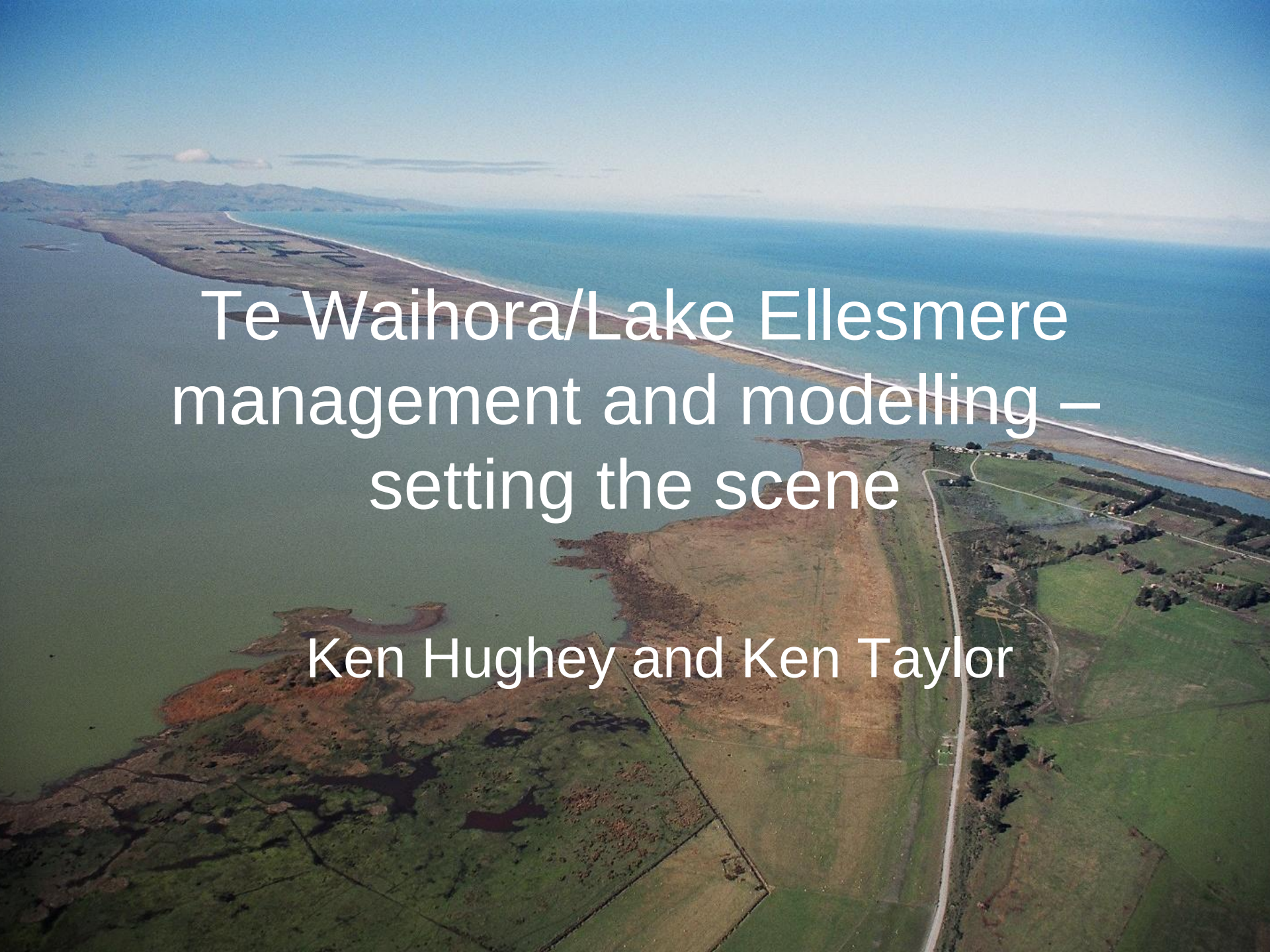


Te Waihora/Lake Ellesmere management and modelling – setting the scene

Ken Hughey and Ken Taylor

Outline

- The state of the lake and its resources in 2007
- Three catchment-wide possible future scenarios envisaged in 2007 and reconsidered in 2009
- Where these 3 scenarios fit with the lake model to be discussed today
- Resilience, adaptive cycles and tolerance ranges
- The principles and practices of modeling
- Options considered within the lake model

