

Theme#2

Water Allocation & Governance for Resilient Catchments

Andrew Fenemor

Tim Davie

Joseph Thomas

Jagath Ekanayake

Timothy Hong, Chris Daughney

Mike Stewart, Paul White

Roger Young, Dean Olsen , Jim Sinner

Diarmuid Neilan, Kiran Kumar

Landcare Research, Nelson

LCR, now ECan

TDC

Landcare Research, Lincoln

GNS

GNS

Cawthron

Students

Motueka catchment water issues

Sub-Catchments



Water Allocation & Governance

Research Questions

1. How do land uses affect the water yields over the catchment?
2. What is the most defensible way to allocate water resources over the catchment?
3. How can water quality, aquatic habitat and isotope data inform water allocation?
4. How do economic returns affect irrigators' uses of water?
5. What governance and policy approaches would improve effectiveness of water management plans and planning processes?



Groundwater Allocation issues

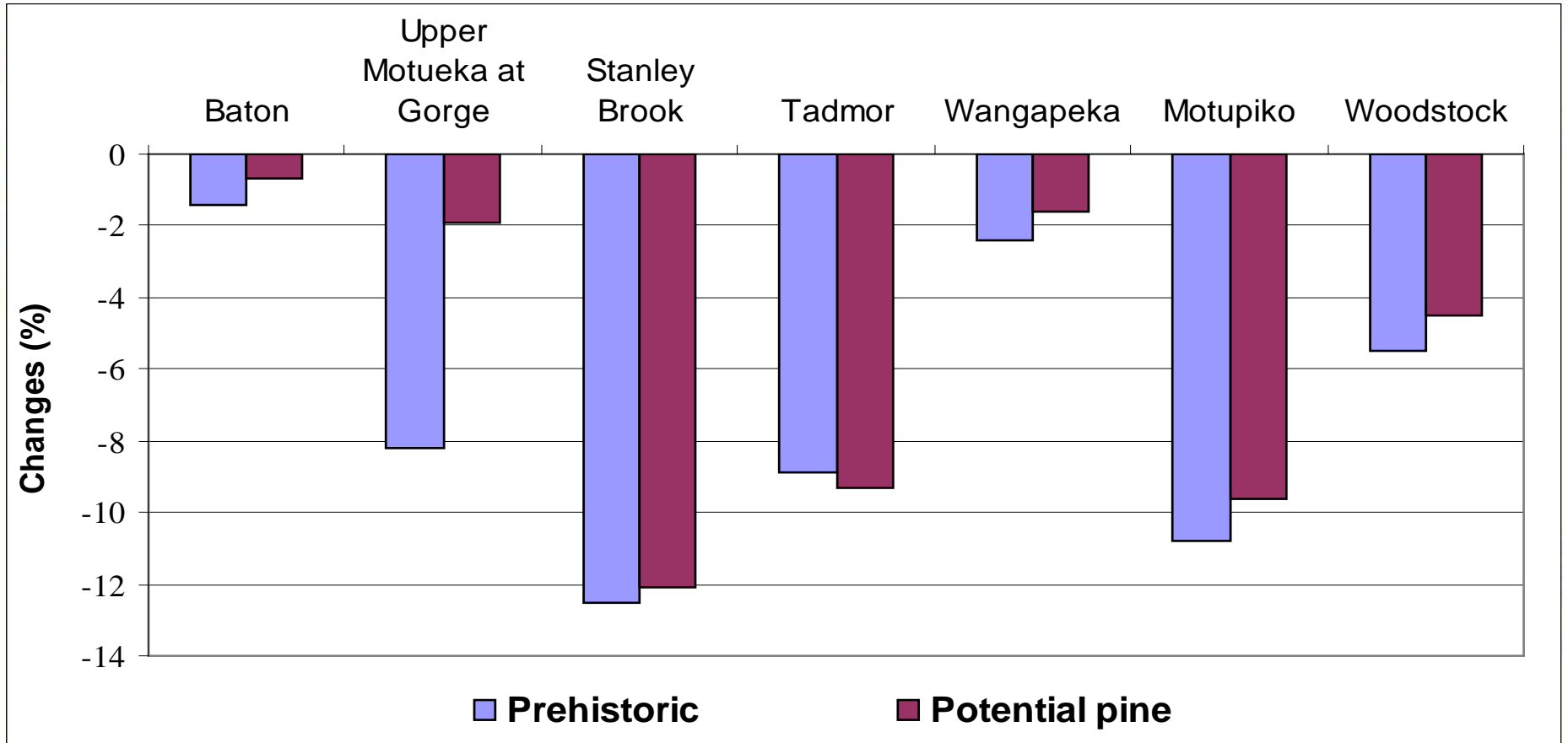
- How do land uses affect the water yields over the catchment?
- What is the most defensible way to allocate water resources over the catchment?

Major areas of investigation

- Catchment scale hydrological modelling
- Hillslope recharge to aquifers & wetland water balance
- River-aquifer modelling for setting water allocation limits

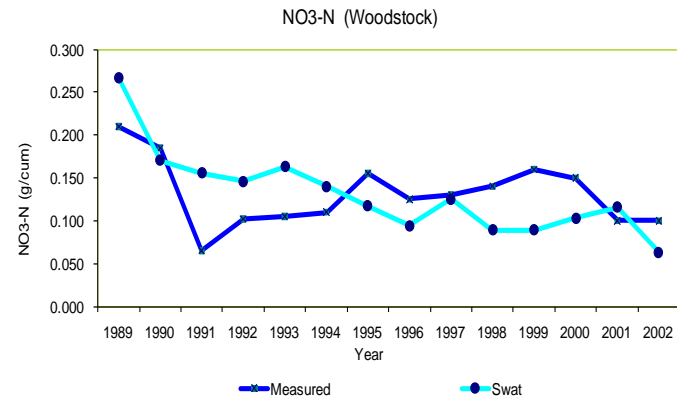
Catchment Hydrological Modelling

SWAT catchment water balance model shows river flow at Woodstock is about 21% higher now than under prehistoric bush land cover, and with maximum possible afforestation would be about 16% higher.



