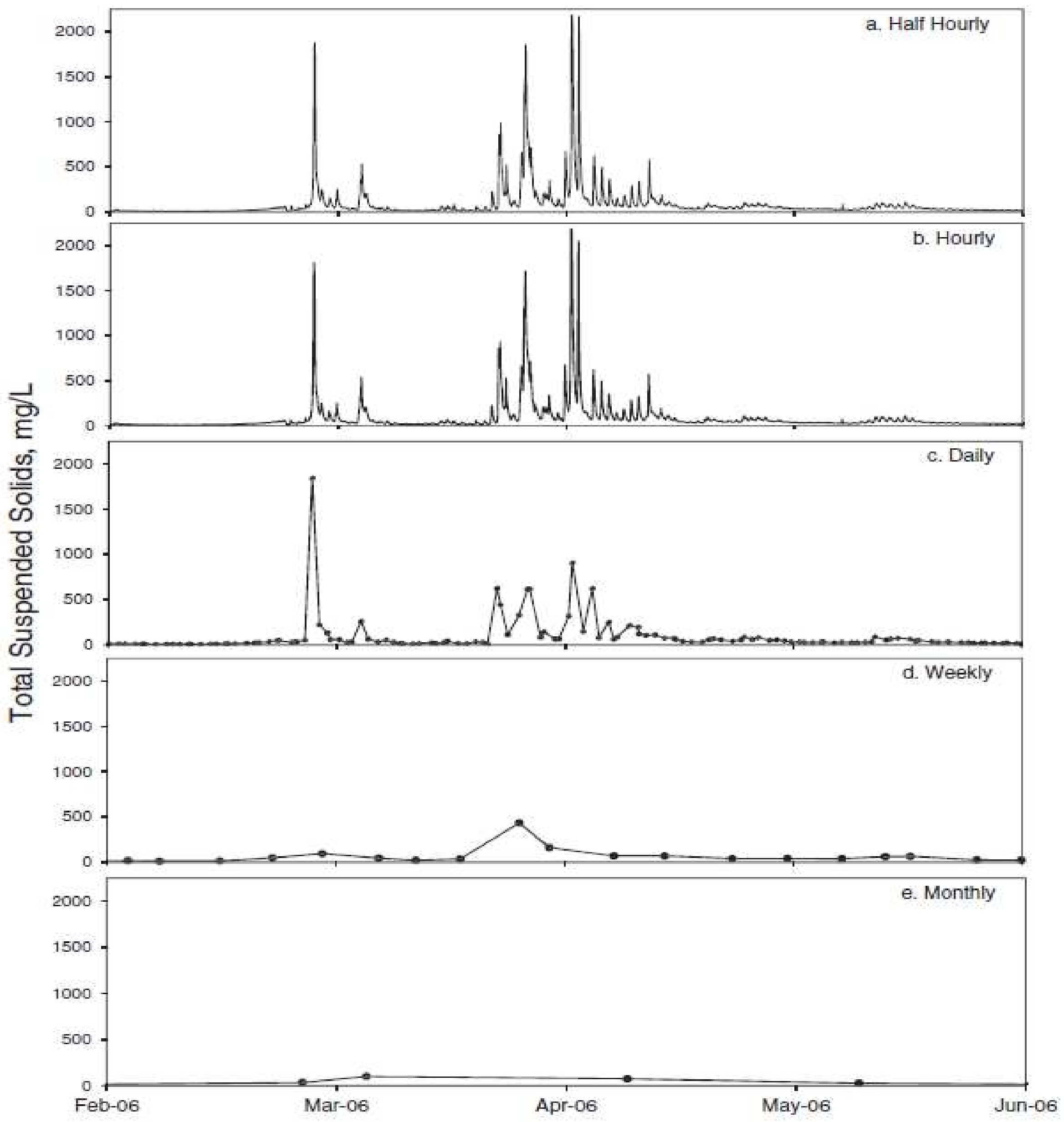
Globally recognised and documented– "Bermuda Triangle?"

Water contains lots of info (signals)

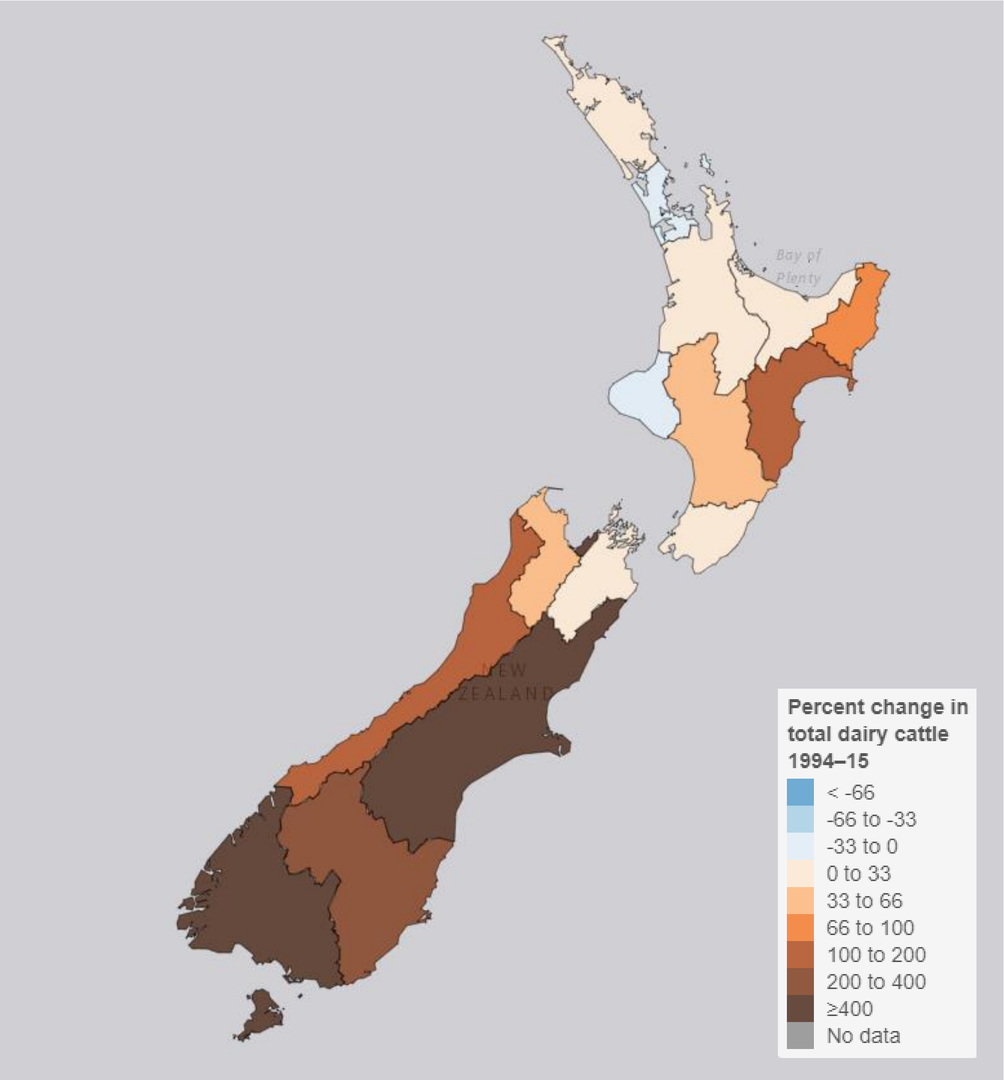
Forensic approach:

- Hydrological
- Redox
- Major ion facies
- Isotopic
- Saturation indices
- Physical and biological signals
  - Water Composition
    - **Not just N,P, Sed, M**





Jones et al., 2012



- Highest number of dairy cattle in 2015:
  - Waikato (1,761,949)
  - Canterbury (1,253,993)
  - Southland (731,209)
  - Taranaki (541,931)

- % increase of dairy cattle between 1994 and 2015:

  Southland - 539 percent (616,831)

  Canterbury - 490 percent (1,041,501)

  Otago - 368 percent (302,806)

Data Source: Stock numbers – StatsNZ

http://www.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Land/livestock-numbers

Fast Facts I

- **Initial concept developed at Environment Southland (Physiographics of Southland)**
  - Significant evolution since

- **Uses the signals in water to identify what is actually important in controlling water quality**
  - Not a top down risk model!
  - *Forensic* approach

- **Not an allocation framework**
  - Fundamental knowledge layer
  - Not a numerical model

- **Most accurate estimation of surface and ground water quality of any model applied in Southland…**
  - Surface and ground water
  - All GW N, P and M hotspots identified

Fast Facts II

- **Directly links land and water**
  Connects soil zone to shallow ground water and surface water
  - Beyond the root zone

