Unifying Concepts, Principles & Practices in Environmental Restoration Planning & Adaptive Decisionmaking

by

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Need

- The present legally over-constrained, scientifically under-constrained approach to restoration planning and problem-solving cannot guarantee the development and implementation of the optimum restoration plan.
- Instead, it has resulted in unacceptable false positive (Type I) & negative (Type II) errors in problem conceptualization, hypothesis formulation, study design, and data analysis, integration & synthesis.
Need

• That has, in turn, caused or contributed to:
  • A misallocation of staff, physical & fiscal restoration resources for monitoring, research, and modeling
  • An unacceptable risk of irreversible adverse consequences for which there is no acceptable adaptive response
Purpose

• To foster a paradigm shift ...  
• ... that results in the adaptive evolution of the optimum approach for increasing knowledge & understanding ...  
• .. that facilitates well-informed, robust allocation of limited monitoring, research & modeling resources...  
• ... to facilitate wise restoration decision-making that avoids unacceptable Type I & II errors.
Approach

• Balances
  • Holism vs. Reductionism
  • Over- vs. Under-simplification
  • Theoretical, Basic & Applied Research
  • Research, Monitoring & Modeling
  • Physical, Statistical & Mechanistic Modeling
  • Pedagogy, Publication & Pragmatism
Approach

- Checks
  - Peer review of design, implementation & interpretation
  - Consistency with unifying concepts, principles & practices in mathematics, science & engineering
  - Self-consistency
  - Diagnostics, QA/QC & Feedback
Unifying Concepts, Principles & Practices

• Mathematics
  • Symmetry
  • Chaos Theory
  • Fractal Theory
  • Optimization Theory

• Complex Systems
  • Analog vs. Digital Representation
  • Conceptual, Statistical, & Mechanistic Models
  • Systems Analysis/Operations Research
  • Interpolation, Extrapolation, & Scaling

• Physicochemistry
  • Mass & Energy Balance
  • Principle of Indeterminacy
  • Principle of Least Action
  • Principle of Ergodicity
  • Nonlinear Thermodynamics & Kinetics
Unifying Concepts, Principles & Practices

- **Mathematics**
  - Symmetry
  - Chaos Theory
  - Fractal Theory \(\rightarrow\) derivation of allometric \(M^{3/4}\) metabolic scaling law (West et al., 2002)
  - Optimization Theory

- **Complex Systems**
  - Analog vs. Digital Representation
  - Conceptual, Statistical, & Mechanistic Models
  - Systems Analysis/Operations Research
  - Interpolation, Extrapolation, & Scaling

- **Physicochemistry**
  - Mass & Energy Balance
  - Principle of Indeterminacy
  - Principle of Least Action
  - Principle of Ergodicity
  - Nonlinear Thermodynamics & Kinetics
Unifying Concepts, Principles & Practices

- **Biology**
  - Phylogeny Recapitulates Ontogeny
  - Nature vs. Nurture
  - Systematics

- **Ecology**
  - Information Theory
  - Bioenergetics
  - Stoichiometrics
  - Stochastic Dynamics

- **Ergonomics**

- **Diagnostics**
  - Uncertainty/Sensitivity Analysis
  - Quality Assurance/Quality Control
References