What are we trying to achieve in river rehabilitation interventions?

A personal perspective on international activities

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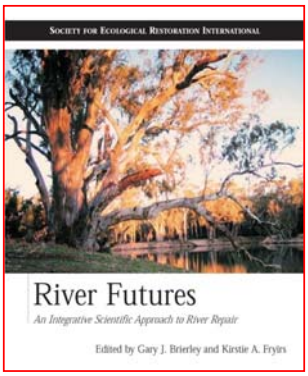
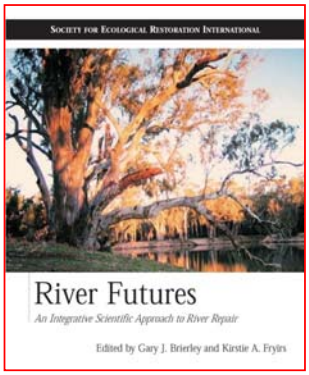
Fashioning river futures



- Using insights from the past to inform future practices (Wilderness is Dead; Wohl, 2013)
- Not re-engineering
  - Restoration versus rehabilitation
  - Rivers as living, dynamic systems
- Working towards the best achievable state

Fashioning river futures



- Concerns for river condition, and moves towards river improvement, take very different forms in differing environmental, socio-economic, cultural and institutional contexts
  - United States
  - Europe
  - Japan
  - South Africa
  - Australia

What do <u>we</u> seek to achieve in river rehabilitation?

Values and mindsets: Who is we?

Location (geography and history), socio-cultural and economic issues, perception, outlook on life, relationship to nature, professional training, etc, must be considered.

Very different perspectives and answers would be generated in a room of hydropower engineers, irrigators, dairy farmers, fishermen, etc …

Concern for negotiation and debate in visioning processes

- Critical role of facilitators
- Recognize the inevitability of a divergence of perspectives while striving for a consensus of opinion (agreement, ownership) on a plan of actions (Emery et al., 2013)

A personal perspective on goals of river rehabilitation

a) Healthy river system with appropriate structure, function and connectivity, while meeting human needs (and providing appropriate ecosystem services)
   - Concern for naturalness and place

b) Socio-cultural engagement with the river, and ownership of adjustments as a living, dynamic system
   - While minimizing costs for ongoing repair

c) Flexible and enabling institutional arrangements that support a and b
   - Proactive framing, recognizing that surprising outcomes are inevitable

My talk today is concerned solely with the first issue, with thoughts on scientific considerations that can help us achieve this

Background principles that underpin what follows

- Looking forward … beyond 're' words/terminology … restoration, rehabilitation, re-creation, remediation, etc
- Rivers as living, dynamic, emergent entities … not furniture, an art work, a car, a building
- Learning from the past: What has gone before fashions what is achievable today
- Catchment-specific (place-based) relationships
- Incorporation of local knowledges (and values)

Concern for ecosystem integrity

- Physical integrity ⇔ Ecological integrity
- 'Whole of system' approach … there are too many species to save them one at a time … Must meet requirements for all parts of life cycles
- Effective river management builds upon a landscape template, recognizing geomorphic influences upon:
  - Habitat diversity in the channel & riparian zone
  - Appropriate water quality & vegetation interactions
  - Free passage between different habitat zones (including floodplain connectivity)
  - Natural flow & temperature regimes
  - Ecosystem functionality – biofilms & food web processes
  - Framing reaches in their catchment context

Integrative river science and management

- Geomorphic platform as a basis for integration … linking rivers to their landscapes (catchments)
- Hydromorphology AND water quality
- Restoration AND flood protection
- Ecological AND engineering practices
- Environmental AND socio-economic/cultural values

Integrative River Science (Potamology)

Geomorphology

Hydrology

Aquatic ecology, water quality

Differing knowledge structures:

- Precision, accuracy, error, uncertainty, replicability, etc
- Fragmented science leads to fragmented management – need an integrative platform for appropriate decision-making … scientific responsibility
- Geo-eco-hydrology must be framed alongside engineering sciences

