A few thoughts on riparian ecosystem restoration......

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How do we measure success?

1. **Ecosystem improvement**, as indicated by
   a) Improved water quality, b) increased riparian vegetation abundance, c) increased population viability of target species, d) increase in bioassessment indices

2. **Increased resilience**: System should have the capacity to recover from natural disturbances such as fire, floods, drought, as indicated by
   a) Few interventions needed to maintain the site


Longitudinal connectivity:

Lateral connectivity

Vertical connectivity

Source: USEPA

Source: UNEP

Source: SMSU

Source: Wyoming state

Source: USEPA
We need to pay attention to the landscape in which a restoration site is embedded and ask,

Is restoration success feasible given the landscape setting?

Where and how can we re-establish connectivity within and between river sites?

What on-going interventions will be necessary, if connectivity can’t be restored?
We need to increase awareness of the connection between ecosystem **function** and **structure**; and between ecosystem **process** and **pattern**, and ask,

**Where and how can we restore the fundamental processes that shape riparian ecosystems?**

Small floods to wet floodplain soils, disperse seeds, trigger seedling germination, stimulate organic matter decomposition

Large floods to move sediment, scour vegetation, drive patch dynamics and successional change

Surface and groundwater flows to sustain growth of channel-side plants and floodplain phreatophytes

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Ward J.V., Tockner K., Uehlinger U., & Malard F. 2001 Understanding natural patterns and processes in river corridors as the basis for effective river restoration Regulated Rivers- Research and Management **17**: 311-323.

San Pedro River re-watering restoration project:

The Nature Conservancy/U.S. Bureau Reclamation; purchase of ranch (6 river miles) and retirement of agriculture pumping on free-flowing river. Restoration cost: $2.8 million, 0.2 million per mile

Upstream perennial reaches will provide seed sources for revegetation, following stream rewatering. Tamarisk shrublands will give way to cottonwood-willow, following flooding.

Flood pulse restoration projects, on dammed rivers

Restoration of heavily modified urban rivers

Rio Salado Ecosystem Restoration project on Salt River-Phoenix. U.S. Army Corps of Engineers/City of Phoenix; Federal Water Resources Development Act. Approximate restoration cost = $85 million; $17 million per mile

Connectivity reduced due to upstream diversion dam, adjacent urbanization, and stream channelization
If key fluvial processes cannot be restored, and if connectivity remains low, ongoing intervention will be required and restoration success will be reduced.

“One begins to get a whiff of ‘disneyfication’ in the whole idea…
… come see a genuine replica of a forest”

Holland N. Undated. The integrity of nature over time.
How do we measure success?

3. Allowing for **Ecosystem Dynamism**, as indicated by
   a) Design plan not centered around a single, fixed, invariant endpoint

4. **Cause No Lasting Harm:** Restoration intervention itself should not damage the ecosystem, as indicated by
   a) Little vegetation removed or damaged in restoration implementation

We need to be cognizant of the fact that ecosystems are “open” and dynamic, and change over time.

We need to have frank discussions about whether lists of “target species” and of “uninvited guests” are compatible with the notion of a “non-fixed, variable endpoint”

“...the use of exotic versus native species in designed landscapes is an issue that seems to bring out the worst in people, not unlike the debate on abortion or gun control” (Tredici 2004)

The plant community in a restored reach may differ from some idealized target for many reasons:

1. Environmental conditions in the river have been fundamentally altered, with historic conditions not restorable, thereby favoring a new suite of species

2. The landscape in which the riparian site is embedded has been altered, as have landscape processes such as seed dispersal, thereby adding a new suite of species to the site

…..if groundwater levels can not be raised at the restoration site, conditions will favor deep-rooted phreatophytes over shallower-rooted phreatophytes

…..if urban rivers no longer flood frequently, site conditions will favor species adapted to more stable conditions, many of which dispersed from landscape plantings

Tamarisk tap root

Middle Gila River

Salt River-Phoenix area

Functional comparisons:

There is no *a priori* reason to assume that a recent immigrant has lower functional value than a long-term resident.

Aesthetic functions

“Beauty is in the eye of the beholder”

Hydrologic or geomorphic functions

Influenced more by plant growth form than by phylogenetic heritage
Influenced by community-level properties (i.e., species diversity)

Animal habitat:

Influenced by both vegetation structure and floristics, as well as by community and landscape level traits.
Riparian functions: maintaining bird habitat

Riparian corridors are composed of a mosaic of landscape patches

Cottonwood-willow forest patch

- High avian density of:
  - Common yellowthroat
  - Yellow-billed cuckoo
  - Song sparrow

Tamarisk shrublands:

- High diversity of patch types can increase avian diversity in the landscape

- High avian density of:
  - Mourning dove
  - Verdin

Brand LA, BR Noon. In prep. Abundance of breeding birds on the San Pedro River as a function of habitat and hydrologic regime.
“What’s striking about this restoration process is that it looks an awful lot like gardening, with its ongoing need for planting and weeding.…

Is “landscape restoration” really just gardening dressed up with jargon to simulate ecology, or is it based on scientific theories with testable hypotheses?” (Tredici 2004)
Monitoring is critical to assess these measures of success

Pre-project monitoring:

Adequate pre-project inventory of biotic and abiotic conditions, to allow for assessment of success and to prevent inadvertent biotic impoverishment

Intra-project and post-project monitoring:

Monitoring and adaptive management should continue during project initiation and extend for several years after project completion

“About half the project managers surveyed reported the collection of baseline data and the use of biological, physical, chemical, or other... measures” (Bash and Ryan 2002)


We need to bridge the gap between science and practice, and effectively utilize scientific information in restoration planning.

Take advantage of the many data bases and journals devoted to river restoration.

Develop conceptual models of ecosystem dynamics to work from.

Encourage external peer-review of project design by a wide range of stakeholders and scientists.


Take advantage of rapidly proliferating information

**Journals of Professional Societies**
River Research and Application
Restoration Ecology
Wetlands

**Online journals and Websites**
San Francisco Estuary and Watershed journal
Freshwater Life web site

**River Restoration Data Bases**
Nat’l River Restoration Science Synthesis
Army Corps of Engineers
Bureau of Land Management
Forest Service
Nat’l Park Service
American Society of Civil Engineers
European River Restoration Network

**Books**
Restoration of Aquatic Ecosystems (NRC)
Handbook of Ecopsystem Restoration (Cairns)

**Conference Proceedings and On-line technical documents**
River Restoration in Europe: Practical Applications
Active Restoration Projects in the Phoenix Metropolitan Area

Create opportunities for experimentation

Experiment and test hypotheses within a project area

Design large-scale experiments, with each restoration project or river reach functioning as an experimental unit

‘Multi-task’: Coordinate water and river management efforts among management entities to achieve greater success and avoid being at cross-purposes...

While some river reaches are being rewatered and planted, at great expense, riparian vegetation is cleared or suppressed at others.

Granite Reef Underground Storage Project on Salt River.
Source: SRP

Agua Fria Recharge Project
Source: CAP

Focus on conservation/protection of rivers

Degradation gradient
Severe.................................................................Minimal

Restoration success probability
Low........................................................................High

Restoration cost
High........................................................................Low

An ounce of prevention is worth a pound of cure