



Metadata

Early Career Faculty and Postdoctoral Training

Samantha Romanello

Long Term Ecological Research

University of New Mexico





In this session we will discuss...

- ❑ Metadata: what are they? and why should they be created?
- ❑ Metadata standards: why do we need them?
- ❑ Metadata tools: what's out there to help?
- ❑ Creating metadata: just how much work is this?
- ❑ Finding and evaluating metadata: what is good?
- ❑ Metadata resources: what's out there?



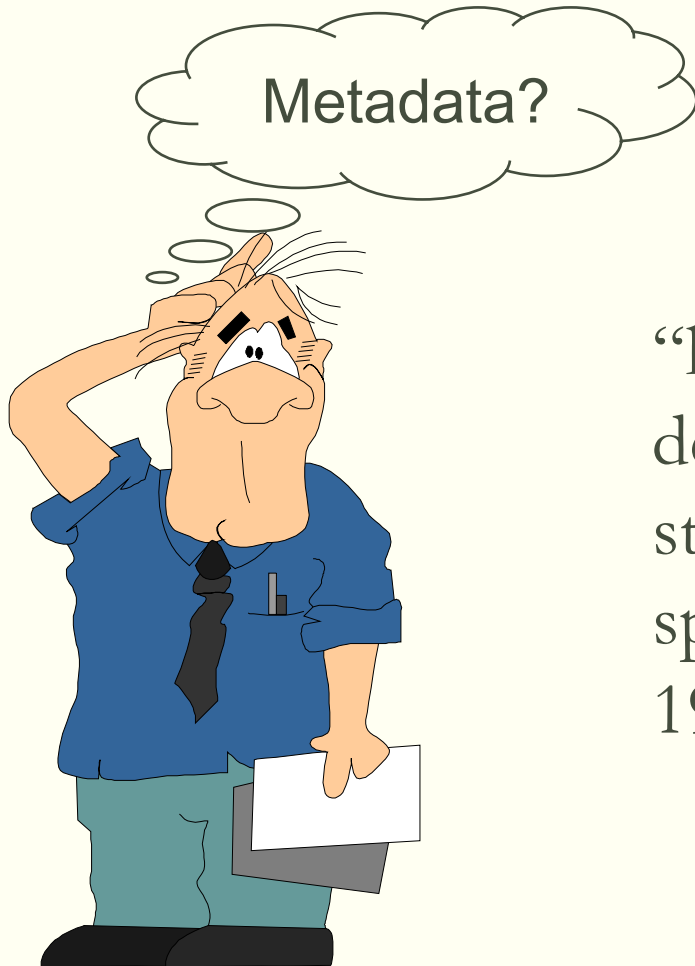
Metadata

what are they? and why should
they be created?





What are metadata?



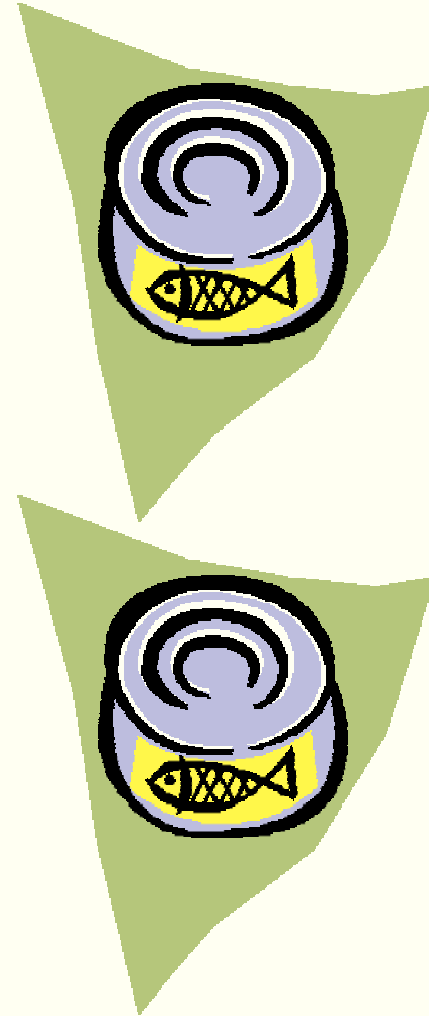
“higher level information that describe the content, quality, structure, and accessibility of a specific data set” Michener et al., 1997





Example

In front of you are two tuna shaped cans. How do you decide which can you would like to eat?





Metadata helps you
decide which can you
would like to eat !





Metadata are

- The label
- The information the label contains
- Our understanding of what a label is and the information it describes

Nutrition Facts		Amount/Serving	%DV*	Amount/Serving	%DV*		
Serving Size: 2 oz. drained (56g - about 1/4 cup)		Total Fat	0.5g	1%	Total Carb.	0g	0%
Servings about 2.5		Sat. Fat	0g	0%	Fiber	0g	0%
Calories 60		Cholest.	30mg	10%	Sugars	0g	
Fat Cal. 5		Sodium	250mg	10%	Protein	13g	23%
Percent Daily Values (DV) are based on a 2,000 calorie diet.		Vitamin A 0% • Vitamin C 0% • Calcium 0% • Iron 2%					
INGREDIENTS: LIGHT TUNA, SPRING WATER, VEGETABLE BROTH, SALT							

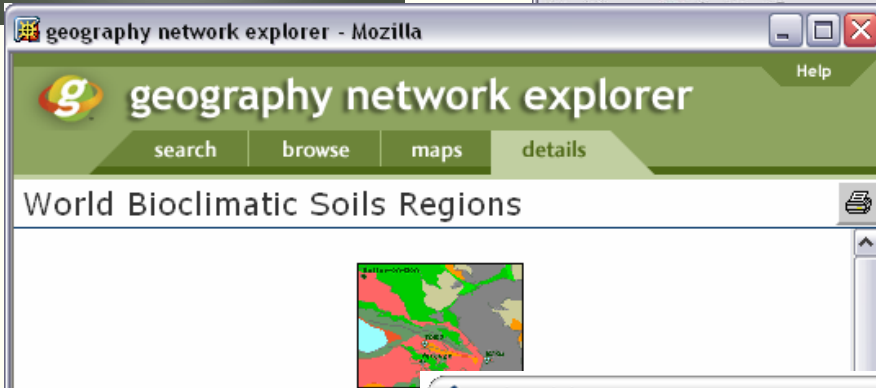


Metadata

- ❑ Provides the context of when, where, why, and how the data was collected
- ❑ It also provides the who – some insight into the analytical framework of the scientist who collected the data



Metadata is all around...



Content Citation:

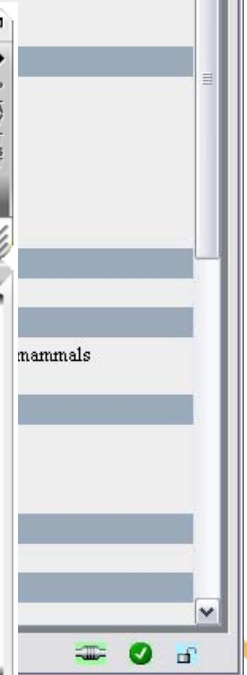
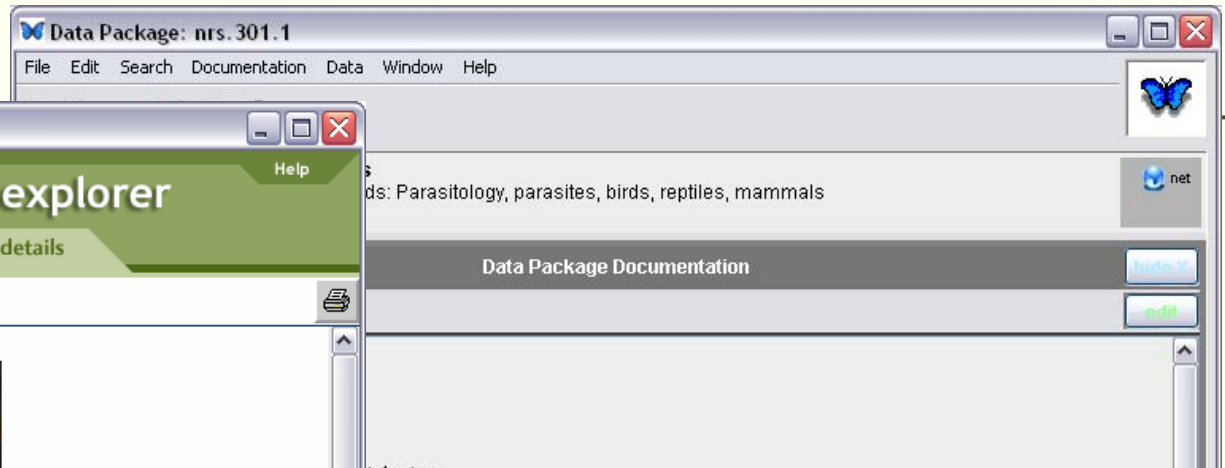
Title of Content: World Bioclimatic Soils Regions
Type of Content: Live Data and Maps
Latest Status: Service Running
Content Publisher: ESRI
Publication Date: 1997

Content Description:

Content Summary: The ESRI Bioclimatic Soils Regions map shows snow cover polygons, country boundaries, and traditional soil cartographic boundaries of areas were defined by quaternary, and other factors. @Biod between living things and the climate changing weather.

