LERNZ
Lake Ecosystem Restoration
New Zealand

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

Managing New Zealand lakes: Potential challenges

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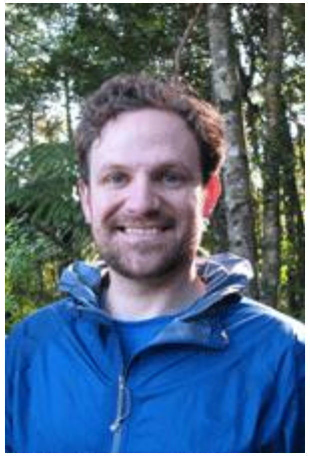
Acknowledgements

Prof David Hamilton

Bay of Plenty
REGIONAL COUNCIL



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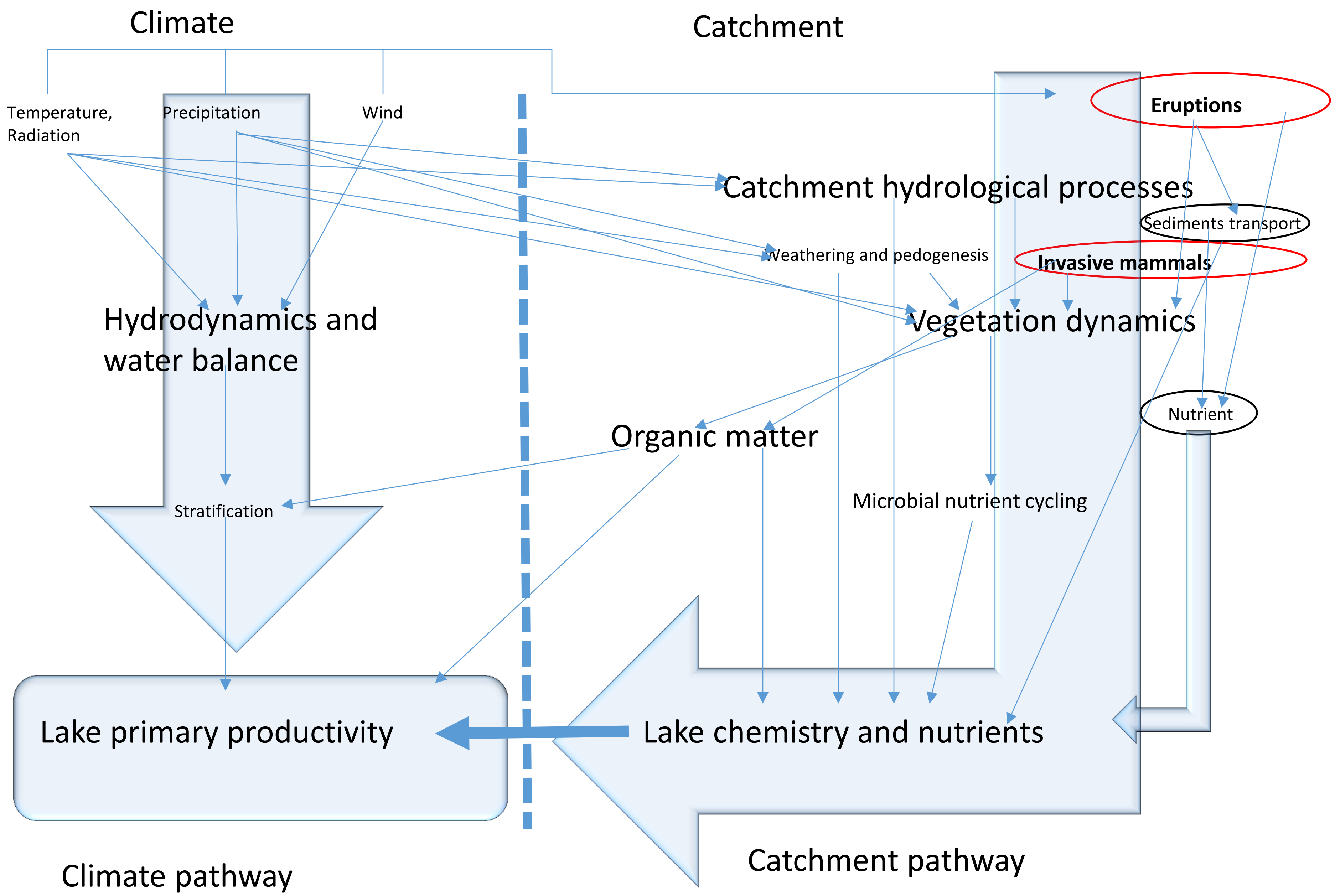
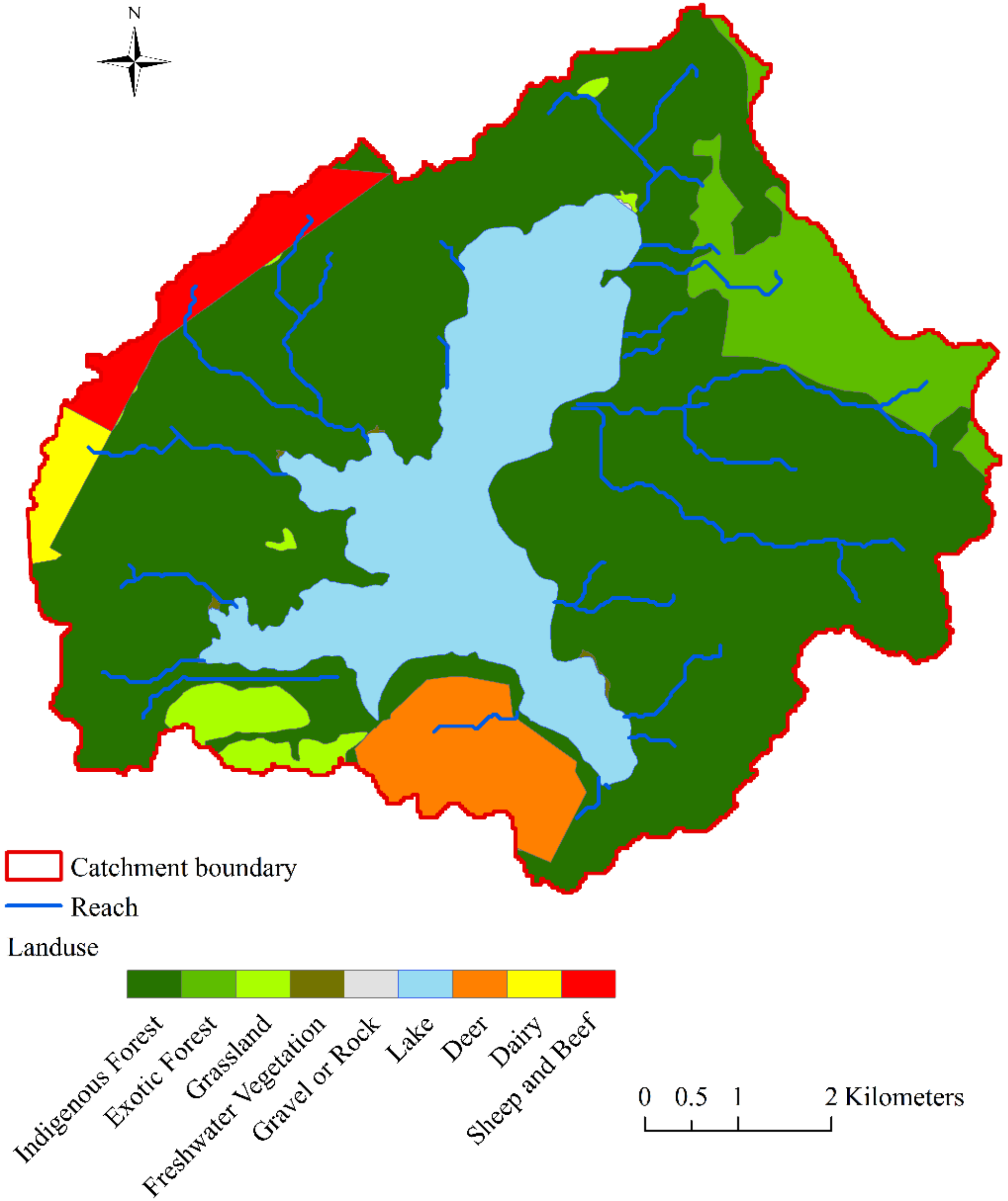
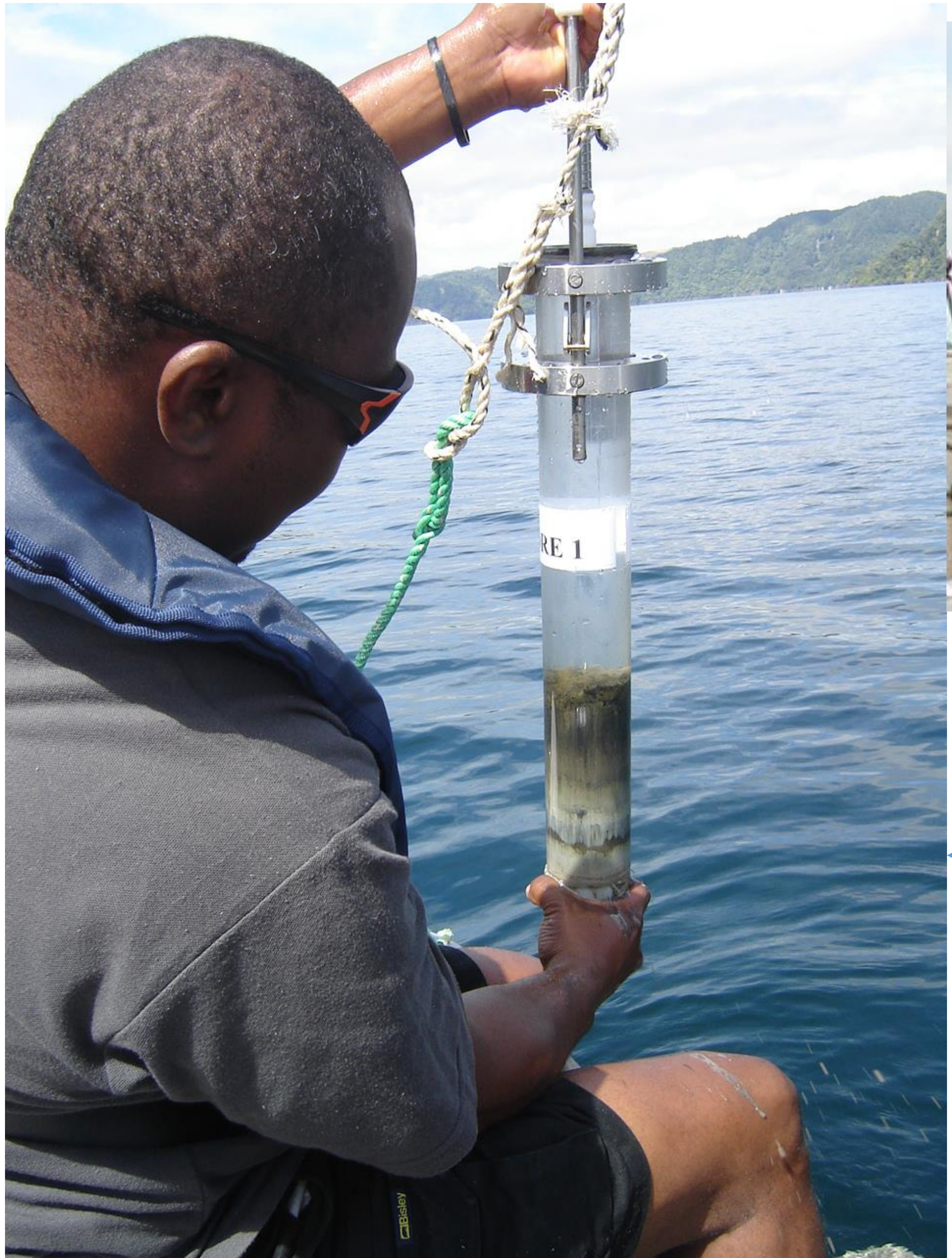
Benchmarking management targets: Potential challenges