Catchment Modelling

SWAT also simulates N and P losses from catchment to coast with changing land use



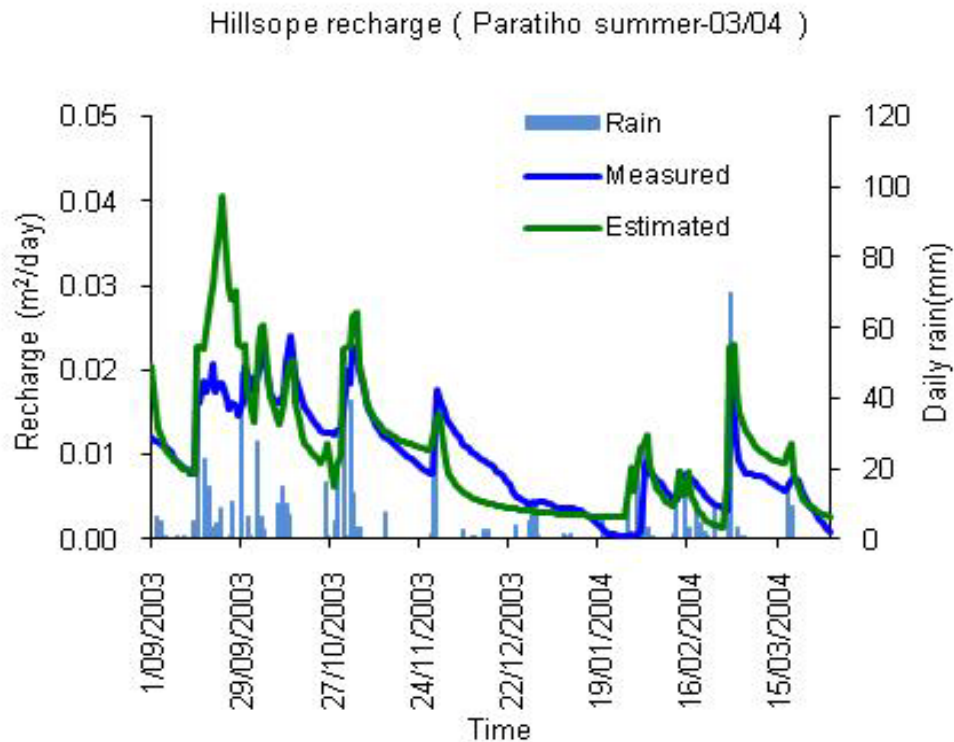
WATYIELD water balance model estimates annual water yields and 7-day minimum flows for catchments with changed land cover (eg planting or harvesting forests)

Improved WATYIELD model available for download
<http://icm.landcareresearch.co.nz/>

Fahey et al 2010: Using the WATYIELD water balance model to predict catchment water yields and low flows. J Hydrol. NZ submitted

Area-specific Hillslope Recharge Model

- Needs only the rainfall time series to estimate ground water recharge.

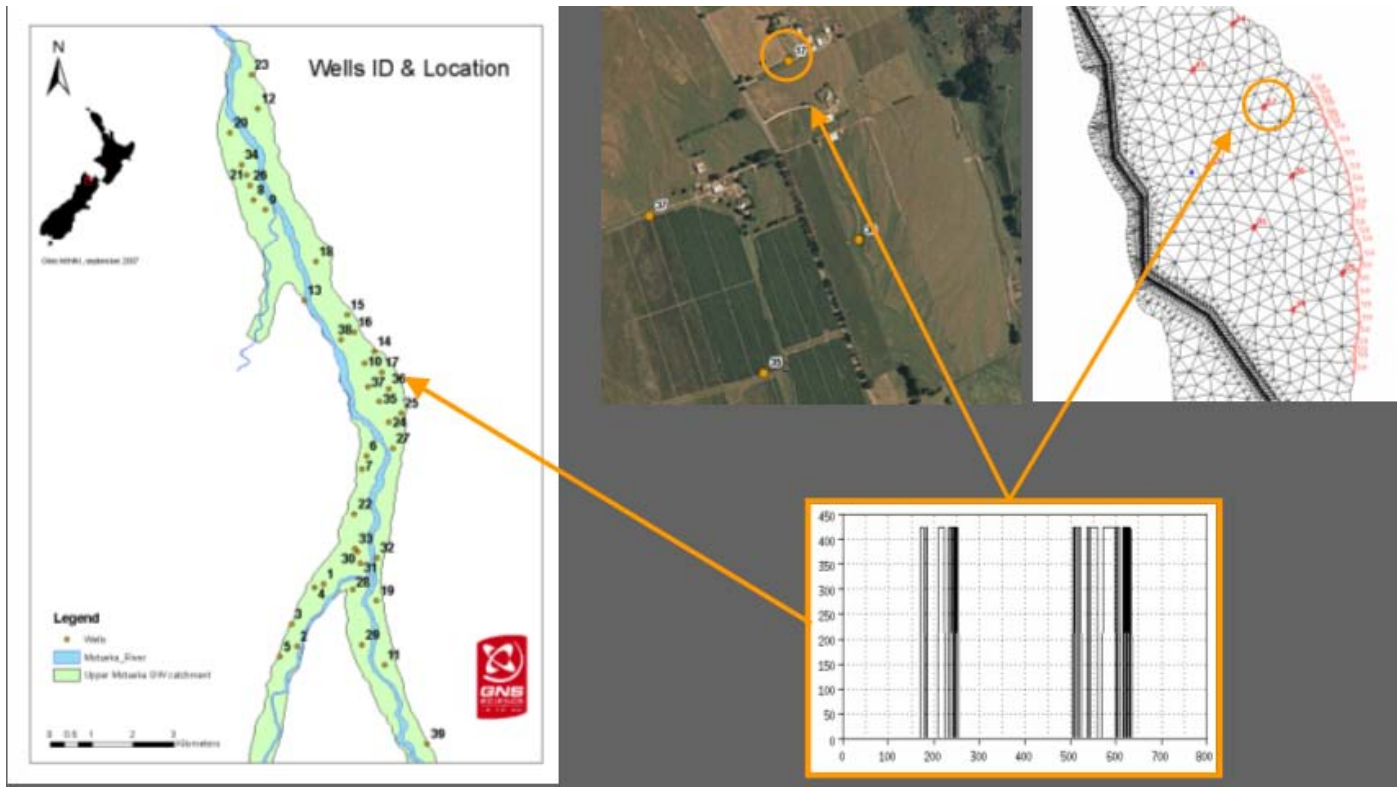


Hillslope recharge & wetland influences in groundwater balance

- Daily transpiration rate of crack willows in the Waiwhero wetland could be more than four times that estimated for pasture (peak diff)
- ***A new model for estimating hillslope recharge in narrow valley alluvial aquifers***
- ***Insights into high water losses from wetland willows***

