Restoration Ecology of Streams and Looking Forward.

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- Ecological restoration is concerned with the recovery of degraded ecosystems to achieve stable forms of ecological sustainability.

- Restoration ecology can be defined as the theoretical and empirical study of principles and theories concerning the recovery of degraded ecosystems

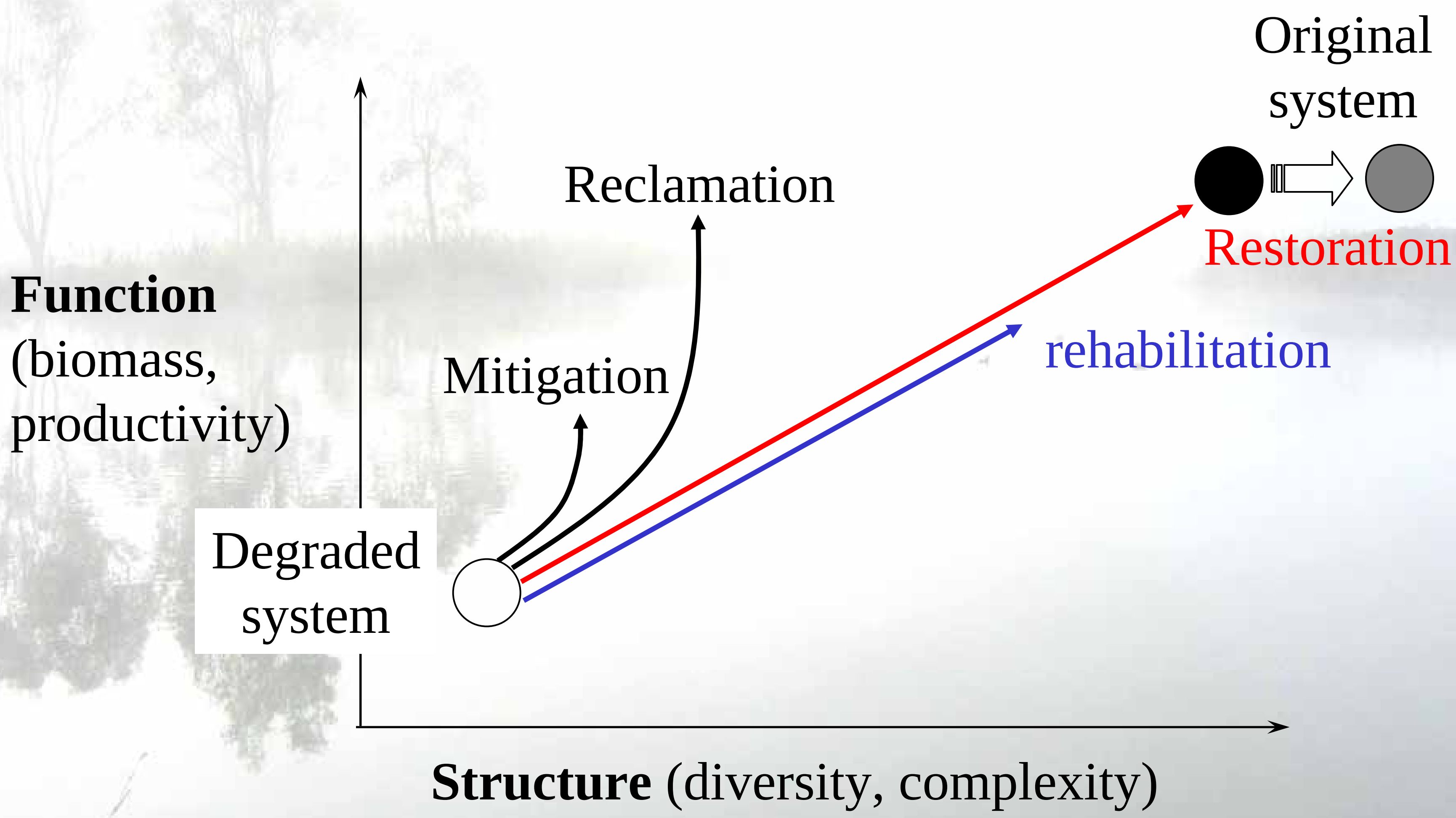
Restoration Ecology

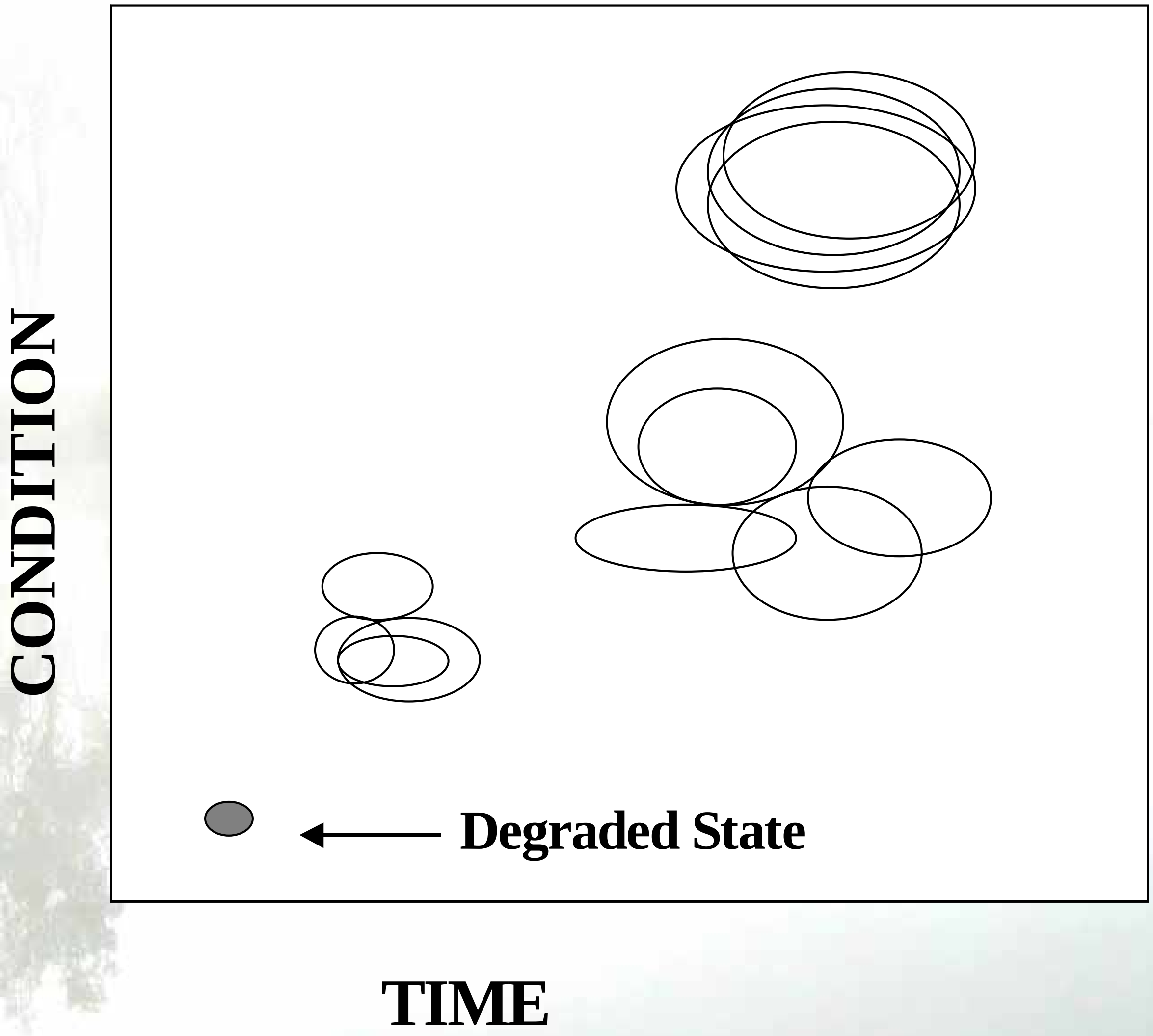
- Restoration ecology combines two major elements of ecology:
- **Disturbance ecology**—an understanding of types of disturbances, how they act and the nature of the responses
- And **Succession**—the ecology of community and ecosystem development from the primary or secondary (often human-degraded) condition.

Ecological Sustainability

- Ecological sustainability refers to the sustained maintenance of biodiversity and ecological processes that occurs in intact ecosystems
- If such ecosystems are exploited by humans then this does not reduce the sustained and dynamic maintenance of biota and processes.
- Ecologically sustainable ecosystems have resistance /resilience to natural disturbances and may have resistance/ resilience to some anthropogenic disturbances.
- Sustainable systems may differ from pristine systems.