- **Communicates 'how' and 'why' water quality varies in space**

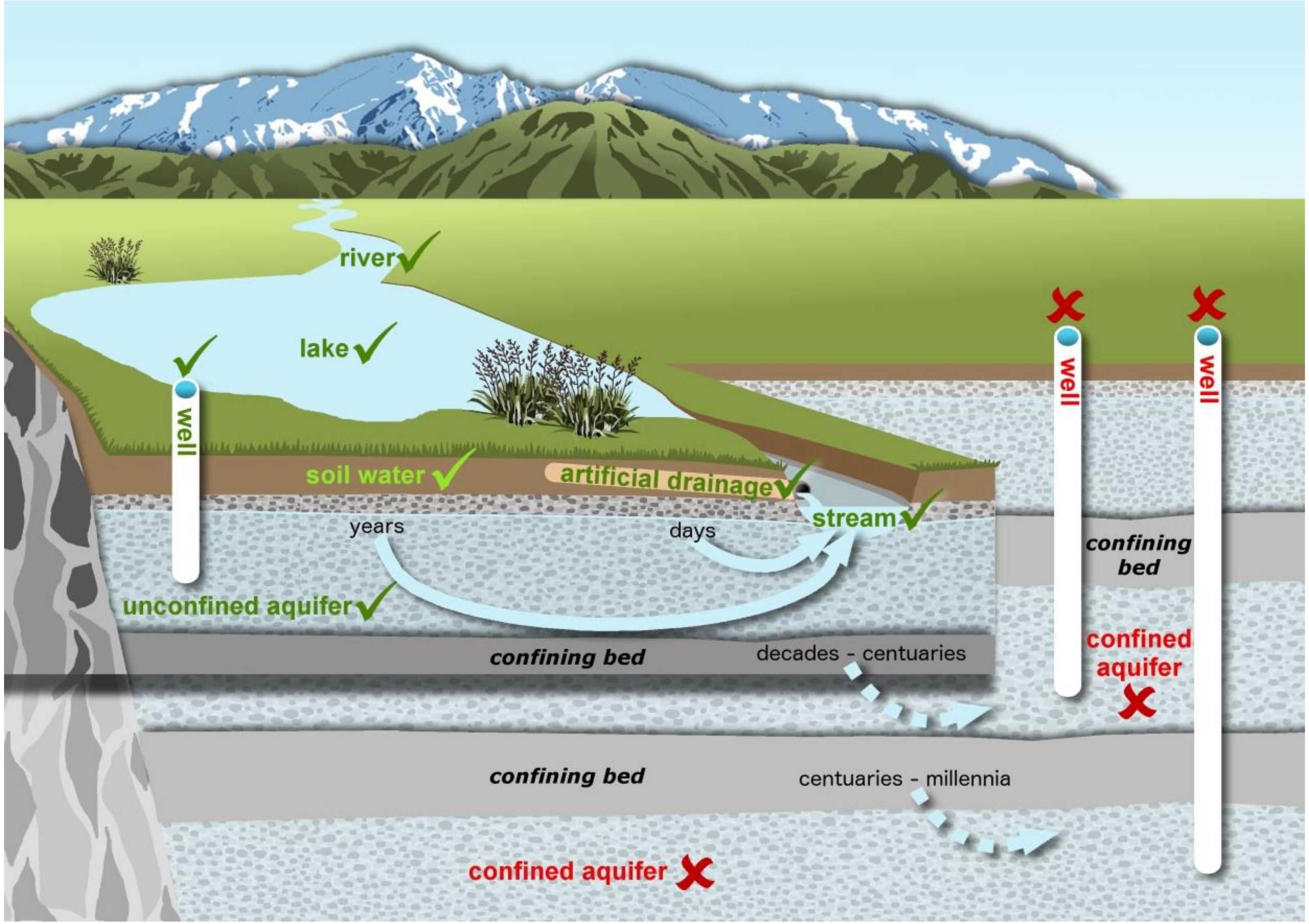
- **Utilises existing geospatial and water quality data**
  - Incorporates extra measures of water
  - Process based – **not a 'black box'**

- **With fine flow path modelling the work is providing paddock and sub-paddock scale resolution over water quality controls**
  - DOC-Fonterra, Living Waters
  - SFF

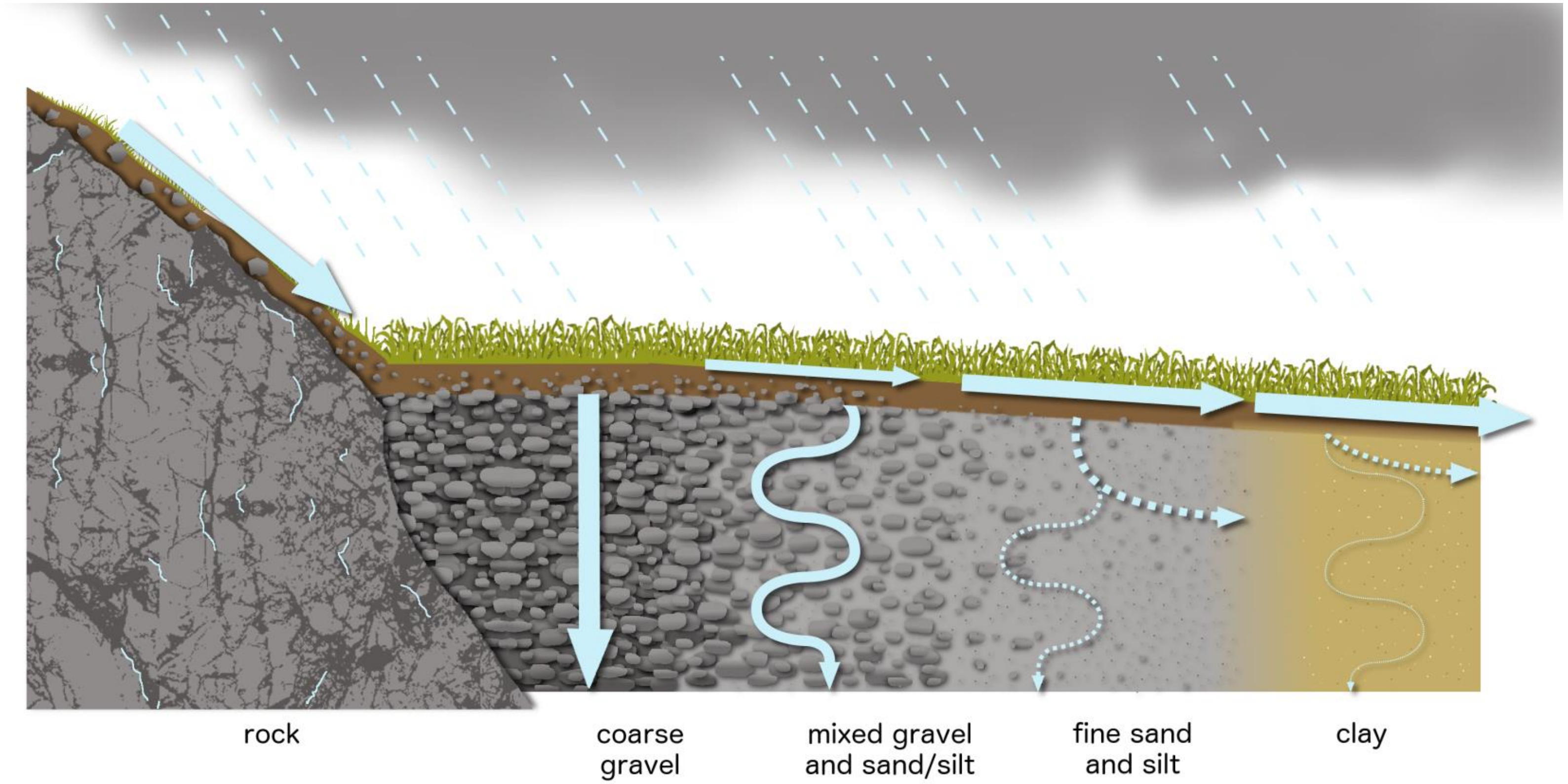
- **Recognises the uniqueness of a given land parcel**

