# 134SRPP
## Stream Revitalization: Principles & Practices

**LECTURE 1**

# Introduction to: Ecological Engineering and Stream Revitalization

**Winter 2019 Semester**

**23 September 2019**

# *Defining* Ecological Engineering

***Ecological Engineering*** is "the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both" (Mitsch 1998).

**Two key elements**:

1) recognizing the self-maintaining ability of ecosystems, and
2) basing the design approaches on a theoretical base, not just empiricism.

# *Defining* Ecosystems

## *Ecosystems*

***Structure*:** a community of organisms together with their physical-chemical environment or habitat; and

***Function*:** the energetic interactions among community members, forming emergent properties as an organic whole, and form predictable patterns of member use of different habitat qualities.

Ecosystems are physical, chemical, and biological systems.

# Disturbance: Environmental Impacts

***Disturbance***:

**Disturbance** is an interruption of "normal" ecosystem processes resulting in a community change of species. Recovery from disturbance is not possible or too slow resulting in the permanent loss of intolerant species from an area.

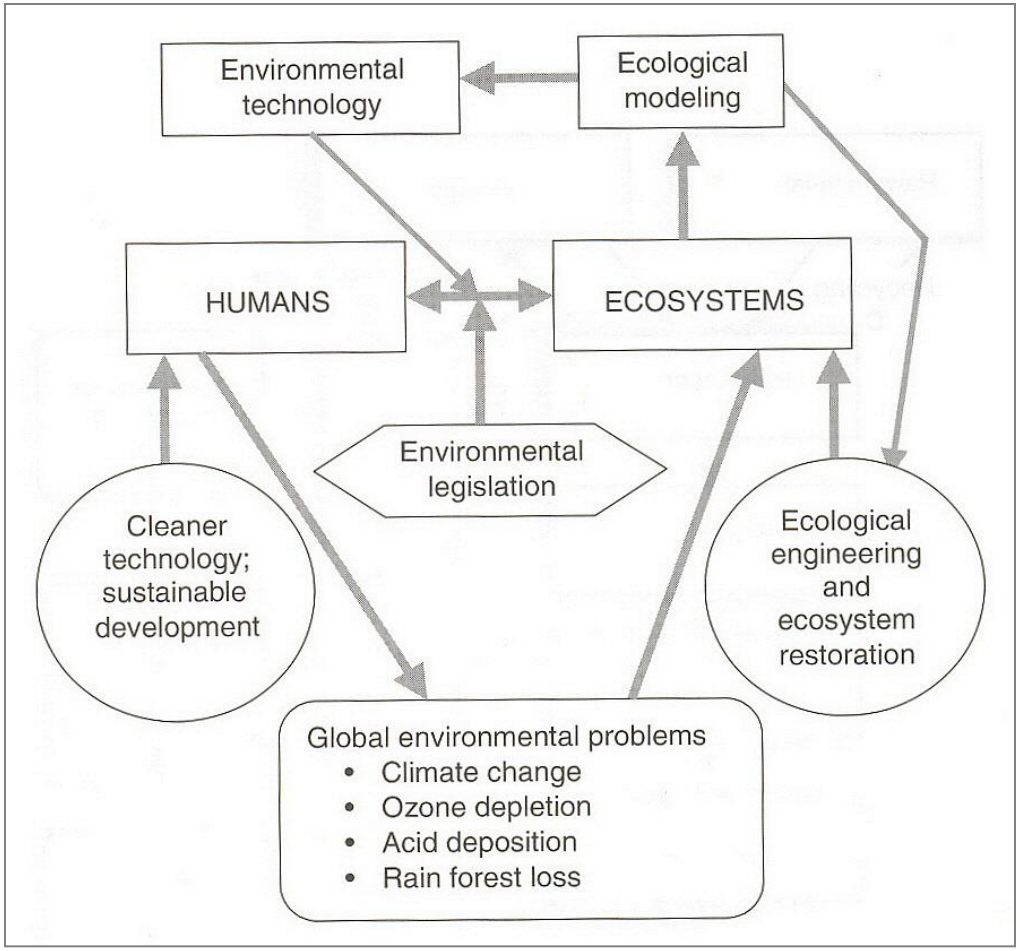
*Anthropogenic Impacts to the Riverine Environment*:

+ Watershed land use changes (e.g., urbanization, deforestation)
+ Channelization of river and streams; dams; canals
+ Climatic change; water withdrawals; pollutant discharges
+ Habitat loss or modification; introduction of exotic species
+ Over exploitation of fish and wildlife
+ Others……..