The importance of conceptual models

- How does the river work (function)?
- How have process relationships changed over time?
- How are process relationships likely to change into the future?
- Evolutionary trajectory (imprint of history)
- Use of modelling applications (DPSIR)
- Identification of threatening processes and 'thresholds of potential concern)
- Model provides a platform to test our understanding, as well as develop and implement management applications

Hunter Project, New South Wales, Australia (2004-2008)

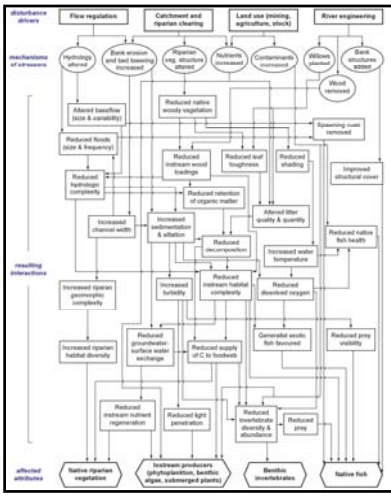
Large cross-disciplinary rehabilitation project with state government and industry support

Challenge of finding common ground and perspectives

Conceptual model emerged at the end of the project (Mika et al.)

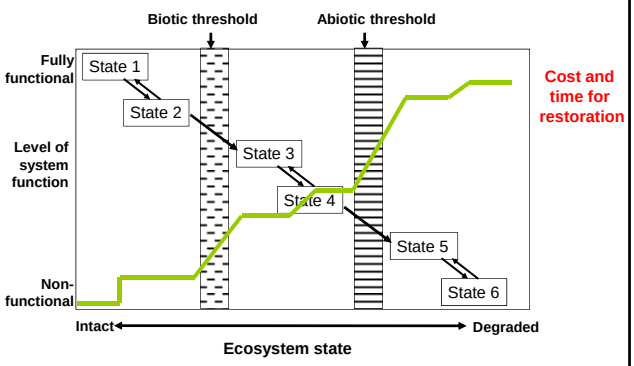
Engineered log jams & Fish Hotels!

A conceptual model outlining the functionality of the Upper Hunter River, Australia



Mika et al. 2010. Inside the 'black box' of river restoration: Using catchment history to identify disturbance and response mechanisms to set targets for process-based restoration. *Ecology and Society*. 15(4): 8

An economic case for environmental protection



(Hobbs, 2001)

Some propositions/provocations

- **Science has genealogy; it cannot be meaningfully separated from values**
  - Landscapes are not simply observed, they are invented
- **'Science' does not drive innovation in river management**
  - People drive innovation … this is an inherently political process
- **Social science is the poor cousin in river management**

An era of river repair: Real or illusory?

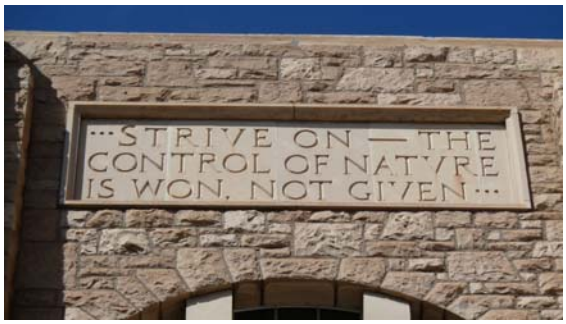
- Few would argue that our actions in river management best reflect what we know.
- How visionary and coherent are our management applications?
- Are contemporary practices and approaches to river management sustainable? What will be our legacy for future generations?
- Is river health (condition) improving, or not?
- How effectively are we learning as we go?