- **Our Land and Water National Science Challenge Project**

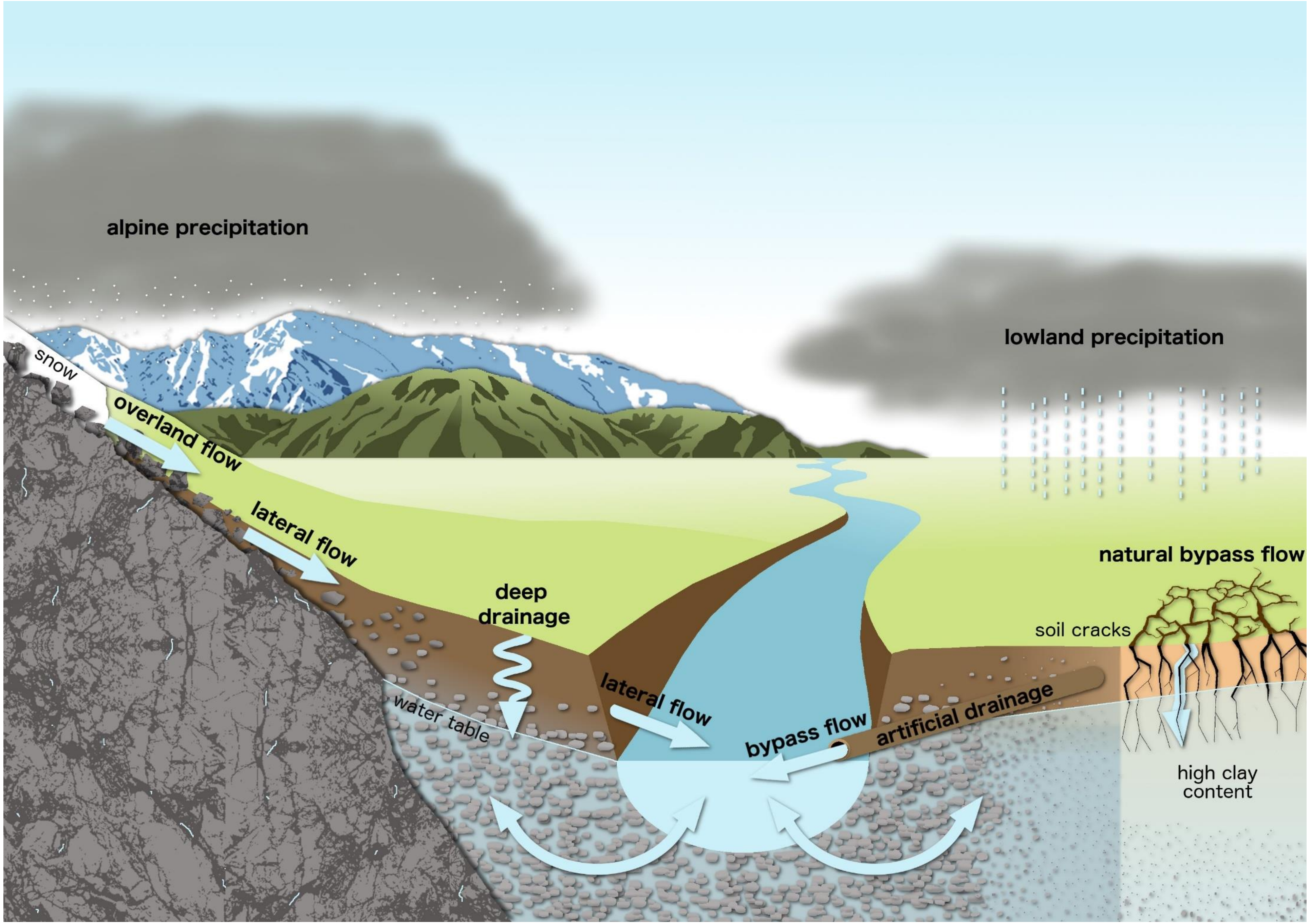
Domains of Interest



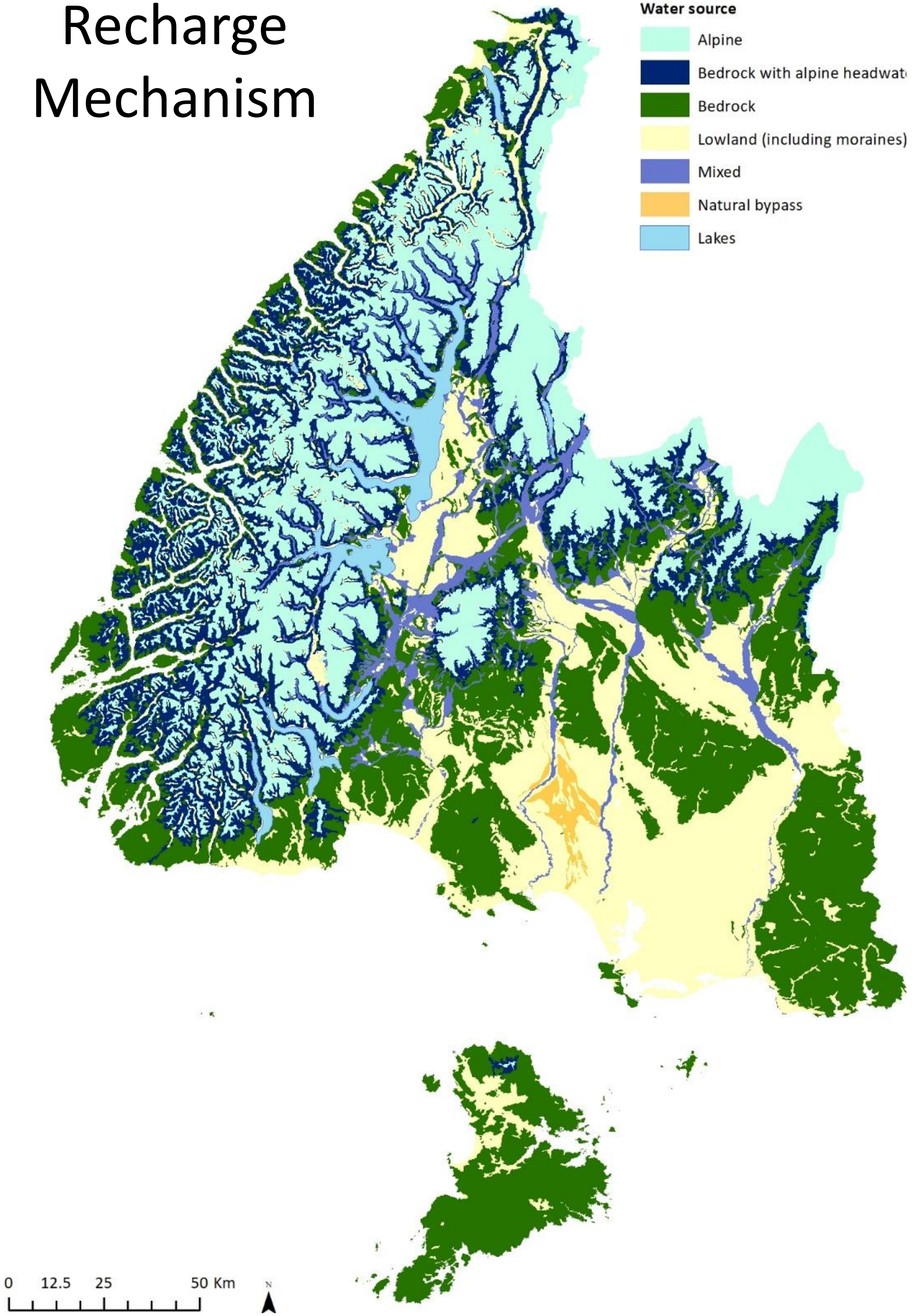
Hydrological Process-Attribute Gradient (H-PAL)



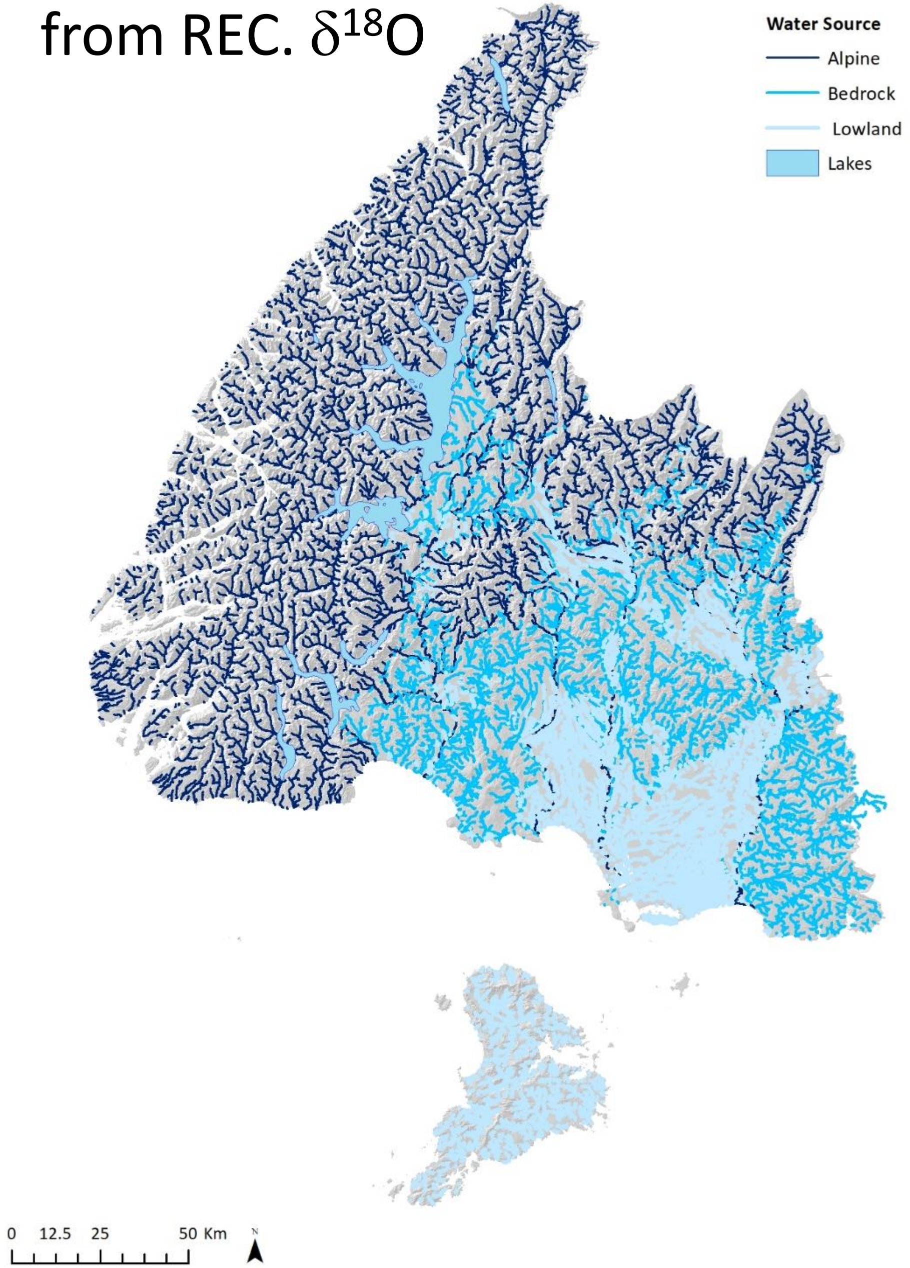
Landscape controls over water source, recharge mechanism and pathway.


