Restoring our Rivers: the Need for Environmental Flows.

by P.S. Lake

Natural Flow-regime paradigm (Poff *et al*., 1997).

- The structure and function of a riverine ecosystem (aquatic and riparian species) are dictated by the pattern of temporal variation in river flows.
- In ecological terms, primary components of flow regime are magnitude, frequency of events (high and low), seasonal timing, predictability, duration and rate of change of flow conditions.
- Extreme events (floods and droughts) are held to exert primary selective pressure for adaptation.

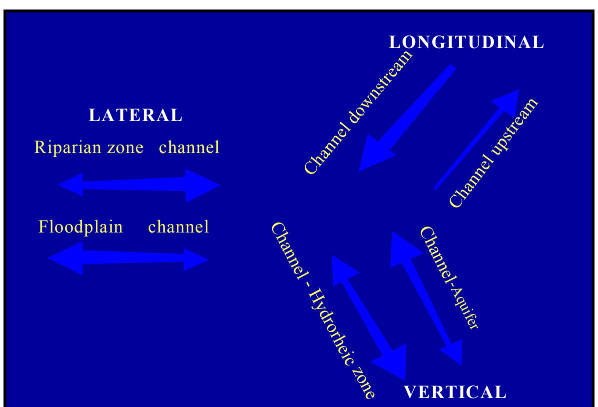
Adaptations to Natural flow regimes 1.

(Bunn & Arthington 2002, Lytle & Poff 2004)

- Flow is a major determinant of physical habitat in streams, and thus in turn a major determinant of biotic composition and diversity (Flow→Structure→biota).
- Operates from patch to catchment scales, and influences morphology, resource utilization, behaviour and life history characteristics.
- Evidence is largely correlative and much is revealed by effects of regulation- such as reduction of flow variability and lotic to lentic changes.

Adaptations to Natural flow regimes II. Extremes of floods and droughts.

- Life history adaptations: e.g., synchrony of life cycle events—reproduction and diapause—bet hedging. Use of flooded floodplains for feeding and breeding.
- Behavioural adaptations: e.g., early detection and refugia seeking and use,
- Morphological adaptations: e.g., plants anchorage, aerenchyma, branch sacrifice.
- Activation of subsidies.



Connectivity

- Dams act as barriers to animal migration and dispersal (eggs, seeds, larvae).
- Impoundments store carbon (POM) and nutrients reducing supply downstream.
- Released water may have low water quality, especially with hypolimnial releases. (Temperature, H_2S, low oxygen).
- Lateral connectivity to floodplain impeded by regulated flows and barriers (levees).

Ecologically Relevant Components of the Flow Regime

- ***Magnitude*** **of discharge**
- ***Frequency*** **of occurrence**
- ***Duration*** **of a given flow condition**
- ***Timing*** **or** ***Predictability*** **of flows**
- ***Rate of Change*** **or** ***Flashiness*** **of flows**

Literature review by L.Poff & D.Pepin.

- Confirmation that flow alteration has *dramatic* ecological effects
  - Reduced species diversity in response to many altered flow components
  - Shift in community dominants
  - Establishment of exotic species
  - Effects on ecosystem function
  - **Flow effects can be independent of other drivers (but interactions are important)**
- Most work done on flow magnitude

State of our rivers.

- Generally accepted that European settlement in 200 years has severely damaged our rivers and their floodplains on an immense spatial scale (e.g., National Land and Water Resources Audit 2002).
- Rivers have been dammed, regulated and have been degraded by unwise catchment development (e.g., clearing and grazing) and riparian zones have been depleted.
- Floodplains have been cleared, drained, cropped, grazed and built on---divorcing lowland rivers from their floodplains.

Pressures on Water Use .

- Water extracted from rivers for irrigation, industrial use and human consumption.
- Both irrigation and domestic consumption continue to rise. 2000-2001 consumption at 25,000 gigalitres----16,700 Gl to agriculture.
- Rice at 1951 Gl, cotton at 2908, dairy 2834 cf ., total domestic consumption at 2181 Gl.
- Water use efficiencies in cubic metres per ton: vegetables 135, citrus fruit 350, rice 1099, raw cotton 5454 (Gordon et al., 2003).