Moves towards an ecosystem approach to river repair

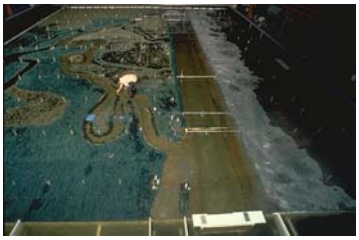
- A whole of system approach … beyond one species at a time!
- Beyond compromise 'solutions': What is half a habitat?
- Legislative framings such as the Water Framework Directive brings genuine prospects … substantive changes in approach (mentality) and practice are already underway
- So, what will (could) this look like?
  - Concern for transferability of understandings … responses will take differing forms in differing situations
  - It all starts with values and mindsets …

Mindsets & training: Faculty of Engineering, University of Wyoming

Strive on – the control of nature is won, not given



Beyond Technofix

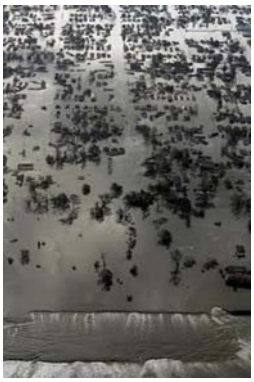


Kissimmee River, Florida, US

Boutique restoration (Higgs, 2003)

Not Disneyland!

New Orleans (August 2005)



"If I had $10 to spend on a levee, I would put $8 on people and $2 on dirt."

Robert Bea, Civil Engineer, UC Berkeley
New Scientist, 28 April 2007, p10

New approaches to flood management … space to move (freedom space) initiatives.

Transition from 'command and control' to ecosystem perspectives

Command and control approach

Ecosystem- based approach

Lessons from history: Dujiangyan (near Chengdu), Sichuan, China

Work with nature …
c250BC Governor Li Bing: channeling and dividing the Min River
Flood prevention and irrigation source on the Chengdu Plain for more than 2000 years
Importance of sediment maintenance!

Dujiangyan (Min River, Sichuan)

cf., Sanmenxia (Professor WanLi Huang)

Contrasting scientific perspectives

	COMMAND & CONTROL (ENGINEERING) APPROACH	ECOSYSTEM APPROACH
Goals and aims	Quest for stability over decadal timeframes	Work with natural variability over centuries or millennia
	Desire for certainty in outcomes	Recognizes uncertainty and complexity
Perception of rivers	Clean and tidy, hydraulically efficient channels	Messy, 'natural' systems
Approach to science	Discipline-bound, reductionist	Holistic, cross-disciplinary
	Single-purpose, deterministic, cause and effect	Multi-purpose, probabilistic
	Site-specific or reach-scale applications	Catchment (landscape) framed approach

Contrasting approaches to river management

	COMMAND & CONTROL (ENGINEERING) APPROACH	ECOSYSTEM APPROACH
Institutional arrangements	Top-down, politically driven (expecting 'others' to 'fix' things)	Bottom-up, participatory; promotes societal engagement; enabling, flexible institutions
Approach to management	Technical (engineering) focus, with a construction focus	Social-ecological considerations; considers a continuum of interventions - including the 'do nothing' option and space to move programs. Allows the river to speak for itself.
Prioritization	Short-term focus upon 'quick-fix' solutions	Long-term commitment, framed in relation to a strategic plan of action
Auditing and monitoring	Limited monitoring	Adaptive management … learning by doing; management as experimentation

Everything is contextual: Geography & History matter; Institutional framings

Working with nature

- Respect diversity (geodiversity and biodiversity)
- Process-based understandings
- Catchment-scale relationships: Know your Catchment
- Evolutionary trajectory
- Integrative, coherent scientific applications
  - Ecosystem-scale: Not one species at a time
  - Habitat availability and viability
  - Not 'carbon copy' referential approaches

Some principles of effective river rehabilitation practice

- Don't fight the site
- Naturalness and place
- Appraise what is realistically achievable

