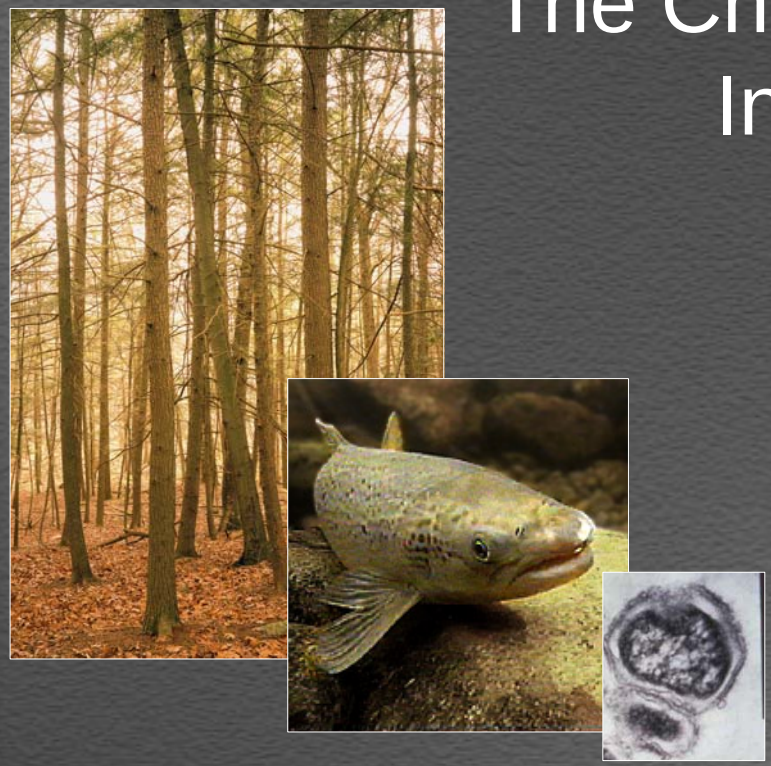
Biological Informatics:

The Challenge of Data Integration



Gladys Cotter
Associate Chief Biologist for Information
U.S. Geological Survey

Aquatic food webs

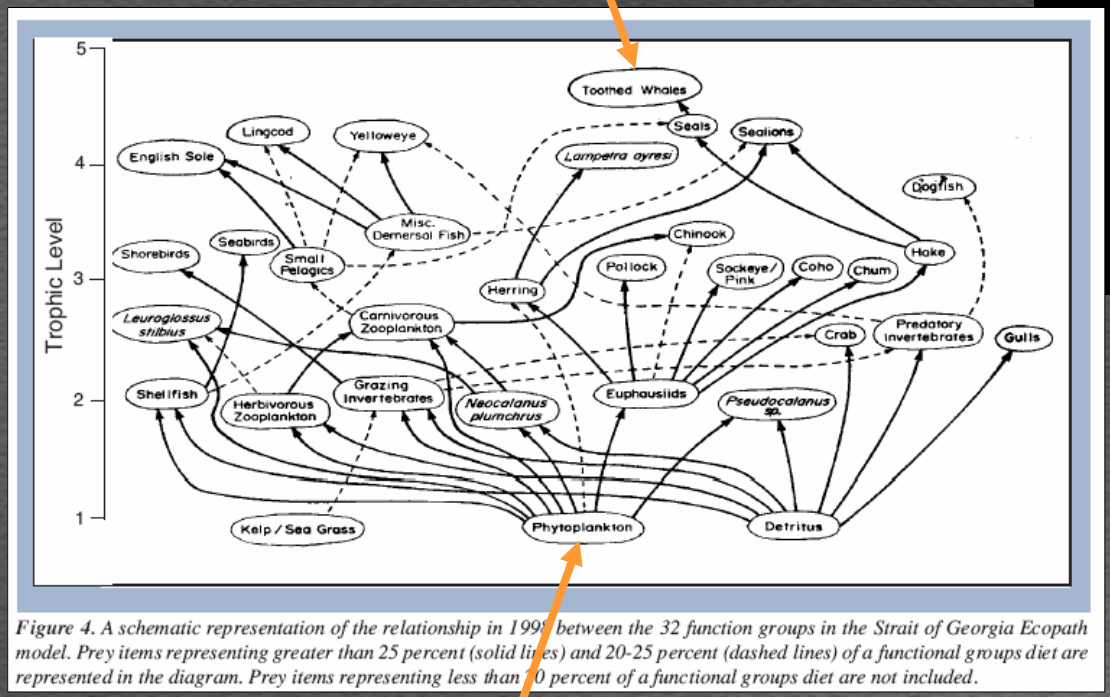
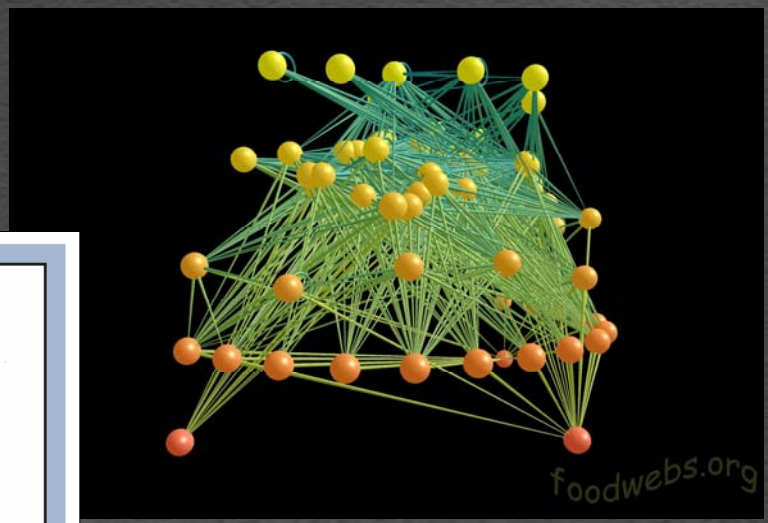


Figure 4. A schematic representation of the relationship in 199[illegible] between the 32 function groups in the Strait of Georgia Ecopath model. Prey items representing greater than 25 percent (solid lines) and 20-25 percent (dashed lines) of a functional groups diet are represented in the diagram. Prey items representing less than [illegible]0 percent of a functional groups diet are not included.