alpine precipitation
lowland precipitation
snow
overland flow
lateral flow
deep drainage
water table
lateral flow
bypass flow
artificial drainage
natural bypass flow
soil cracks
high clay content

Recharge Mechanism

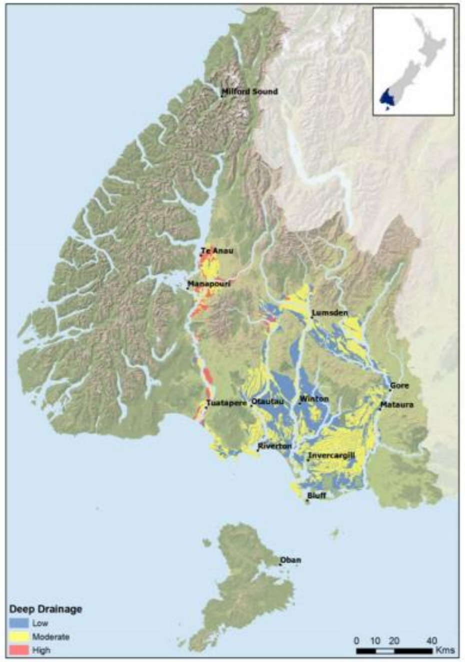


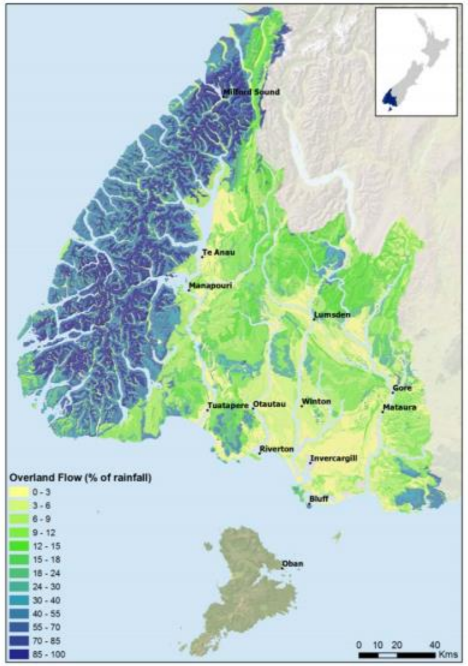
River network from REC. $\delta^{18}O$

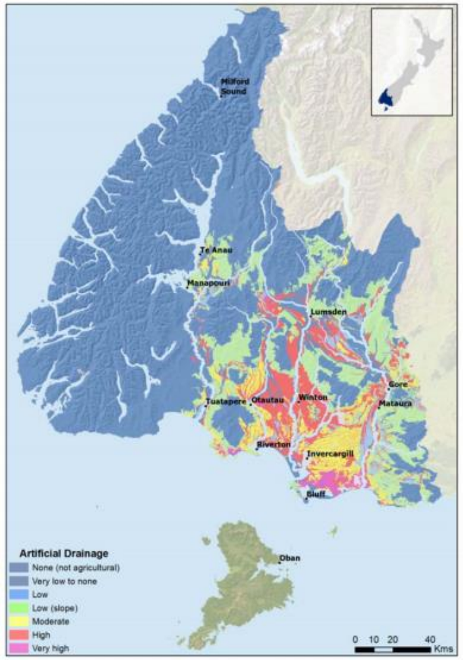


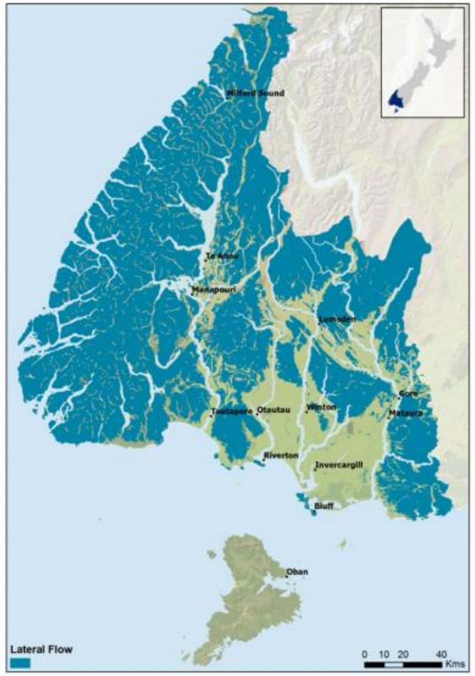
Water Pathway (Fine scale)

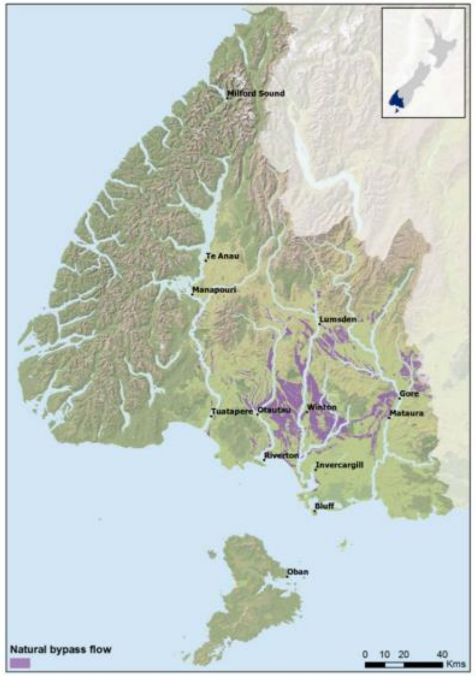
- Deep drainage
- Overland flow
- Artificial drainage
- Lateral flow
- Natural bypass