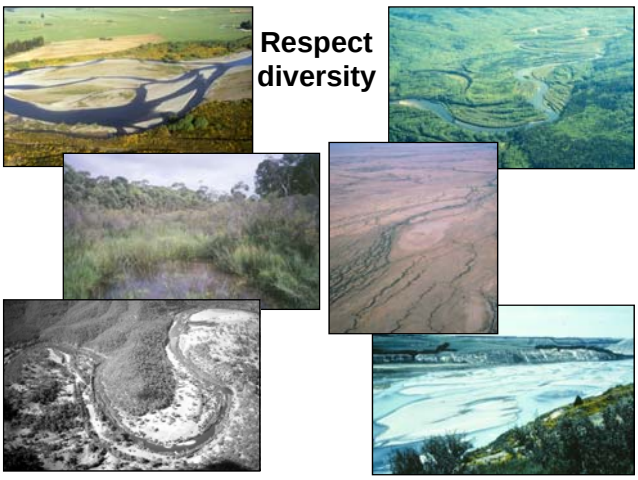
Don't Fight the Site

a) Respect diversity

b) Understand process relationships that influence reach and catchment-scale river adjustments

c) Frame management actions in relation to the evolutionary trajectory of the river

Brierley and Fryirs. 2009. Don't fight the site: Three geomorphic considerations in catchment-scale river rehabilitation planning. *Environmental Management*.

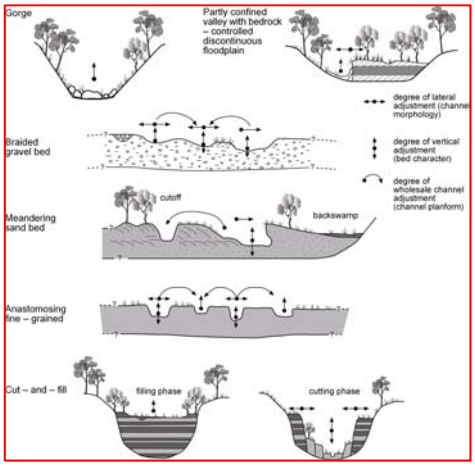


Process-form relationships for different types of river

Differing forms of adjustment

Variable capacity for adjustment

Variable rates of activity (sensitivity)



Naturalness and Place

- Framing what is expected …
  - Is the system naturally heterogeneous or homogenous (structurally complex or relatively simple)?
  - Is the system naturally connected or disconnected?
- These considerations have significant implications in determining appropriate measures of river condition (i.e. what we measure against)
- Assess what is achievable if the present state is not the desired state

Fryirs and Brierley 2009. Naturalness and place in river rehabilitation. *Ecology and Society*. 14:20.

Heterogeneity and homogeneity

Active meandering sand bed … structurally complex

But what do you measure?
Quantifying physical diversity (O/E)
Process relationships (bank erosion)

Intact swamp, discontinuous watercourse… structurally simple

Connected and disconnected landscapes (riverscapes)

Coupled hillslope-channel system

Connected landscape

Major implications for flow and sediment flux

Decoupled hillslope-channel system

Disconnected landscape

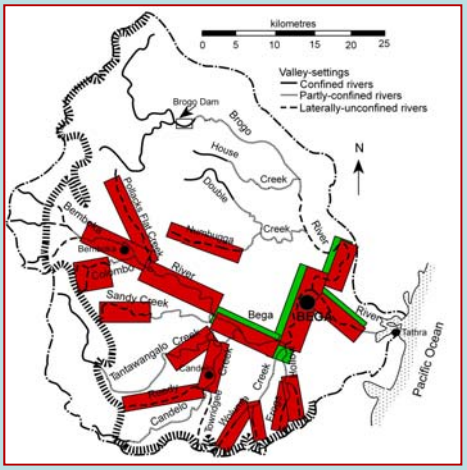
Appraise what is realistically achievable

- Use historical analyses and modelling applications to assess likely future adjustments
  - Is change to a different type of river likely?
  - Is recovery possible?
  - This reflects the capacity for adjustment a river, its sensitivity to disturbance events, responses to past events, and catchment-scale connectivity (and fluxes)
- Using recovery notions to prioritize river rehabilitation activities