Beamish et al., 2003



Provided by the PEaCE Lab (www.foodwebs.org)

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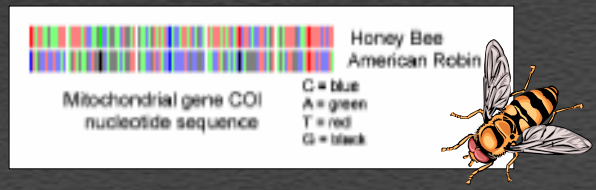
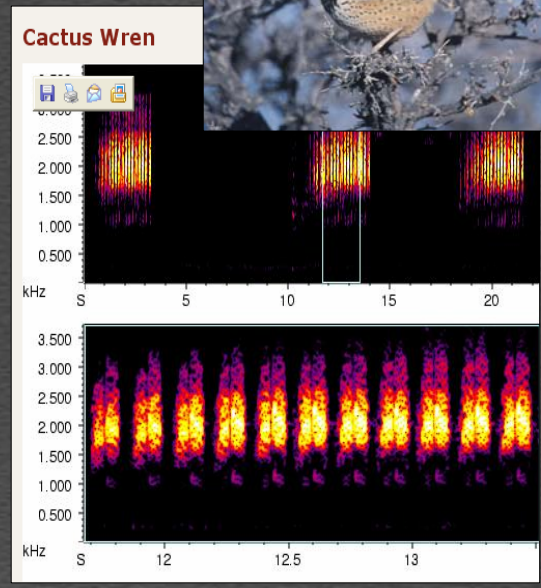
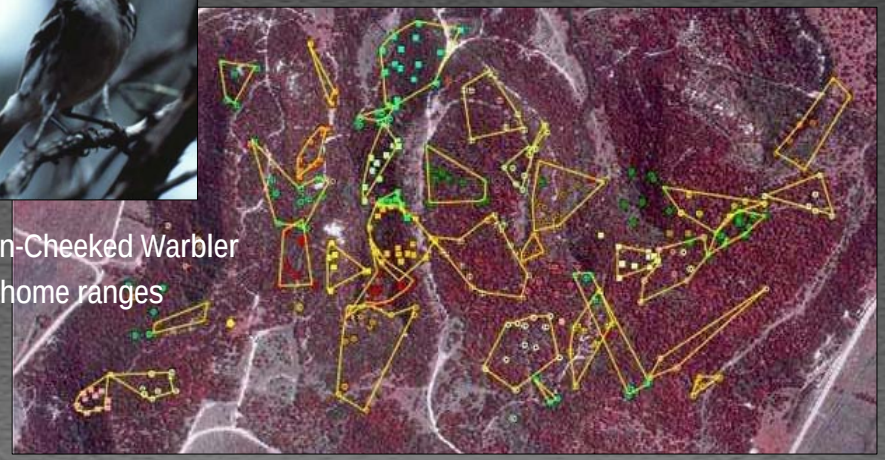




Cactus wren, *Campylorhynchus brunneicapillus*
©2004 Cornell Lab of Ornithology

Golden-Cheeked Warbler
home ranges



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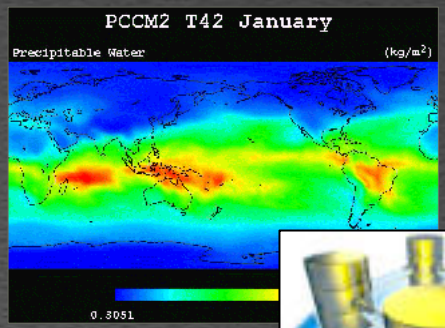
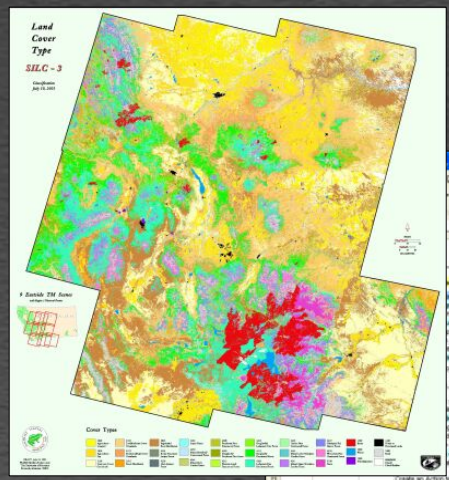
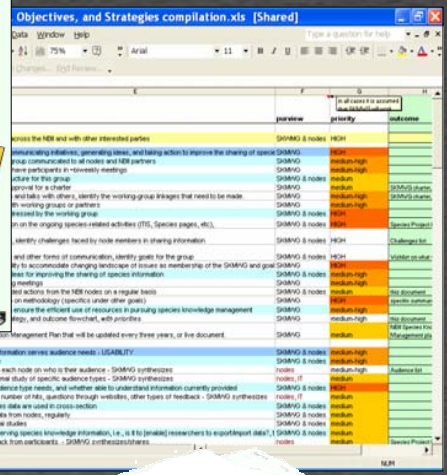
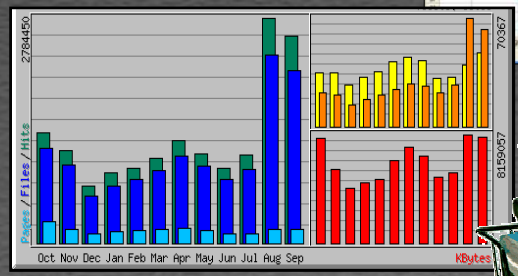
Biological information

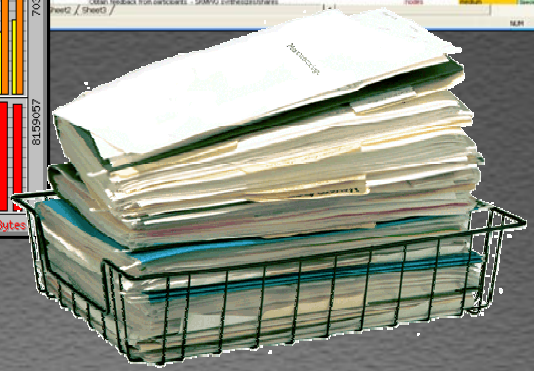
Data format diversity

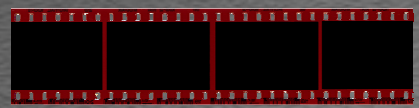












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Biological Informatics

- A new field at the intersection of biological sciences, information science, and computer technology.
- Helps save, assemble, organize, integrate, and disseminate information on the natural world.
- Covers all biological, spatial, and temporal scales.
- Data comes in a wide variety of formats, and from diverse disciplines.
- Challenge is to meet new and rapidly evolving data and information needs.

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Data and Information Needs

- Research needs:
  - make own data longer-lived and more valuable;
  - Seek additional data for use in validating methods and models; and
  - Seek additional data to answer new, complex questions that involve multiple factors

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One Goal - Ecological Forecasting

The potential effect of climate change on the distribution of the Green-striped brush finch, *Atlapetes virenticeps*

University of Kansas

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Data and Information Needs, continued

- Research needs:
  - make data longer-lived and more valuable;
  - seek data for use in validating data and models; and
  - seek data in order to answer new, complex questions that involve multiple factors.

- Societal need to have accessible, accurate, and integrated scientific information for:
  - increased understanding; and
  - Informed decision-making about the environment.