Potential outcomes of restoration




CONDITION
Degraded State
TIME

Restoration ecology grows mainly by empirical means, but progress is currently limited by:

- poor planning (especially scale issues)
- poor project design (hypothesis testing?)
- little or no monitoring
- little information on suitable indicators
- little or no reporting of results
- lack of long term commitment from funding and resource management agencies.
- BASICALLY WE ARE LEARNING VERY LITTLE SCIENTIFICALLY FROM THE MANY PROJECTS.

The Catchment and its Streams.

- Long been known that the catchment , substantially governs the nature and dynamics of streams. This needs to be recognized in stream restoration.
- Headwater streams—high stream power -sources of sediments, nutrients and OM. Refugia (?).
- Such streams have been neglected in restoration.

  ISC and middle order streams (?).
- Need to evaluate catchment land use and condition of riparian zones—the problem of little bits.

Riparian Zones.

- Riparian zone perform critical functions—temperature moderation, OM + CW supply, nutrient and sediment regulation, subsidies.
- Intact riparian zones are wide in water-gathering areas--narrow in gorge-valley reaches --very wide on floodplains.
- Riparian zone integrity degraded by land-use intensification and riparian zone thinning.
- Thin bands of “restored” vegetation constitute ineffective restoration. Such strips only carry out partially key functions of intact riparian zones.

Economics and the need for change

- Clearly our rivers are under increasing pressure largely to meet agricultural demands.
- Pressure from a diminishing sector of the economy:
  - Agriculture
    - **1950**; 26.1% of GDP and 85.3% of exports
    - **2001**; 3.2% of GDP and 2.6% of exports (4.7% of workforce)

    ABARE(2002)
- 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 catchment land use?

Steps in a <u>restoration ecology</u> project (modified from Hobbs & Norton 1996)

1. Assessment of damaged state
2. Identification and evaluation of disturbances
3. Setting of goals/targets and hypotheses
4. Selection of indicators & design of monitoring program
5. Implementation of restorative measures
6. Evaluation of progress, success and of hypotheses
7. Reporting the findings of the project.

Assessment of damaged state.

- This involves a multidisciplinary appraisal of the hydrology, geomorphology and ecology of stream system and catchment.
- Such an appraisal may be based on historical changes and/or differences with reference state.
- The appraisal must address the required spatial scale of the restoration (scope).
- Large spatial scale equates with long response time and increased funding—but large scale projects may be much more effective than small-scale projects.

Identification and evaluation of disturbances

- Need to address historical legacies and current disturbances.
- Identification of disturbances by spatial-temporal scale (scope) and by strength.
- Ascertain interactions between disturbances.
- Important to rank disturbances in terms of feasibility and timing of restoration.

- The catchments of the Strathbogie Ranges were settled by squatters by the 1850’s.
- Land clearing (ringbarking) began in the 1860’s and continued to the 1920’s, leaving only a few remnants of native vegetation (e,g., ~2% on Castle Creek catchment). Erosion started in the late 1800’s.
- Massive channel incision and sediment export occurred episodically—1916 massive flood, 1952-1956 three very wet years, 1980-2000 (1982-83 drought, 1990-91 bushfires, 1993-94 floods).
- Sediment exported downstream to “the Flats” generating sand slugs. (240000m^2 in Creightons).
- Sand Slugs now immobile.

Downstream on the ‘flats’, the streams were typical chain-of-ponds with deep clay-bottomed pools and short runs.

Setting of goals/targets and hypotheses

- Goal setting is difficult and takes time
- Goals should ideally be quantifiable and set in relation to current reference and/or historical states.
- Goals should be selected in terms of relevant and easily measured indicators
- Goals preferably involve linked parameters and have variable response times.

Selection of indicators.

- Progress and testing of hypotheses can only be determined by rigorous monitoring of selected indicators.
- Indicators linked to goals, simple and inexpensive to measure, good knowledge base and sensitive to changes toward goals.
- Indicators can be selected for different response times.

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.
- Fallacy of managerialism.
- Hence degradation-restoration hysteresis—development can be accelerated, but restoration is invariably much slower.

Time Spans for restoration

- Times for 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.
- Politically implementation of restoration can take time . Provision of environmental flows (28% a.n.f) in the Snowy River may take longer than the time to build the entire Snowy Mountains Scheme (~20 years ? vs 19). Murray River environmental flows?

