Organizing Science in Large Scale River Restoration Programs

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Organizing Science in Large Scale River Restoration Programs

• Rationale for large-scale river restoration
• Basic principles for effective river restoration
• Two successfully implemented large scale river restoration projects (Kissimmee River and Healthy Waterways)
• Institutional challenges to river restoration
• Science and phases of river restoration
• Insights and sage advice
Dual Challenge to Rivers Worldwide

- Rivers are the chief source of renewable freshwater supplies for humans and contain high levels of biodiversity
- 80% of the world’s population is exposed to high levels of threat to water security
- 65% of riverine habitat is moderately to highly threatened

Vörösmarty et al. 2010 (Nature)
Threats to Rivers

• River Biodiversity
  – Destruction or degradation of habitat
  – Impacts from overexploitation (overfishing)
  – Invasion by non-native species
  – Water pollution
  – Flow modification

• Water Supply
  – Climate change
  – Climate variability
  – Salinization
  – Water pollution
Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity

Four Guiding Principles

- **Principle 1:** Flow is a major determinant of physical habitat in streams, which in turn is a major determinant of biotic composition.
- **Principle 2:** Aquatic species have evolved life history strategies primarily in direct response to the natural flow regime.
- **Principle 3:** Maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species.
- **Principle 4:** The invasion and success of exotic and introduced species in rivers is facilitated by the alteration of flow regimes.

Five Criteria for Measuring Success

• Design based on a specified guiding image of the outcome
• River’s ecological condition must be measurably improved
• River ecosystem must be more self-sustaining and resilient to perturbations
• No lasting harm should be inflicted on the river ecosystem
• Pre- and post-assessment must be completed and data/results made publically available

- Physical HABitat SIMulation (PHABSIM) has had a global impact by internationalizing the setting of flow criteria and promoting new science.
- Physical models (hydrological and hydraulic) have advanced substantively – supporting biological evidence has been slower to emerge.
- Need long-term research involving both physical scientists and biologists that link population dynamics and hydrodynamics.
- Importance of variability in riverine ecosystems needs to be better understood by policy makers, politicians, and the public.
Successful Large-scale River Restoration
The Kissimmee River Restoration Project

Restoration of the Kissimmee River
Pre-channelized Kissimmee River
Kissimmee River Basin in South Florida

Restoration Goals
• 70 km channel
• 11,000 hectares of wetlands
• Rigorous evaluation program
Anatomy of the Phase I Backfilling

- Backfilled C-38
- Remnant River Channel (Micco Bluff Run)
- Degraded Spoil Area

February 9, 2001
Kissimmee River Restoration
60 Restoration Expectations (Metrics)
Ecosystem Perspective

- Hydrology - 6
- Geomorphology - 2
- Water Quality - 4
- Vegetation - 10
- Invertebrates - 11

- Algae - 2
- Amphibians - 2
- Fish - 7
- Birds - 11
- Listed Species - 5

Each expectation linked to an experimental design, location and frequency of measurements, methods to be used, and ways to analyze and report the resulting data.
Healthy Waterways Initiative–Southeast Queensland

- 15 major catchments
- 22,672 km²
- 19 local government areas
- Population 2.5 m
- Fastest growing region in Australia
Ecosystem Health Monitoring Program (EHMP)

Freshwater EHMP
- Designed stage 3; Implemented 2002

Integrated monitoring for South East Queensland waterways

The South East Queensland (SEQ) Ecosystem Health Monitoring Program has two integrated components: the estuarine and marine EHMP includes Moreton Bay, the Stradbroke and all of the SEQ estuaries. The freshwater component includes rivers and streams above the estuaries.

120 freshwater sites (sampled 2x/yr)
Report Cards on Progress

Freshwater Report Card 2004

For the waterways of South East Queensland

Legend
- Catchment border
- Monitoring sites
- Excellent
- Poor
- ND
- No Grade

Ecozone River Catchments
- The change in grades has been due to improvements in water quality that have resulted from good catchment management

Marine Coastal Catchments
- Rivers enter the Moreton Bay marine environment in poor condition, but streams in both patchy grades or moderate to good conditions

Coral Reef Productive Catchments
- This marine productive catchment has good status, although there are some local areas where the grades have been downgraded from B to C

River Catchments
- Maintains core assets across Spring 2004 contributed to a decline in grade for this catchment from a C to a D in this report

Lake catchments
- The high degree of urban and industrial development in a catchment in southern Queensland has contributed to a decline in grade for this catchment from an A to a B in this report

Salinity Catchments
- This marine productive catchment has good status, although there are some local areas where the grades have been downgraded from B to C in this report

Detailed information on the Catchments and WATREs included in the WATREs can be found in the Ecosystem Health Monitoring Program 2003-2005 Annual Technical Report published by the WATREC or by visiting the Healthy Waterways website at healthywaterways.org.au

Ecosystem Health Monitoring Program

WATREs - Value Added from Adaptive Management
- Similar situations
- e.g. other catchments
- Wider public
- Decision makers

Improved Understanding
- Report card
- Science roadshow
- Audit reports
- Annual report
- Market research
- Science Expert Panel
- Research workshops
- Ecosystem Health Monitoring
- Implementation audits
- Financial tracking
- Market research
- Off-ground actions e.g. STP upgrades, riparian management
- Healthy Waterways campaign
- Science and Research program
Defensible Science and Effective Communication
Institutional Challenges to Large Scale River Restoration

- Uncertainty – communicating uncertainty and taking action when faced with uncertainty
- Breaking the loop of endless planning – moving on to implementation
- Communication – effectively engaging the public, decision makers, stakeholders, and politicians
- Synthesis and integration – well-designed evaluation programs, good data management, and polymaths
Science and Phases of River Restoration Programs – The California Delta

• Science and Planning – getting good science into the planning process in a timely manner
• Science and Implementation – developing a robust evaluation program with clear expectations
• Science and Communication – providing timely and comprehensible scientific input
• Science and Adaptive Management – stronger emphasis on the data management, synthesis, integration, and improved understanding steps

- 2888 stream flow sites evaluated throughout the United States
- Compared stream alteration to other stressors and found that streamflow alterations have the greatest impact
- Streamflow magnitudes were altered in 86% of assessed streams
- Strong association between diminished streamflow magnitudes (highs and lows) and impaired biological communities for fish and aquatic invertebrates
Characteristics of effective question-driven monitoring programs:

1. Good questions
2. A conceptual model of an ecosystem or population
3. Strong partnerships between scientists, policy-makers and managers
4. Frequent use of data collected
The role of science in decision making: does evidence-based science drive river conservation policy?

  – Considerable time may elapse between detecting environmental problems and taking political action
  – Dealing with human-accelerated environmental changes requires better communication among scientists, managers, policy makers, the media, and the public
  – Scientists need to demonstrate ethical behavior and have unassailable data, perseverance, and good communication skills.