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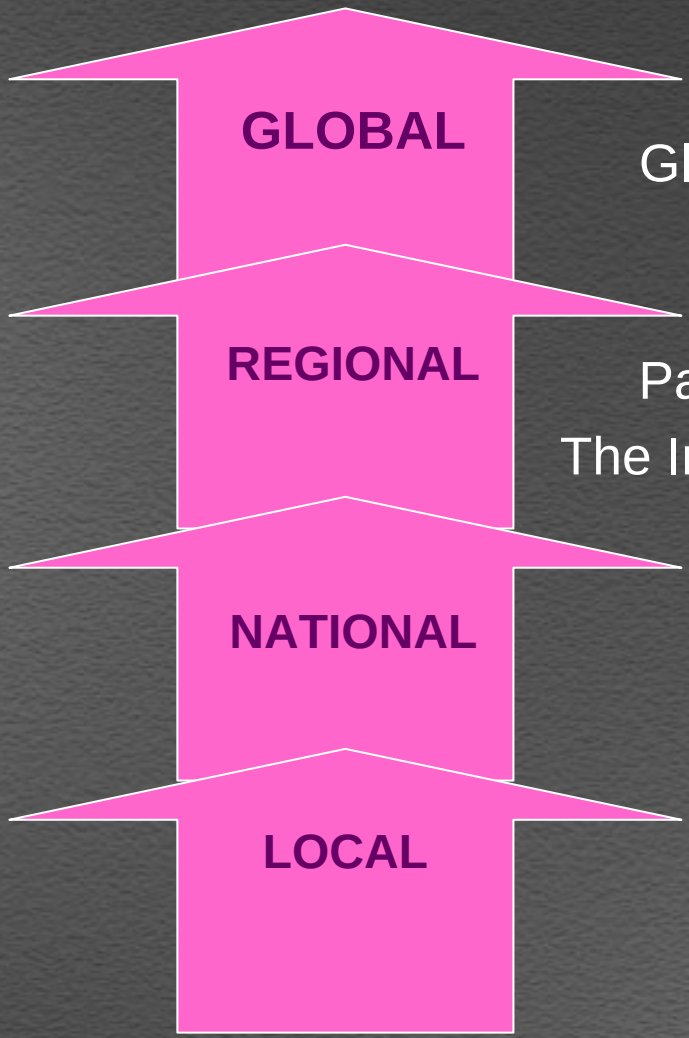
Biological Informatics Systems



World Data Center for Biodiversity and Ecology (WDCBE), Global Biodiversity Information Facility (GBIF), Clearinghouse Mechanism (CHM)

Pacific Biodiversity Information Forum (PBIF), The Inter-American Biodiversity Information Network (IABIN)

NBII (US), CBIN (Canada), ERIN (Australia)

State Heritage Programs, GAP Analysis, Universities, County Park Information

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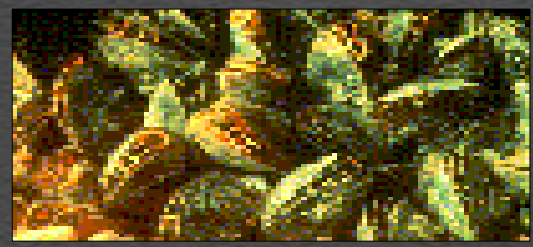
NBII

The National Biological Information Infrastructure

A broad, collaborative program to provide access to data and information related to our environment



www.nbii.gov

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Biological Informatics - Challenges in Integrating Data

- Links among complex data from within, and from outside biology (geology, meteorology)
- Different methodologies:
  - recording of a location (“Tyler, Texas” versus latitude/longitude);
  - Different equipment used; and
  - Different data formats - museum specimens versus observations versus satellite images.
- …..

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The Virtual Herbarium of Mexico
700,000 registers from 25 Herbaria
In Mexico and the United States.

CONABIO

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Biological Informatics - Challenges in Integrating Data, continued

- Links among complex data from within, and then outside biology (geology, meteorology)
- Different methodologies, e.g.:
  - recording of a location ("Tyler, Texas" vs. lat/long);
  - different equipment used; and
  - different data formats - specimens, observations, satellite images.
- Inaccessible, missing, and deteriorating data
- Quality control, intellectual properties, and secure storage
- Training needed that combines biology, computers, and information science
- Linking people of different disciplines

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Challenges, continued

Linking data of different scales within:

- Biology
- Space
- Time

Scale is the main challenge in integrating data for analysis and understanding.

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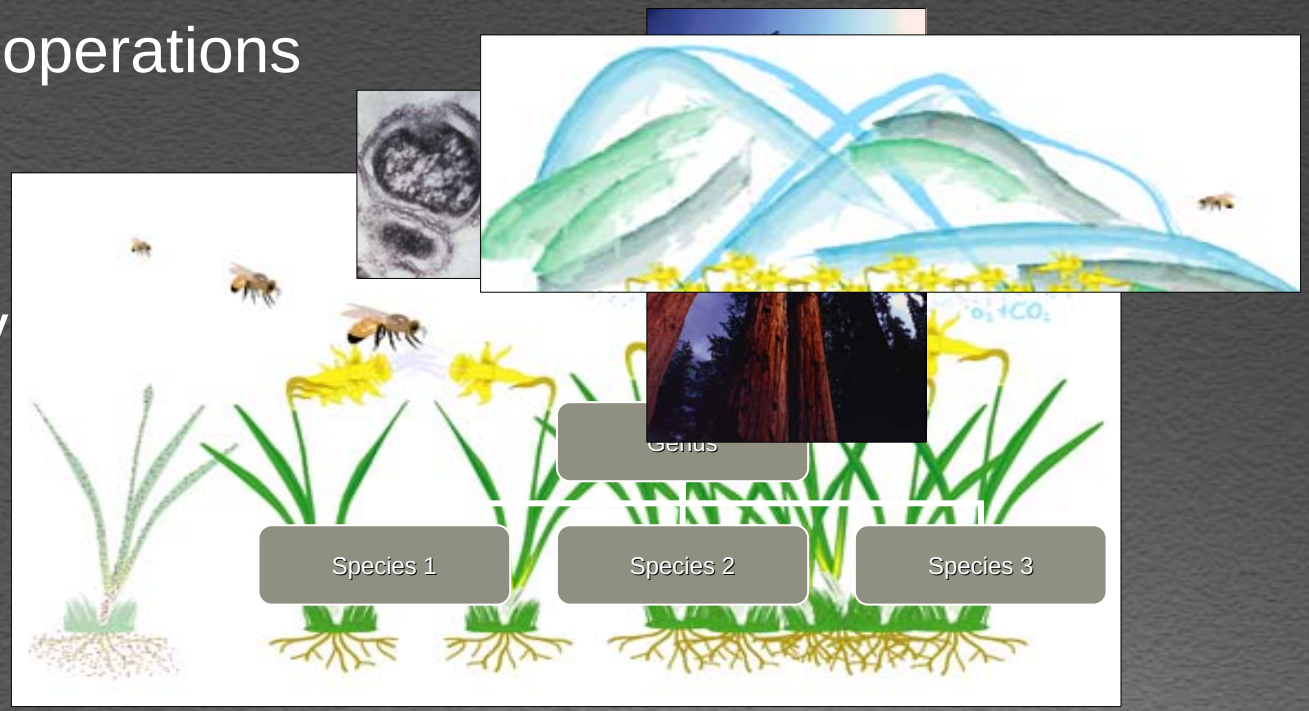
Biological Scales