The 2007 symposium – state of the lake

- We asked experts to report on the state of the lake and its resources as at 2007, compared for earlier, typically against the regional council's 1995 report.
- Overall, we have found the lake was 'alive', with lots of values rated highly but others in a poor and sometimes worsening state of health – the brown trout fishery was worst of all …

State of values - 2007

‘Value’	Range of states
Catchment Hydrology	Upper: ‘very good’ Lower: ‘very bad’
Water quality of tributaries	‘good’ to ‘very bad’
Water quality of lake	‘fair’ to ‘bad’
Vegetation	Vegetation (incl. macrophytes): ‘very good’ to ‘poor’ Rare plants: ‘very good’ to ‘very bad’ Woody weeds: ‘very bad’
Brown trout recreational fishery	‘very bad’
Commercial fisheries	‘good’ to ‘bad’
Wildlife	‘very good’ to ‘bad’
Recreation	‘very good’ to ‘very bad’
The Ngai Tahu Values	‘bad’

Future scenarios –

Based on these findings and multiple other considerations and given the international and national level importance of the lake for multiple values, in 2007 we proposed three future scenarios, which from 2009 (in brackets) have been referred to as:

1. An Improved Status Quo & Maintenance (An improved environmental future);

2. Realistic and Resilient Environmental Future (Enhanced environmental future);

3. Ideal Conservation Based (Strong environmental future).

Evaluation of the scenarios by value set:

Resource	1. Improved Status Quo & Maintenance	2. Resilient and Realistic Environmental Future	3. Ideal Conservation Based
The Ngai Tahu Values	Moderate Ngai Tahu values	High values including improved mahinga kai access	Outstanding values including improved mahinga kai access, restoration activities
Indigenous vegetation	High value native vegetation protected, some revegetation	High value native vegetation, including restored areas, all diversity retained	High value native vegetation, including restored areas, all diversity retained, major revegetation efforts
Indigenous fisheries	Sustainable commercial eel fishery	Sustainable eel & flounder fishery	Maintain / increase species diversity, increase eel nos., increased customary harvest
Wildlife	High wildlife values including maintenance of species diversity	High values incl. maintenance of species diversity, including restoration of swamplands	High values incl. maintenance of species diversity, restoration of swamplands, and reintroduction of brown teal and SI fernbird
Recreational fishing	Poor value trout fishery	Regionally significant trout fishery	Nationally important trout fishery
Recreation	Moderate recreation in terms of both level and quality	High level and quality of use, aware of opportunities, not conflicting with conservation & Ngai Tahu values	Very high levels and quality of recreation use, not conflicting with conservation and Ngai Tahu cultural values
Farming	Individual value to farmers retained, some minor loss due to changes in lake level management	Reduced farming around edge as land purchased and more conservation grazing	Conservation grazing only; Fencing off stock from all inflowing streams, or supplementation of flows

Scenario 1: Improved Status Quo and Maintenance

	Temporal scales		
Spatial scales	Short term: <5 years	Medium term: 5-10 years	Longer term: >10 years
Lake level	○ Existing practice	○ Existing practice	○ Existing practice
Lake bed management	○ Investigate macrophyte re-establishment, undertake weed control	○ Continue all short-term actions	○ Continue all short and medium term actions
Riparian management	○ Active programme to maintain native vegetation and begin restoring key areas	○ Continue all short-term actions ○ Undertake willow control in key areas	○ Continue all short and medium term actions
Catchment management	○ Active programme to maintain current and where possible increase stream flows and groundwater levels (restorative streams consents review programme)	○ Continue all short-term actions ○ Restore flows and groundwater levels as consents renewed and community irrigation schemes developed	○ Maintain restored flows