River changes in Bega catchment since European settlement

Erosion

Deposition



Landscape connectivity in Bega catchment

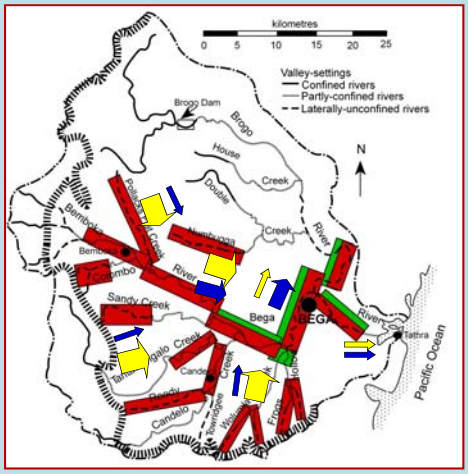
Pre ES Post ES

strong

weak

disconn

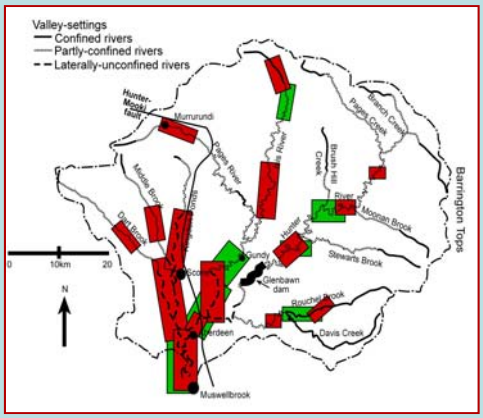
Enhanced connectivity since European settlement



River changes in Upper Hunter catchment since European settlement

Erosion

Deposition



Landscape connectivity in the Upper Hunter catchment

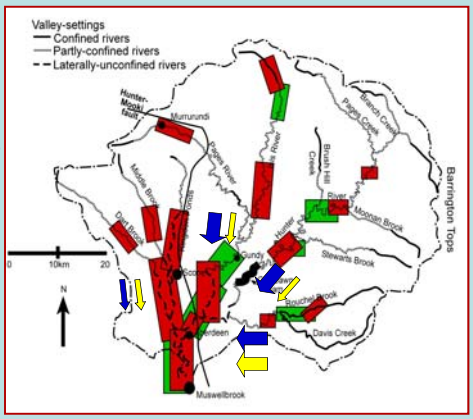
Pre ES Post ES

strong

weak

disconn

Remains relatively disconnected since European settlement



Differing evolutionary trajectories fashion likely river futures

- Reflects sensitivity to change, disturbance events, and connectivity of the system
- Management implications:
  - Bega Catchment
    - *Increased connectivity - lock sediments up in incised valley fills*
  - Upper Hunter Catchment
    - *Maintain disconnectivity*

Brierley et al. 2008. Working with change: The importance of evolutionary perspectives in framing the trajectory of river adjustment. In: Brierley and Fryirs (eds.) *River Futures. An Integrative Scientific Approach to River Repair*.

Fryirs et al. 2009. Post-European settlement response gradients of river sensitivity and recovery across the upper Hunter catchment, Australia. *Earth Surface Processes and Landforms*.

THE RIVER STYLES FRAMEWORK

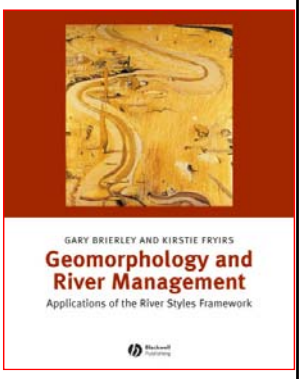
Stage 1: River character, behaviour and pattern

Stage 2: River evolution & geomorphic condition

Stage 3: River recovery potential (trajectory)

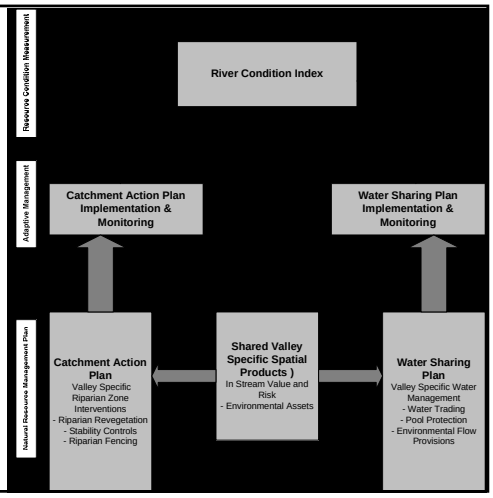
Stage 4: Management applications
- Catchment-scale vision
- Target conditions
- Prioritisation
- Monitoring