Lake Okataina: A natural field laboratory



Research approach



paleolimnology

Long-term monitoring

Identifying historical changes

Top of the core (2009) Large populations of invasive mammals

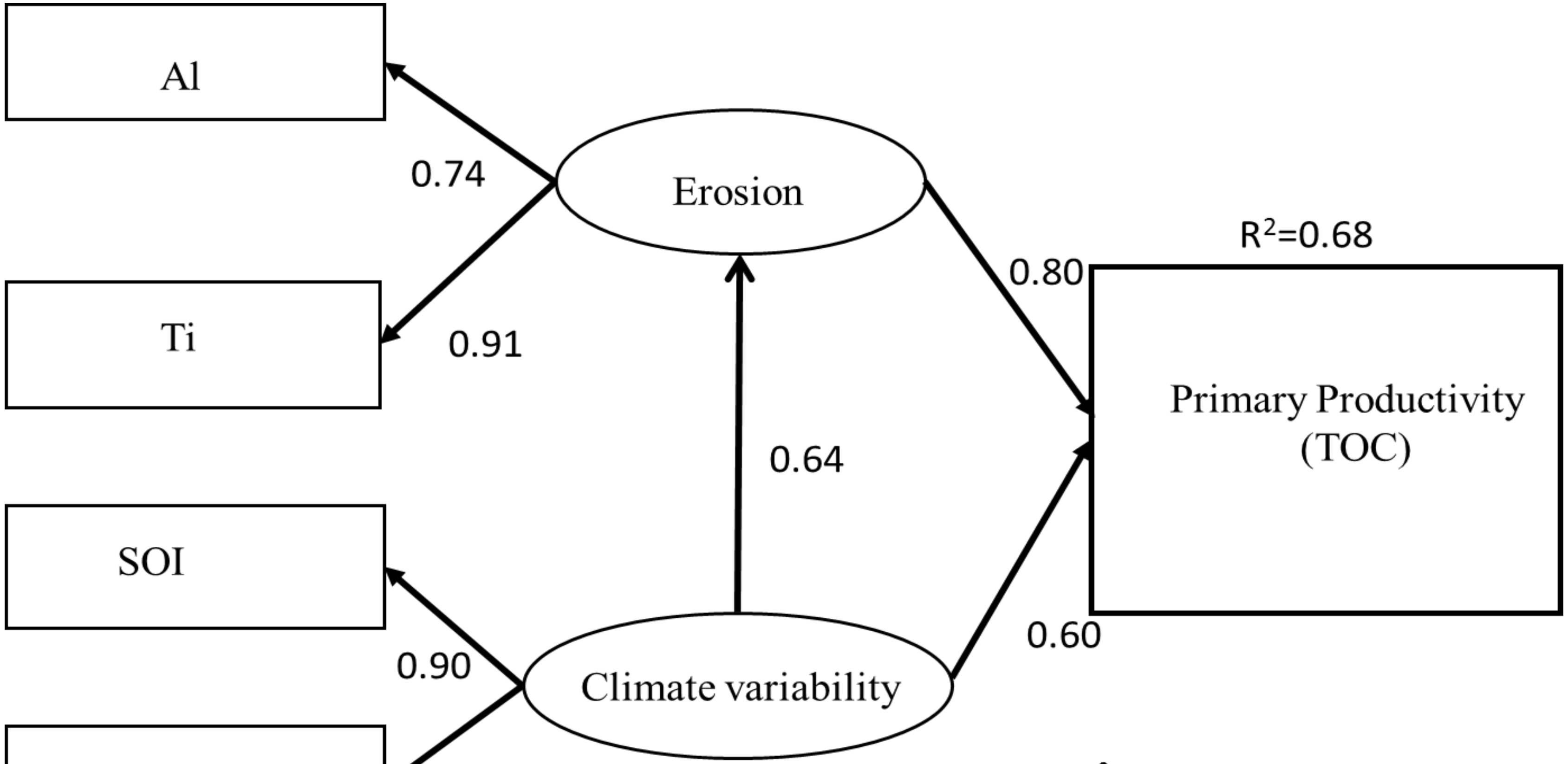
1900 Introduction of wallaby, possum and deer