- Organism size
- Biological operations
- Taxonomy



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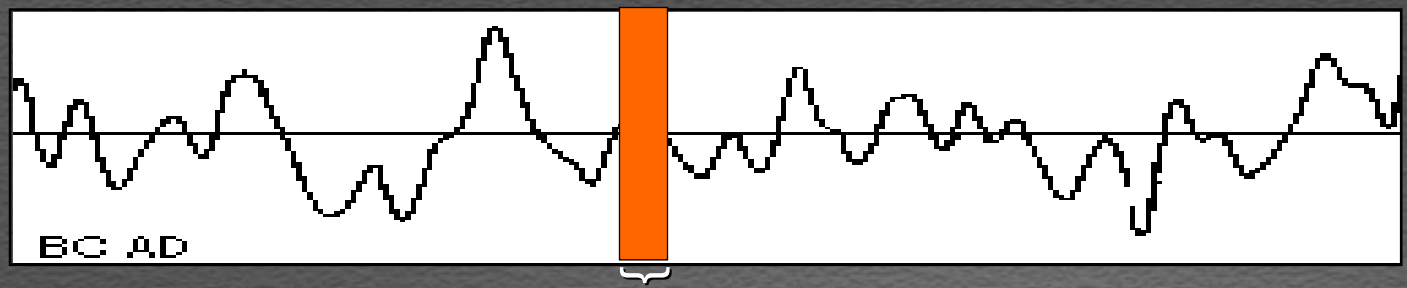
Space and Time - Continuous dimensions

1 centimeter, or 10 millimeters



100 years

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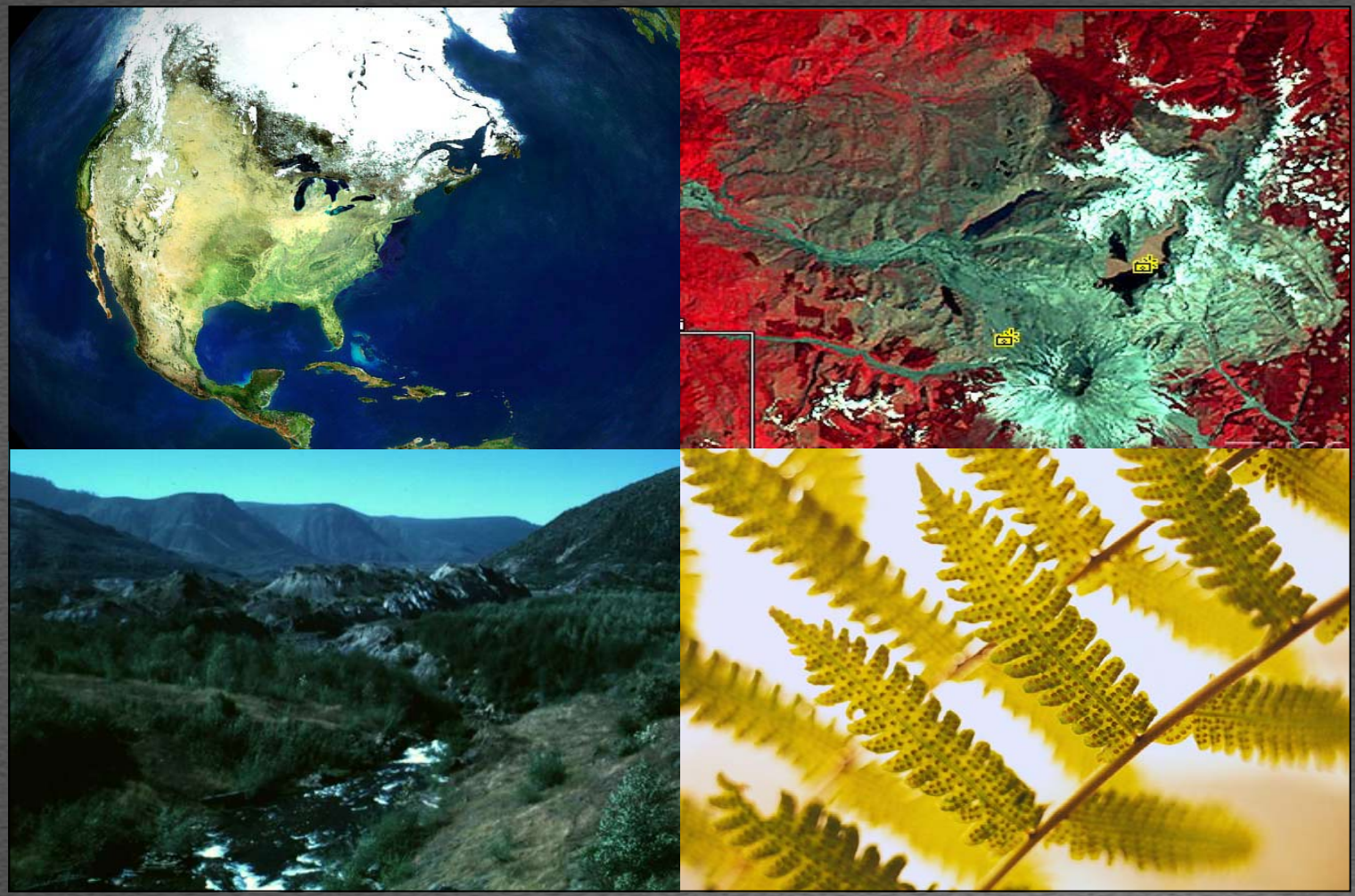
Different scales of observation