Economics and the need for change

- Clearly our rivers are under pressure, increasing pressure, to meet agricultural demands.
- Pressure from a diminishing sector of the economy.
- ABARE: Agriculture in 1950; 26.1% of GDP and 85.3% of exports. In 2001 3.2% of GDP, 2.6% of exports with only 4.7% of workforce.
- Given the loss of ecologically sustainable rivers, the shortage of available water and the decline in agriculture, surely the time has come to restore ecological damage and re-think land use patterns?

Setting of Targets

- In quite a few cases the targets are diffuse—e.g., creating a "healthy", working river.
- In many early projects the target was flow-habitat restoration for single species (or groups). (e.g., trout, salmon, blackfish).
- Increasingly multiple endpoints (targets) are being set—ranging from physico-chemical to biotic.

Environmental flow methodologies I (Tharme 2003).

- Hydrological EFMs .e.g., Tennant (Montana), % of AAF with minimum flow and some with flow variability (RVA). (30% of global total).
- Hydraulic rating methodologies. Mainly developed for salmonids; wetted perimeter method. Gippel & Stewardson (1998). (11% of global total).

Environmental Flow Methodologies II

- Habitat Simulation methodologies. IFIM (instream flow incremental methodology), PHABSIM etc. Assumes knowledge of preferred hydraulic conditions for biota—mainly fish. (28% of total).
- Holistic methodologies. Attempts to integrate hydrology, channel and riparian attributes, and biota. Bottom-up –building block methodology BBM, and top-down –downstream response to imposed flow transformation DRIFT. Expert panel approach—mostly bottom-up. (8 % of total).

Dealing with Barrier Effects

- Multi-level and surface offtakes to minimize temperature effects. Aeration of hypolimnion.
- Fish ladders, fishways and fish lifts.
- Are all dams/barriers necessary? Has this question ever been asked? Removal of dams where costs outweigh benefits—economic and/or ecological.
- Dam removal increasing in USA. Ecological knowledge growing on dam removal effects and abatement of effects—channel reformation, sediment and chemical legacy.

Assessment of responses to flows.

- Monitoring is essential if progress toward targets is assessed. Costs may be low in relation to economic benefits..
- Both duration and distance affected may be long.
- Indicators may be targets.
- Indicators should be simple and cheap to sample, relatively easy to process, with a good knowledge base, and with a clear unambiguous signal linked to flow.
- Hydrological, geomorphological and biological--(populations, communities, ecosystem processes)

Achieving goals and time.

- We live in a time of short-termism; J.Gleick (1999) "Faster. The Acceleration of Just about Everything", society (e.g., politicians, business & resource managers etc) expects activities to be done faster (e.g., business plans, milestones), but natural processes, such as those in restoration, have their own time spans.
- Hence degradation rapid-restoration slow hysteresis—development can be accelerated, but restoration is invariably much slower and may not be accelerated.

Time Spans for restoration

- Times for restorative responses e.g., –Pacific Northwest salmon streams: 1-5 yrs for instream structures, 5-20 yrs for riparian vegetation. Floodplain restoration: Kissimmee River, Florida ; aquatic plants 3-8 yrs, invertebrates 10-12 yrs and fish 12-20 yrs.
- Political implementation of restoration can take time . For example, provision of environmental flows (28% a.n.f) in the Snowy River may take longer to implement than the time to build the entire Snowy Mountains Scheme (~20 years ? vs 19). Murray River environmental flows??

Study Design and Monitoring.

- Cooperative partnerships between resource managers and scientists on selected projects are required.
- Important to select indicators and sites early on and design project to collect before-intervention data.
- Indicators can be linked e.g., logs →fish, riffles→biofilms→grazers.
- Indicators selected for different timed responses (scopes).
- Long-term but inexpensive after-intervention monitoring

Adaptive Management.

- Project framed with key hypotheses in relation to flow intervention.
- Samples analysed after flow intervention.
- Hypotheses evaluated and possible modifications made to flow intervention.
- Modified hypotheses tested—evaluated and discussed again by project team.
- Learning by doing.
- Dangers include: changes made before sufficient time for responses, compromised decisions eventuate.

Environmental Flow Projects in Australia

- Limited amount of flow releases that have been monitored e.g., Mersey River, Cotter River, Snowy River, Barmah water allocation (King et al., 2003). Some non-events –Campaspe.
- Clear need for environmental flow regimes to be implemented and rigorously monitored, so that we can plan ecologically sustainable flow regimes.