Tarawera eruption (June 1886)- smaller impact on vegetation

19% forest cleared by Polynesian settlers

Kaharoa eruption (AD 1314±12)- A near total vegetation destruction

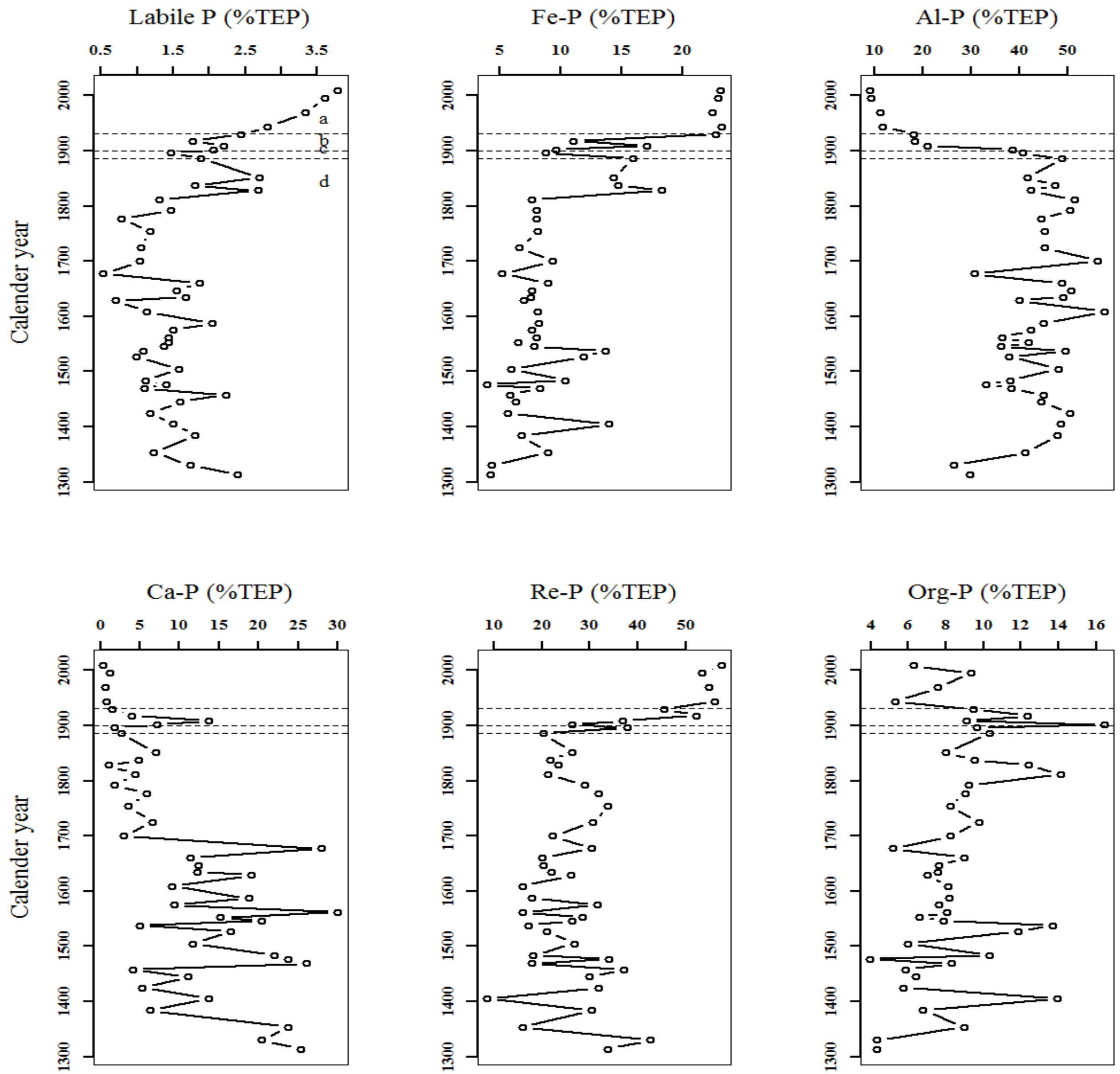
Comparing the impact of climate and catchment disturbance: A structural equation modelling



X^2=0.76
P-value(X^2)=0.71
d.f=6
CFI=0.97
SRMR=0.09
n=23

- Catchment disturbance is the dominant pathway to increasing primary productivity
- Climate variability plays a significant role in directly modifying primary productivity
- Climate variability also modifies primary productivity indirectly by impacting catchment processes