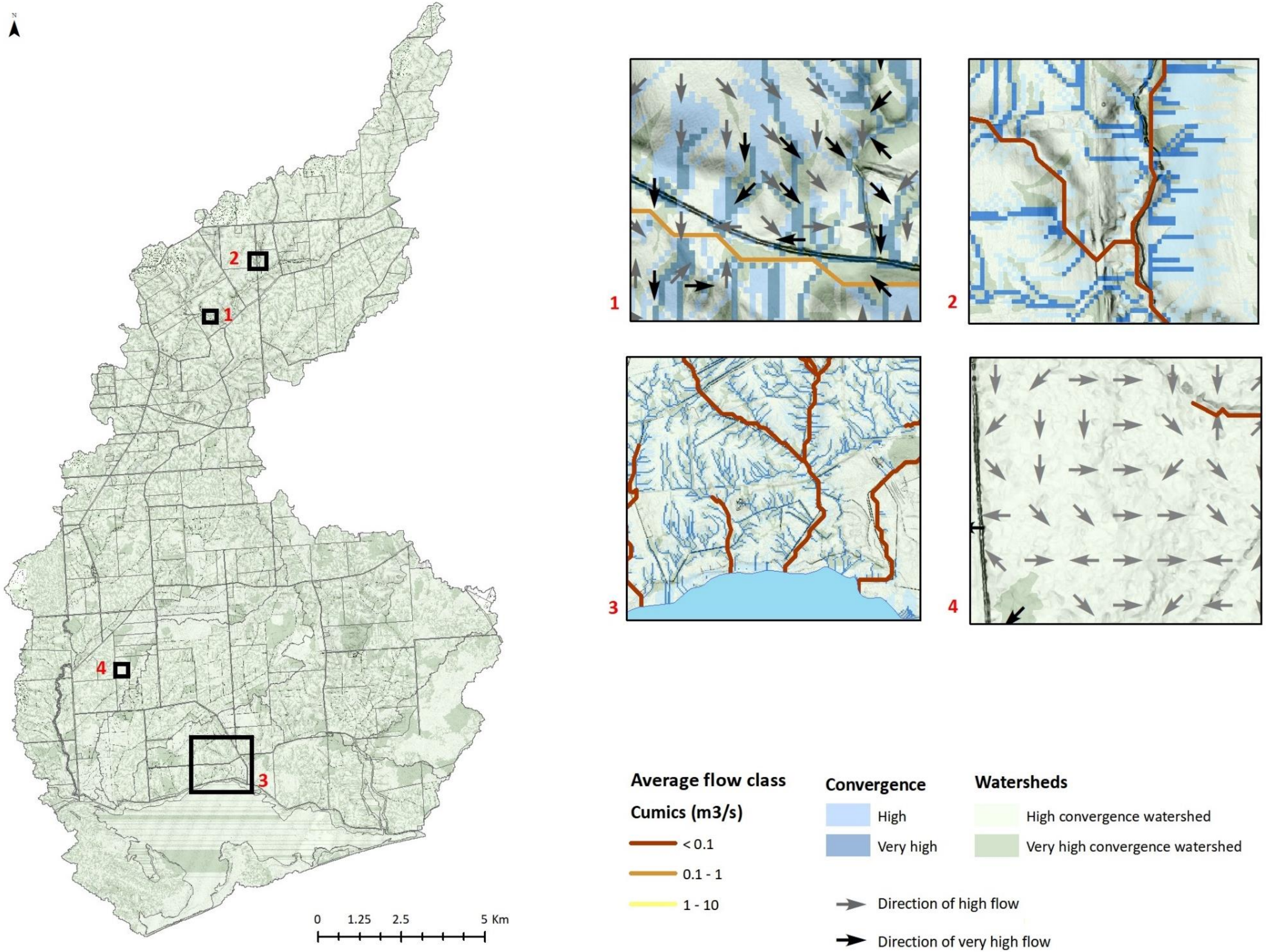








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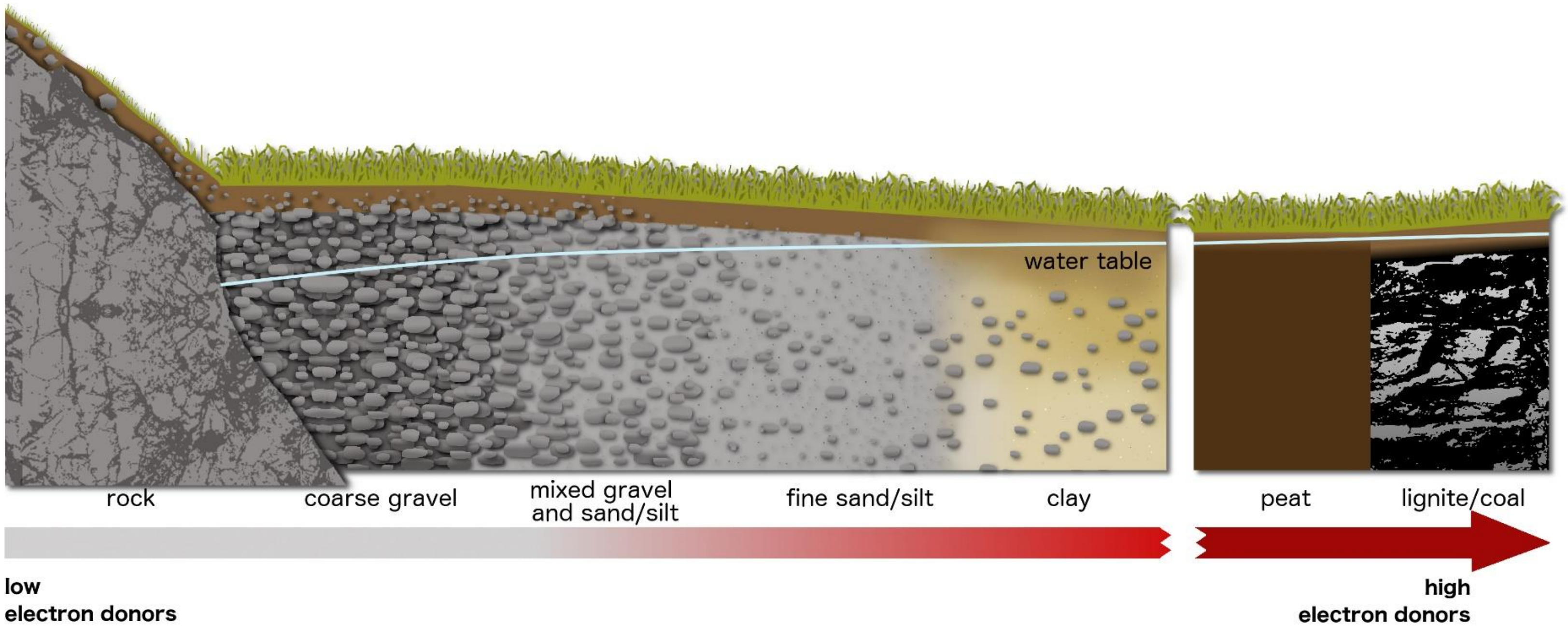
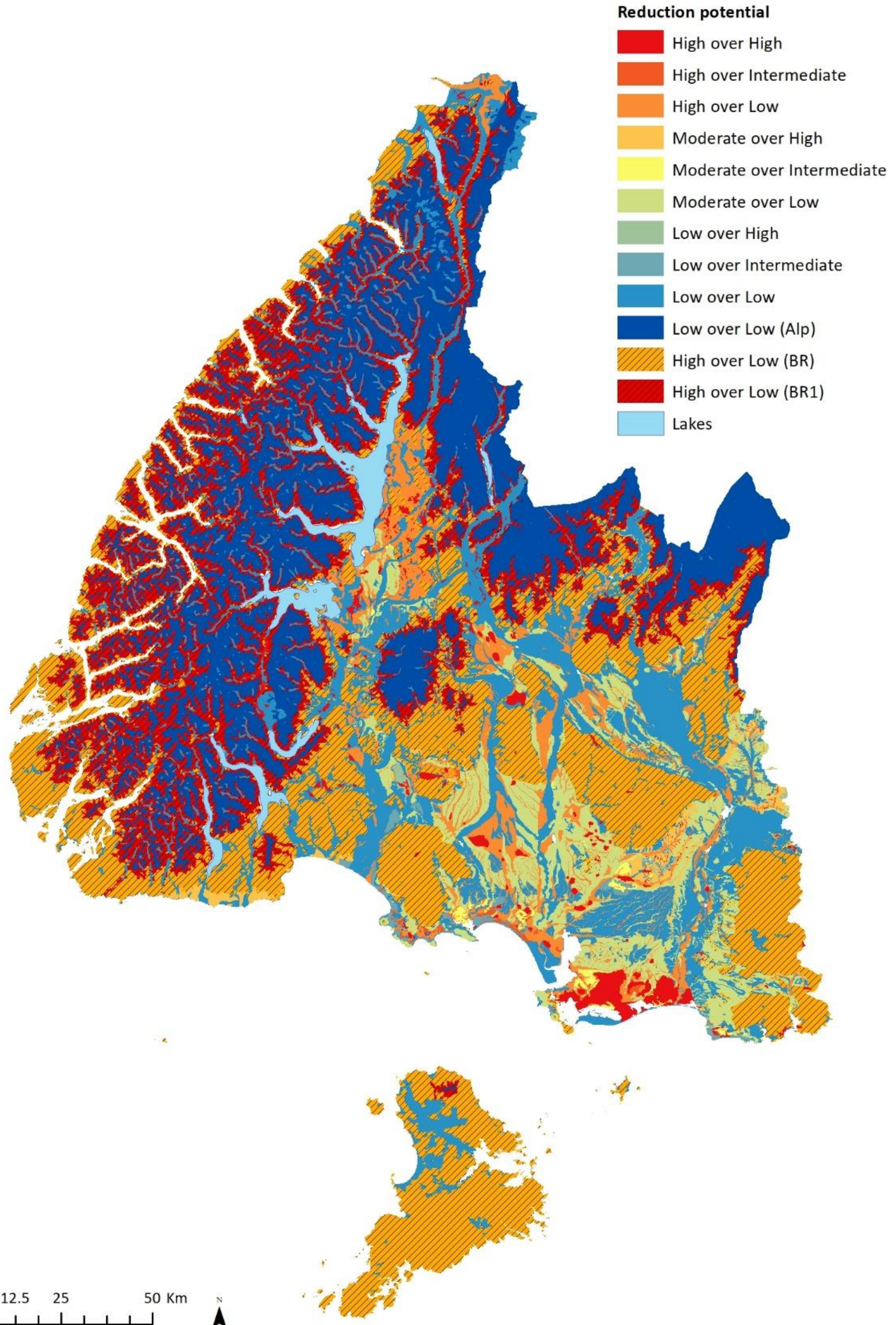
5 Km
Average flow class
Cumics (m3/s)
< 0.1
0.1 - 1
1 - 10
Convergence
High
Very high
Watersheds
High convergence watershed
Very high convergence watershed
Direction of high flow
Direction of very high flow

Redox Process-Attribute Layer (R-PAL)

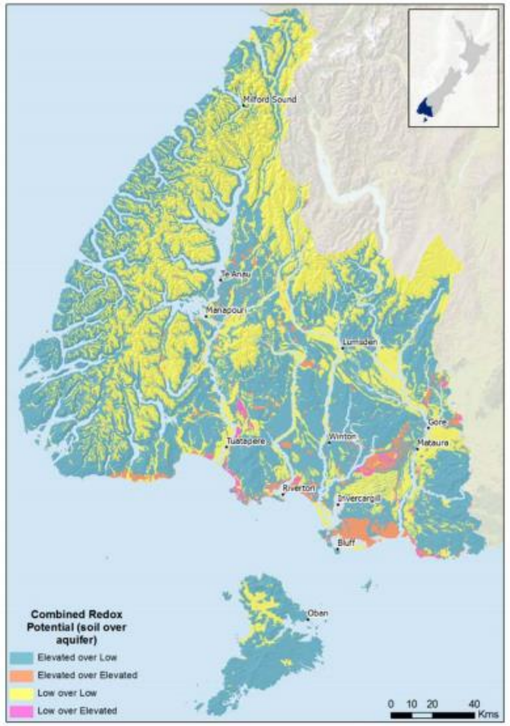


Soil and aquifer reduction potential
controls denitrification, the solubility, leachability
and mobility of redox sensitive species



