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 -→ derivation of allometric $M^{3/4}$ metabolic scaling law (West et al., 2002)**
  - Optimization Theory
- Complex Systems
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  - Conceptual, Statistical, & Mechanistic Models
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- Physicochemistry
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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

- West, G.B, W.H. Woodruff and J.H. Brown. 2002. Nat'l Academy of Sciences Press. 99: 2473-2478