Content Purpose: This map service which other layers may be displayed.

Content Themes: Biologic and
<http://www.geog...log>



072998 29.5 17.0

073098 29.7 6.1

073198 29.1 0



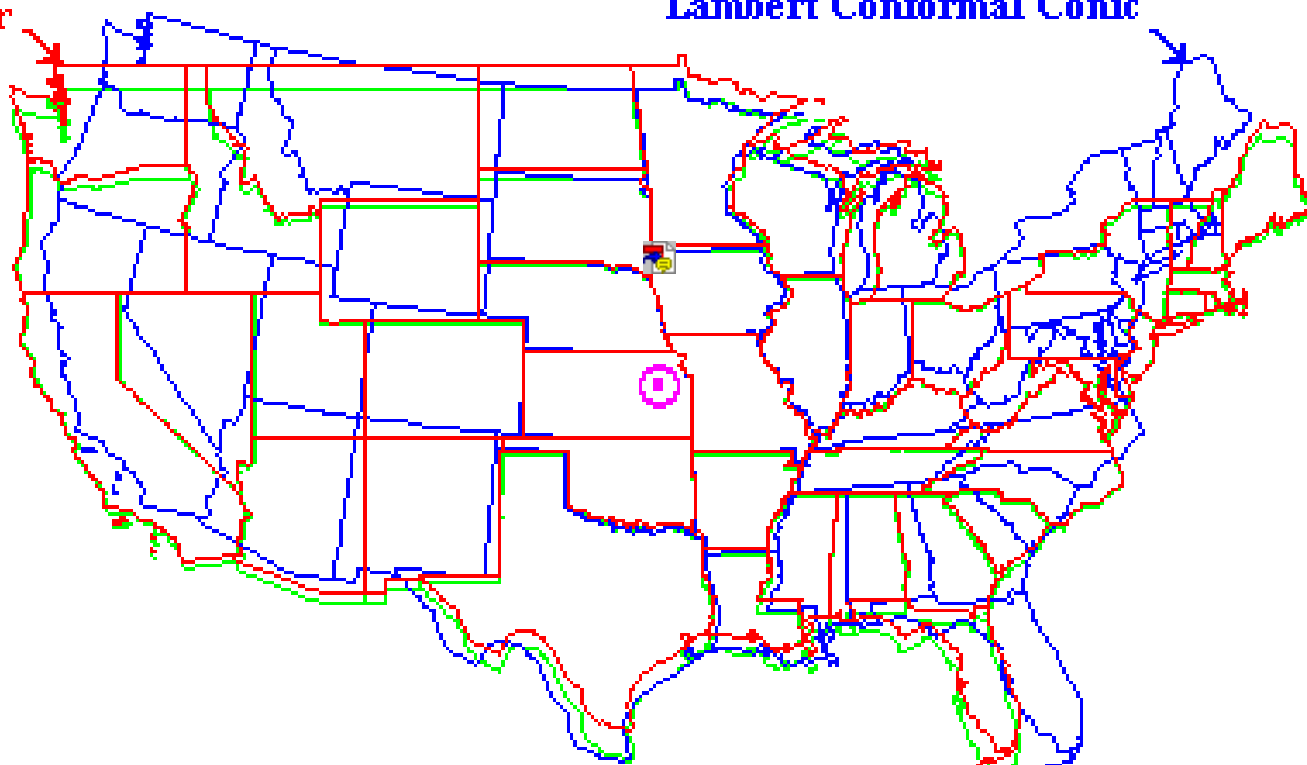
Data -- Metadata

	Date	Temp (C)	Precip. (mm)
Obs. #1	072998	29.5	17.0
Obs. #2	073098	29.7	6.1
Obs. #3	073198	29.1	0

Three Map Projections Centered at 39 N and 96 W

Mercator

Lambert Conformal Conic



Un-Projected Latitude and Longitude

Peter H. Dana 6/23/97



Value of Metadata

- ❑ Maintains internal investment in data
- ❑ Provides information to data catalogs and clearinghouses
- ❑ Promotes data sharing
- ❑ Leads to potential research partners (e.g., promotes data discovery)
- ❑ Clarifies semantics
- ❑ Enables machine-processing



Metadata describe:

- Who?
- What?
- When?
- Where?
- How?

about every facet of the data !



Metadata Standards

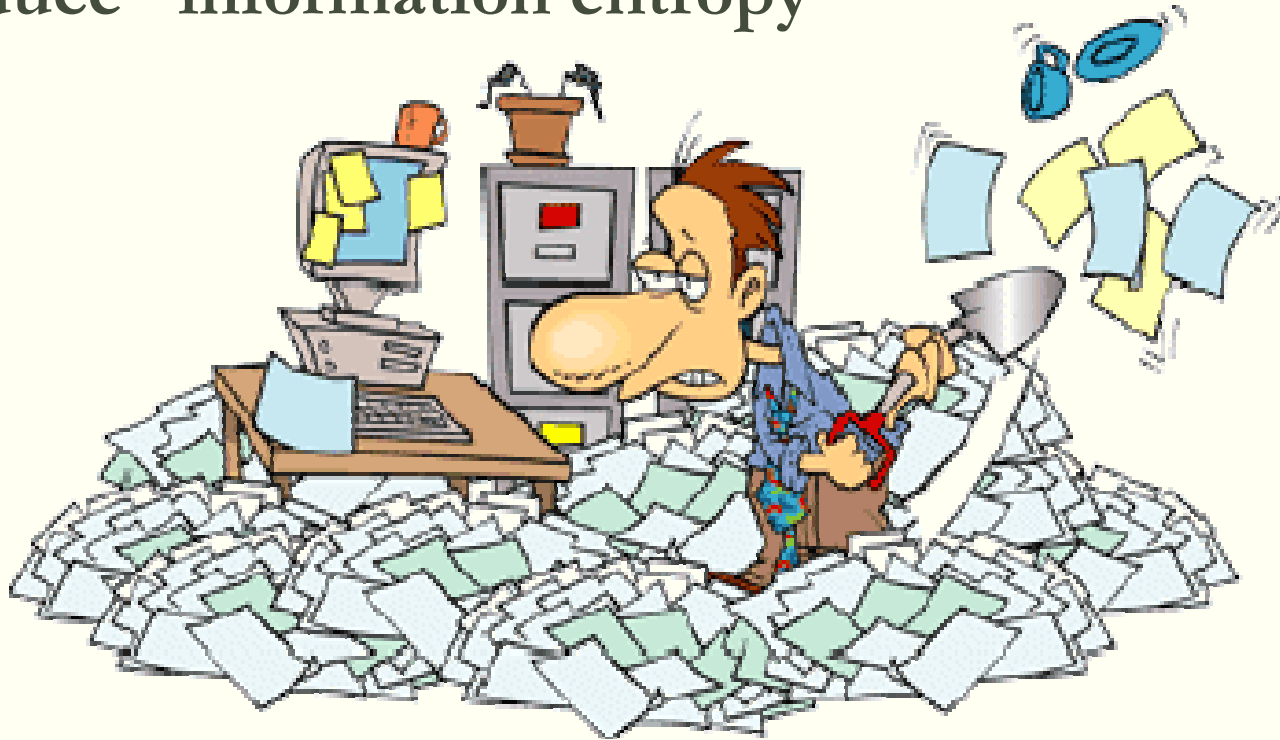
What are they and why do we
need them?