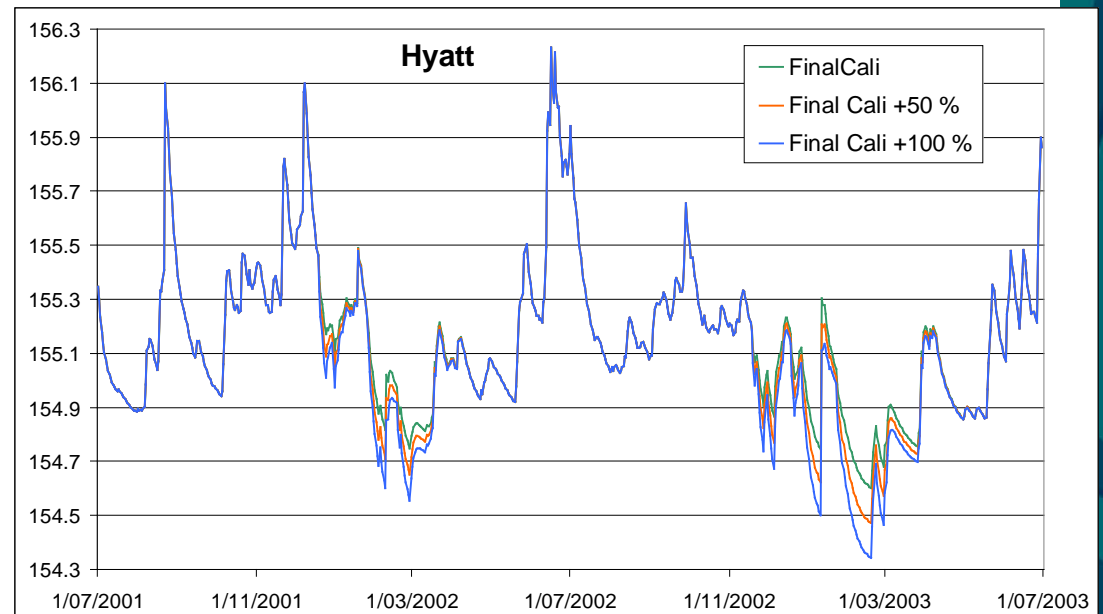
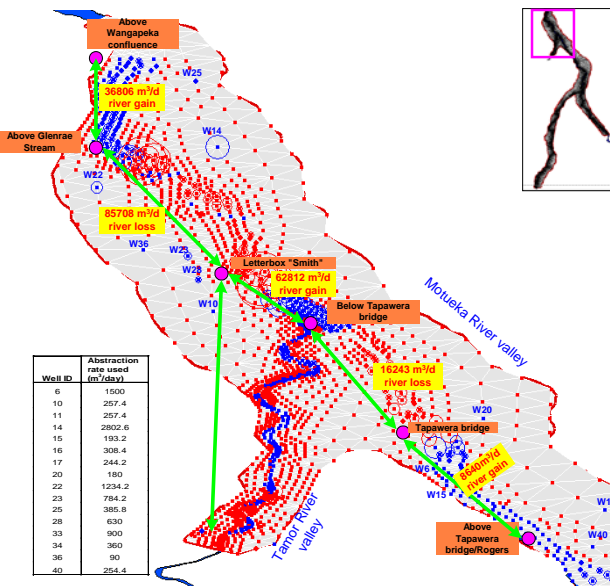
River-aquifer modelling to set water allocation limits

- GNS 3D-model components (Annual average to daily time series):
 - Rainfall recharge through soil (separate LCR model)
 - Hillslope contribution (LCR field experiment)
 - Groundwater extraction (LCR model of crop requirements)
 - Side valley inputs (LCR separate model)
 - Integrate with river ecology & flow preferences for fish (CAW)



River-aquifer modelling: management scenarios

- 1: Fully allocated (up to allocation limit as at present)
- 2: Fully irrigate all irrigable land
- 3: Raise riverbed levels by equivalent of last 40 years decline, 0.3 m av
- 4: Climate Change effects on water balance translated into pumpage and recharge
- 5: Effects of upstream land use change: Forestry vs pasture vs harvest scenarios





Aquatic Ecology Limits

Dean Olsen, Cawthron Institute

Contributors:

Joe Hay, John Hayes, Rob Holmes, Aaron Quarterman, Roger Young, Rowan Strickland – Cawthron

Ricky Olley, Gerry Closs - University of Otago

Lawson Davey, Neil Deans – Fish & Game

Joseph Thomas, Trevor James – TDC

Mike Stewart - GNS

Motueka River

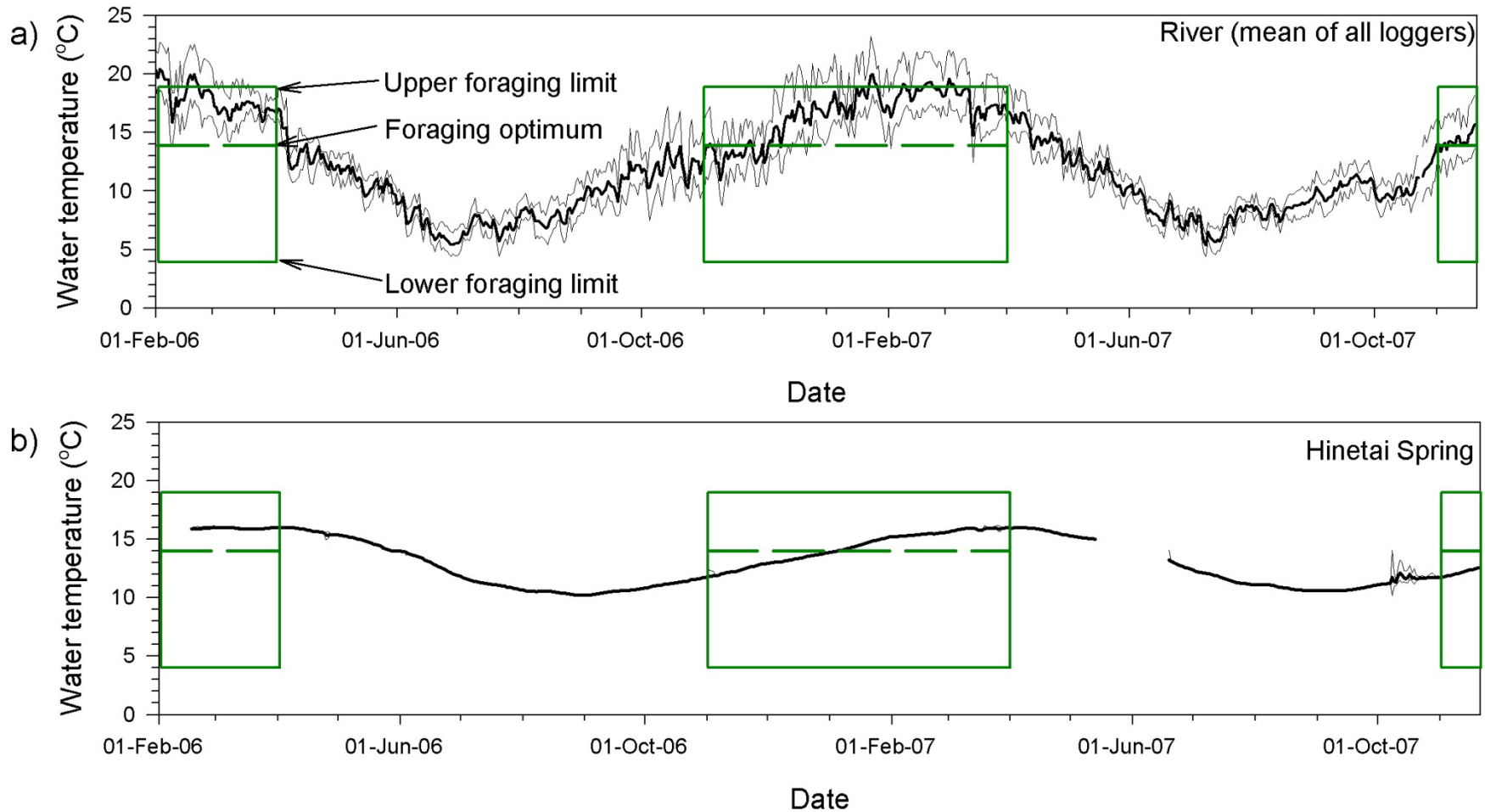
- Nationally significant brown trout fishery
- WCO in 2004
 - Protects:
 - Water quantity
 - Water quality (including temperature)
 - Fish passage