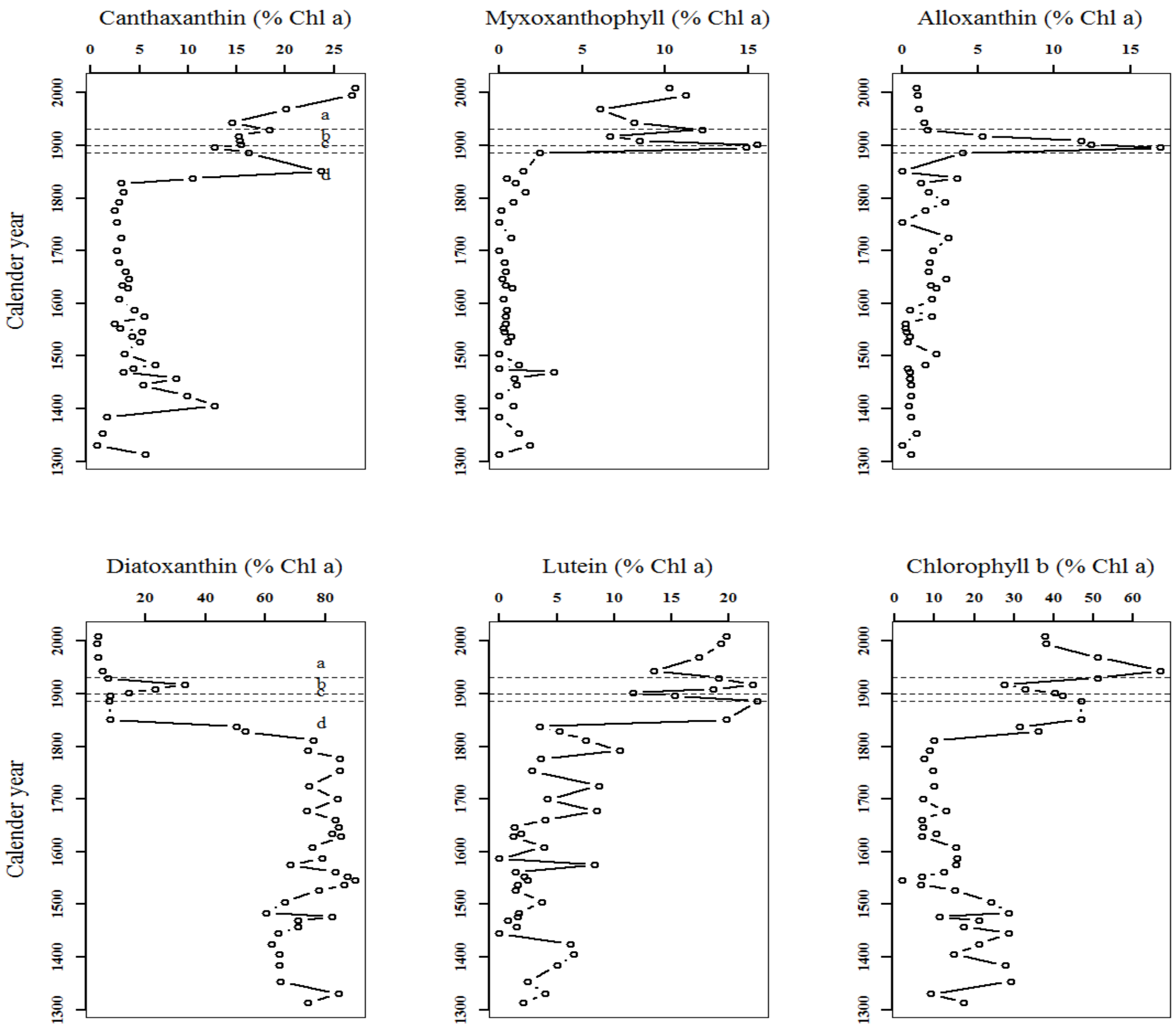
Sediment phosphorus speciation and pigment composition to infer historical lake phytoplankton phenology



What is the impact of catchment disturbance as a consequence of two volcanic eruptions, introductions of invasive mammals, and climate on the speciation of phosphorus and algal pigments in a sediment core retrieved from Lake Okataina.

- P species associated with Al was dominant in the until about 1900
- Labile P and Fe-P are becoming increasingly dominant ~1932
- Ca-P decreased rapidly after ~1700

Sediment phosphorus speciation and pigment composition to infer historical lake phytoplankton phenology



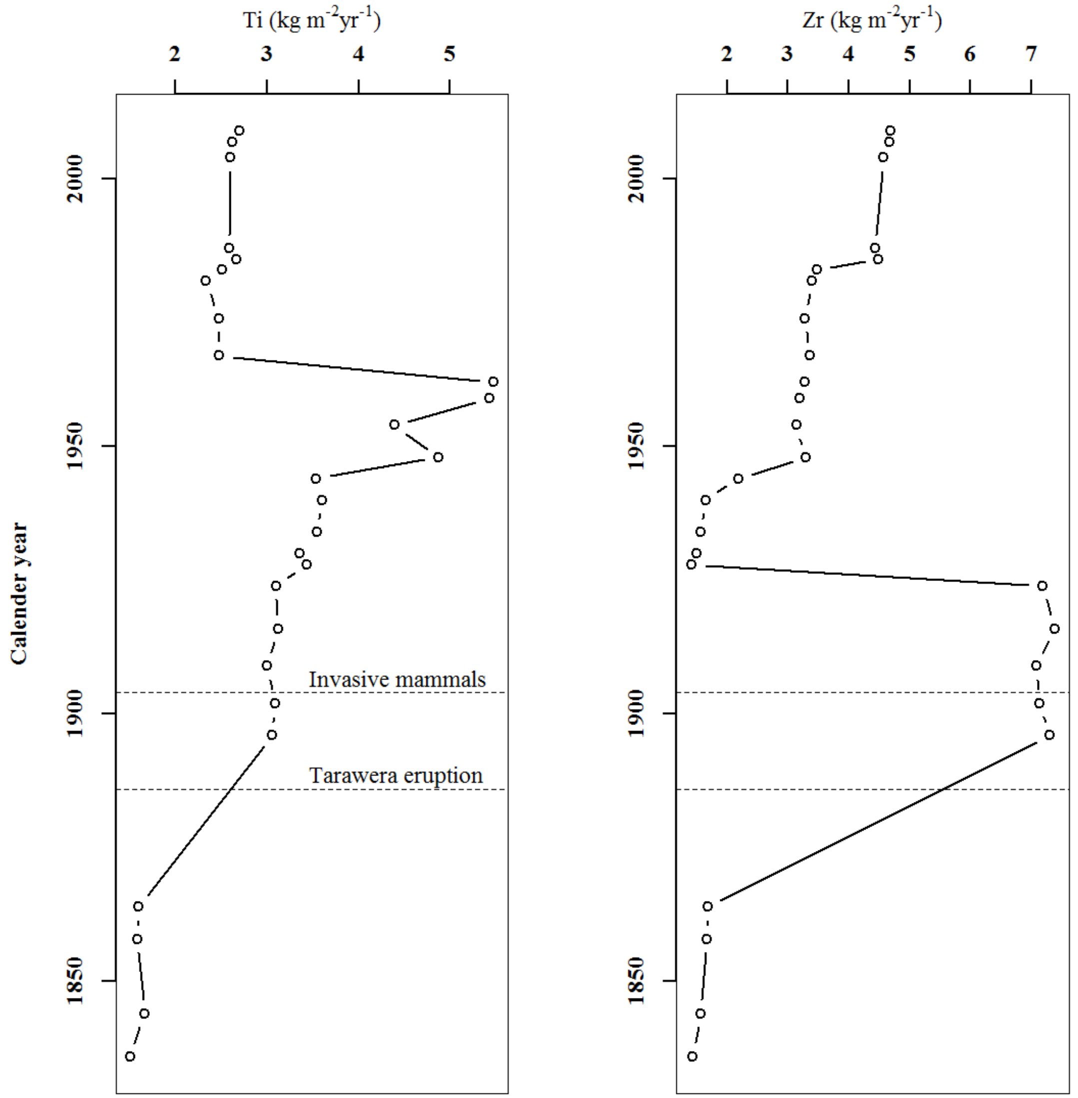
- Diatoms were dominant between ~1314 and 1900
- Cyanobacteria and green algae are became increasingly dominant prior to the Tarawera eruption