Why do we need Metadata Standards ...

... to reduce “information entropy”



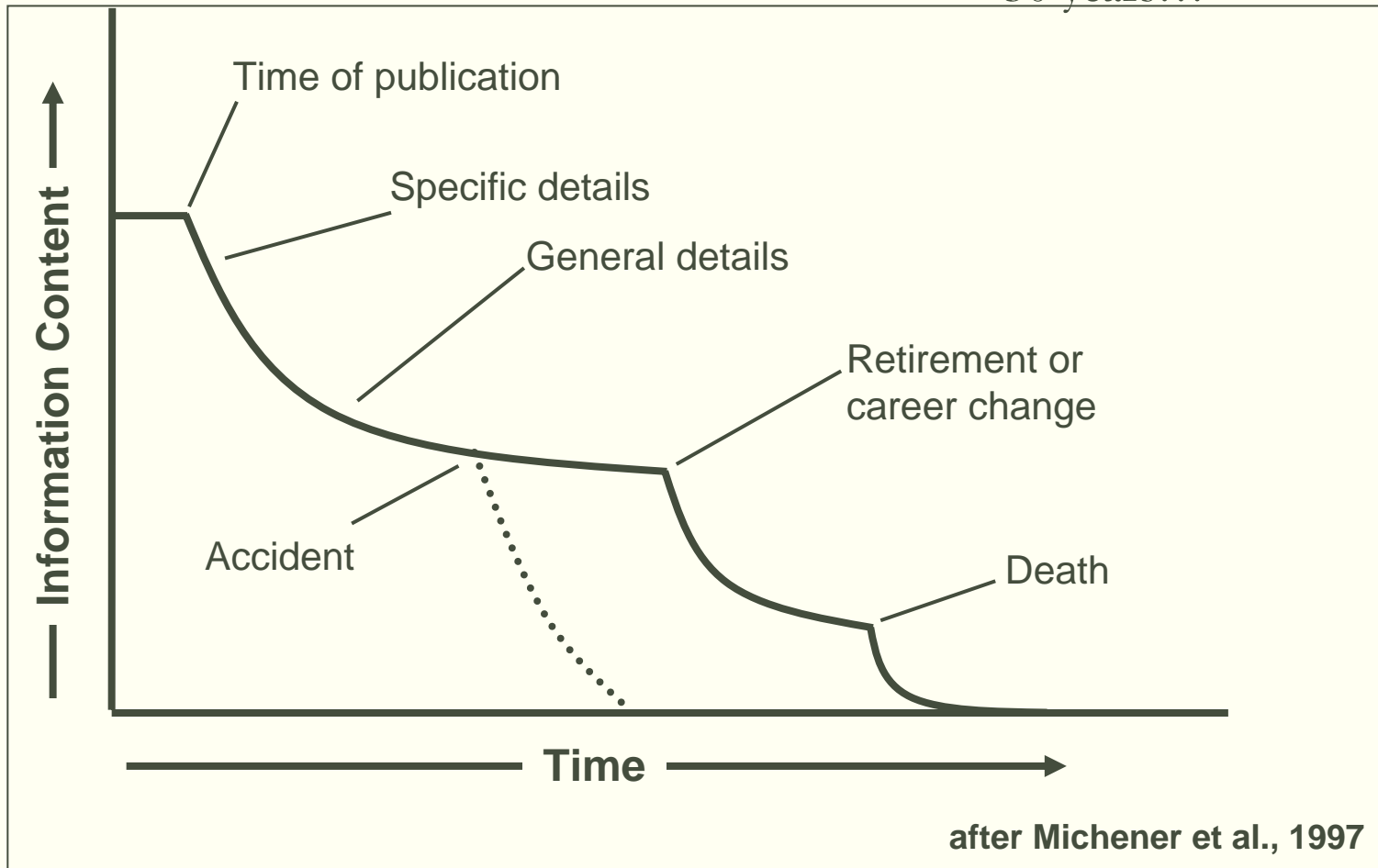
en tro py : a process of degradation
or running down or a trend to
disorder – Merriam-Webster





Information Entropy over Time

Information usefulness at 10 years, 20 years,
30 years...





Why are metadata standardized ?

- ❑ To provide a common set of understandable terms to describe data;
- ❑ To facilitate entry and retrieval of metadata and data; and
- ❑ To create tools which can automate entry, search and integration of data



Metadata Standardization

- ❑ Defines a common terminology
 - Allows for system “cross-walks”; that is, mapping one metadata structure to another
- ❑ Format and Structure
 - Binary (GeoTIFF header) ... Text (XML)
 - Proprietary (MrSID) ... Open (EML)
- ❑ Allows software engineers to automate
 - Entry
 - Searching
 - Integration
 - Synthesis





Metadata Content Specifications

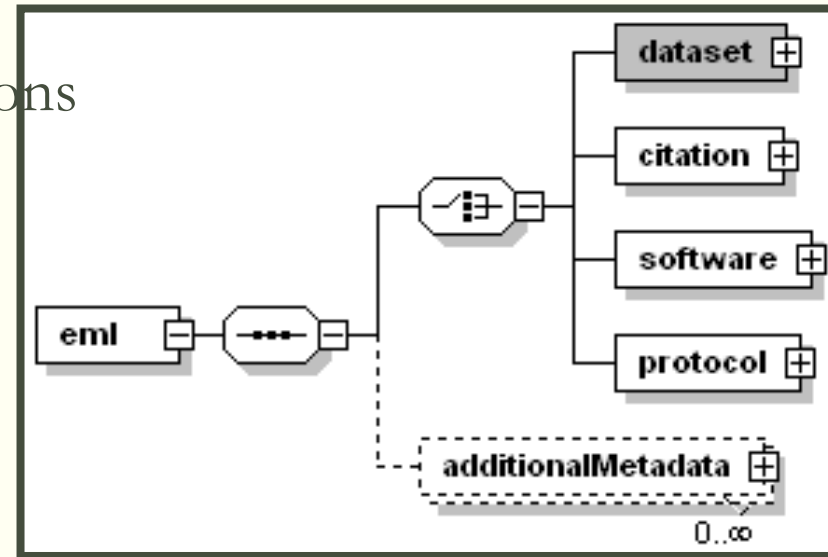
- ❑ Dublin Core
- ❑ NBII (National Biological Information Infrastructure) Biological Data Profile / CSDGM (Content Standards for Digital Geospatial Metadata)
- ❑ ISO (International Organization for Standardization) CD 19115, Geographic information - metadata
- ❑ LTER Data Table of Contents
- ❑ Darwin Core
- ❑ Ecological Metadata Language (EML)





Ecological Metadata Language

- ❑ Adopted by the LTER Information Management
- ❑ Metadata specification developed by the ecology discipline for the ecology discipline
- ❑ Based on prior work of Ecological Society of America and others (Michener et. al., 1997)
- ❑ Seven years in development – 14 versions
 - EML 2.0.1
- ❑ Implemented as an XML Schema
- ❑ Supports four separate modules
 - Dataset
 - Citation
 - Software
 - Protocol





5 Classes of ecological metadata descriptors

- Data set
- Research origin
- Data set status and accessibility
- Data structural
- Supplemental



Metadata Descriptors

- ❑ What relevant data exist?
- ❑ Why were those data collected and are they suitable for a particular use?
- ❑ How can these data be obtained?
- ❑ How are the data organized and structured?
- ❑ What additional information is available that would facilitate data use and interpretation?





XML: eXtensible Markup Language

- ❑ Development influenced by SGML and HTML – Version 1.0 in early 1998 **W3C**
- ❑ A semantic language that lets you more meaningful annotate text (where HTML lets you define how text can be displayed, XML provides it with meaning).
- ❑ Important for presentation, exchange, and management of information
- ❑ Tools include DTD, Schema, XSL, and more...





Metadata tools

what's out there to help?