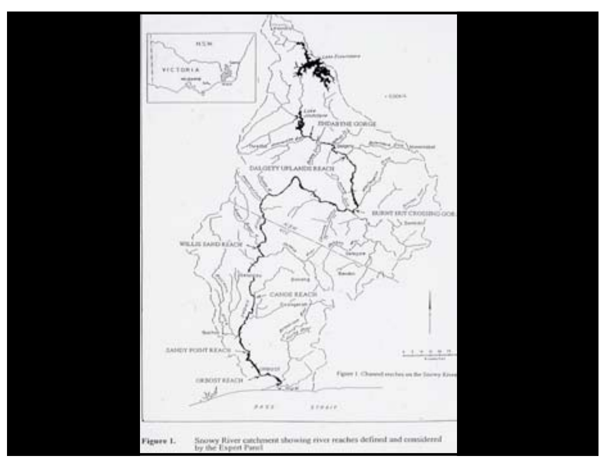
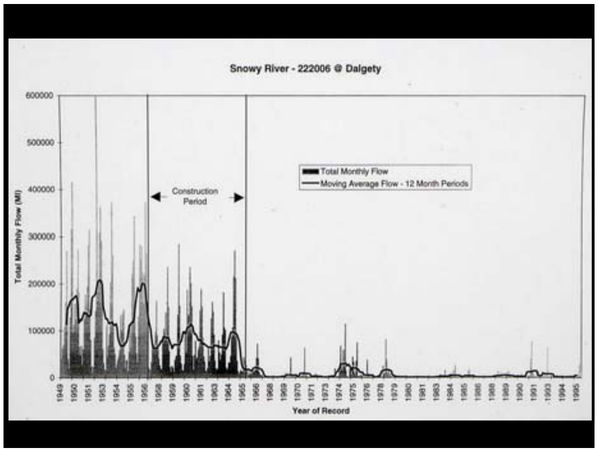
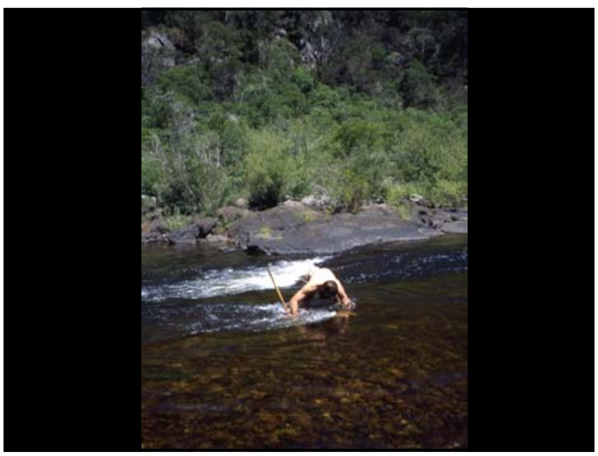
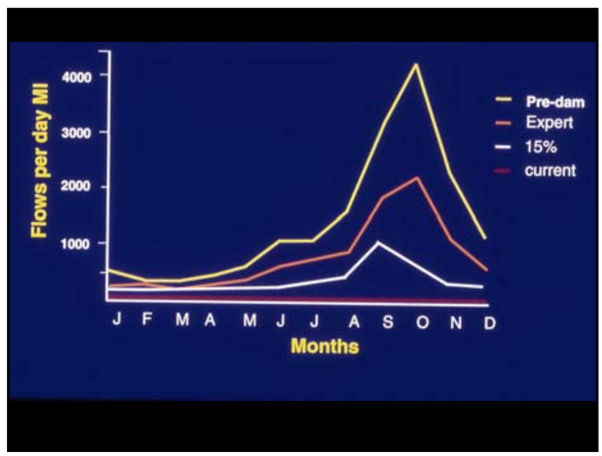


Figure 1. Snowy River catchment showing river reaches defined and considered by the Expert Panel


Snowy River - 222006 @ Dalgety
Total Monthly Flow
Moving Average Flow - 12 Month Periods
Construction Period
Total Monthly Flow (Ml)
600000
500000
400000
300000
200000
100000
0
Year of Record




Flows per day Ml
4000
3000
2000
1000
J F M A M J J A S O N D
Months
Pre-dam
Expert
15%
current

Conclusions

- Many of our rivers are degraded and under tremendous pressure to supply water.
- Water use must become much wiser and ecologically sustainable to restore our rivers.
- Such restoration will require a concerted, well-planned and resourced effort.