Scenario 2: Resilient and Realistic Environmental Future

	Temporal scales		
Spatial scales	Short term: <5 years	Medium term: 5-10 years	Longer term: >10 years
Lake level	○ Research (and if beneficial) implement spring opening, S-O, where forecasted conditions appear suitable ○ Establish autumn opening ○ Implement closing regime ○ Research (and if beneficial) implement changed commercial fishing practices	○ Maintain opening and closing regimes ○ Higher average lake level	○ Maintain opening and closing regimes ○ Investigate permanent controlled outlet and if feasible implement
Lake bed mgt	○	○ Trial macrophyte re-establishment, after lake level management changes	○ Continue all short and medium term actions where beneficial
Riparian mgt	○ Via policy initiatives, etc., ensure no further loss of native vegetation allowed ○ Begin significant revegetation programmes ○ Negotiate changed farming practices to achieve conservation outcomes ○ Acquire and manage remaining lake edge farmlands	○ Maintain benefits from all short-term actions and: ○ Undertake willow control in key areas ○ Protect key riparian habitats ○ Investigate the re-introduction of brown teal for conservation and Ngäi Tahu cultural harvest purposes ○ Implement changed farming practices to achieve conservation outcomes	○ Continue all short and medium term actions where beneficial ○ Re-introduce brown teal for conservation and Ngäi Tahu cultural harvest purposes
Catchment mgt	○ Active programme to maintain current and where possible increase stream flows and groundwater levels (restorative streams consents review programme)	○ Restore flows and groundwater levels as further consents renewed and/or community irrigation schemes developed	○ Maintain restored flows and groundwater levels ○ Maintain and improve nutrient

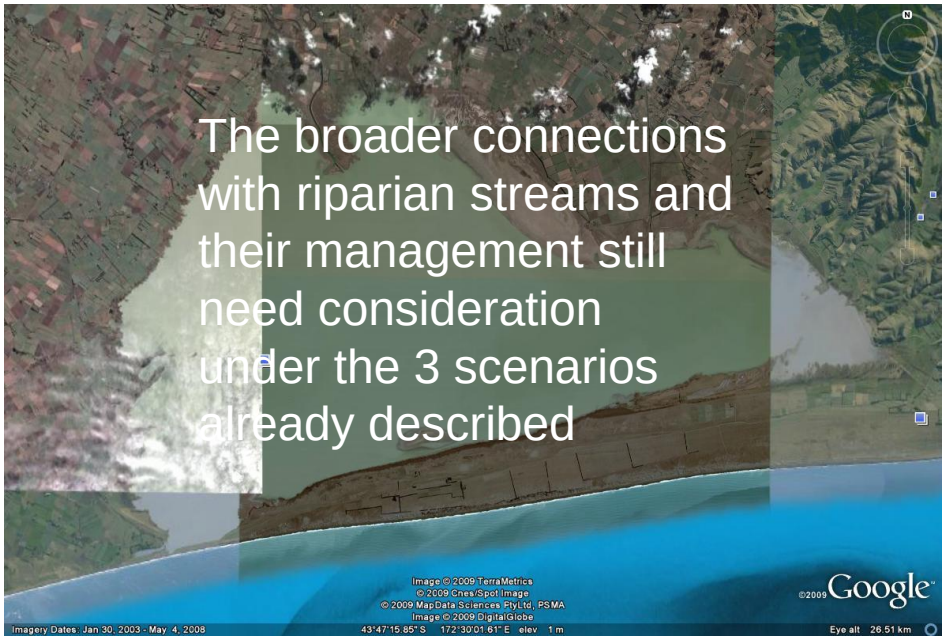
Scenario 3: Ideal Conservation Based

	Temporal scales		
Spatial scales	Short term: <5 years	Medium term: 5-10 years	Longer term: >10 years
Lake level	○ Research and (if beneficial) implement spring opening, S-O, where forecasted conditions appear suitable ○ Establish autumn opening ○ Implement closing regime ○ Research (and if beneficial implement) changed commercial fishing practices	○ Maintain opening and closing regimes (where proven beneficial for conservation purposes) ○ Act to result in higher average lake level ○ Investigate permanent outlet with mgt focused on environmental outcomes	○ Maintain opening and closing regimes, and if appropriate from previous: ○ Build and operate permanent outlet operated under conservation management regime
Lake bed mgt	○ Investigate and trial macrophyte re-establishment, undertake weed control, after lake opening and closing regimes implemented	○ Major macrophyte re-establishment programme	○ Continue all short and medium term actions
Riparian mgt	○ Via policy initiatives, etc., ensure no further loss of native vegetation allowed ○ Begin significant revegetation programmes ○ Initiate major willow control ○ Begin programme to protect all riparian zones in tributary inflows ○ Negotiate changed farming practices to achieve conservation outcomes ○ Purchase/acquire lake edge properties and manage for conservation	○ Willow control completed ○ All riparian habitats protected ○ Re-introduce brown teal for conservation and Ngäi Tahu cultural harvest purposes ○ Implement changed farming practices to achieve conservation outcomes ○ Acquire remaining lake edge properties and manage for conservation	○ Continue all short and medium term actions ○ Major enhancement programmes underway.
Catchment mgt	○ Very active programme to increase stream flows and groundwater levels (restorative streams consents review programme) ○ Ensure community irrigation development contributes positively to water quantity and quality changes	○ Continue to restore flows and groundwater levels as consents renewed and community irrigation schemes developed ○ All new catchment developments have nutrient and sediment budgets with a lake focus	○ Maintain all short and medium term actions