A Smorgasboard of Metadata Tools

- ❑ Proprietary
- ❑ Non-proprietary
- ❑ On-line
- ❑ Standalone
- ❑ Windows
- ❑ ASCII
- ❑ Unix





Tools for Managing Metadata

- ❑ Flat-file System
- ❑ Hybrid Flat-file System
- ❑ Relational Databases
 - Oracle, PostgreSQL, MySQL
- ❑ Hybrid Relational Databases
 - Metacat, Digital Library eXtension Service
- ❑ Hierarchical Databases
 - Adabas, IMS
- ❑ Object-Relational Databases
 - Birdstep, XDb, JADE





Metacat Data Repository

KNB :: The Knowledge Network for Biocomplexity - Mozilla

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop

http://knb.ecoinformatics.org/index.jsp#

Home Bookmarks mozilla.org mozillaZine mozdev.org Comcast Belk

Mozilla

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop

http://metacat.nceas.ucsb.edu/knb/servlet/metacat

Go Search Print

Organization Keywords

PA) Pymatuning Laboratory of Ecology	species list Pennsylvania Pymatuning biodiversity
Hastings Natural History Reservation	Hastings Reserve, distributions, observations, records, dates, habitats, behavior, Senior Thesis, Amphibians, Reptiles, Herptiles
CA) Hastings Natural History Reservation	distributions observations records dates habitats behavior
Hastings Natural History Reservation	Hastings, vertebrate species, phenology, occurrences, Reptiles, Amphibians, Mammals, Birds
J. H. Barrow Field Station, Hiram College	reptile amphibian beech maple forest inventory
FL) Disney Wilderness reserve	Trapping Wildlife monitoring Florida Herps

Data set description

Ecological Metadata Language

Metadata Identifier: obfs.334.2

Metadata Catalog System: knb

Metadata Identifier: obfs.334.2

Metadata Catalog System: (PA) Pymatuning Laboratory of Ecology

Title: Amphibian and reptile species for the Pymatuning area

Data Set Owner(s):

Individual: Joanne Anderson

Address: 13142 Hartstown Road,
Linesville,
Pennsylvania 16424
USA

Phone: (814)683-5813

Email Address: ple@toolcity.net

Role: Metadata Provider

Individual: Joanne Anderson

Address: 13142 Hartstown Road,
Linesville,
Pennsylvania 16424
USA

Phone: (814)683-5813

Email Address: ple@toolcity.net

Done

NSF

KNB



Tools for Creating Metadata

□ Text editors

- Notepad (Windows)
- Emacs, vi (UNIX, Linux, ...)
- XML Specific (XMLSpy, oXygen, ...)

□ Custom software

- NBII Metamaker
- ESRI ArcCatalog
- ecoinformatics.org Morpho





ESRI ArcCatalog Metadata

- Metadata properties: Derived from the data itself and automatically created by ArcCatalog
- Documentation: Written by a person
- Metadata editor enforces Federal Geographic Data Committee (FGDC) standards
- Stored in XML format within the geodatabase
- Automatically exports/transfers with coverages





Morpho

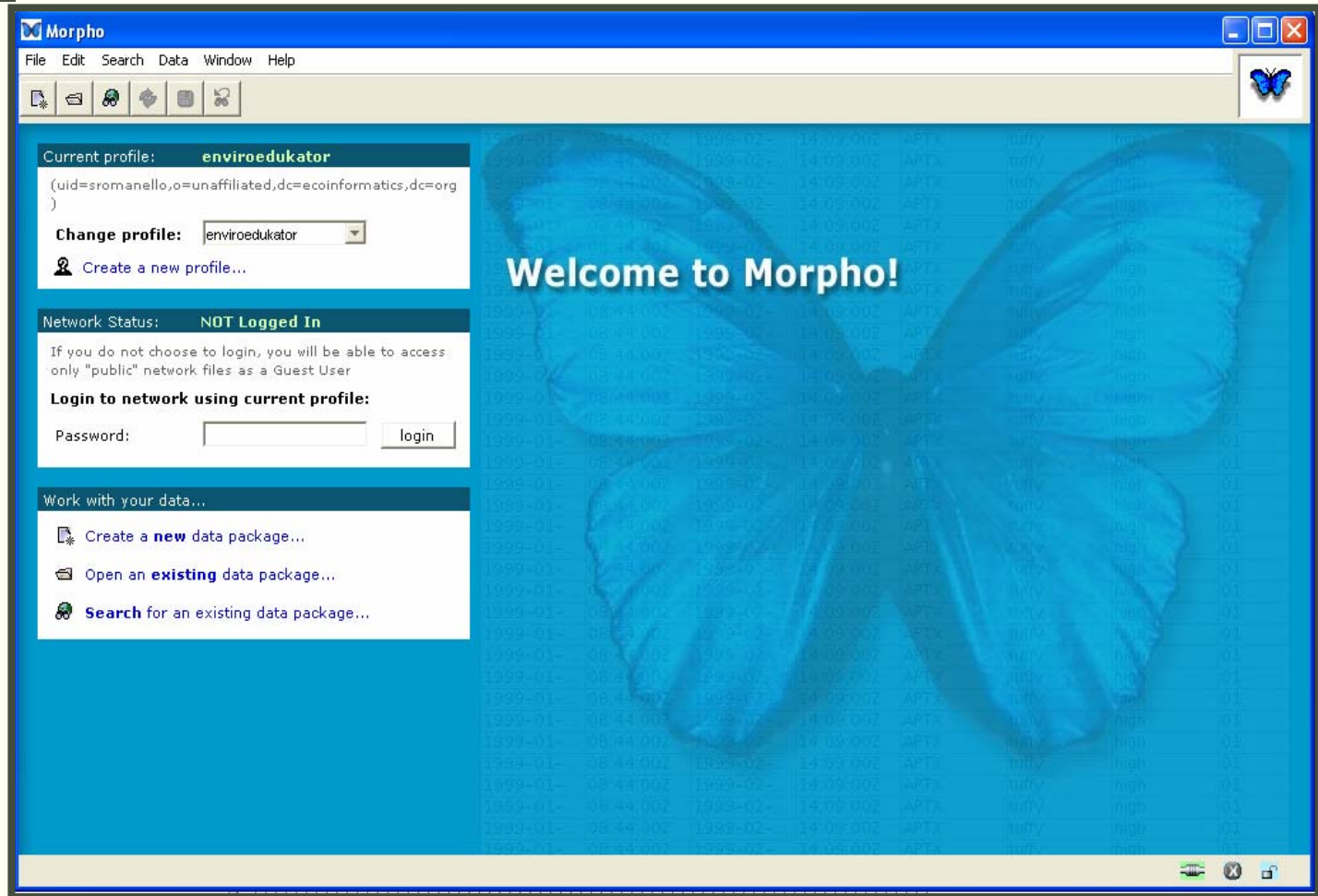
- Metadata editor enforces EML 2.0 standards
- Stored in XML format within Metacat server
- Automatically imports Metadata and data
- 5 Classes of Metadata Descriptors
 - Data set descriptors
 - Research origin descriptors
 - Data set status and accessibility
 - Data structural descriptors
 - Supplemental descriptors





Morpho

- Create & Edit Metadata
- Search & Query Metadata Collections





Creating Metadata

Just how much work is this?





How much work is
this going to
be???





Benefits of using Metadata

- Information entropy ↓, data longevity ↑
- Data reuse and sharing ↑
 - Even original researchers need refreshing
- System interoperability ↑
- Broad-based data synthesis ↑
- Compliance with funding agencies ↑





Canadian Information Management Resource Centre

The benefits of using a systematic way of assigning and structuring metadata include:



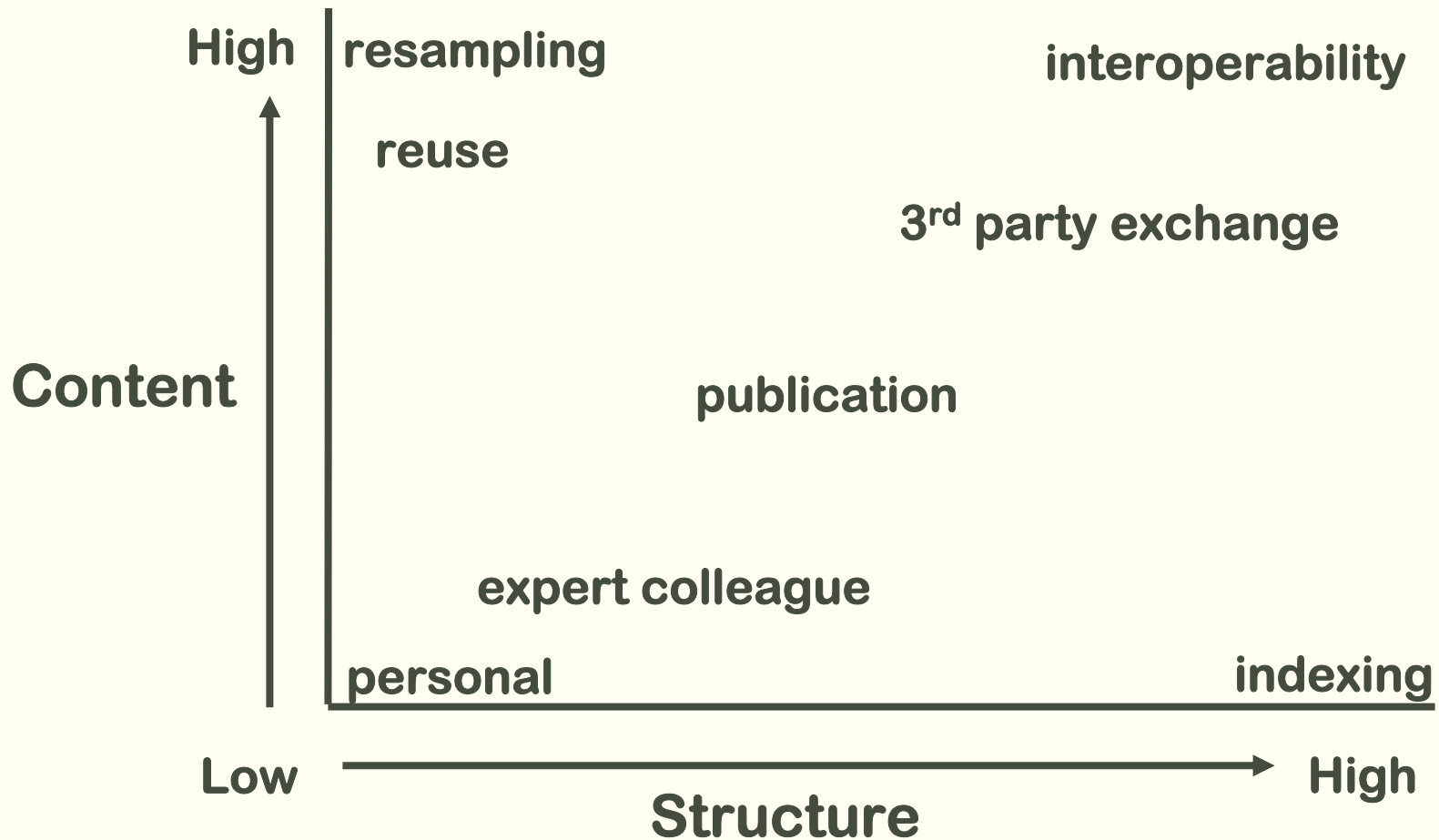
- **Reliability:** providing information that search engines can use to find relevant documents in large collections such as web sites or document databases where text search alone brings up many irrelevant documents or lists of documents too long for users to look at.
- **Identity:** providing descriptive information so that users can tell how old a document is, who wrote it, or how to get additional information. Most documents on government web sites now cannot tell the user whether they are 5 days old or 5 years old. Sometimes the user wants one, sometimes the other.
- **Inventory:** a list of what information the Government holds so that the information can be managed, tracked, updated, analyzed and used efficiently.
- **Consistency:** an international metadata standard provides the framework and many of the rules for use so that metadata can be applied consistently in large and diverse organizations such as the Government of Canada. This creates an environment in which users can search for and find information without needing to know which department produced it or to which program it relates.
- **Interoperability:** an international metadata standard provides a way for information resources in electronic form to communicate their existence and their nature to other electronic applications (e.g. via HTML or XML) or search tools and to permit migration of information between applications or search systems.
- **Policy compliance:** a critical component of meeting the Management of Government Information Holdings (MGIH) policy requirement to know and be able to find the information Government holds.





Variable Levels of Metadata Content & Structure Necessary for Specific Objectives

(Michener 2000)





Rules of Thumb (Michener 2000)

- ❑ The more comprehensive the metadata, the greater the longevity (& value) of the data
- ❑ Structured metadata can greatly facilitate data discovery, encourage “best metadata practices” & support data & metadata use by others
- ❑ Metadata implementation takes time!!!
- ❑ Start implementing metadata for new data collection efforts and then prioritize “legacy” & ongoing data sets that are of greatest benefit to the broadest user community





The price you have to pay...

- Personnel costs
 - time for learning and training
 - additional effort
- Media for metadata storage
- Hardware/software requirements
- Long-term stewardship and curation



Make metadata implementation a team effort

- ❑ Team Leader
- ❑ GIS Specialist
- ❑ Field Personnel
- ❑ Database Manager
- ❑ Laboratory Specialist
- ❑ Voucher/Repository Specialist
- ❑ And others as appropriate....



The Planning Process

- ❑ Develop a community-based plan
 - Legacy conversion
 - Present to future data entry
 - Metadata storage strategy
- ❑ Determine infrastructure needs
 - Personnel
 - Hardware
 - Software
- ❑ Reuse standards where possible
- ❑ Be flexible when necessary





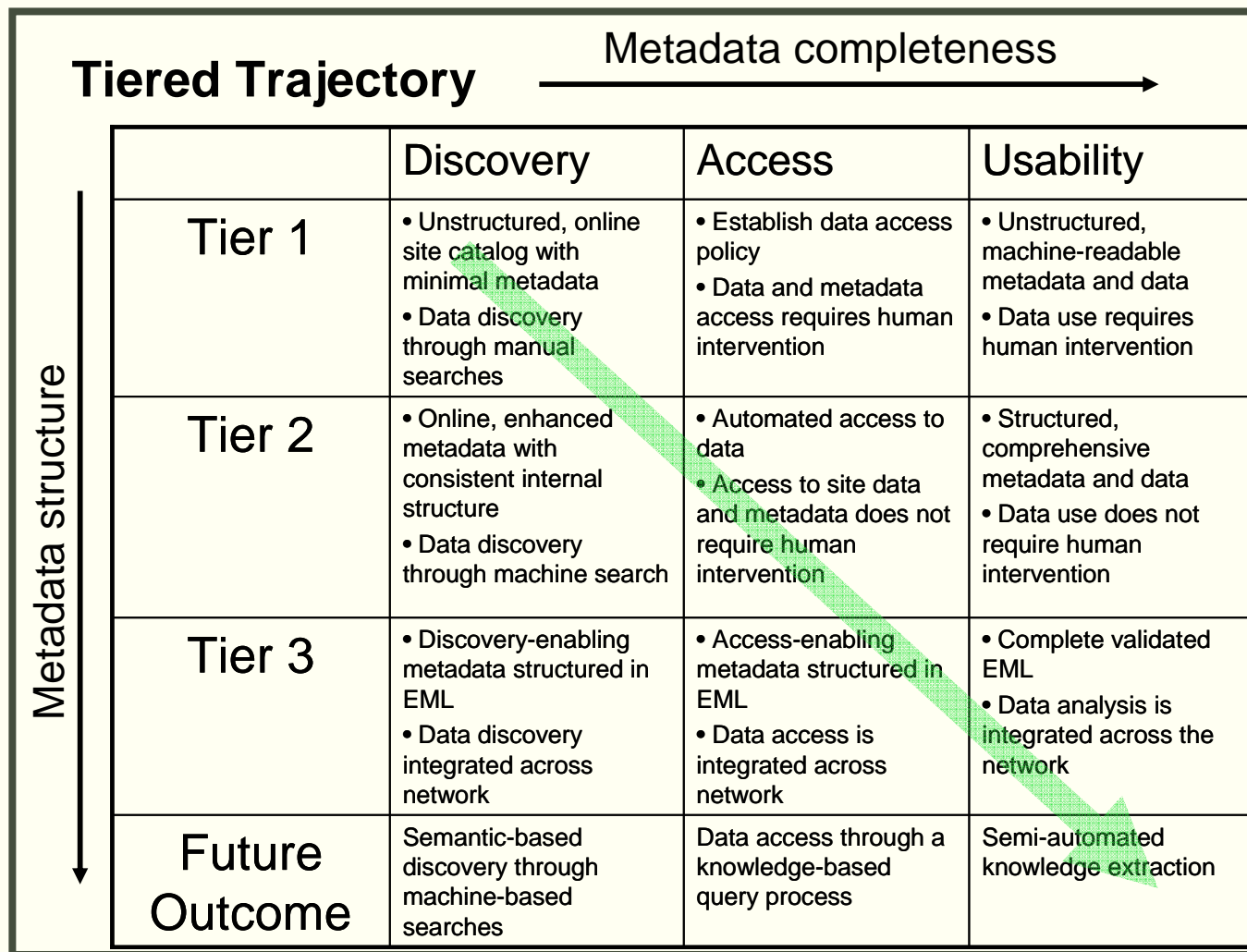
Long Term Ecological Research Network

- 26 U.S. LTER sites
 - 20 Continental/Coastal United States
 - 2 Alaska
 - 1 Puerto Rico
 - 2 Antarctica
 - 1 French Polynesia
- Funding Agency – NSF
- 20+ years of research
- IM → IMExec → CC