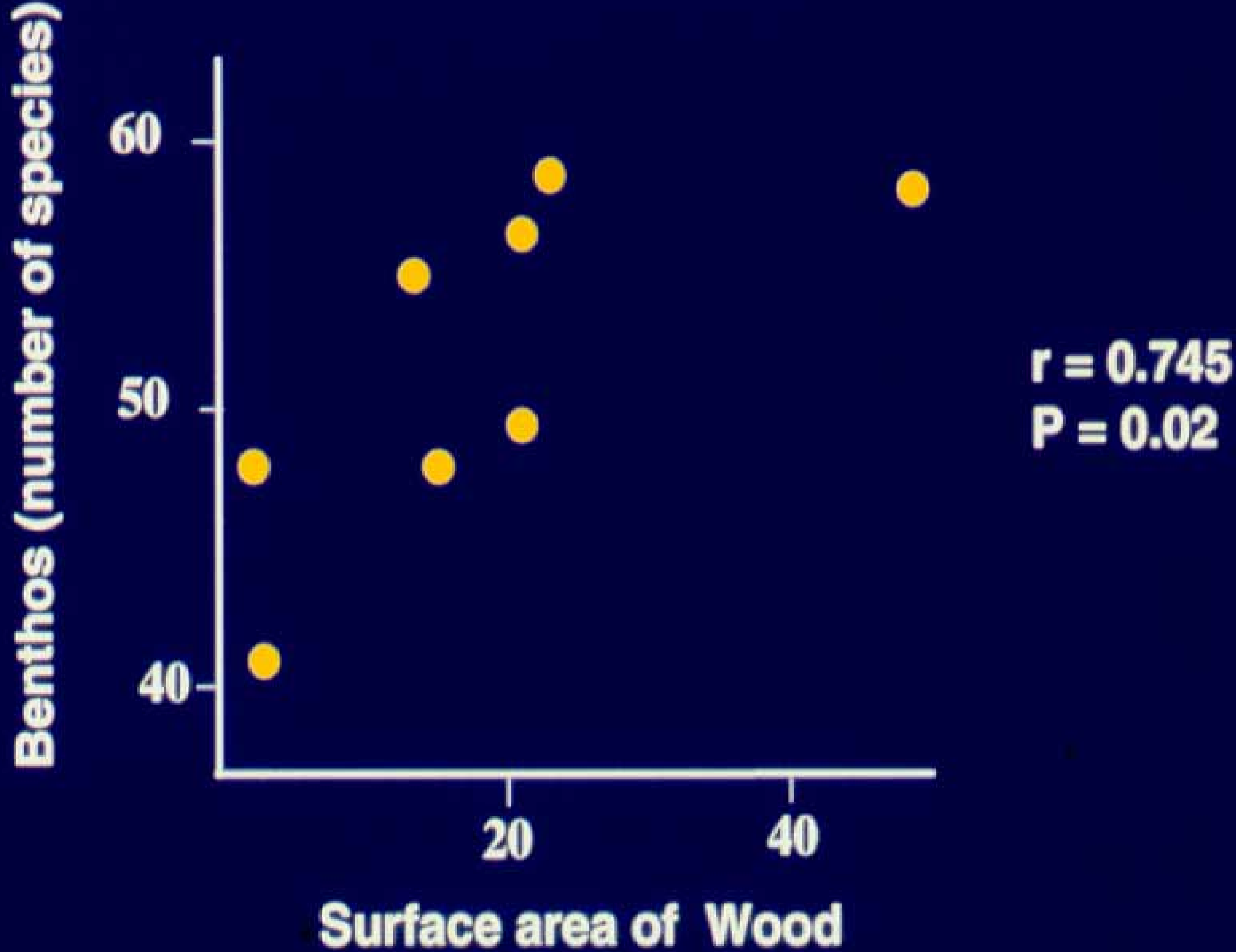
Design of monitoring program

- Crucial components of design include availability of before-restoration data sampled in same way as after-restoration data.
- Availability of control C (i.e., degraded), reference R (i.e. goals) and Treatment T sites (undergoing restoration). Design will be determined by availability.