Sediment phosphorus speciation and pigment composition to infer historical lake phytoplankton phenology

Response variable	Equation	R^2	p
Canthaxanthin	5.25+ 254.79LA-P +33.57Fe-P – 11.30Al-P -11.73Ca-P	0.71	<0.001
Myxoxanthophyll	71.53+ 2.64LA-P -67.88Fe-P – 73.71Al-P -65.49Ca-P-52.29Re-P	0.62	<0.001
Alloxanthin	9.72-93.20LA-P -7.58Fe-P -6.48Al-P -13.15Ca-P	0.10	0.42
Diatoxanthin	58.21-684.53LA-P -150.82Fe-P +53.28Al-P +70.48Ca-P	0.69	<0.001
Lutein	19.48-31.21LA-P +18.27Fe-P – 21.72Al-P -30.79Ca-P	0.61	<0.001
Chlorophyll *b*	-3.53+ 529.04LA-P +121.58Fe-P	0.58	<0.001

The relative abundance of the algal groups can be determined from multiple phosphorus species

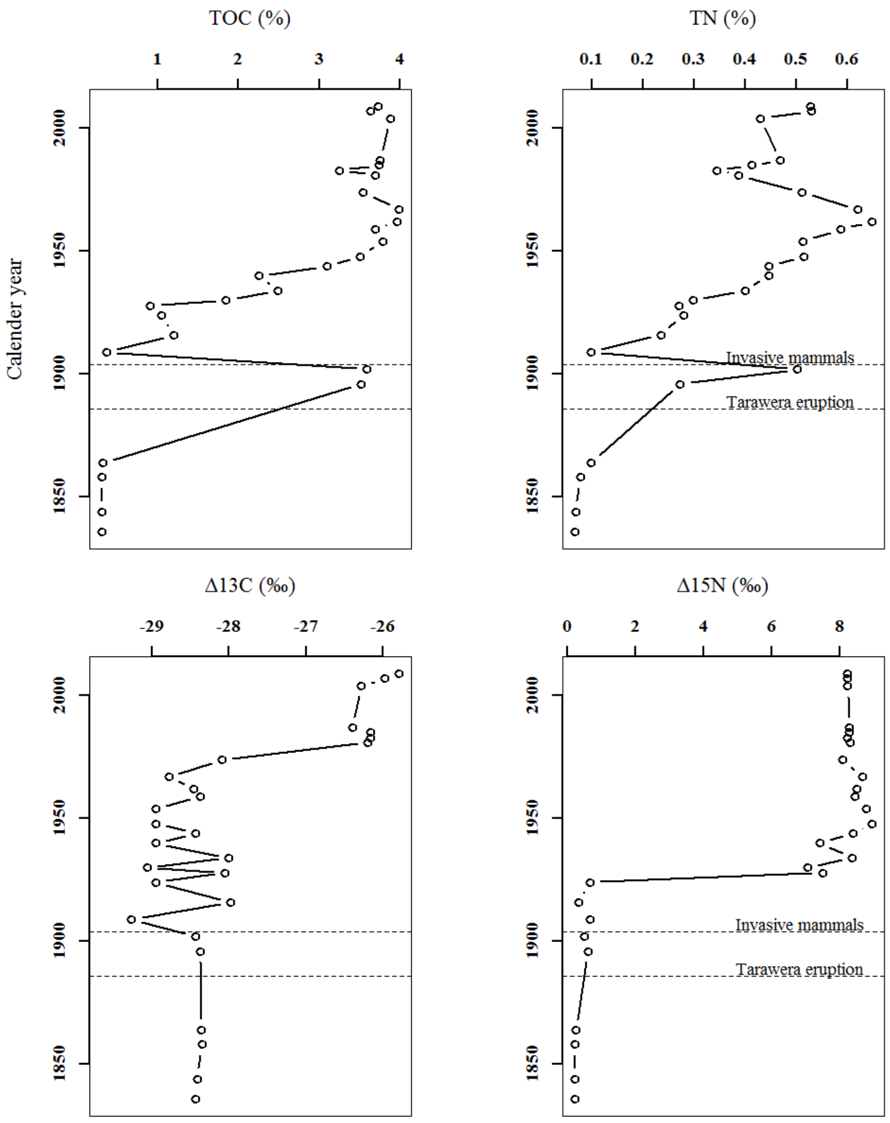
Changes in water quality and invasive mammal populations in the catchment of Lake Okataina

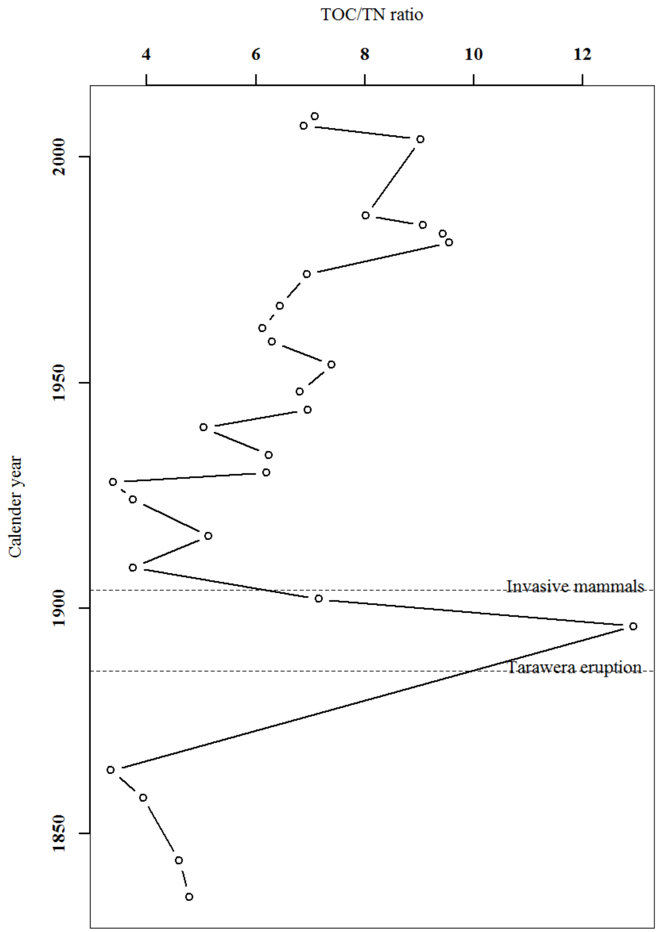


To identify changes in the water quality of the lake in the last ~170 years using geochemical proxies

- Erosion rate increased after the Tarawera eruption
- The rate of erosion has not returned to pre=eruption conditions