Redox

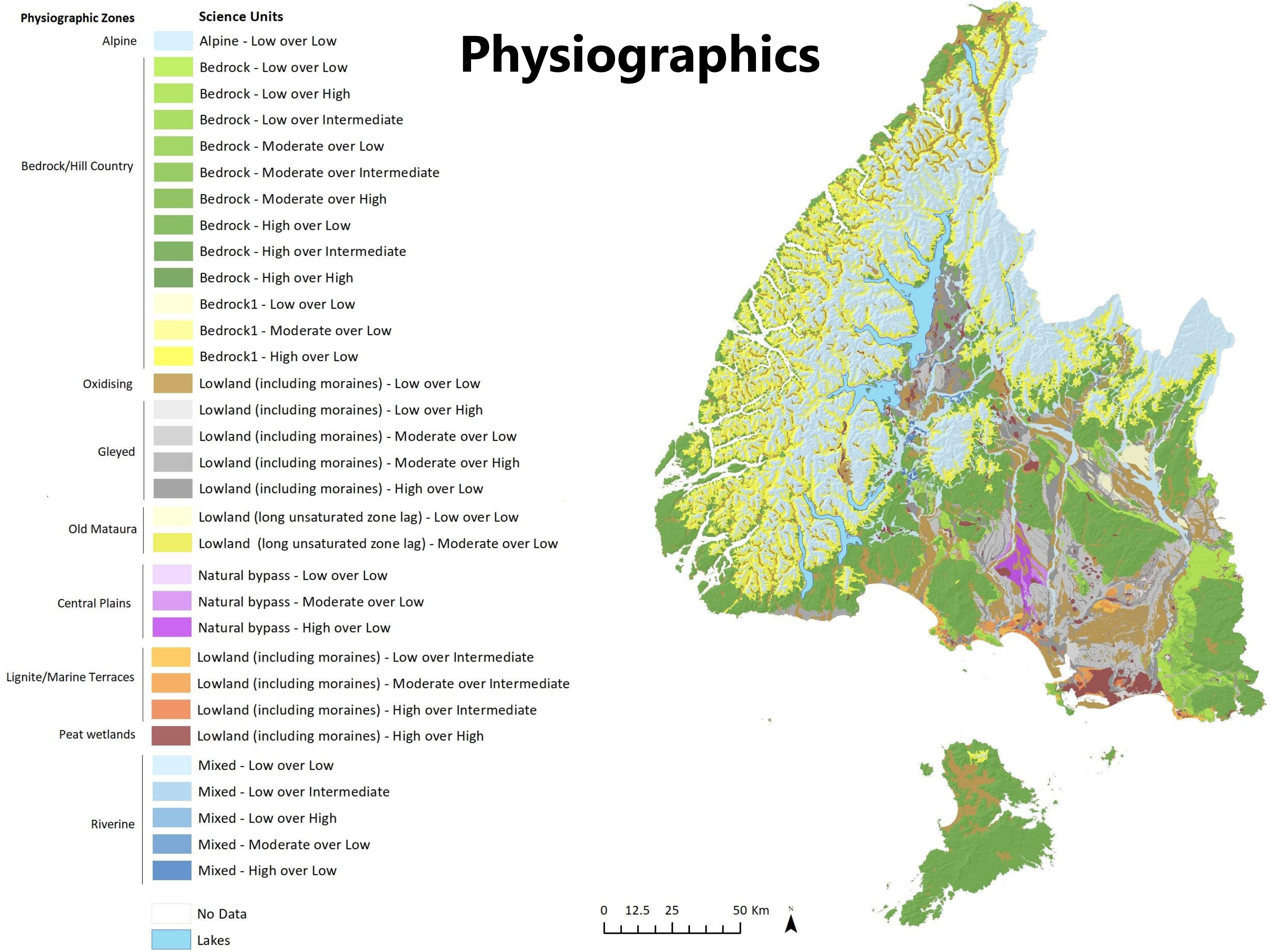
- Combined Reduction Potential
- Soil zone over aquifer