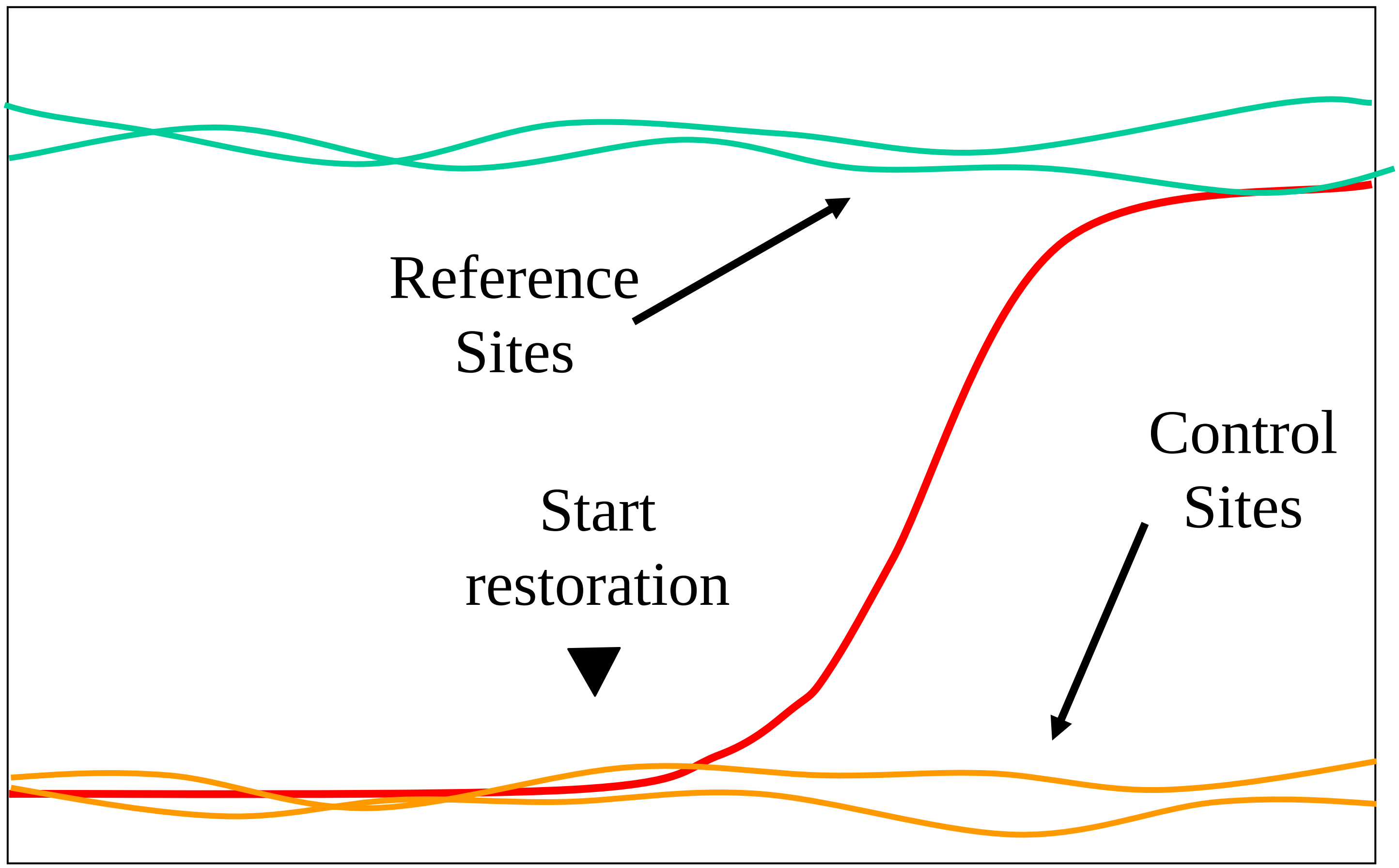
Implementation of restorative measures

- Many measures available with a plethora of manuals available (from Rosgen to Rutherfurd).
- Measures include environmental flows, enhancing habitat structure, barrier removal—dams, riparian zone replenishment.
- “Silver bullets” are rare.
- Measures may be more than one, requiring coordination and allowing for synergistic interactions.

Benthos in sandy sections vs. CWD



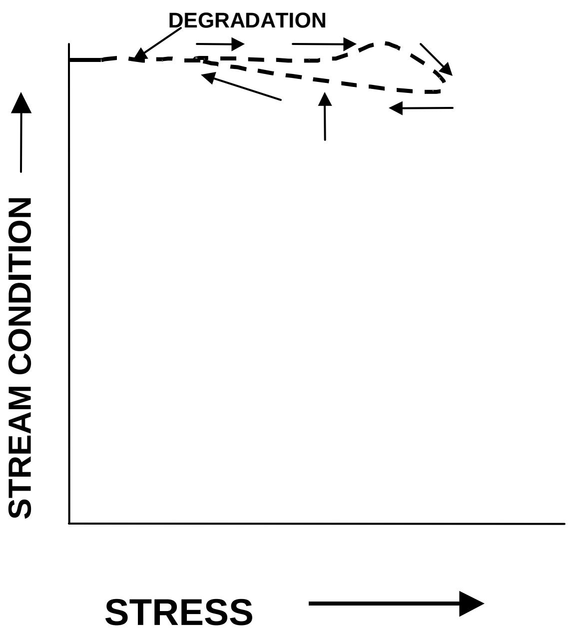
Assessing Restoration Success – convergence toward reference or divergence from control conditions.