Groundwater allocation

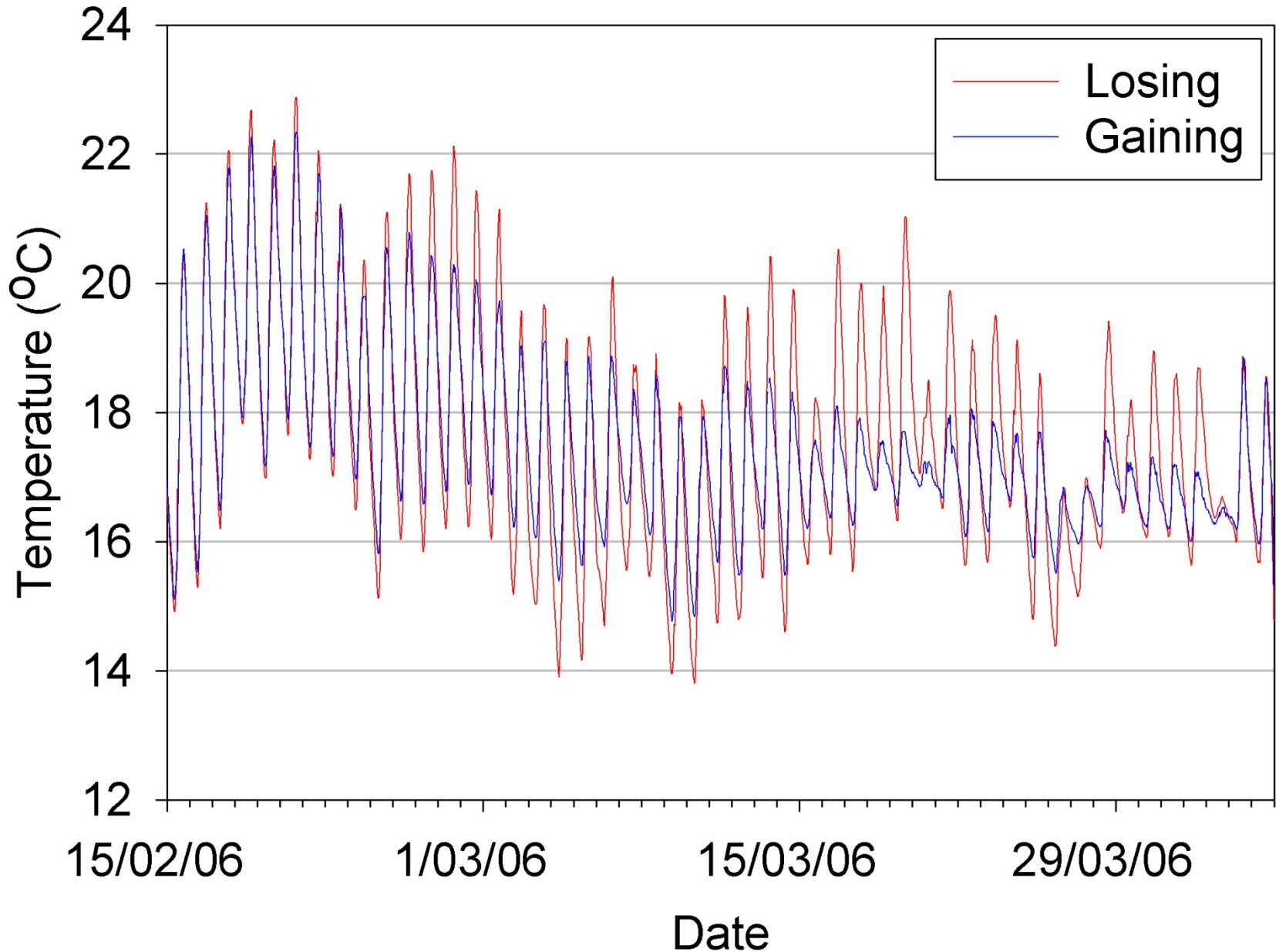
- Groundwater (GW) – river linkages?
- Do GW inputs affect temperature patterns?
 - Consequences for trout habitat suitability/growth?

Do high temperatures limit trout growth?