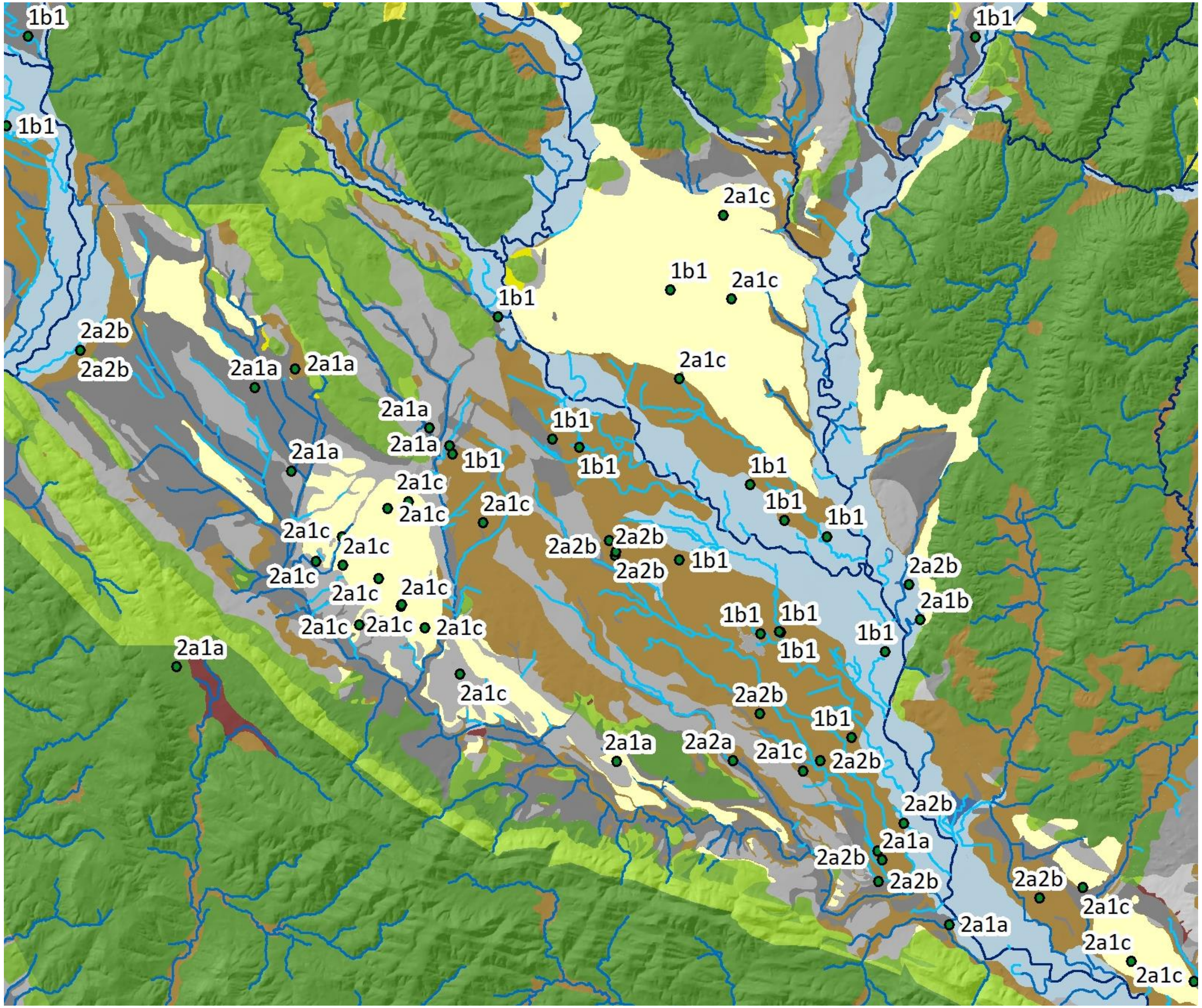


ES Policy layer less resolved

GIS Demo

Physiographics

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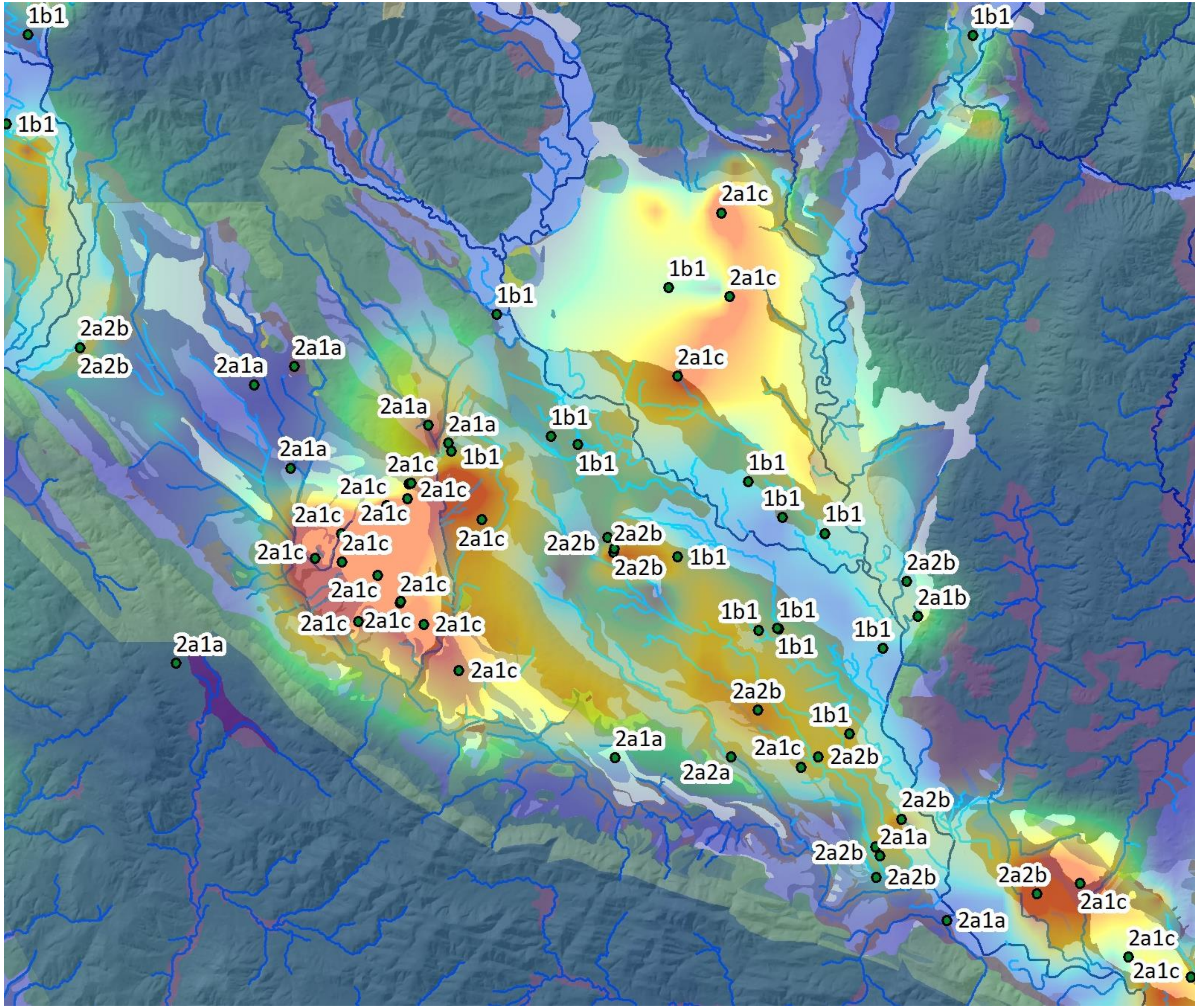

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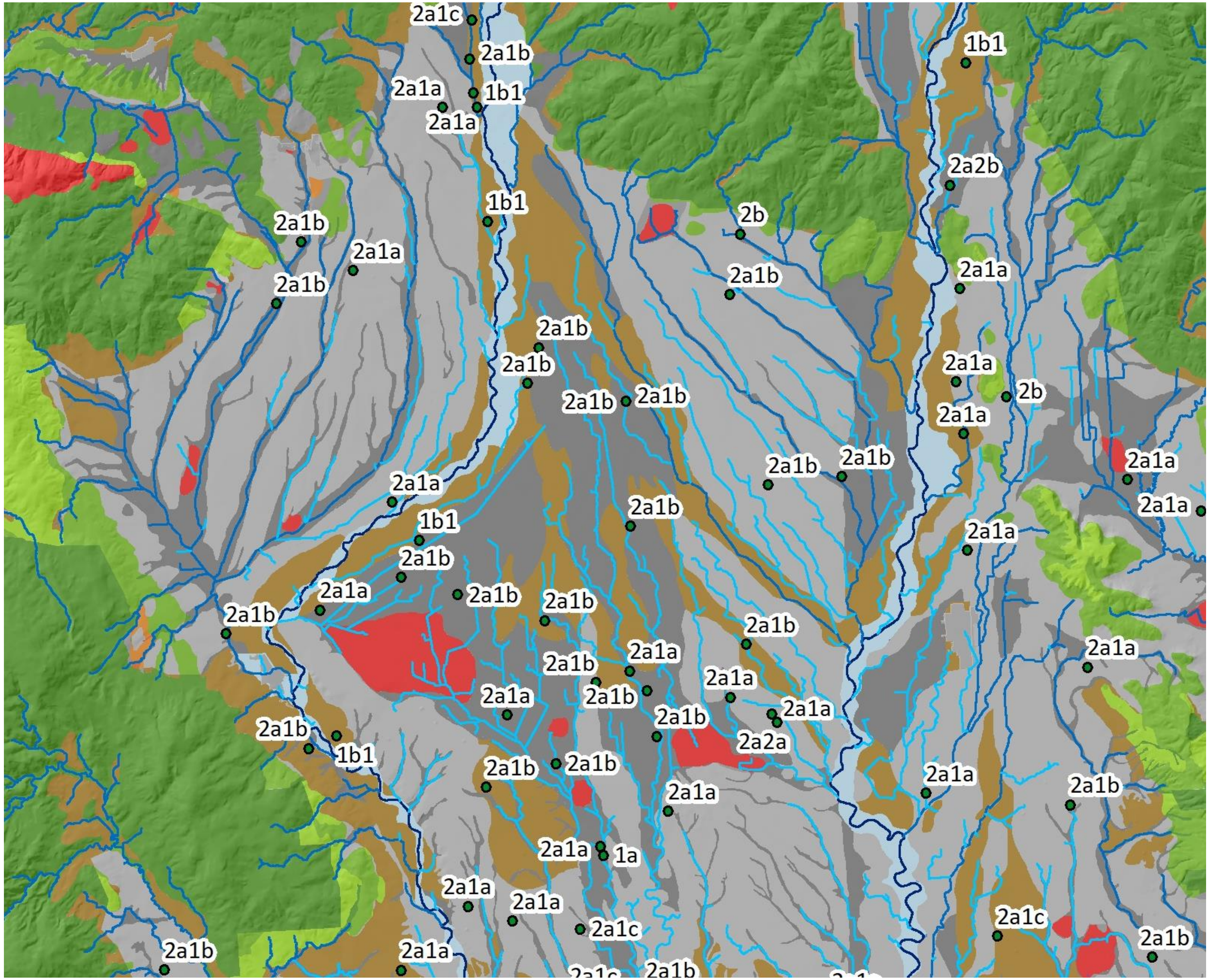
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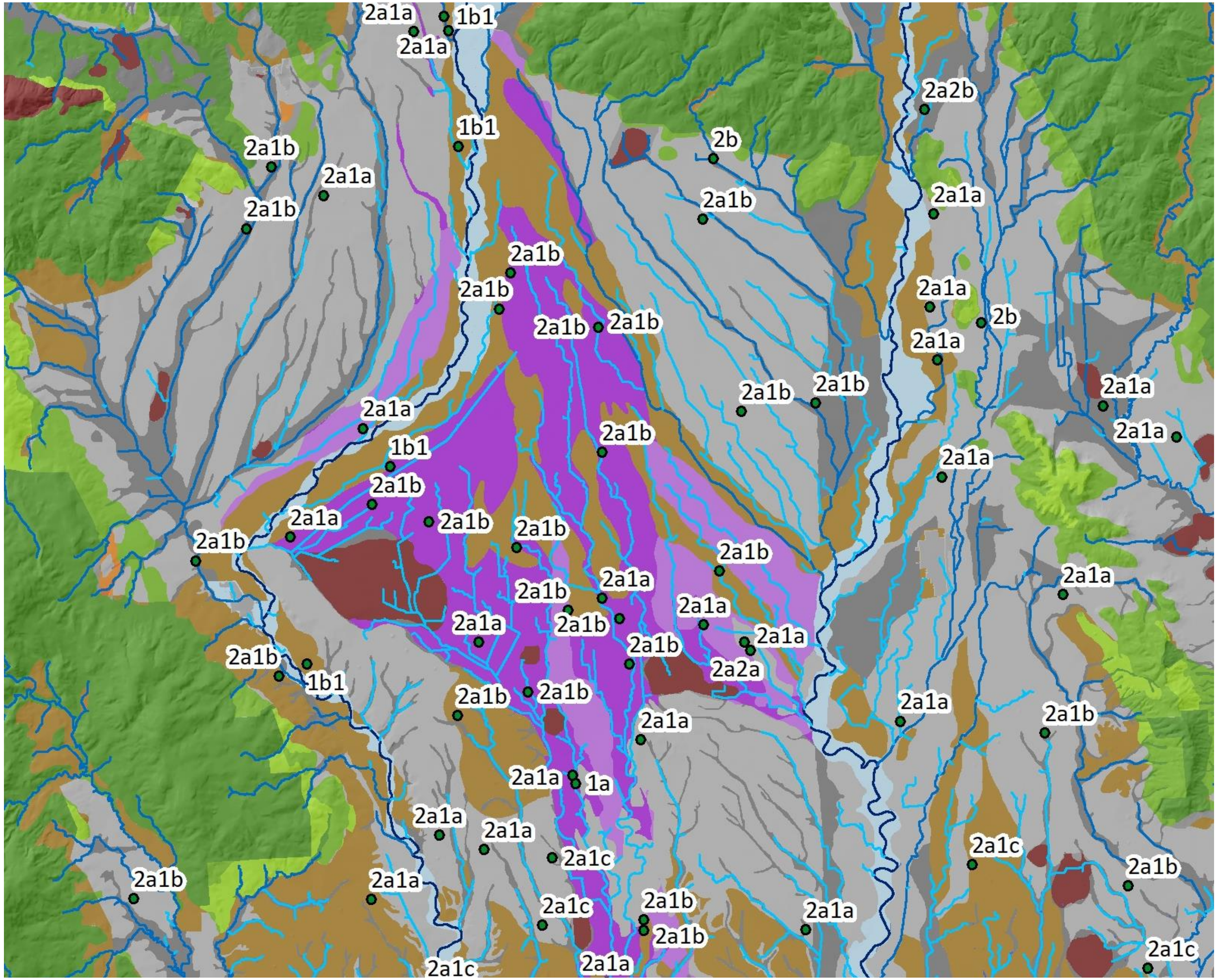
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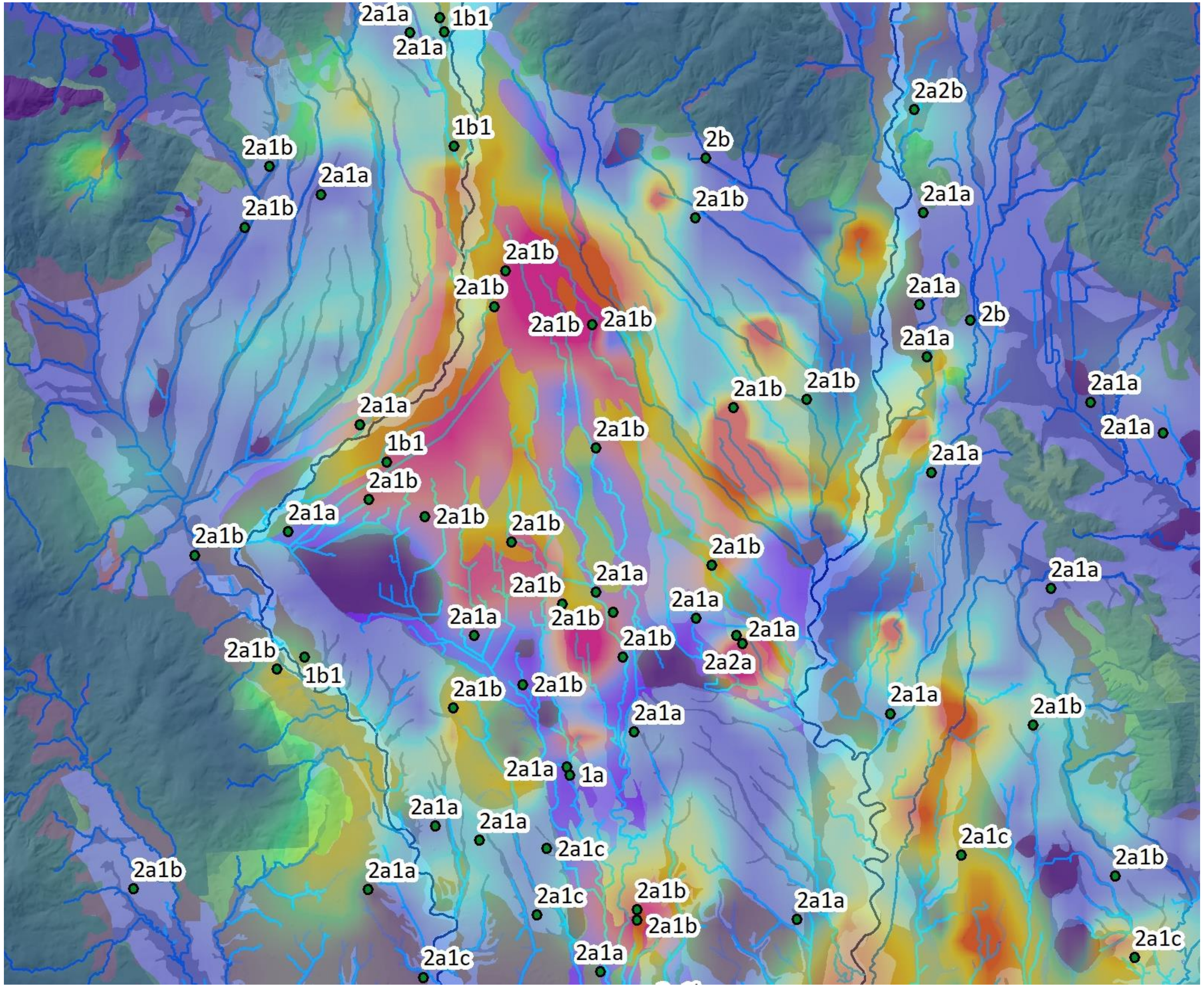
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Physiographic Environments of New Zealand