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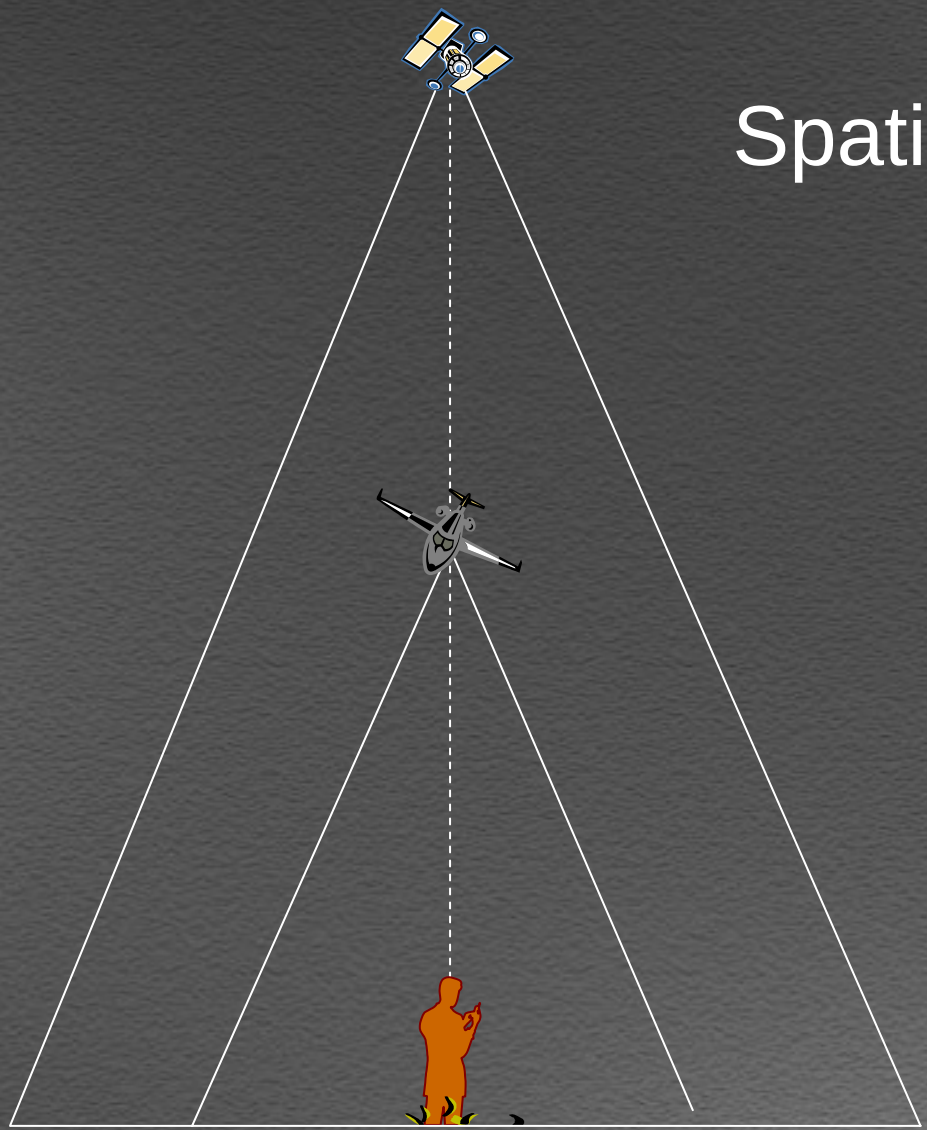
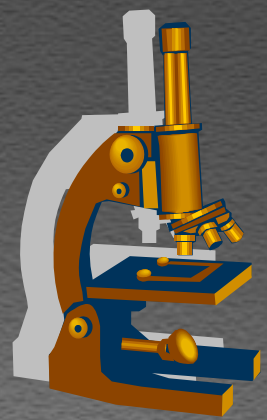
Spatial resolutions





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Challenges with integrating data of different scales

- Different units chosen
  - Matching
  - converting
- Taking into account variability
- …..

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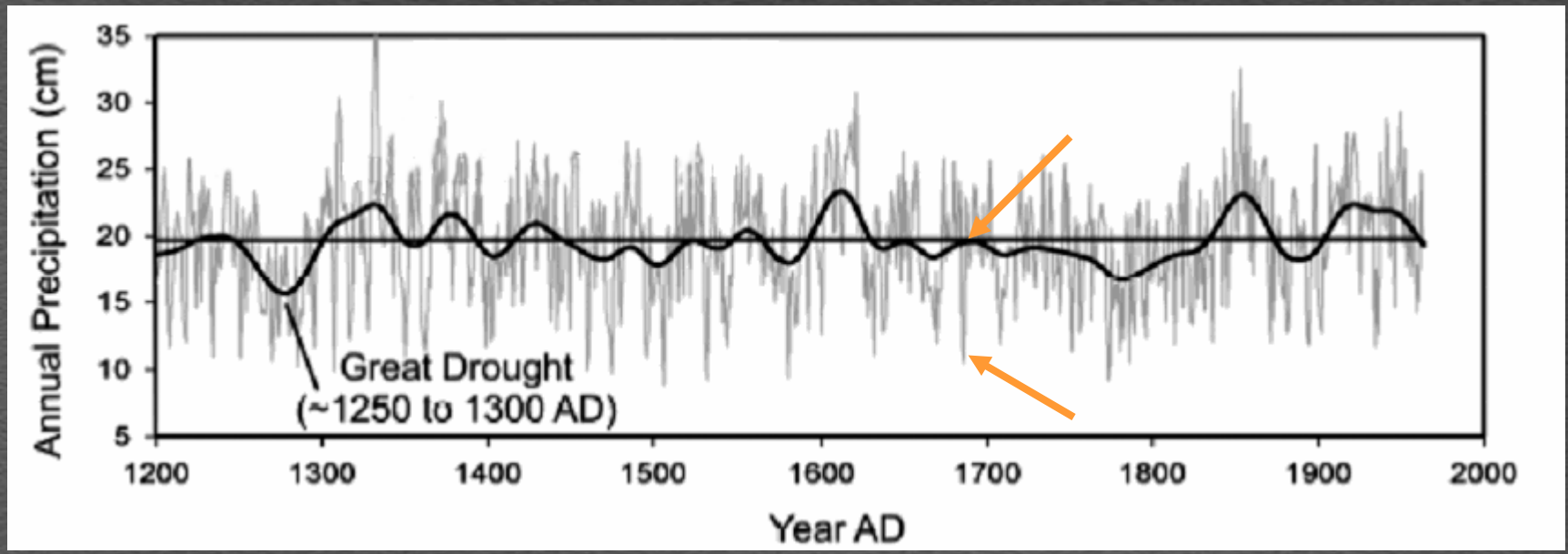
Variability at different scales



Gray et al., Ecology, in press., modified with permission.

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Challenges with integrating data of different scales, continued

- Different units chosen
  - Matching
  - Converting
- Taking into account variability
- Taking into account uncertainty

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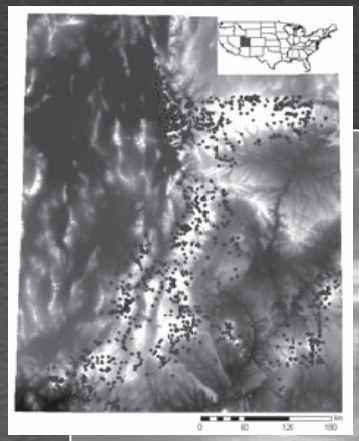
Spatial Uncertainty