- **A 'learning tool' … a way of thinking about river systems = adaptive, flexible**

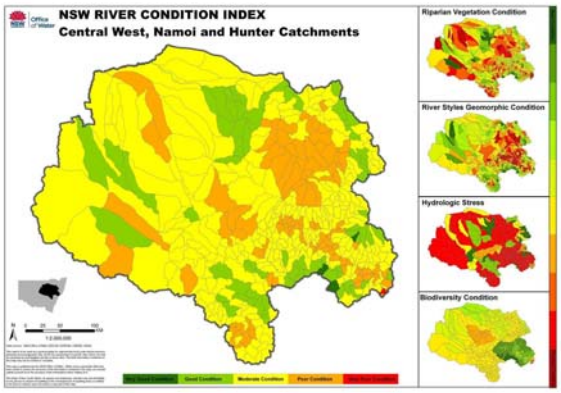


www.riverstyles.com

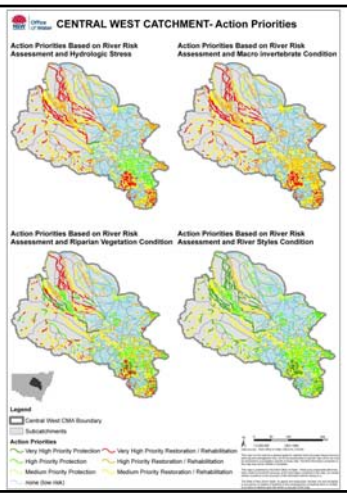
Alignment of Water and Catchment Management Plans in NSW, Australia (Brierley et al., 2011)



Regional-scale river condition assessment (Brierley et al., 2011)



Regional-scale prioritisation of management actions (Brierley et al., 2011)



Catchment-framed prioritization of river conservation and rehabilitation programs

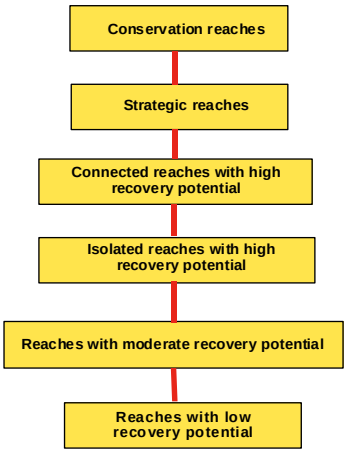
Working with river recovery (assisted/enhanced recovery)

Conservation first: Look after the good bits and unique attributes

Target key problems in a strategic (proactive) manner – identify and rectify problems (causes, not symptoms)

Minimize off-site impacts - Link reaches to enhance prospects for sustainable success (e.g. consideration of sand slugs, head cuts, etc)

Small successful efforts engender greater community (and political) support

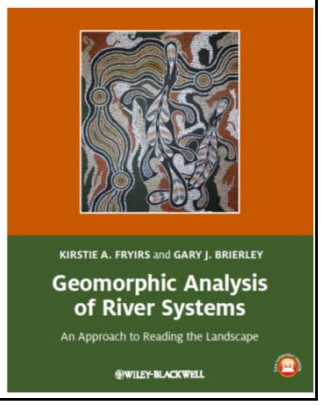


Emerging trends - River restoration as part of integrated river basin management

- Working with natural processes at the catchment scale – rivers as dynamic, living, emergent systems
- Visioning what we are trying to achieve … setting goals and priorities with clear and measurable objectives
- Co-ordinated planning for multiple uses, values and benefits,
  - Safeguarding water resources
  - Flood risk (safety) management
  - Socio-cultural and biodiversity values (ecosystem services)
  - Economic priorities … what is affordable?; what can we not afford not to be doing (intergenerational equity)?