So, given this context what are we now going to talk about

- Our 2007 research showed that the key, or one of the highest, drivers of change to most values was lake level (but not for example for trout where it is thought the biggest issue is around tributary flows)
- We therefore decided to develop an interactive model of the lake, to help better understand how different values might behave and interact under different lake level management regimes
- This model has been developed by John Raffensperger (Fritz) at UoC with management advice from a team of myself, Ken and Whit, and input from multiple people.
- But, a model is a model – it is not reality, but it can provide insights, and it is these insights we are going to test and discuss over the rest of today.
- BUT …

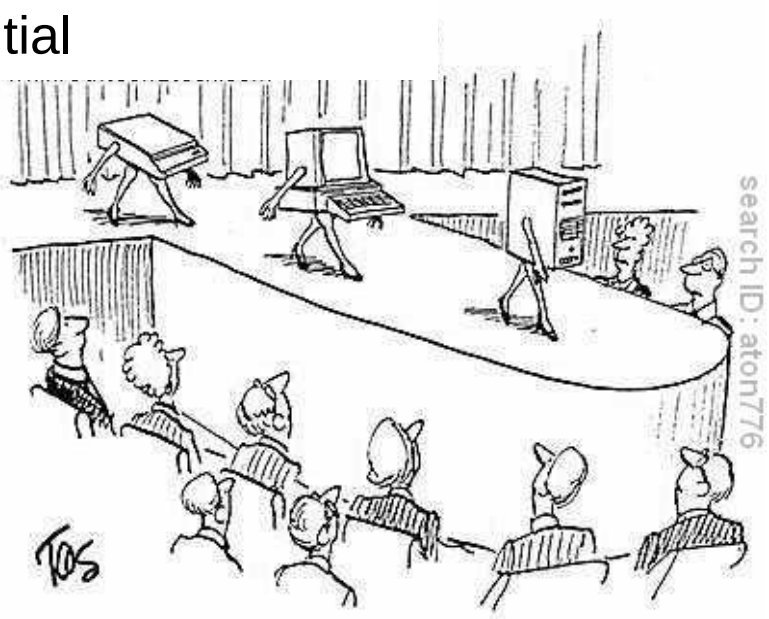
You need to remember …




Models
Making sense of a complex world

Lots of labels….

- Physical
- Mathematical
- Empirical
- Theoretical
- Stochastic
- Deterministic
- Descriptive
- Conceptual
- *A priori*
- *Posteriori*
- Symbolic
- Normative
- Explanatory
- Predictive
- Analogous
- Differential
- Linear
- ...



But it all boils down to…

- A simplification or approximation of reality (environmental systems are particularly complicated)
- A simulation
- “getting to grips” with systems beyond our grasp

“*a temporary device to represent what we think a structure may, or ought to be*”