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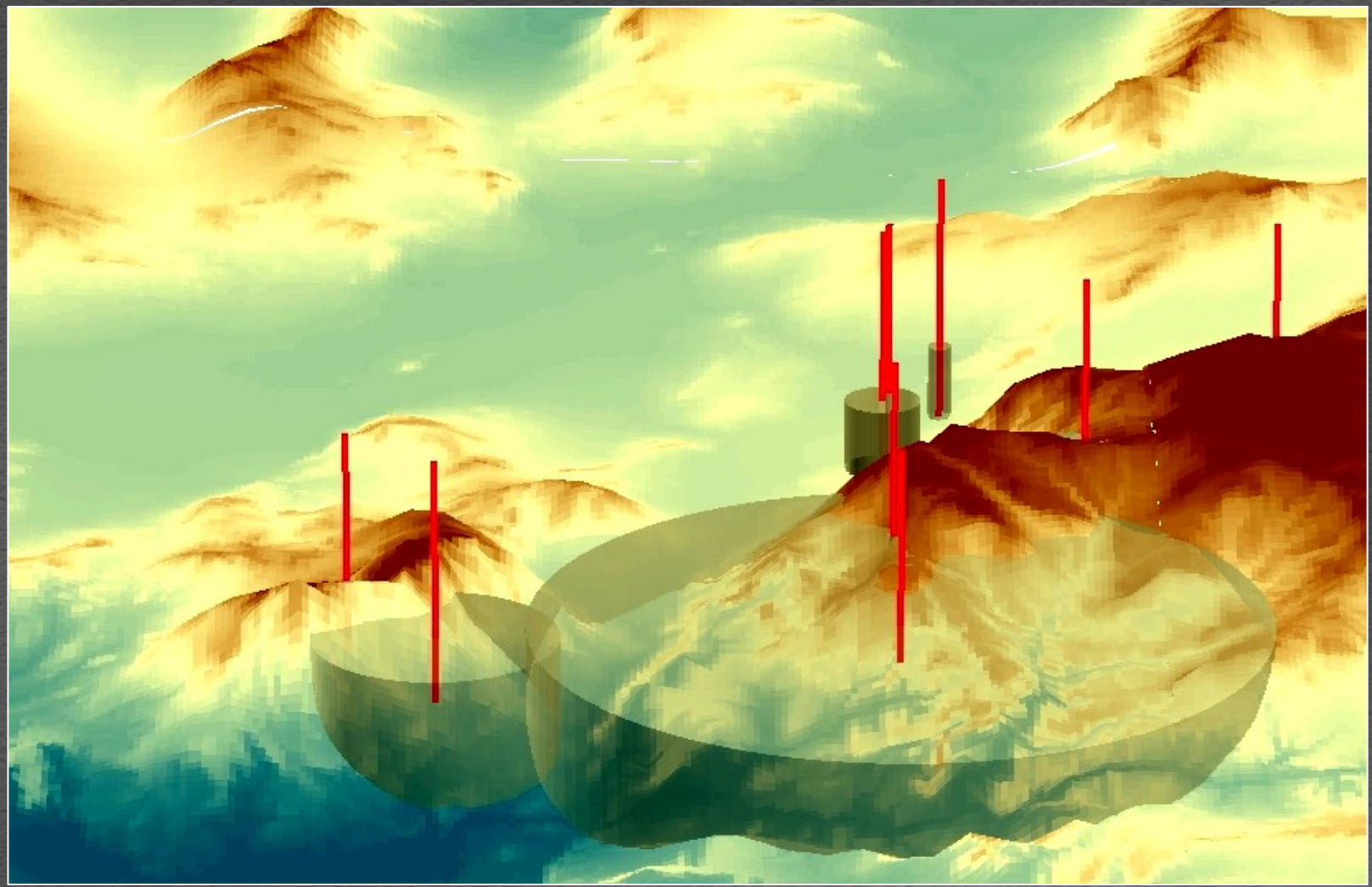
Rowe RJ. 2005. Journal of Biogeography 32: 1883-1897

Uncertainty in 3 dimensions



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Rowe RJ. 2005. Journal of Biogeography 32: 1883-1897

Solutions to the various challenges in biological informatics

Chip Clark, NMNH

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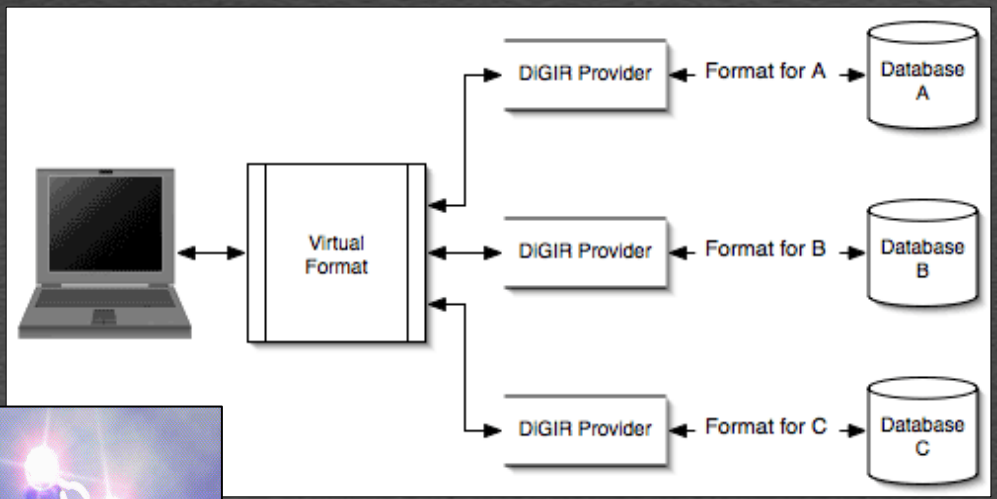
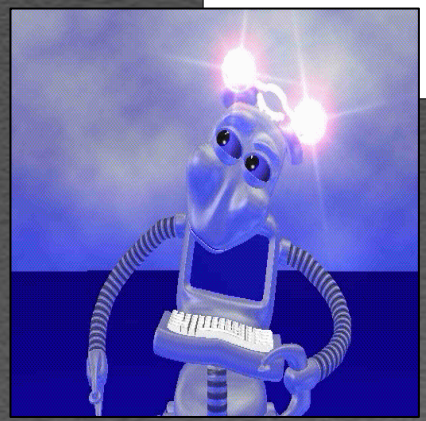
Data Linkages