LTER Tiered Trajectory for Metadata





LTER Best Practices

- ❑ Identification
- ❑ Discovery
- ❑ Evaluation
- ❑ Access
- ❑ Integration
- ❑ Semantic Use

Completeness Level	Description and Major Elements Added
1: Identification	Minimum content for adequate data set discovery in a general cataloging system or repository (functionally equivalent to LTER DTOC): <ul style="list-style-type: none"> • title • creator • contact • publisher • pubDate • keywords • abstract (recommended) • dataset/distribution (i.e. url for general dataset information)
2: Discovery	Level 1 content, plus coverage information to support targeted searches <ul style="list-style-type: none"> • geographicCoverage • taxonomicCoverage • temporalCoverage
3: Evaluation	Level 2 content, plus data set details to enable end-user evaluation of the methodology and data entities: <ul style="list-style-type: none"> • project • methods • entity • attributes (strongly recommended, as possible) • intellectualRights
4: Access	Level 3 content plus data access details to support computer-assisted data retrieval: <ul style="list-style-type: none"> • access • physical
5: Integration	Level 4 content plus complete attribute and QA/QC details to support computer-assisted data integration and re-sampling <ul style="list-style-type: none"> • attribute (required) • measurementScale • units • constraint • qualityControl
6: Semantic Use	Level 5 content plus semantic information (currently under development by SEEK, and may require extension to the EML schema)





In this session we will discuss...

- ❑ Metadata: what are they? and why should they be created?
- ❑ Metadata standards: why do we need them?
- ❑ Metadata tools: what's out there to help?
- ❑ Creating metadata: just how much work is this?
- ❑ Finding and evaluating metadata: what is good?
- ❑ Metadata resources: what's out there?





Finding & evaluating metadata

what is good?





Finding Data & Metadata

- ❑ Colleagues
- ❑ Scientific literature
- ❑ WWW searches
- ❑ Data and metadata registries
 - Global Change Master Directory
- ❑ Metadata Clearinghouses
 - National Biological Information Infrastructure





Finding Data & Metadata

US Dept of Interior USGS-BRD NBII Metadata Retrieval - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Stop

Bookmarks Location: http://www.emtc.usgs.gov/cgi-bin/meta_isite/zgate What's Related

Instant Message WebMail People Yellow Pages Download New & Cool Channels

NBII Clearinghouse Nodes to Query

Select one or more NBII Clearinghouse nodes in the list below. You may query multiple nodes to query simultaneously. Hold your shift or control key down while selecting multiple nodes.

See Descriptions of [NBII Clearinghouse Nodes](#)



- NBII Metadata Clearinghouse
- Eastern Sierra Geospatial Data Clearinghouse
- EMAN Data Set Library (Environment Canada Server)
- National Wetlands Research Center (NWRC) Clearinghouse Node
- ONRC Clearinghouse for the Olympic Peninsula

Maximum Number of Responses to View: 20

Reset the form to default values.

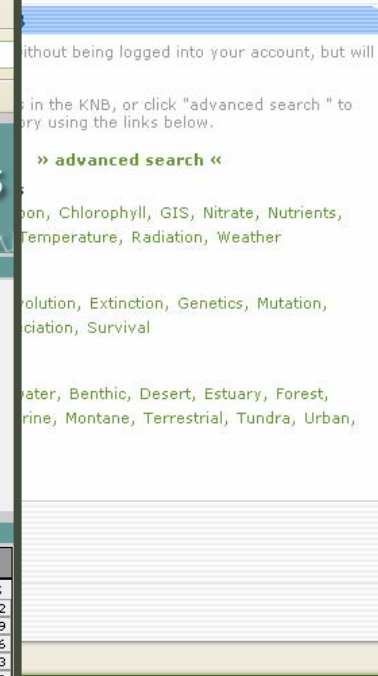
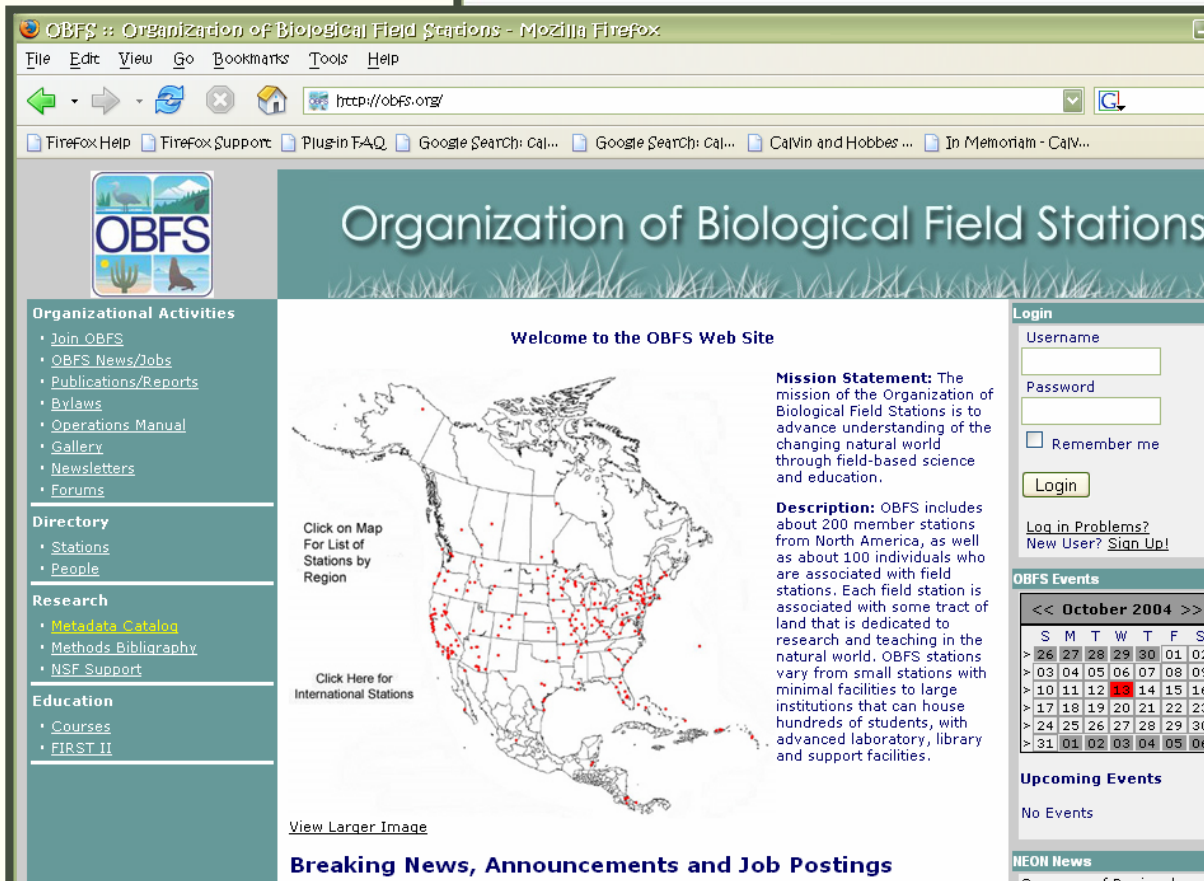
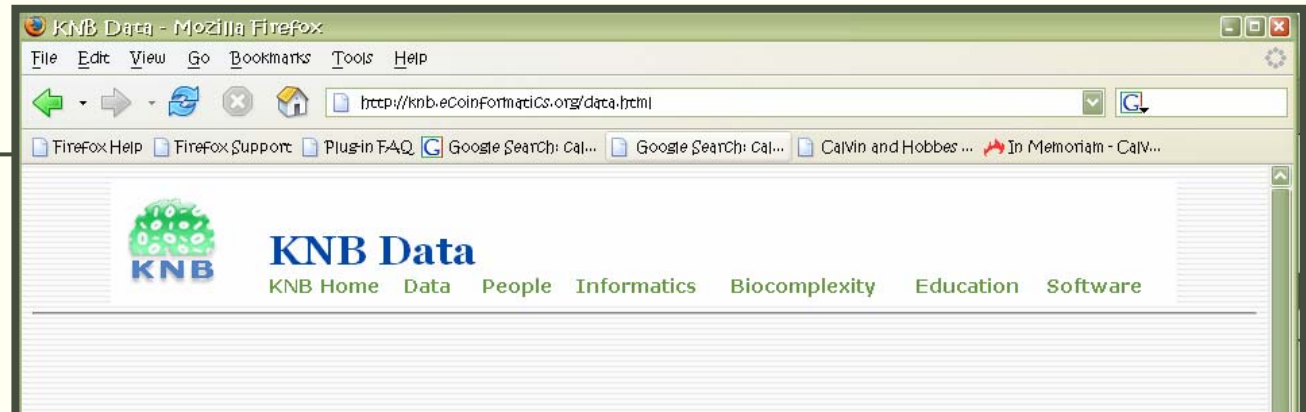
When you are done searching, please give us your [comments](#), and then select the **LOGOUT** button