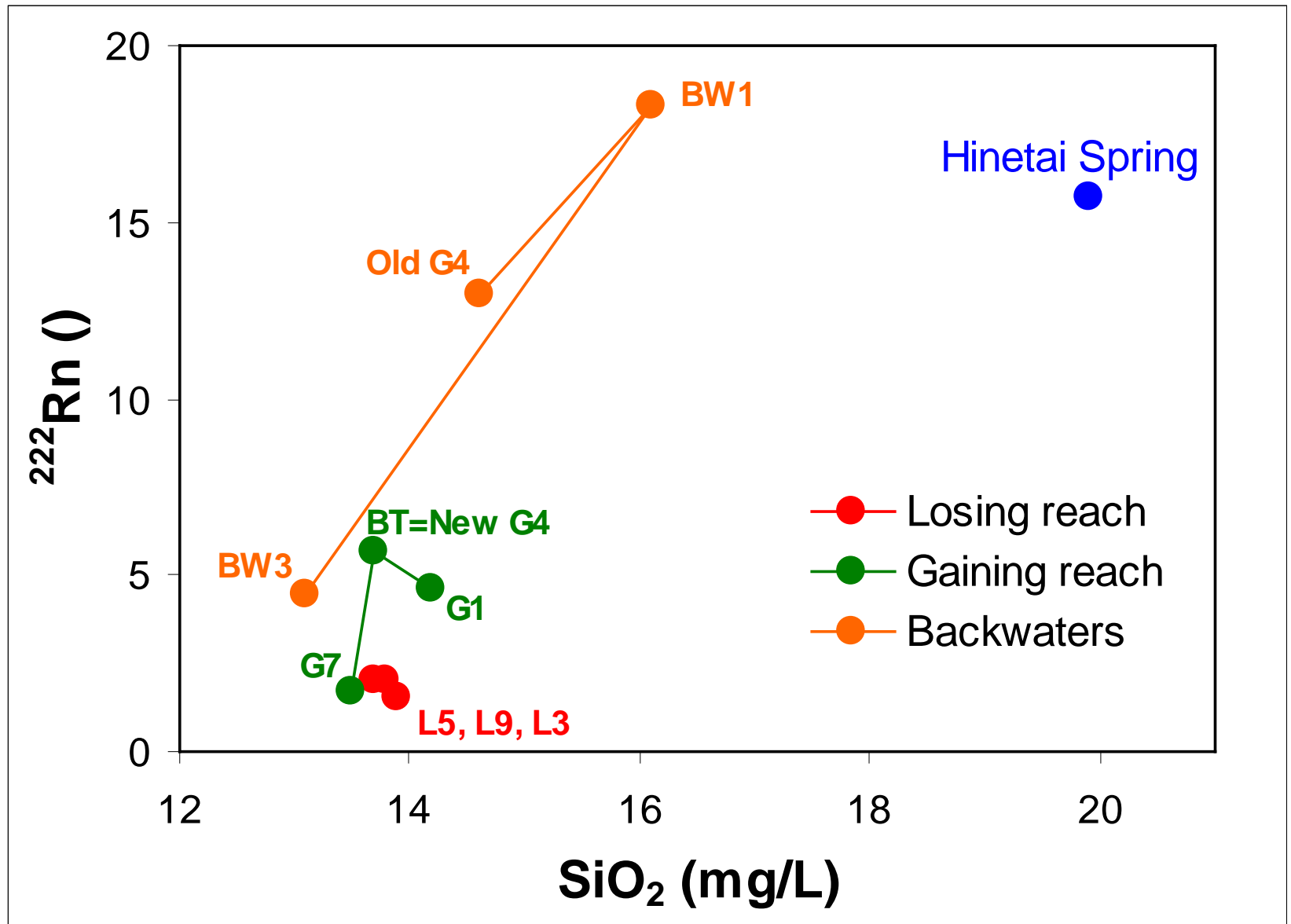
Source: Olsen & Young (2009) *Hydrogeology Journal* **17**: 175-183

How do GW inputs affect temperature patterns?



Radon in the U. Motueka River

(courtesy Mike Stewart, GNS)



What temperature and radon tell us

(courtesy Mike Stewart, GNS)

1. Temperature differences reveal groundwater input
2. Radon reveals groundwater input
3. In winter (Aug '06), groundwater input at Tadmor confluence was steady at 2.5 ± 0.5 cumec (and contributed 10-25% of river flow)

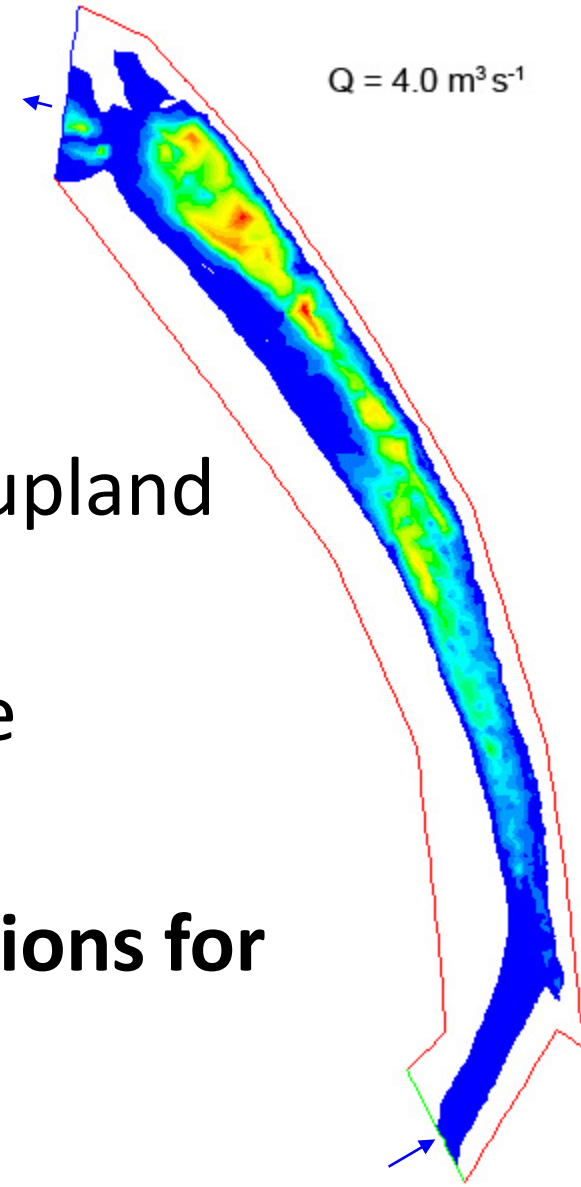
Groundwater allocation

- River & GW connected
 - Up to 25% of base flow from GW
 - GW inputs affect water temp in gaining reaches
 - Temperature effects not likely to substantially affect trout growth