- New query protocols,
  e.g., DiGIR



- Intelligent search agents,
  e.g., BioBot



- Customization
- Multi-lingual interfaces
- Improved visualization

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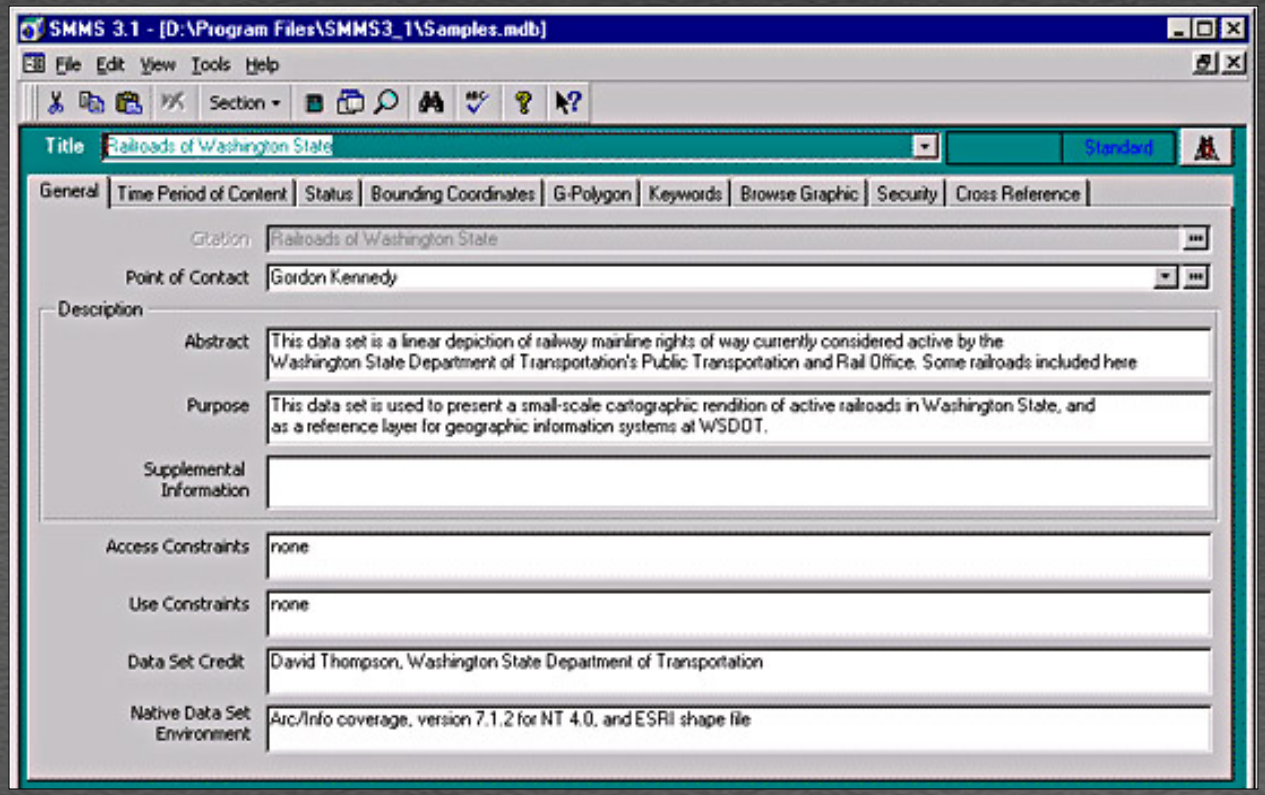
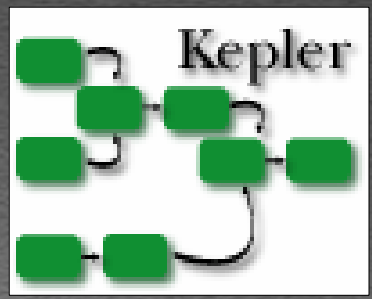
Information describing the data



Metadata



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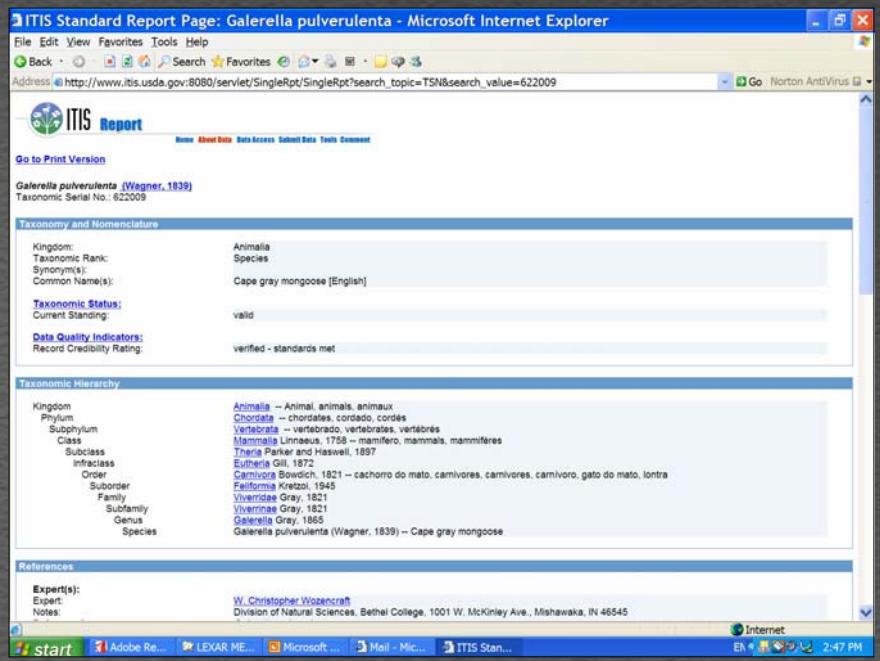
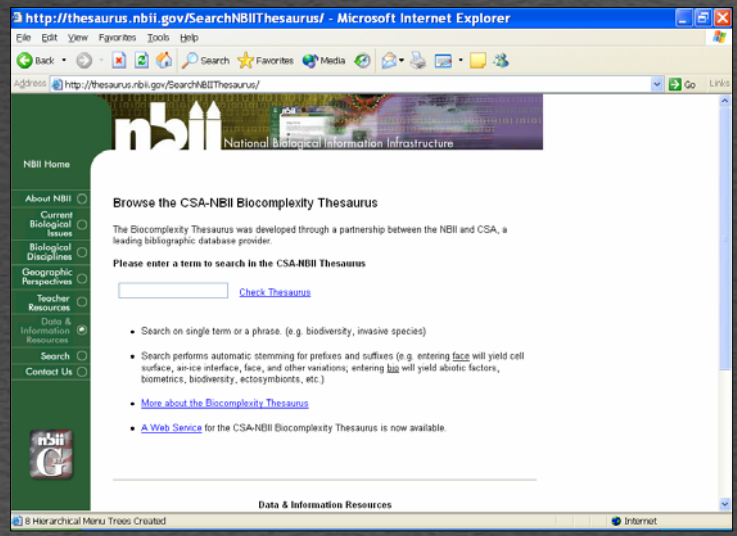
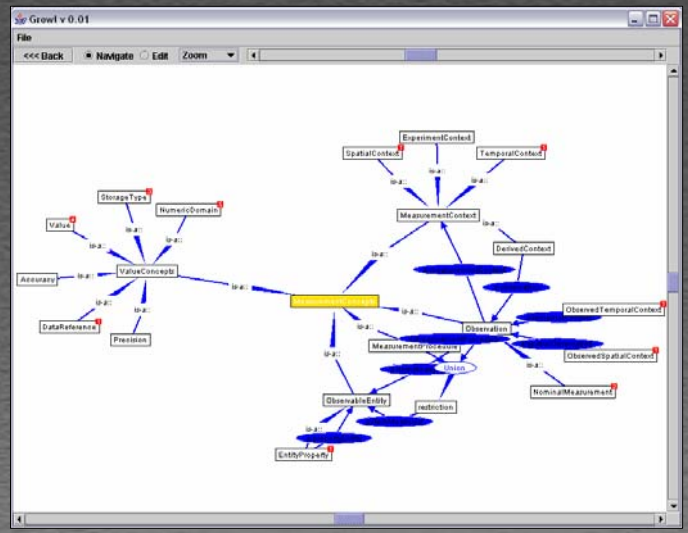
Terminologies and research protocols