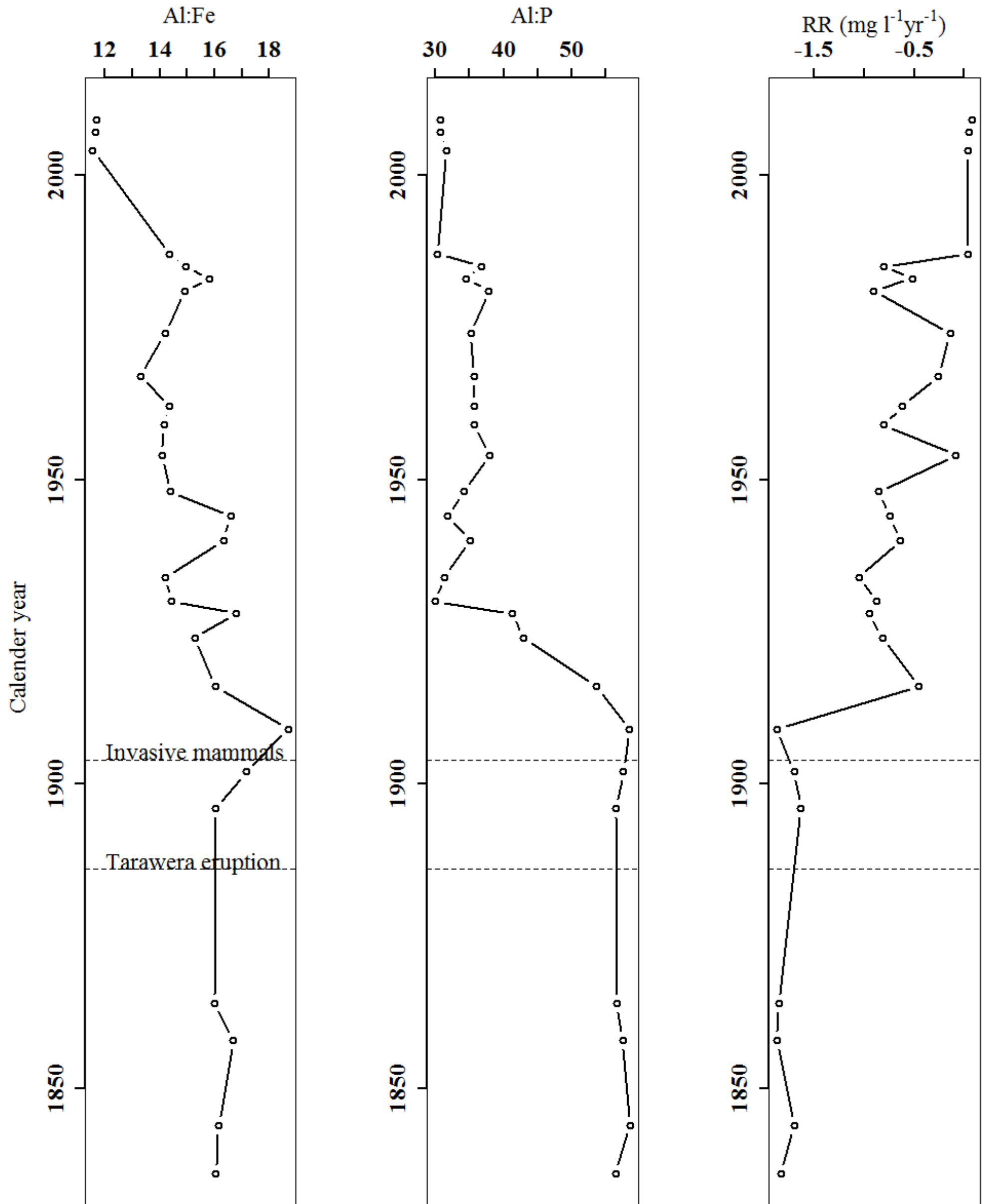
Changes in water quality and invasive mammal populations in the catchment of Lake Okataina





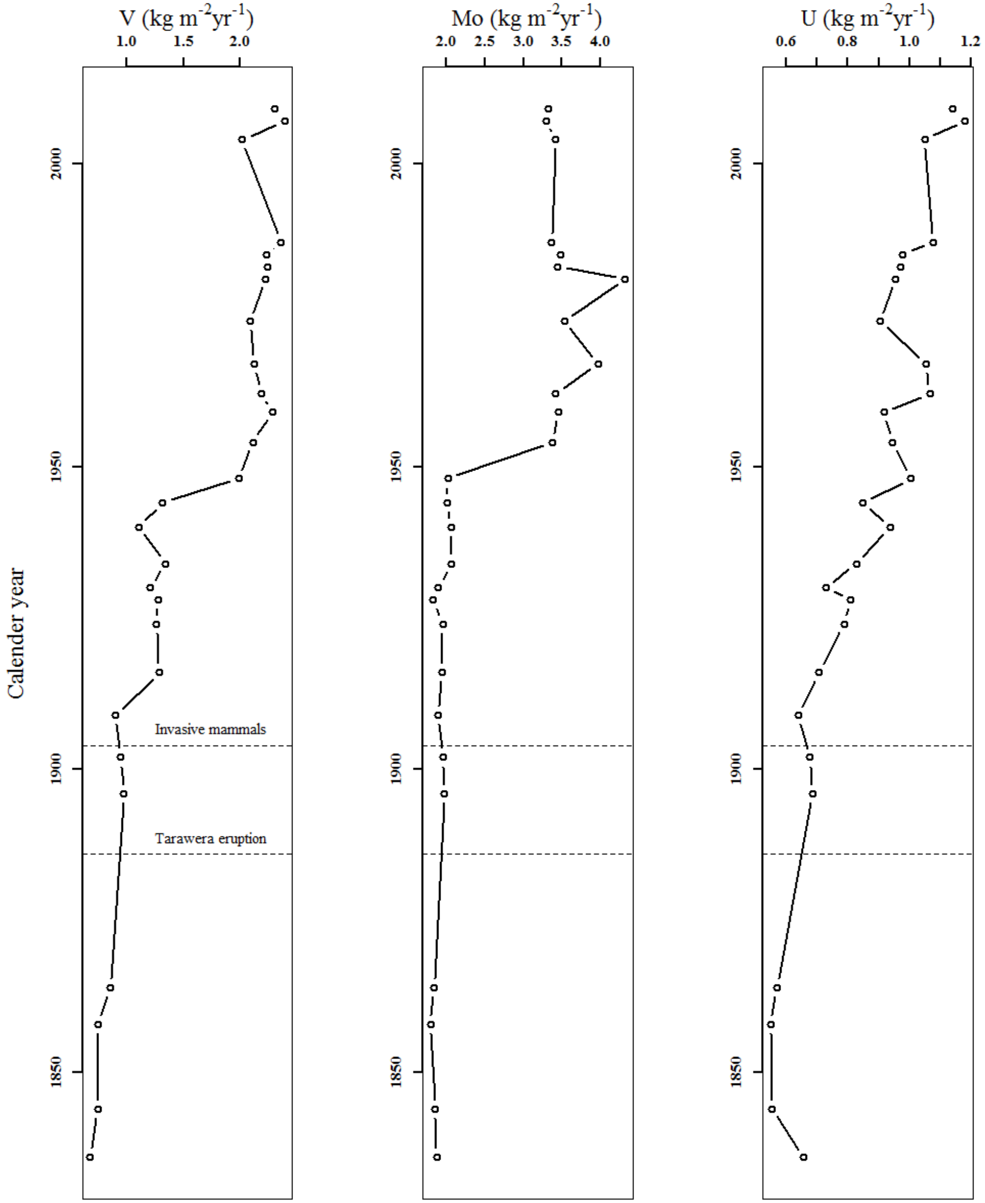
- Source of organic matter in the lake is mainly autochthonous
- After the Tarawera eruption, this briefly changed to allochthonous
- Organic matter loading to the lake have bee consistently increasing after ~1900