Emerging technologies and field applications

- Advances in geospatial techniques (remote sensing and measurement techniques, dating technologies)
- Modelling applications
- Reading the Landscape: field skills
- Role of critical thinking … moves beyond prescriptive, cook-book (tick-box) applications



Mainstreaming river restoration

- Ecosystem-framing: Achieving a new accommodation with nature
  - Conservation ethos … minimize deterioration of rivers as they are, as well as promoting improvement in river condition
  - Use of green infrastructure
- Envisioning river futures
  - Concern for process and product … how we derive visions alongside statements outlining the vision itself
  - Determination of what is realistically achievable?
  - Derive a clear statement of what we seek to achieve (protect/rehabilitate) and why
  - Defining measurable goals
  - Negotiating an agreed plan of actions
  - Implementation and monitoring

Gregory and Brierley 2010. Development and application of vision statements in river rehabilitation: the experience of Project Twin Streams, New Zealand. Area.

Restore Uncertainty?

- Scientific determinism can have significant (negative) consequences … caution in communication is required
- Emergence, contingency, non-linearity, complexity are critical contemporary buzz-words … how do we transition such understandings into management framings?
- Novel ecosystems … dangers of prescriptive applications

Hillman and Brierley 2008. Restoring uncertainty: Translating science into management practice. In: Brierley and Fryirs (eds.) River Futures. An Integrative Scientific Approach to River Repair.

Social engagement … work with communities (participatory practices)

- Biophysical-and-cultural landscapes. Link to local communities (their river). Imperative to incorporate socio-economic and cultural values in the stewardship of river systems
- Working with social scientists is critical … environmental economics, environmental law, environmental education, whoever deals with permits, etc
- Incorporation of local knowledges
- Shifting baseline of societal aspirations and expectations … what we are familiar with
- Processes of negotiation … ownership of outcomes?
- Environmental and social justice … who speaks for the river?

Spink et al. 2010. Has river rehabilitation begun? Social perspectives from the Upper Hunter Catchment, New South Wales, Australia. Geoforum.

Institutional framings and management practices

- Governance framework (flexible, enabling)
  - Policy setting & Institutional framing
  - Engendering political support … democracy not technocracy … not ecological engineers, but servants of scientifically-informed societal aspirations
- Learning approach
  - Evidence base to initiate and support applications
  - Adaptive, knowledge sharing, appropriate documentation and information bases
  - Use of demonstration sites … need for catchment-framed applications
  - Getting started with small acts, rather than waiting for a comprehensive and integrated approach to happen

Gregory, C., Brierley, G.J. and Le Heron, R. 2011. Governance spaces for sustainable river management. Geography Compass. 5, 182-199.
Gregory, C. Fisher, K., Brierley, G.J. and Clifford, N. 2011. Approaches to participation in sustainable river management: A comparative analysis of contemporary practices in New Zealand and Europe. The International Journal of Environmental, Cultural, Economic and Social Sustainability. 7, 85-107.

CONCLUDING STATEMENT

- We are potentially at a major transition point in river management practices:

  a) Re-restoration - Re-engineering rivers framed in relation to interpretation of some 'past' river morphology (and process regime)

  b) Genuine commitment to processes of river repair - Promoting accommodation with nature … rivers as living, dynamic entities
     - *Prioritizing conservation and rehabilitation activities*
     - *Minimizing deterioration, promoting improvement*
       - Space to move, freedom space, channel migration zone, etc
       - The self-healing, no maintenance option … Leave it alone, do nothing

CONCLUDING STATEMENT

- Many scientific frameworks and toolkits are available to inform the process of river repair.
  - There is broad consensus on what we need to be doing to improve ecological health of rivers.
  - Emerging technologies support these developments, but place-based understandings and applications are vital.
- Approaches to river repair are socially, culturally and institutionally situated.
  - Legislative framings such as the Water Framework Directive have already been transformative.
  - It offers the prospect of significant transformations in what we seek to achieve and how we go about it.
  - Healthy rivers are products of healthy societies.