Integrated Taxonomic Information System



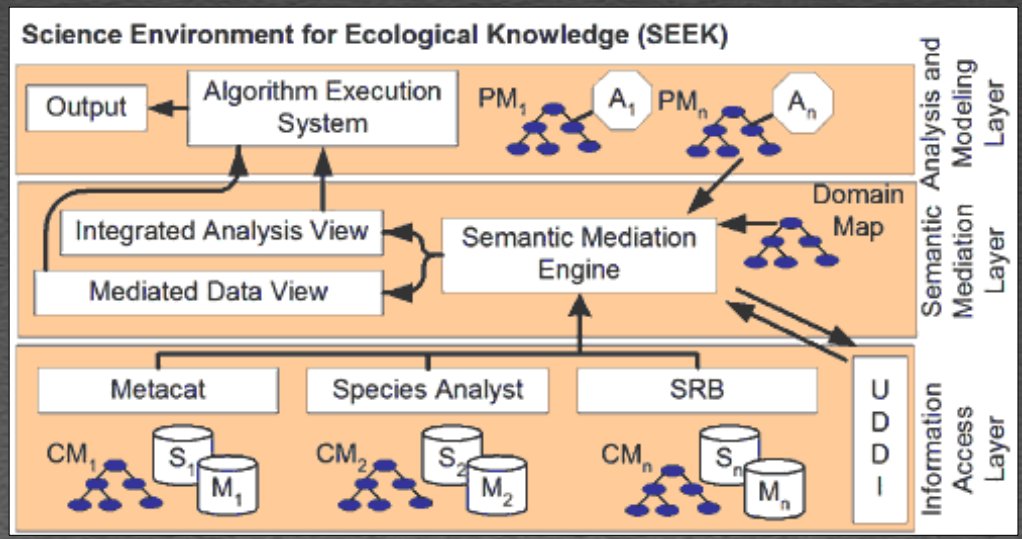
Biodiversity Complexity Thesaurus



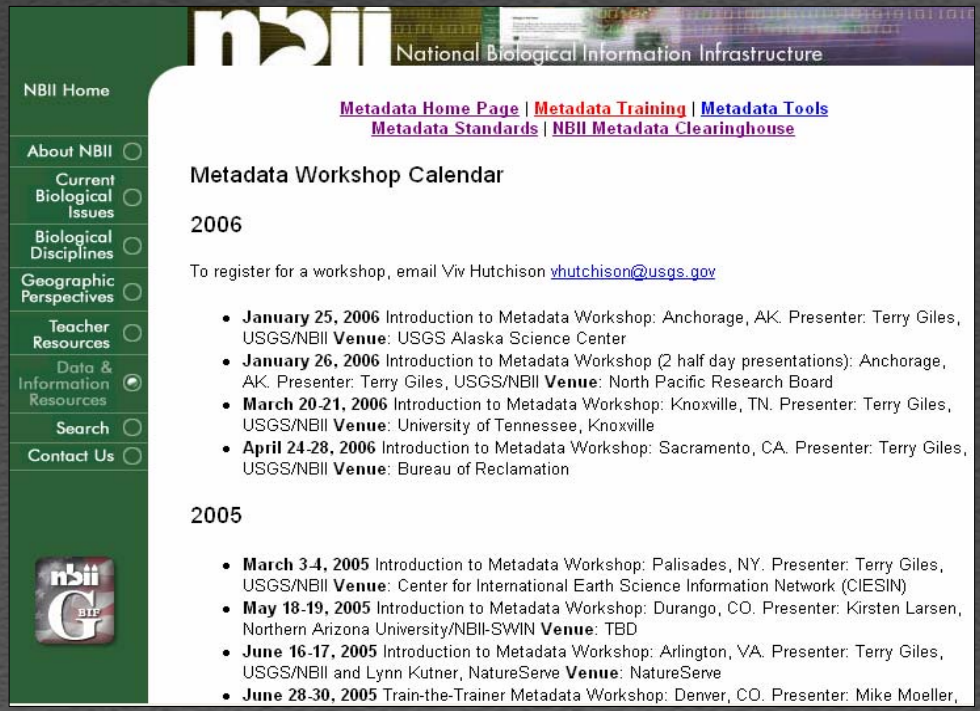
Pacific Ecoinformatics and Computational Biology Lab

Processing power and tools

- Mass computation capacity
- EcoGrid computing



Training and education



IGERT
Integrative Graduate Education and Research Traineeship
NATIONAL RECRUITMENT PROGRAM

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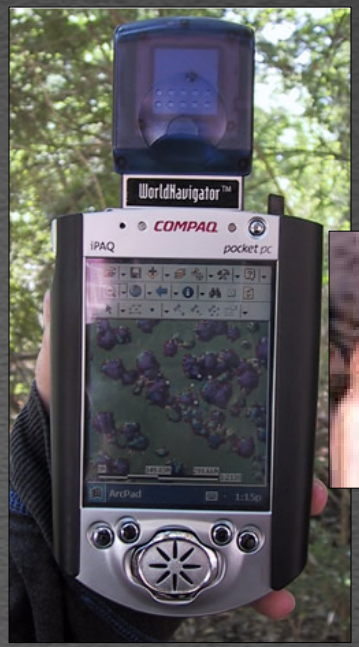
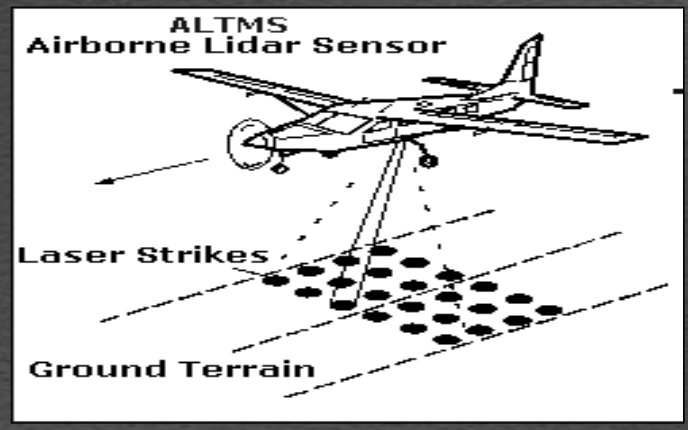
New Data Collection Techniques



Field computers

Smart Dust



LIDAR

UAV

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New opportunities for Science Disciplines

- Interdisciplinary collaborations allows investigation into new questions

- More communication
  - Highlighting important results
  - Illustrating interlocking biological systems
  - Providing ecological forecasts

- Sharing data
  - More valuable to more people
  - Longer-lived data

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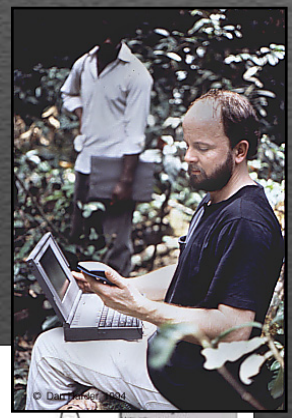
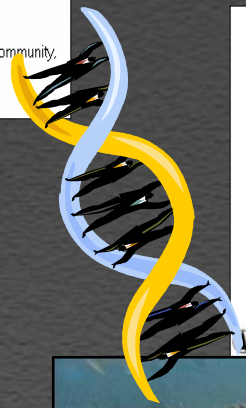
The Vision for the Future





"Research is conducted in virtual laboratories in which scientists and engineers can routinely perform their work without regard to physical location, interacting with colleagues, accessing instrumentation, sharing data and computation resources, and accessing information in digital libraries"

(President's Committee of Advisers on Science and Technology, 1998)

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Thank you

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