# Ecological Engineering: Useful Tools for Environmental Management

*Complexities of environmental management - -*

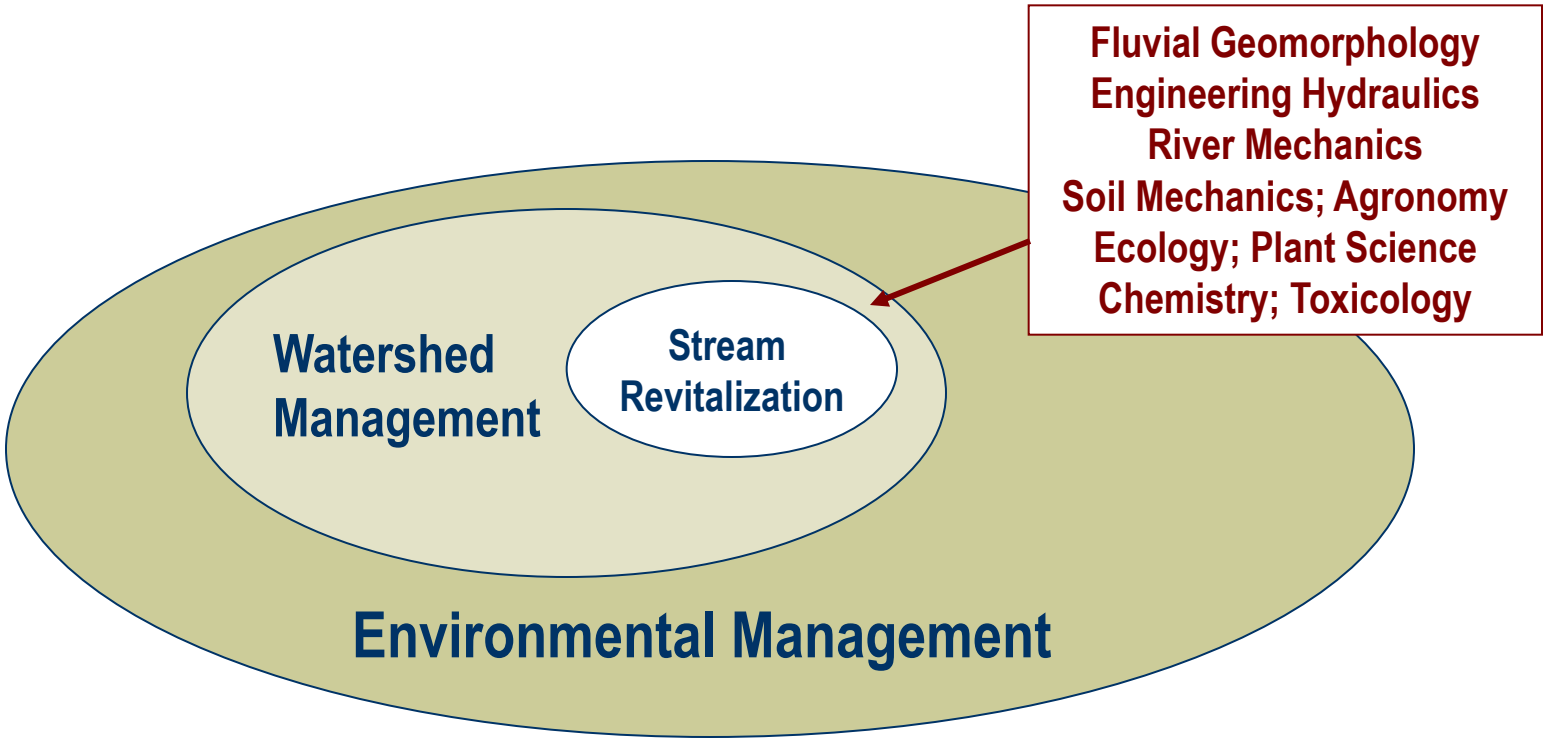
**Interrelationships** between **humans** and **ecosystems**




**Mitsch and Jorgensen (2003)**

# Multidisciplinary Technological Framework

Environmental problems, disturbances to ecosystems, are by definition ***multidisciplinary*** –



# *Defining* Ecological Restoration

***Ecological Restoration*** is defined as "the return of an ecosystem to a close approximation of its condition prior to disturbance" (National Research Council, 1992).

Cairns (1988) closely defined ***restoration ecology*** as "full or partial placement of the structural or functional characteristics of ecosystems that have been extinguished or diminished in quality from a pre-disturbed state."