⇒ **River and GW should be managed together**

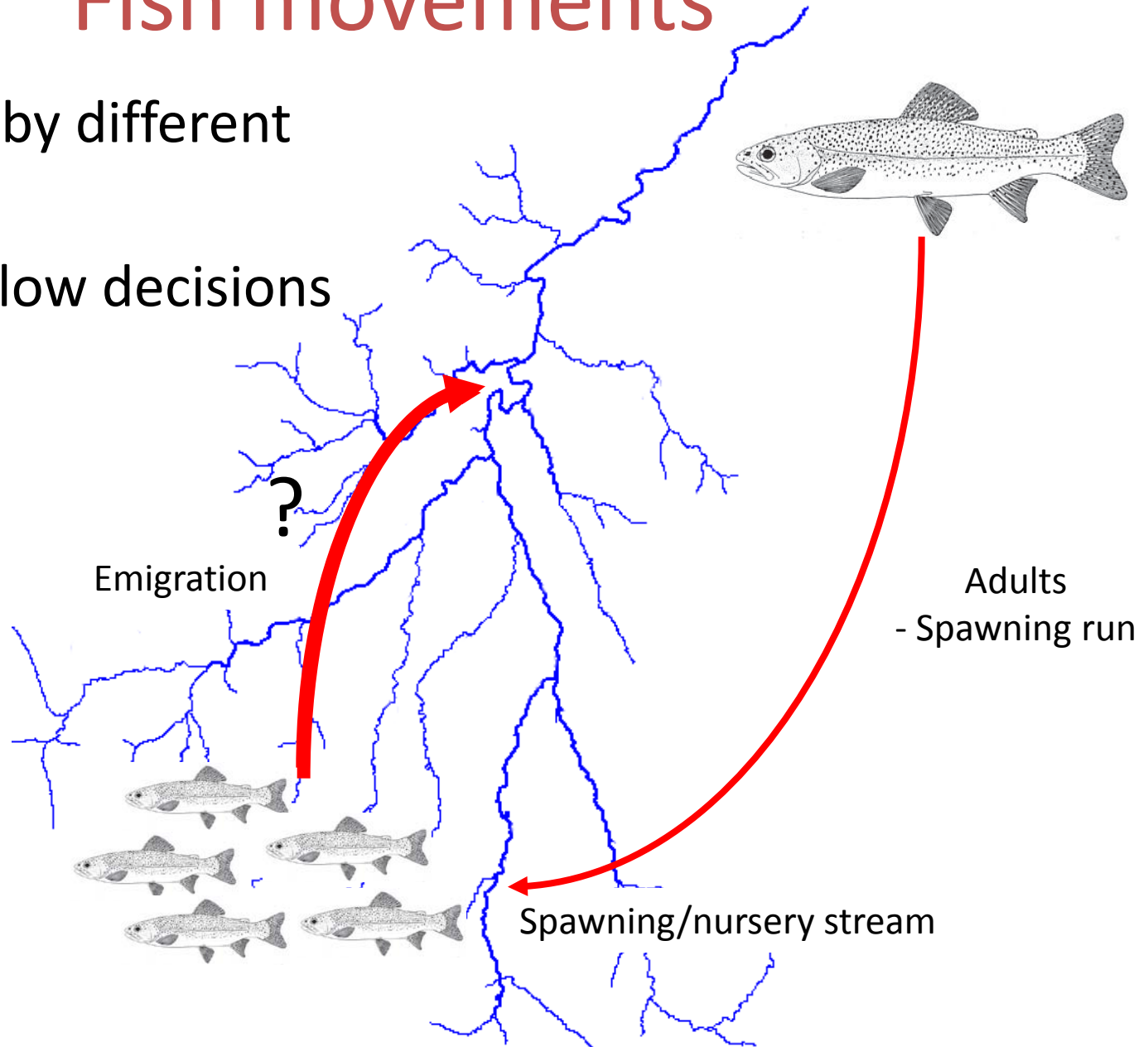
Minimum flow setting

- Instream habitat modelling
 - 1-D & 2-D at several sites
 - Adult & juvenile trout
 - Trout spawning
 - Longfin eel, dwarf galaxias, upland bully
 - Adult brown trout critical value
- ⇒ **Minimum flow recommendations for WCO**



Fish movements

- Habitat use by different life-stages
⇒ to inform flow decisions



Fish movements

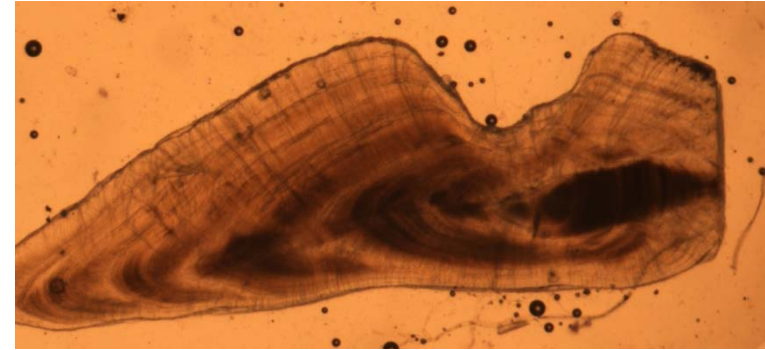
- Radio-tagged adult trout monitored for 11 months
- Moves up to 41 km recorded
- Most fish moved <1 km
- Movement affected by temperature (↓) and discharge (↑)
- 60-70% mortality during 1-in-50 y flood



Source: Young *et al.* (2010) *Transactions of the American Fisheries Society* **139**: 137-146

More on movements

- Otolith microchemistry
 - Natal stream
 - Use of ocean/estuary
 - Movements within catchment



- PIT tagging
 - Part of long-term study of juvenile trout in Rainy River
 - Emigration of juveniles from spawning stream

⇒ **Methods have already been used to inform several hearings**





Water Economics issue

- How do economic returns affect irrigators' uses of water?

Major areas of investigation

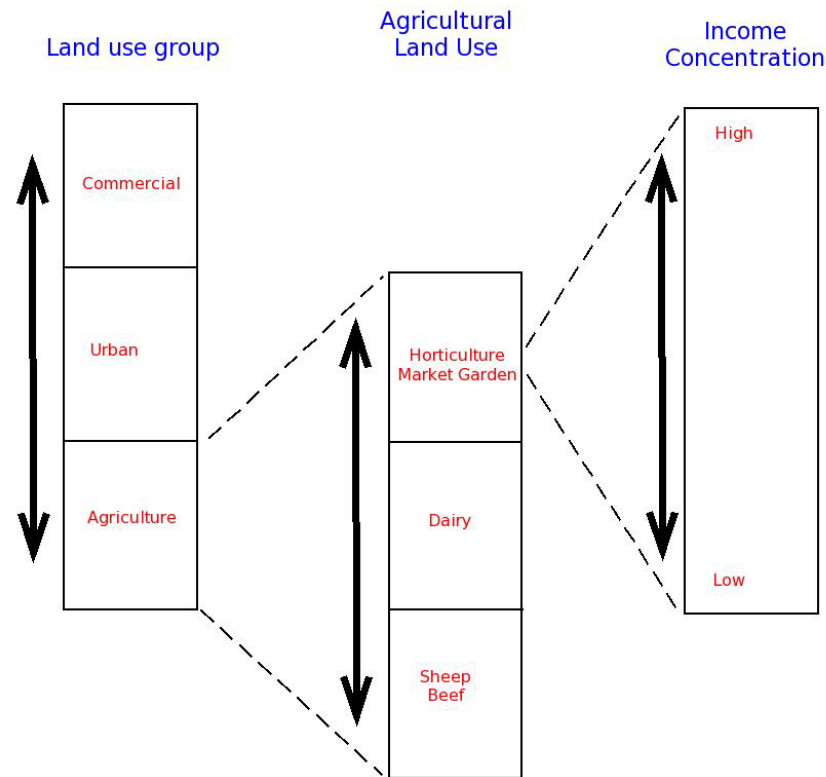
- Economic drivers of groundwater use

Thank you to the ICM for supporting this work

Water economics

- Aims to assess
 - productive sector values;
 - *in situ* and non-use values.
- Aims to assess trade offs
 - within the productive sector
 - between productive and *in situ* uses

Productive sector water use: aim to assess economics of land use and water use



Agricultural land use

- Land owners have an economic incentive to intensify land use;
- For example land use in a longitudinal survey in part of the Waimea Plains between 2003/2004 to 2007/2008 (Figure 1) showed:
 - a decline in land use by dairy and apples
 - an increase in land use by horticulture and market gardening