Harvey, 1969

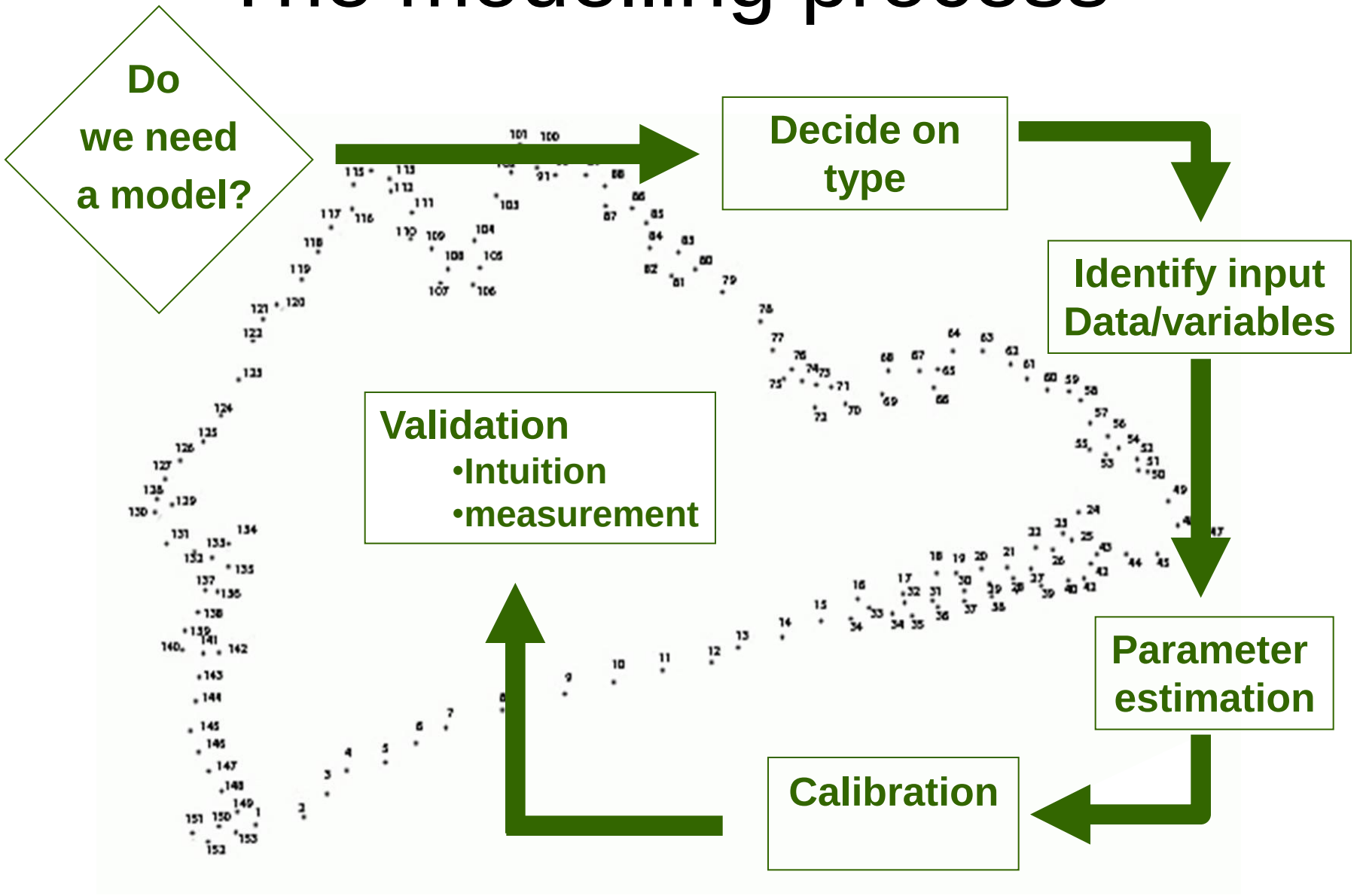
- Essentially there are just two types..

1. Descriptive – picturing what we are interested in - structure and processes - & explaining how things work

2. Normative – making predictions about what happens if things change - scenario-building, “what if”…

NB – generally, you need to do 1. before you can do 2.