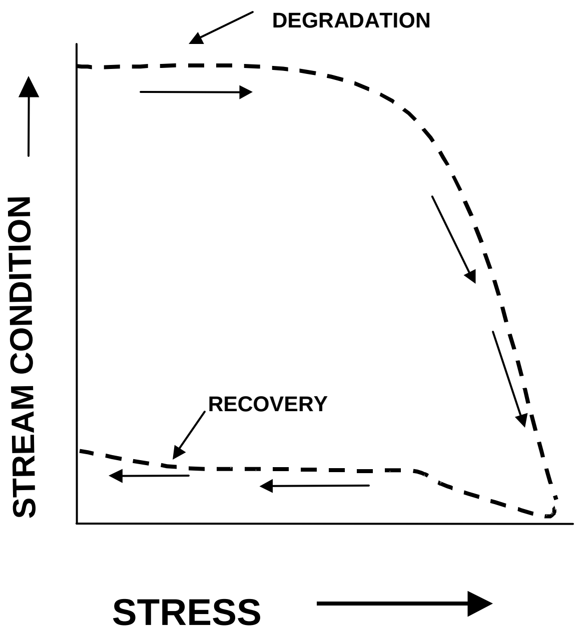
Achievement

- Full restoration is rarely possible, especially for streams in settled catchments.
- Restoration may end with dynamically stable states resilient to prevailing disturbance regime.
- Need for results to be written up.

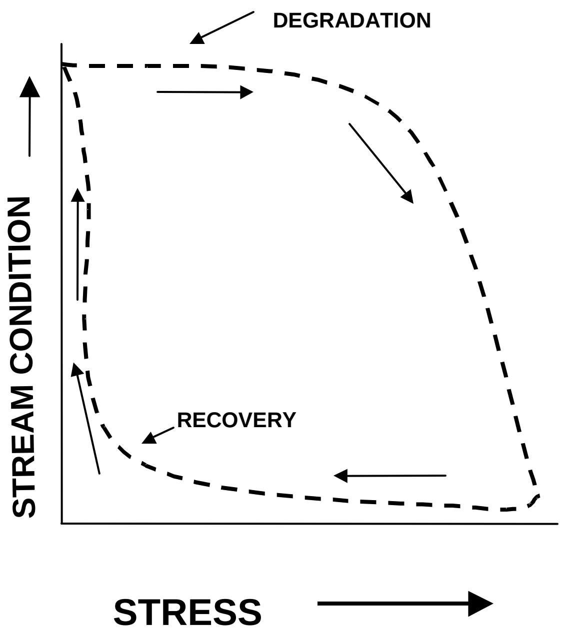
Rubber Band Model



Humpty-Dumpty Model



Hysteresis Model



after Sarr (2002)

Five Criteria of Ecologically Successful Restoration. (from Palmer, M.A. et al 2005. J.Appl.Ecol.)

- A guiding image exists: a dynamic ecological end point is identified *a priori*.
- Ecosystems are improved: the ecological conditions are measurably enhanced.
- Resilience is increased; self-sustainability is strengthened.
- No lasting harm is done.
- Ecological assessment is completed.

Advancing restoration ecology I

- Clear need for partnerships between scientists and resource management agencies to tackle <u>selected</u> restoration projects.
- Such projects could follow AEAM (Adaptive Environmental Assessment and Management) process.
- Replace “learning by trial and error” by “learning by doing”.
- Requires long-term commitment by managers and funding agencies.

Advancing restoration ecology II

- Development is still rapid and relatively unimpeded –restoration is slow and subject to much prevarication and obstruction; perhaps with the aim of maintaining the status quo-- a stable state of continued degradation—bureaucratic hysteresis.
- Need to change culture, leadership style and structure of “conventional bureaucracies” and create flexible “adaptive organizations”.

The Future

- Pressing need to halt continuing degradation (e.g., land clearing, salinization, water extraction).
- Recognition of very poor record of ecological stream restoration in Australia.
- Clear fusion between restoration ecologists and practitioners.
- Vision and action to undertake large-scale and ambitious restoration to create ecologically sustainable systems (stream and catchments).