Document Done





Finding Data & Metadata





Finding Data & Metadata

KNB Data - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://knb.ecoinformatics.org/data.html

Firefox Help Firefox Support Plugin FAQ Google Search: Cal... Google Search: Cal... Calvin and Hobbes ... In Memoriam - Calv...

KNB Data

KNB Home Data People Informatics Biocomplexity Education Software

search for data on the KNB

You are NOT logged in (Login). You may search the KNB without being logged into your account, but will have access only to "public" data (see "login & registration")

Enter a search phrase (e.g. biodiversity) to search for data sets in the KNB, or click "advanced search" to enter more-detailed search criteria, or simply browse by category using the links below.

>> advanced search <<

Taxonomy

Amphibian, Bird, Fish, Fungus, Invertebrate, Mammal, Microbe, Plant, Reptile, Virus

Level of Organization

Molecule, Cell, Organism, Population, Community, Landscape, Ecosystem, Global

Ecology

Biodiversity, Competition, Decomposition, Disturbance, Endangered Species, Herbivory, Invasive Species, Nutrient Cycling, Parasitism, Population Dynamics, Predation, Productivity, Succession, Symbiosis, Trophic Dynamics

Measurements

Biomass, Carbon, Chlorophyll, GIS, Nitrate, Nutrients, Precipitation, Temperature, Radiation, Weather

Evolution

Adaptation, Evolution, Extinction, Genetics, Mutation, Selection, Speciation, Survival

Habitat

Alpine, Freshwater, Benthic, Desert, Estuary, Forest, Grassland, Marine, Montane, Terrestrial, Tundra, Urban, Wetland

Waiting For metaCat.nCeas.ucsb.edu...

You can perform a simple search by either clicking on given keyword or typing in your own





Finding Data & Metadata

The screenshot shows a Mozilla Firefox browser window titled "KNB Data :: Advanced Search - Mozilla Firefox". The address bar displays the URL "http://knb.ecoinformatics.org/advancedsearch.jsp". The browser's menu bar includes File, Edit, View, Go, Bookmarks, Tools, and Help. The toolbar shows navigation buttons (back, forward, home, stop, reload) and a search icon. The bookmarks bar lists links to Firefox Help, Firefox Support, Plugin FAQ, and several Google Search results. The main content area features the "Biocomplexity Data Search" header with the KNB logo and a "Home" link. Below this is a section titled "advanced search options" which includes a login notice: "You are NOT logged in (Login). You may search the KNB without being logged into your KNB account, but will have access only to 'public' data (see 'login & registration' on homepage). Select more-detailed criteria and a search phrase (e.g. biodiversity) to search for data sets in the KNB." The search interface includes a "Find data where:" dropdown menu with options "Any Field", "Author Last Name", and "Title" (selected). A "contains:" text input field contains the word "biodiversity". A "Search KNB" button is located to the right of the input field.

Or, You can perform an advanced search





Search Results

31 data packages found

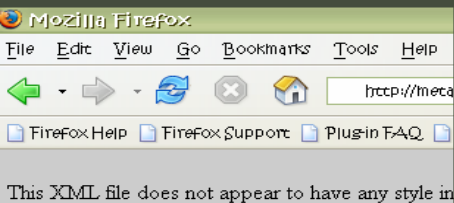
Title	Contacts	Organization	Keywords
» Amphibian and reptile species for the Pymatuning area ID: obfs.334.2	Anderson Joanne M. Anderson Anderson	(PA) Pymatuning Laboratory of Ecology	species list Pennsylvania Pymatuning biodiversity
» A survey of the aquatic vascular plants of seven natural lakes in Northwestern Pennsylvania ID: obfs.338.2	Anderson Anderson Joanne M. Anderson	(PA) Pymatuning Laboratory of Ecology	aquatic plants species list biodiversity Pennsylvania lake
» Bird species for the Pymatuning area ID: obfs.328.2	Anderson Joanne M. Anderson Anderson	(PA) Pymatuning Laboratory of Ecology	Pymatuning biodiversity species list Pennsylvania
» Browns Creek, stream and groundwater temperatures ID: obfs2.366.1	Almendinger	St. Croix Watershed Research Station	Urbanization Rivers/Streams Water Temperature Rivers/Stream Habitat Trout
» Fire severity research of 2002 Wulin Fire in Taiwan data created by fire lab of Taiwan Forestry Research Institute ID: tfriim.3.2	Lin	Taiwan Forestry Research Institute	fire severity satallite image fire intensity fire ecology
» Fish species for the Pymatuning area ID: obfs.332.2	Anderson Joanne M. Anderson Anderson	(PA) Pymatuning Laboratory of Ecology	Pennsylvania Pymatuning biodiversity species list
» Global elevational distributions of small mammals	McCain	National Center for Ecological Analysis	elevation range



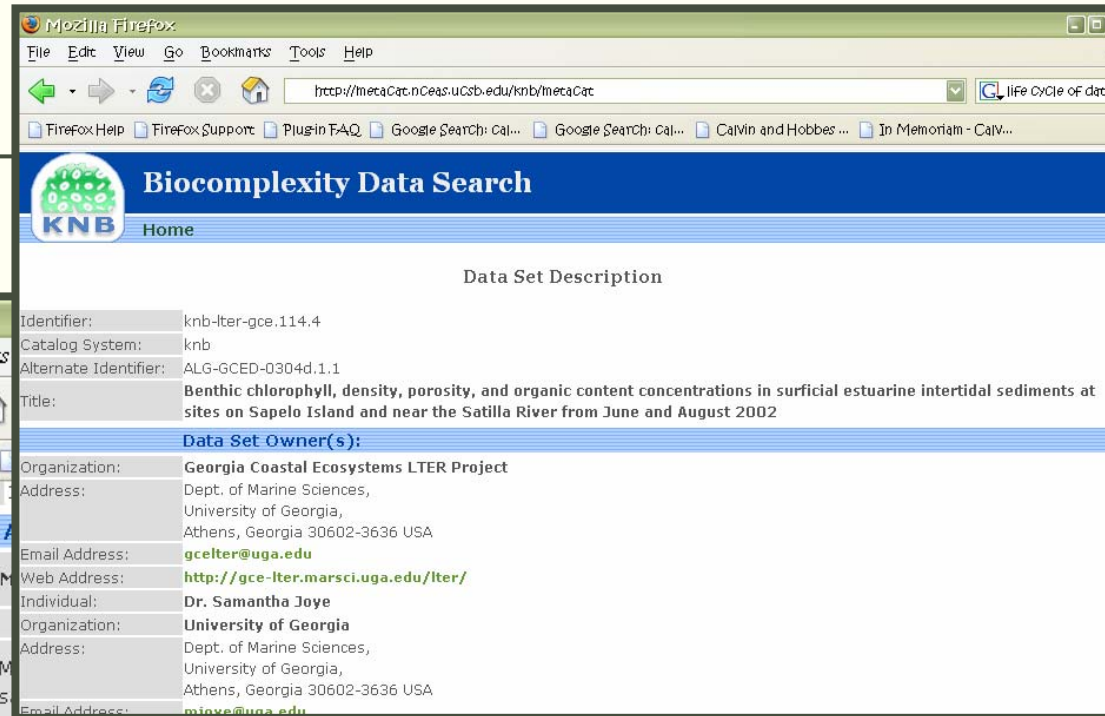
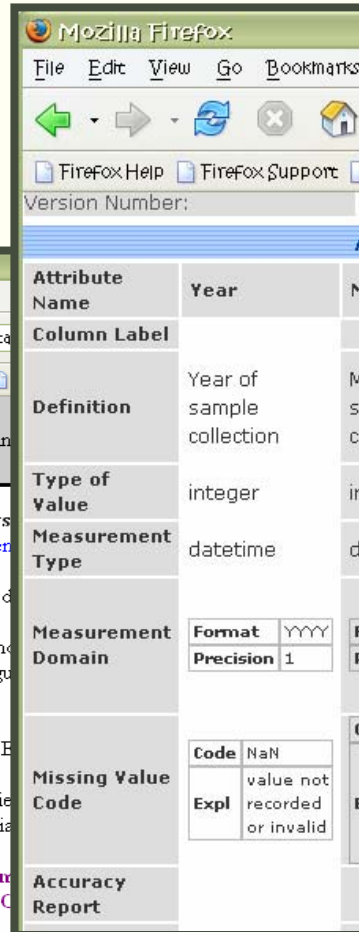