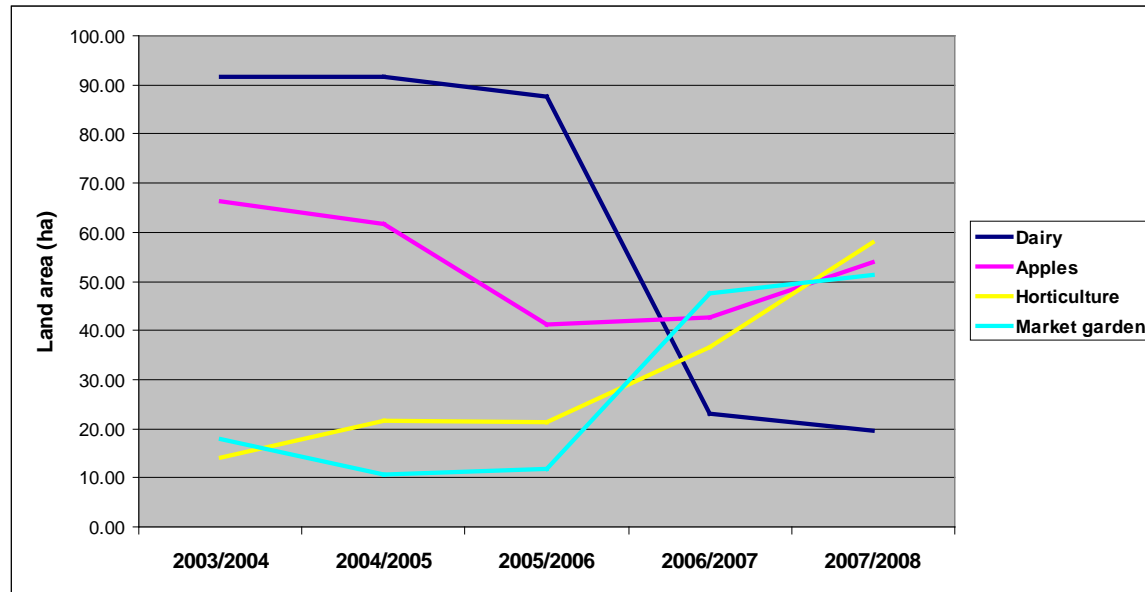


Figure 1. Land use by agriculture 2003/2004 to 2007/2008, Waimea Plains survey.

Agricultural land use

However, higher revenue land use don't necessarily mean increased irrigated water use (Figure 2).

Main economic activity	Average revenue (\$/ha)	Average irrigation (m ³ /ha)
Horticulture	53500	1852
Market garden	46000	1855
Apples	32400	3250
Dairy	10200	3147

Figure 2. Land use by agriculture 2003/2004 to 2007/2008, Waimea Plains survey.

Product price and income concentration

Product price has some control on income concentration (i.e. revenue per m³ of water used), e.g.

- prices for apples went down in 2004/2005 (Figure 3);
- income concentration increased 2004/2005 to 2006/2007 (Figure 4).

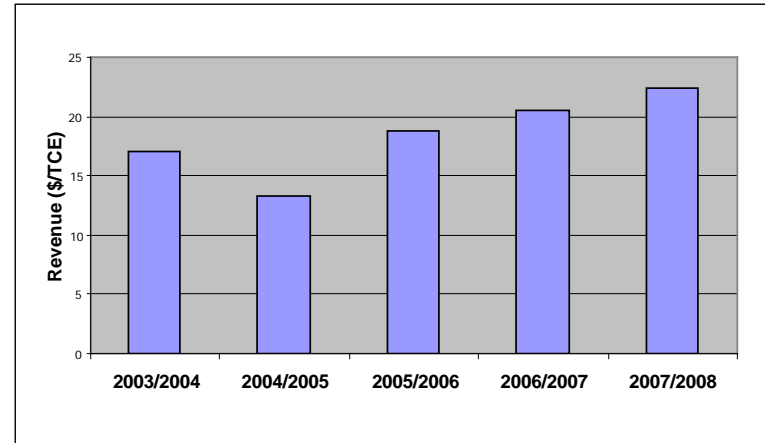


Figure 3. Revenue to growers from apples.

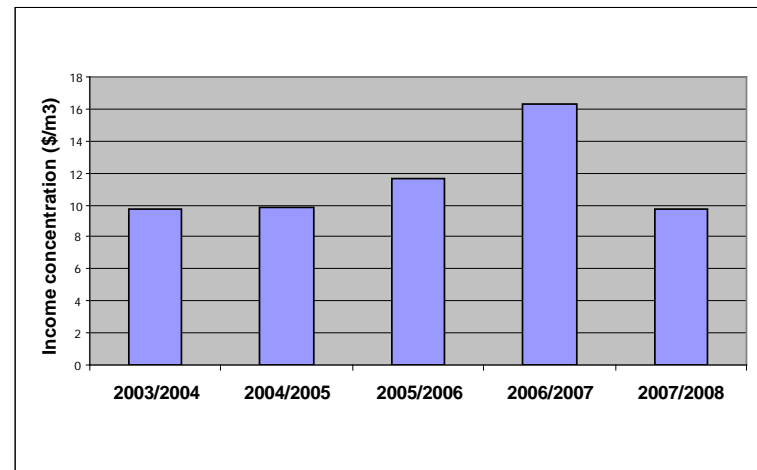


Figure 4. Income concentration, apples.

Production and water use

However changes in farm operation can have a significant influence on water use, e.g. in one orchard (Figure 5):

- significant decrease in production of apples, water use and land area 2004/2005 to 2006/2007 as blocks were removed;
- water use increased in 2007/2008 due to development of blocks with new apple varieties

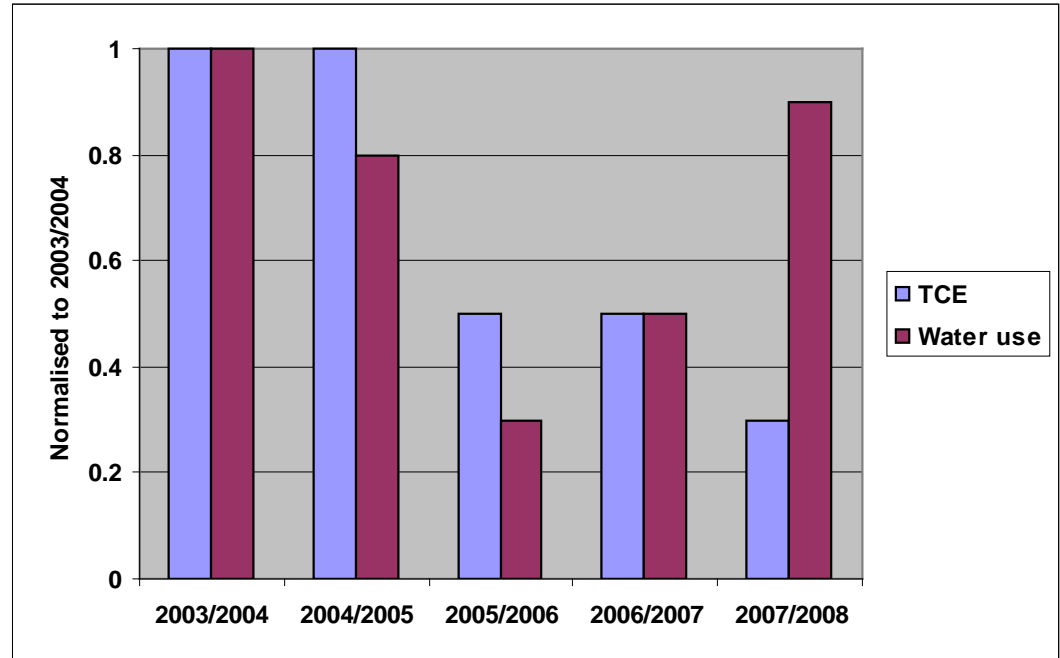


Figure 5. Production and water use in one apple orchard, Waimea Plains, 2003/2004 to 2007/2008.