Key element: *functional ecosystems*

# *Defining* the Restoration of Streams

***Stream Restoration*: Reestablishment of the structure and function of ecosystems. Ecological restoration is the process of returning an ecosystem as closely as possible to pre-disturbance condition and functions. The restoration process reestablishes the general dynamics of self-sustaining behavior of the ecosystem.**

***Stream Rehabilitation*: Partial reestablishment of the structure and function of ecosystems, and ecological processes. Rehabilitation does not necessarily reestablish the stream to a pre-disturbance condition, but generally establishes a geomorphologically stable fluvial system and natural ecosystem.**

***Stream Revitalization* (Europe) = *Stream Rehabilitation* (US)**

# *Defining* the Restoration of Streams

***Stream Naturalization*: A conceptual design framework for stream rehabilitation in human-dominated landscapes, which recognizes that land use constraints prevent return to a pristine stream condition. Therefore, partial reestablishment of the structure and function of ecosystems, and ecological processes.**

**Naturalization design process is an engineering approach integrating geomorphological, hydraulic, and ecological criteria; with the objective to construct a stable fluvial system that is hydraulically- and morphologically-varied and promotes biological diversity.**

**Design endpoint involves both stakeholders and water resource professionals – embraces the notion that conceptions of "natural" are community-based and place-specific.**

# *Defining* the Restoration of Streams

***Stream Reclamation*: A series of recovery-induced activities intended to change the biophysical capacity of an ecosystem. The resulting ecosystem is different from the pre-disturbance condition; return to pristine condition is impossible.**

***Preservation*: Activities to maintain current structure and function of ecosystems, or to protect from the future damage or losses.**

***Mitigation*: An activity to compensate for or alleviate environmental damage. It involves site "restoration" to an acceptable regulatory condition, but not necessarily to a pre-disturbance condition.**

***Enhancement*: Activities undertaken to improve one or "a few" physical habitat attributes with the expectation that ecological condition will respond favorably, with partial recovery of a degraded ecosystem.**

# Stream Restoration Approaches

***In general, <u>four</u> approaches are commonly observed in practice today*:**

***Natural Channel Design*: A reference-based approach relying on hydraulic geometry empirical relationships and fluvial geomorphic principles; attempts to incorporate some habitat elements; also commonly referred to as the "Rosgen" method.**

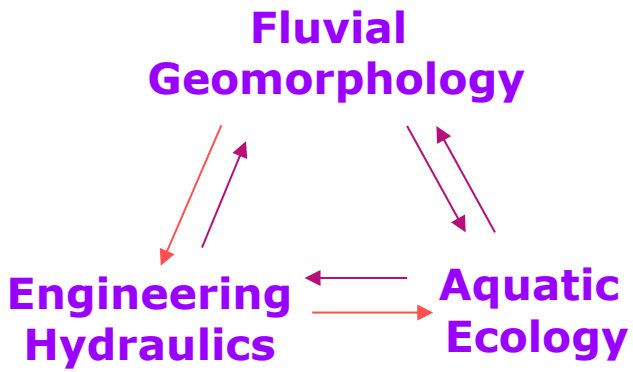
***Hydraulic Channel Design*: A non-reference-based relying on hydraulic and sediment transport principles, and bank stability analysis for stable channel design (regime theory).**

***Ecohydraulic Habitat Design*: A non-reference-based coupling the hydraulic channel design approach with ecological principles; see restoration definition of stream naturalization.**

***Habitat Enhancement*: see definition for enhancement restoration.**

# Ecohydraulic Habitat Criteria for Stream Restoration Design

- **Incorporating ecological criteria into the restoration design process by**
  1) **linking physical habitat with basic biological needs of stream organisms, and**
  2) **linking multi-dimensional hydraulics with organism use of stream habitat.**
- **Stream restoration practices need to consider bank and bed structure in the design process.**
- **A 2D hydrodynamic model is a necessary design tool when lateral habitat is considered.**



# Multidisciplinary Technological Framework

*A special task committee, the Curriculum Working Group, of the American Fisheries Society developed a 2004 white paper on - -*
**Recommendations for Academic Curricula:**
**Engineering for Restoration of Rivers and their Ecological Systems**

**Summary of Recommended Disciplines:**
**Principles of Fluid Mechanics / Hydrology**
**Engineering Hydraulics** (hydraulic design and hydrodynamic modeling)
**Fluvial Geomorphology / Watershed Process & Management**
**River Mechanics** (sediment transport and geotechnical analysis of banks)
**Principles of Ecology / Advanced Aquatic (Stream) Ecology**
**Limnology / Aquatic Chemistry**
**Natural Resources Economics / Field Instrumentation** (data collection)
**Environmental Statistics / Statistical Study Design**

# Multidisciplinary Technological Framework

*A special task committee with the American Society of Civil Engineers conducted a survey of current practitioners in 2010-2011, defining a stream restoration "body of knowledge" as a basis for national certification: - -*

**Summary of Recommended Disciplines:** (Niezgoda et al. 2014)

**Hydrology / Engineering Hydraulics**
**Fluvial Geomorphology / Sediment Transport**
**Stream Ecology / Habitat Structure and Function / Fish Biology**
**Plant Ecology and Riparian Dynamics**
**Surveying and Hydrometry / Watershed Analysis**
**Geomorphic and Habitat Assessment / Biomonitoring and Bioassessment**
**Alternative Analysis / Analytical Techniques and Modeling**
**Restoration Design / Project Development / Restoration Policy**
**Uncertainty-Risk Analysis / Communication & Information Management**
**Construction Management / Professional & Ethical Responsibility**