

Spatio-Temporal Data & Remote & *In Situ* Sensing *We gotta DRREAMM!*

Data Retrieval & Representation for Environmental Analysis, Modeling & Monitoring

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Research Summary

- Close-range remote sensing of flora biomass and species diversity (Doruska).
- Reconfigurable wireless networks to monitor environmental microclimates (Flikkema).
- Spatio-temporal data models (image time series) of biogeophysical fields for ecological forecasting (Henebry).
- Generating databases for ecologists from domain-specific spatial data structures (Cushing).

What's the point?

Ecosystem research documents *change*

- **Change detection** – perceiving the differences
- **Change quantification** – measuring the magnitudes of differences
- **Change assessment** – determining the significances of differences
- **Change attribution** – identifying/infering the proximate causes

What do the data look like?

- Image time series
- Multivariate dynamic data streams
- Multi-entity trajectories
- Implicitly spatio-temporal
 - museum voucher specimens
 - systematic surveys

Research Needs Summary

**Data, data [almost] everywhere...,
but what does it *mean*? and how to *get at it*?**

***Given, a confluence of sensing technologies, all with
multiple spatial and scalar dimensionality***

***We need robust data representations that capture
complex environmental patterns and processes, and
derive valid views that are
context- and scale- dependent and variable in time.***

***We need semantic networks --
in the field, in the lab, in the office, in space....***

Five Research Areas

- Adaptive database schema
- Spatio-temporal analysis Algorithms
- Wireless reactive agent networks
- Metadata production, analysis, & management
- Enhanced sensory presentation of environmental data.

Adaptive Database Schema

New! Field research always in flux – Networks reconfigure & data streams change, due to abrupt environment changes.

New! Image time series for multivariate spatio-temporal queries difficult to model.

Urgent! Multiple disciplines require multiple interpretations.

Algorithms for Spatio-Temporal Analysis

- Characterize ecological dynamics latent in datasets that are explicitly spatio-temporal.
- Establish baseline conditions or expected patterns.
- Develop analytical engines with decision support systems to evaluate evidential quality for modeling or policy.

Wireless Reactive Agent Networks

New! “Smart Dust”

Already being demonstrated in the field, *but*

- How do we:
 - Evaluate fundamental performance limits,
 - Design and implement cross-layer algorithms,
 - Develop design and verification tools for network placement and management,
 - Connect these to databases.

Metadata are Essential, but Cultural & Technological Obstacles Abound

Urgent!

Sociological research into scientific research method, then initiate change....

Urgent!

Mechanisms for automated production of metadata at acquisition time and at subsequent processing steps.

- Remove or minimize human intervention in metadata production and updating.
- Develop tools for metadata analysis and management.
- Develop tools to coax data into analysis, database, and visualization software.

New!

XML / EML is a format, not a tool.

Better Presentation of Environmental Data

- Enhanced scientific visualization – animating complex spatio-temporal datasets – inform, enlighten, and empower.
- Need accessible functionality beyond outreach to evaluate high dimensional data spaces
 - New!** – Virtual reality or immersive environments may offer high dimensionality – at a high price.
 - New!** – Further work is needed to understand optimal approaches to sonic and haptic feedback.