Economics and water management in the Motueka catchment

- Seeks to *recognise* economic values for the productive sector and *in situ* uses
- Seeks to *balance* productive sector uses against *in situ* uses
- A simple model, incorporating water economics, follows.

Economics and water management in the Motueka catchment

- an analogy for the model is corporate book-keeping. Corporates summarise their status and activity as two numbers:
 - assets, e.g. 'capital value';
 - income;
- the financial performance of the corporate is judged on these two numbers.
- You need these two numbers to reduce the potential for corporates to fiddle the books!

Motueka catchment water assets

- The Total Economic Value (TEV) method can be used to estimate the value of the water resource. This would include water bodies:
 - surface water, groundwater and Tasman Bay
- the work of the ICM is crucial in identifying links within the catchment and between the catchment and the coastal environment

Motueka catchment TEV and economic value of development

- For example, say you wanted to evaluate the economic effects on the water resource of conversion of sheep farming to horticulture. You could, for relevant water bodies;
 - identify values of TEV;
 - identify values of income;
 - identify potential effects such as reduced base flow and reduced fish numbers;
 - assess changes in TEV and income;
 - assess trade offs

Motueka catchment TEV agriculture

Catchment land use	Land area (approx. ha)	Value irrigation (\$/ha)	Income (\$/ha)	TEV Value (\$M)	TEV income (\$M/yr)
Dairy	650	12150	10000	7.9	6.5
Horticulture	5000	12150	50000	60.8	250
Sheep/beef	56380	100	8	5.6	0.5
Forestry	55565	0	0	0	0
DOC	88200	0	0	0	0
Total	205795			74.3	257

Thanks to Andrew Fenemor for estimates of approximate land area

Lower Motueka river TEV fishing

Licences/year	Licence and gear (\$/day)	Origin of fishing folk	travel cost (\$/yr)	Cost (\$M/yr)	TEV value (\$M)	TEV Income (\$M/yr)
10000	31	50% Nelson	30	0.26		
		10 % Marlborough	80	0.1		
		20% rest of NZ	100	0.24		
		20% overseas	150	0365		
				Total	12.5	1.0

Thanks to Neil Deans for estimates of licences and origin

Assess trade offs

- For example do you want to reduce the value of the Lower Motueka fishery by 50% with 100 ha of horticultural irrigation?
 - TEV fishery loses approx \$6 M
 - TEV horticulture gains approx \$1.2 M
- For example do you want to reduce the value of the Lower Motueka fishery by 50% with 1000 ha of horticultural irrigation?

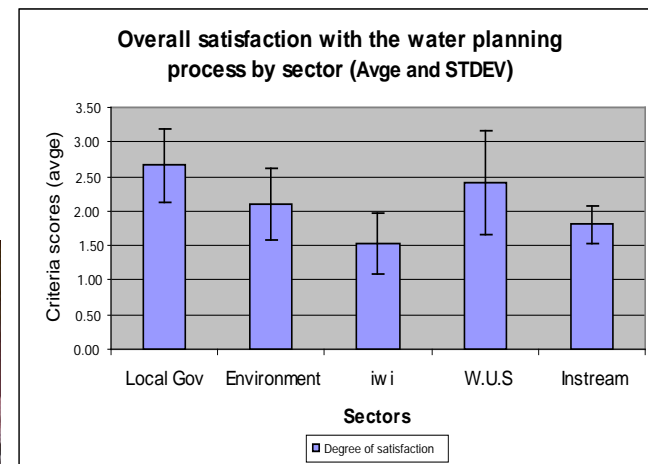


Water Governance issue

- What governance and policy approaches would improve effectiveness of water management plans and planning processes?

Major areas of investigation

- Policy proposals to improve outcomes from water allocation (with Ecologic)
- Stakeholder Views of 5 South Island Catchment Management Processes



Motueka Stakeholder Workshop

Emerging issues

- ❑ Flexibility – users & TDC
- ❑ Security of supply – users
- ❑ Land use impacts >> Water Quality
- ❑ Means of stakeholder input
- ❑ Allocation – competing uses
 - including for in-stream uses
- ❑ Resource rent
- ❑ Water storage/augmentation

Policy Approaches Discussed

- Stakeholder Water Management Committees – to roster water users and manage water quality ✓✓
- More transferability of water allocations – more support from irrigators; temporary transfers preferred ✓
- More explicit Security of Supply – better definition wanted ✓✓
- Water metering – should be mandatory for all ✓✓
- User pays for water management – preferred more by instream users over permit holders ✓
- Alternatives to First In/First Served – none stood out
- Separate permit for site-specific effects – not well understood

Proposition	Overall weighted score	Irrigation interests	In-stream interests	Central/reg gov't	Comm. Dev.	Iwi
9. <i>User pays</i> - Water users should pay for all water monitoring and compliance costs of council, based on amount of water on permit.	4.1	3.0	6.3	3.8	4.0	5.5

Explore the governance factors that create or hinder effectiveness of water management plans and planning processes

Determine the priority attributes for optimal water governance

- Define good governance attributes from water management plans in the South Island
- 5 case studies in 4 jurisdictions
- Interviewed 56 stakeholders
- A cross section of stakeholders from:
 - Government - policy planners, resource scientists
 - Environmental agency - F+G, DoC
 - Iwi
 - Water user stakeholders
 - In-stream - NGOs, independents
- Derived 20 Good Governance attributes: Planning Process Attributes, Plan Design Attributes, Institutional Attributes



Priorities for Stakeholders

Neilan 2009

More holistic land-water planning is sought, especially by iwi

Limits on land activities and uses needed, as well as water body standards and limits

Faster planning processes needed to keep up with resource pressures

User-friendly science, widely available

Formalise involvement of water users & stakeholders in planning and implementation

Communication and engagement of water users and key stakeholders in decision-making during water stress periods creates cohesion and confidence in the water management regime