The modelling process



…and a final word of caution…

One of the most insidious and nefarious properties of scientific models is their tendency to take over, and sometimes supplant, reality”

Charles Chaplin

(US physician)

Resilience, adaptive cycles and tolerance ranges

- In setting up the 3 possible futures in 2007 we were mindful of modern ideas around resilience (the ability to cope with and adapt to change), adaptive cycles (see below) and tolerance ranges (more later).
- To these ends we note that having an informed discussion around the lake opening regime gives us the chance to discuss all of these concepts within the bounds of 5 lake level management scenarios …

Adaptive cycle(s) for some example values, e.g., water quality and fish, in Te Waihora/Lake Ellesmere

ADAPTIVE CYCLE COMPONENT	PHYSICAL PROCESSES
Exploitation – Effects of human use and natural processes	Water quality impacts of land use and sea water inputs - added sediments, nutrients and bacteria - overtopping with sea water Harvest of eels and flounder
Accumulation – Lake as sink for the catchment	Retention of contaminants in lake and lake ecosystem - build-up of sediment, nutrients and bacterial levels - nutrient uptake by plants Fish develop to maturity
Release/disturbance – Lake openings	Flow through constructed cut - contaminants removal during lake discharge - sea water incursion during lake opening - migration of fish depending on timing of openings
Reorganisation – Channel closure	Return to lake conditions - reduced sediment and nutrient concentrations - increased salinity concentrations - fish growth, etc
Resilience/Vulnerability – Sustainability measures	*Lake trophic status (slow response)* *Aquatic ecological health* *Water quality ranges* *Fish stocks*

Lake opening scenarios considered in the model …

	Lake level management scenarios				
	Baseline – status quo lake level management	1	2	3	4
Opening attempted when:	1.13masl 1 April; 1.05masl 1 August; 1.05masl 1 Sept	0.6masl 18 April; 1.2masl 24 July; 0.5masl 20 Sept	0.5masl 18 April; 1.15masl 21 July; 0.5masl 14 October	1.3masl 18 April; 1.3masl 24 July; 1.3masl 20 Sept	0.6masl 22 April; 1.15masl 22 July; 1.0masl 24 Sept
Length of opening attempt and circuit breaker level:	Maintain trigger depth til next date	Maintain opening depth for 30 days only with 1.2masl circuit breaker at other times	Maintain opening depth for 30 days only with 1.2masl circuit breaker at other times	Maintain trigger depth til next date	Maintain opening depth for 30 days only with 1.2masl circuit breaker at other times
Cost of opening the lake	Benchmark				
Salinity	Benchmark				
Nodularia algae risk	Benchmark				
Turbidity	Benchmark				
Sprouting ruppia (an aquatic plant)	Benchmark				
Eel migration	Benchmark				
Flounder recruitment	Benchmark				
Duck hunting, opening day depth	Benchmark				
Wading bird habitat	Benchmark				
Farmland covered by water	Benchmark				
Total direct economic benefit relative to baseline	Benchmark				

We could of course populate such a table with %age changes cf the benchmark …

	Lake level management scenarios				
	Baseline – status quo lake level management	1	2	3	4
Opening attempted when:	1.13masl 1 April; 1.05masl 1 August; 1.05masl 1 Sept	0.6masl 18 April; 1.2masl 24 July; 0.5masl 20 Sept	0.5masl 18 April; 1.15masl 21 July; 0.5masl 14 October	1.3masl 18 April; 1.3masl 24 July; 1.3masl 20 Sept	0.6masl 22 Apr; 1.15masl 22 July; 1.0masl 24 Sept
Length of opening attempt and circuit breaker level:	Maintain trigger depth til next date	Maintain opening depth for 30 days only with 1.2masl circuit breaker at other times	Maintain opening depth for 30 days only with 1.2masl circuit breaker at other times	Maintain trigger depth til next date	Maintain opening depth for 30 days only with 1.2masl circuit breaker at other times
Attributes:					
Cost of opening the lake	Benchmark	↓	↓	↑	↓
Salinity	Benchmark	↓	↓	↑	-
Nodularia algae risk	Benchmark	↓	↓	↑↑	↑
Turbidity	Benchmark	-	-	↑	-
Sprouting ruppia (an aquatic plant)	Benchmark	↑	↑	↑	↑
Eel migration	Benchmark	↑↑	↑↑	↓↓	↑↑
Flounder recruitment	Benchmark	↑↑	↑↑	-	↑↑
Duck hunting, opening day depth	Benchmark	↓↓	↓↓	↑	↓
Wading bird habitat	Benchmark	↑	↑	↓	↑
Farmland covered by water	Benchmark	↑	↑	↓↓	↓
Total direct economic benefit relative to baseline	Benchmark	↑↑	↑↑	↓↓	↑↑