Changes in water quality and invasive mammal populations in the catchment of Lake Okataina



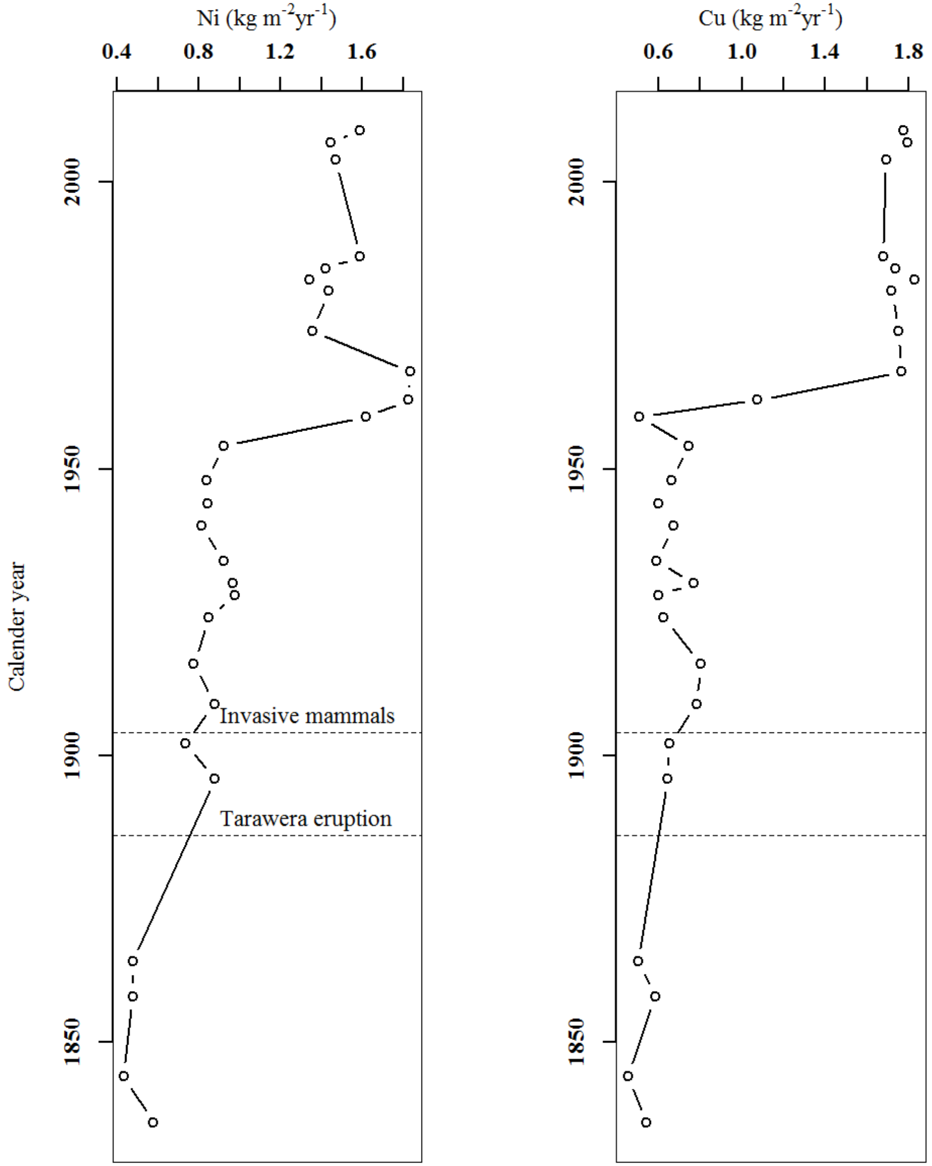
- Phosphorus retention capacity of the sediment began reducing after 1932
- The sediment prior to 2000 was a phosphorus sink

Changes in water quality and invasive mammal populations in the catchment of Lake Okataina



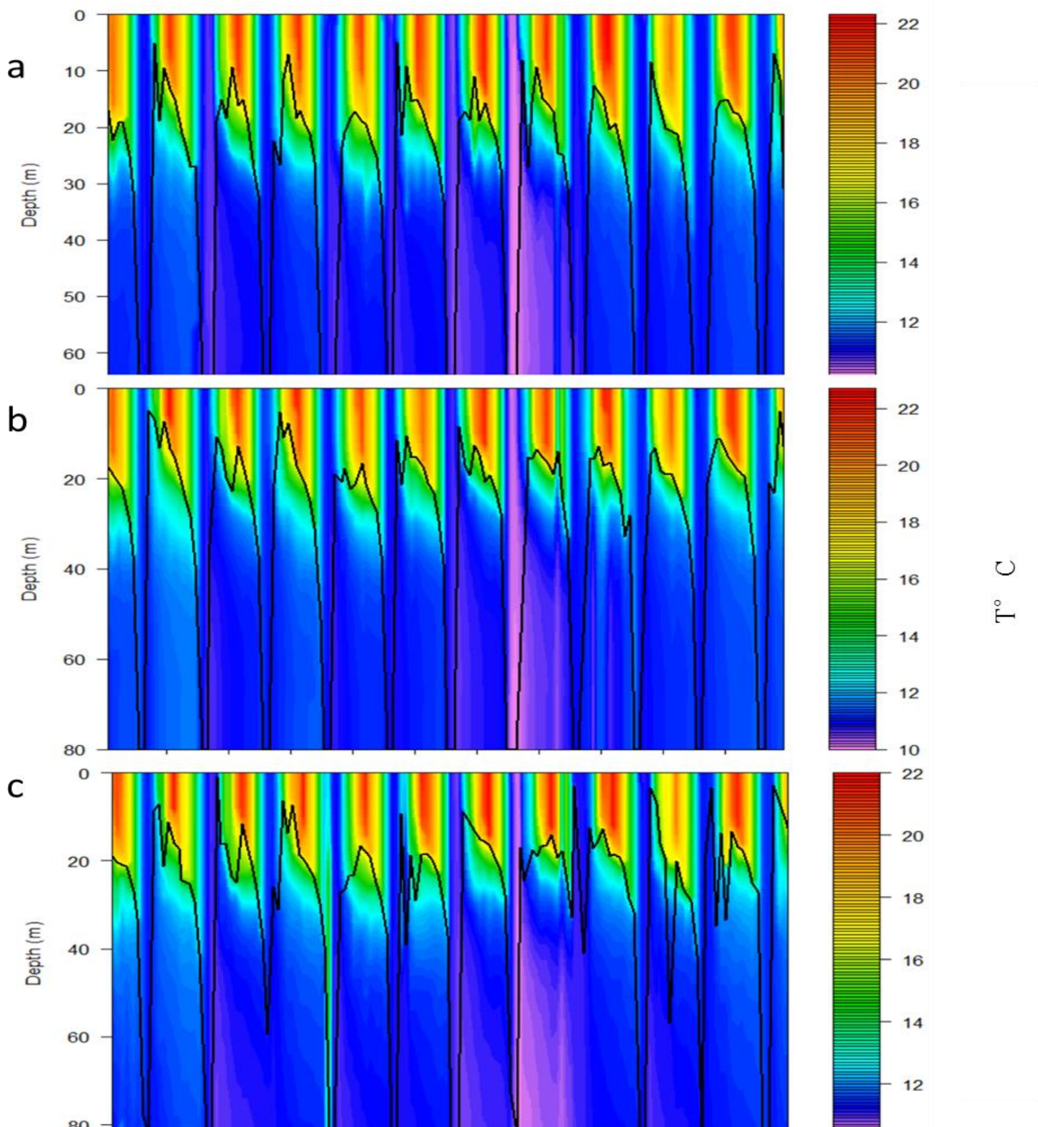
Increasing flux of metals associated with redox suggest decreasing bottom water aeration

