The Selwyn River/Waikirikiriri Living Lake Symposium

Scott Larned & NIWA research team
Waikirikiri
Waikirikiri
Overarching question: What are the ecological effects of flow variability?

Flow variability:

- Intermittence
- Mid-range flow pulses
- Longitudinal flow variability
- Bed-moving floods
- Groundwater-surface exchange
- Connection & disconnection
- Historical trends
- Variable aquifer & runoff input

Complex hydrology:

- Perennial, intermittent, ephemeral reaches
- Run-off dominated, groundwater-dominated reaches
- Floods & droughts
- Effects of long-term water use
Hydrological framework based on flow time series & spot gauging

Spot gauging sites
19 sites, 132 dates
2003 - 2008

Whitecliffs (since 1964)
Scott’s Rd (2005-2009)
Well L36/0092
Well M36/0599
Coes Ford (since 1984)
Flow permanence

Distance downstream (km)

Flow permanence (%)

Losing section
Runoff & trib dominated

Gaining section
Groundwater dominated

Hororata R confluence

Selwyn R mouth
Hydrological framework – ELFMOD
ELFMOD for predicting flow time series at all points on rivers

Albarine River, France
Orari River, New Zealand
Methow River, USA
ELFMOD

Longitudinal flow frequency profile
Longitudinal flow variability

Temporal variation in intermittence
Flow-ecology relationships: hydrological variables

- Flow & flow state at any point (m$^3$ s$^{-1}$)
- Long-term flow permanence at any point (%)
- Distance to flowing reach or perennial reach (km)
- Rate of flow loss or gain (m$^3$ s$^{-1}$ km$^{-1}$)
- Hydroperiod at any point (d)
- Historical trends in intermittence
  - Temporal, e.g., trends in hydroperiod (d)
  - Spatial, e.g., trends in dry length (d)
- Predicted onset of intermittence in perennial rivers
- Standard hydro statistics & flow duration curves for any point (e.g., MALF-7, FRE-3)
Flow-ecology relationships: ecological variables
Flow ecology relationships

- **Total Richness**
- **EPT Richness**
- **Diptera**

![Graphs showing relationships between flow permanence and taxa richness](image-url)
Mean total fish density (m$^{-2}$) vs. Flow permanence.

- **Flow permanence**
  - Rarely used by fish
  - $R^2 = 0.744$
  - $P < 0.001$

- **Equation**: $y = mx + b$
  - $m$: slope
  - $b$: y-intercept
# Flow-ecology relationships (a sample)

<table>
<thead>
<tr>
<th>Hydrological variable</th>
<th>Ecological response</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Dry duration (d)</td>
<td>Aquatic invertebrate richness</td>
<td>Larned et al. 2007.</td>
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<td>Aq Sci 69: 554.</td>
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<td>Dry duration (d)</td>
<td>Sediment respiration</td>
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<td>Esterase activity</td>
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<td>Hyporheic taxon richness</td>
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<td>% Hypogean taxa</td>
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<td>Flow duration (d)</td>
<td>Fish species densities</td>
<td>Davey &amp; Kelly 2007.</td>
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<td>Freshwat Bio 52:1719.</td>
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<td>Flow permanence (%)</td>
<td>Total fish density</td>
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<td>Dry reach length (m)</td>
<td>N &amp; P retention</td>
<td>Datry &amp; Larned 2008</td>
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<td>Flow rate (m³s⁻¹)</td>
<td>N &amp; P retention</td>
<td>CJFAS 65:1532.</td>
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<td>Flow duration (d)</td>
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<td>Arscott et al. 2010</td>
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Surface-groundwater interactions
Surface-subsurface interactions

- Roles of shallow groundwater systems in water purification and other ecosystem services
- Effects of river flow and river management on groundwater ecosystems and their services
- Flow requirements for groundwater ecosystems and their services
Nutrient additions to experimental gravel bars
Experimental river ecology

Invertebrate & fish responses to river drying
For more information

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Water quality & periphyton
Water quality changes with distance downstream

Nitrate (mg/L)

Nitrate = 0.04(Dist) – 0.12
$R^2 = 0.76$

Electrical conductivity (mS/m)

Water quality changes with distance downstream:
- Losing:
  - Nitrate
  - DSIR
  - DRP
  - Electrical conductivity
- Gaining:
  - Nitrate
  - DSIR
  - DRP
  - Electrical conductivity

Equation:

Nitrate = 0.04(Dist) – 0.12

$R^2 = 0.76$
Differences betw. Selwyn sections & flow states

DisC-L = disconnected, losing (u/s)
DisC-G = disconnected, gaining (d/s)
C-L = connected, losing (u/s)
C-G = connected, gaining (d/s)
Differences betw. Selwyn sections & flow states

DisC-L = disconnected, losing (u/s)
DisC-G = disconnected, gaining (d/s)
C-L = connected, losing (u/s)
C-G = connected, gaining (d/s)
Periphyton biomass

MfE guideline:
- for biodiversity
- for trout fishing

Chlorophyll a (mg/m²)

- Riffle
- Run
- Remnant

Losing

Gaining

Remnant
Nutrient-limited periphyton

Periphyton biomass (mg chl a/m²)

- Control
- N
- P
- N&P

Sites
Flagpole Whitecliffs Scotts Rd Chamberlains Upper Huts
Intermittence trends

Length of wetted river (km)
- Mean
- Minimum

Year
- 1985
- 1986
- 1987
- 1988
- 1989
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006

Slope = -0.55 km yr^{-1}
Slope = -0.32 km yr^{-1}
Experimental river ecology

Invertebrate dispersal and colonisation