- “**Illuminates the black box' that is the landscape level controls over water quality by explicitly linking the landscape to water quality outcomes. In awarding the contestable funding, OLW leaders noted both the absence of any equivalent platform and the high potential impact for New Zealand**.” Our Land and Water National Science Challenge

- “**The project entitled “Physiographics of Southland” is a remarkable achievement in interdisciplinary water quality research. Just because of the data-intensive work using state-of-the-art GIS, the project is laudable. What is more significant is its use of a large amount of research-quality data to identify mechanisms that control surface water and shallow groundwater quality, and not simply use the data for some form of black-box statistical analysis. I find the approach taken here compelling and a significant advance on other interdisciplinary approaches worldwide. It is strongly research-based, and pushes the state-of-the-art in terms of field science, data collection, and data analysis**.” Prof. Mark Milke (Department of Engineering and Natural Resources, University of Canterbury) comments:

- The Physiographic approach was described by Associate Professor Peter Almond (Soil and Physical Sciences, Lincoln University) as “**a unique and holistic methodology that has revealed insights yet unrecognised into the drivers of water hydrochemistry and quality**.”

- There is also interest from Australian and US researchers in this novel approach (e-source).

Summary

- Water composition and quality outcomes (risk and state) vary in space even for equivalent land use pressures

- Variation is controlled by the natural variability of the landscape or its “physiographic setting”
    - Physical, chemical and biological attributes of the environment
    - Atmospheric, hydrological and biogeochemical processes

Thank you for attending
Questions?

Data requirements

Data requirements of PENZ

- Minimum of 3 **surface water** sampling runs
  - Target baseflow, moderate, and a high flow event with PENZ test set (see information pack)
  - Ideally 1 year of monthly samples or more + any other chemical analysis of regional surface water

- Minimum of 2 **groundwater** sampling runs
  - Target summer and winter with PENZ test set (see information pack)
  - Ideally 1 year of quarterly samples or more

    + any other regional GW analysis

Data requirements - groundwater

Groundwater test set	
Alkalinity (Bicarbonate)	Magnesium (Dissolved)
Alkalinity (Carbonate)	Manganese (Dissolved)
Alkalinity (Total)	Nitrogen (Nitrate Nitrite)
Anions (Total)	Nitrogen (Nitrate)
Boron (Dissolved)	Nitrogen (Nitrite)
Bromide (Dissolved)	Nitrogen (Total Ammoniacal)
Calcium (Dissolved)	Nitrogen (Total Kjeldahl)
Carbon (Dissolved Organic)	Nitrogen (Total)
Cations (Total)	Phosphorus (Dissolved Reactive)
Chloride (Total)	Phosphorus (Total)
Conductivity (Lab)	Potassium (Dissolved)
E-Coli <MPN>	Silica (Dissolved Reactive)
Fluoride (Total)	Sodium (Dissolved)
Hardness (Total)	Sulphate (Total)
Iodine (Dissolved)	Sulphide (Total)
Ion Balance	pH (Lab)
Iron (Dissolved)	

Field measurement:
Dissolved oxygen

Hydrology must have
Hydrology nice to have
Redox must have

Data requirements – surface water

Field filtered sample - Test Name	**Non-field filtered sample - Test Name**
Iron (Dissolved)	E. Coli (CFU)
Magnesium (Dissolved)	Faecal Coliforms (mf)
Manganese (Dissolved)	Nitrogen (Total Kjeldahl)
Potassium (Dissolved)	Phosphorus (Total)
Sodium (Dissolved)	Nitrogen (Total)
Fluoride (Dissolved)	pH
% Difference in Ion Balance	Turbidity
Hardness	Electrical Conductivity
Anions (Total)	Phosphorus (Dissolved Reactive)
Cations (Total)	Chloride
Alkalinity (Total)	Nitrogen (Total Ammonical)
Silica (Dissolved Reactive)	Nitrogen (Nitrite)
Sulphate	Nitrogen (Nitrate+Nitrite)-Combined
Boron (Dissolved)	Nitrogen (Nitrate)
Calcium (Dissolved)	Dissolved Non-Purgeable Organic Carbon (DNPOC)
Bicarbonate Alkalinity	
Carbonate Alkalinity	**Field measurement of Dissolved Oxygen**
Iodine (Dissolved)	
Bromide	