Changes in water quality and invasive mammal populations in the catchment of Lake Okataina



Primary productivity have been increasing prior to the Tarawera eruption

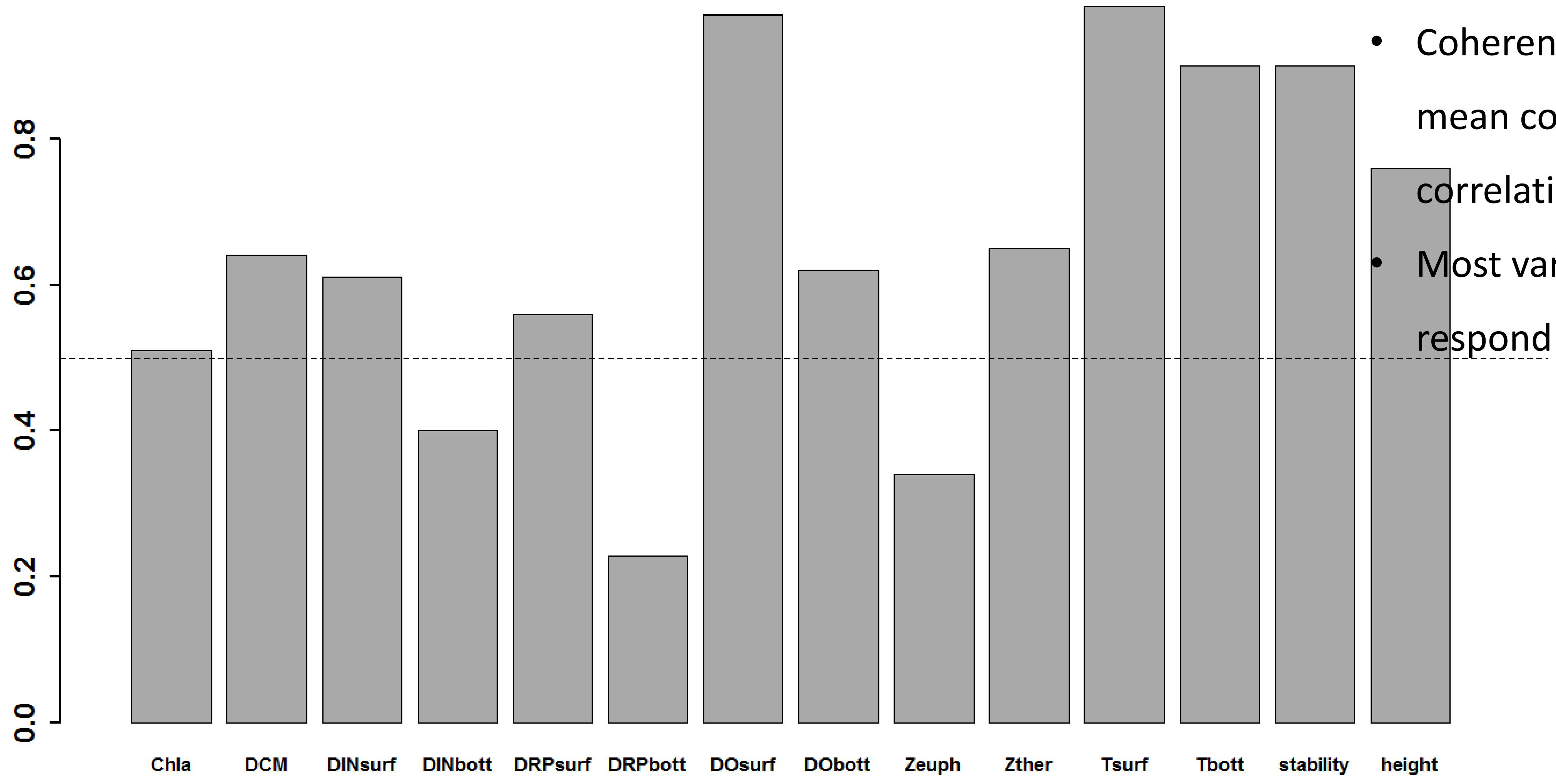
Climate-driven synchronicity of water quality in three deep, temperate, oligotrophic lakes



The objective of this study was to test for patterns of temporal coherence in three deep oligotrophic lakes in a region with similar catchment geology, trophic state and morphometry.

The degree to which lakes in a defined region have similar temporal responses to external forcing factors has been described as temporal coherence or lake synchrony

Climate-driven synchronicity of water quality in three deep, temperate, oligotrophic lakes



- Coherence was measured as mean co-efficient of correlation (r)
- Most variables of the 3 lakes respond to climate

Conclusions

- The effects of the volcanic eruption on the lake were found to be transmitted mostly through catchment disturbance.
- The eruption delivered mostly refractory organic matter from the catchment to the lake, and also increased fluxes of minerals from the catchment.
- Volcanic eruptions and the presence of invasive mammals were also found to have accounted for changes in the phosphorus pool in the lake sediment. This change appeared to be associated with alterations to the composition of phytoplankton groups in the lake.
- The combined effect of eruptions and invasive mammals in the catchment was shown in the study to have contributed to increased erosion into the lake.

Conclusions

- Related to the increased erosion rates are contemporary reductions in dissolved oxygen in bottom waters and increased internal loading of phosphorus.
- The marked increase in primary productivity in Lake Okataina about 1960 followed the reduction in hypolimnetic oxygen and the onset of reduced capacity of bottom sediments to retain phosphorus.
- The effects on lake productivity of climate and invasive mammals have been shown to be pervasive in this study.
- These mammals are the “new normal” in many New Zealand catchments. Their role as conduits for transfer of soil and nutrients from catchments to lakes has been demonstrated.

Implications for management

- To manage lakes effectively in New Zealand under the NPS-FM, will require that stressors are identified and removed or managed.
- Identifying, enumerating and managing invasive mammals in the catchment of lakes could reduce the rate of transfer of sediment and nutrients to lakes, thereby maintaining the integrity of these ecosystems.
- The direct impact of climate on lakes cannot be managed but its indirect effects on catchment erosion and landslides that accompany rainstorms may at least by partly mitigated through careful management and planting of riparian areas, slope stabilization and wise choices about the suitability of different land uses.

Recommendations

- Inflow to the lake be monitored to be used in lake modelling
- Sources of nitrogen input be clearly identified
- Sediment traps be set to monitor sedimentation rates over a period of time
- Measuring catchment erosion in and outside the animal exclusion fence
- A monitoring buoy would help match hypolimnetic anoxia with rates of sedimentation