Associated Metadata

- Data Set
- Data Table
- Xml files



```
- <eml:eml packageId="knb-lter-gce.114.4" sys
http://gce-lter.marsci.uga.edu/lter/files/schemas/em
- <dataset scope="document">
  <alternateIdentifier>ALG-GCED-03040
- <title>
  Benthic chlorophyll, density, porosity, and
  near the Satilla River from June and Augu
</title>
- <creator scope="document">
  <organizationName>Georgia Coastal B
- <address scope="document">
  <deliveryPoint>Dept. of Marine Scie
  <deliveryPoint>University of Georgia
  <city>Athens</city>
  <administrativeArea>Georgia</adu
  <postalCode>30602-3636</postalC
  <country>USA</country>
</address>
  <electronicMailAddress>gcelter@uga
```



collection	collection	code		number																									
integer	integer	string	integer	string	float																								
datetime	datetime	nominal	ordinal	nominal	ratio																								
<table><tr><td>Format</td><td>MM</td></tr><tr><td>Precision</td><td>1</td></tr></table>	Format	MM	Precision	1	<table><tr><td>Format</td><td>DD</td></tr><tr><td>Precision</td><td>1</td></tr></table>	Format	DD	Precision	1	<table><tr><td>Domain Info</td><td></td></tr></table>	Domain Info		<table><tr><td>Domain Info</td><td></td></tr></table>	Domain Info		<table><tr><td>Def</td><td>Sample replicate number</td></tr></table>	Def	Sample replicate number	<table><tr><td>Unit</td><td>milligramsPerSquareMeter</td></tr><tr><td>Precision</td><td>0.1</td></tr><tr><td>Type</td><td>real</td></tr><tr><td>Min</td><td>0</td></tr><tr><td>Max</td><td></td></tr></table>	Unit	milligramsPerSquareMeter	Precision	0.1	Type	real	Min	0	Max	
Format	MM																												
Precision	1																												
Format	DD																												
Precision	1																												
Domain Info																													
Domain Info																													
Def	Sample replicate number																												
Unit	milligramsPerSquareMeter																												
Precision	0.1																												
Type	real																												
Min	0																												
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<table><tr><td>Code</td><td>NaN</td></tr><tr><td>Expl</td><td>value not recorded or invalid</td></tr></table>	Code	NaN	Expl	value not recorded or invalid	<table><tr><td>Code</td><td>NaN</td></tr><tr><td>Expl</td><td>value not recorded or invalid</td></tr></table>	Code	NaN	Expl	value not recorded or invalid		<table><tr><td>Code</td><td>NaN</td></tr><tr><td>Expl</td><td>value not recorded or invalid</td></tr></table>	Code	NaN	Expl	value not recorded or invalid		<table><tr><td>Code</td><td>NaN</td></tr><tr><td>Expl</td><td>value not recorded or invalid</td></tr></table>	Code	NaN	Expl	value not recorded or invalid								
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- ❑ Finding and evaluating metadata: what is good?
- ❑ Metadata resources: what's out there?





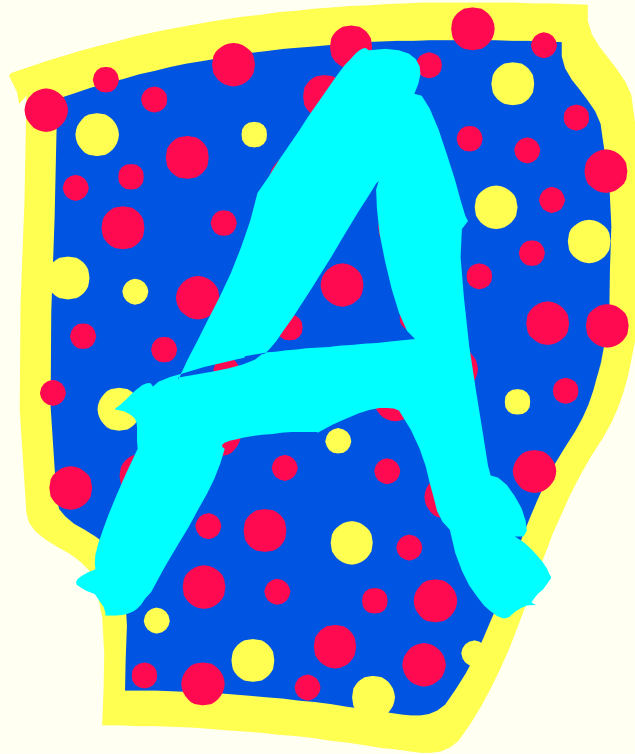
Finding and evaluating metadata

what is good?





Evaluating Metadata



Frequently-anticipated questions:

Q u e s t i o n s & A n s w e r s

- What does this data set describe?
 1. How should this data set be cited?
 2. What geographic area does the data set cover?
 3. What does it look like?
 4. Does the data set describe conditions during a particular time period?
 5. What is the general form of this data set?
 6. How does the data set represent geographic features?
 7. How does the data set describe geographic features?
- Who produced the data set?
 1. Who are the originators of the data set?
 2. Who also contributed to the data set?
 3. To whom should users address questions about the data?
- Why was the data set created?
- How was the data set created?
 1. Where did the data come from?
 2. What changes have been made?
- How reliable are the data; what problems remain in the data set?
 1. How well have the observations been checked?
 2. How accurate are the geographic locations?
 3. How accurate are the heights or depths?
 4. Where are the gaps in the data? What is missing?
 5. How consistent are the relationships among the data, including topology?




Evaluation Service

EML ID and References Parser - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://knb.ecoinformatics.org/emlparser/index.html

Firefox Help Firefox Support Plug-in FAQ Google Search: Cal... Google Search: Cal... Calvin and Hobbes... In Memoriam - Calv...

 **EML ID and References Parser**

KNB Home Data People Informatics Biocomplexity Education Software

This parser will validate that your EML instance file conforms to the rules set forth in the EML spec. It also runs a SAX validation parse to check if your document is schema valid according to the EML schemas.

Browse the file you would like to validate in the space below and click 'submit'. If you would like a file to play with, you can download this [sample EML file](#).

File Name:

OR....You can paste the text of your file in here:

Done

<http://knb.ecoinformatics.org/emlparser/index.html>





Evaluation (in short)

- Do the who? what? where? why? and how? of the data as documented in the metadata meet your particular needs?



Metadata resources

what's out there?





Resources

- ❑ <http://www.nbii.gov>
- ❑ <http://www.megrin.org/>
- ❑ <http://www.eurogi.org>
- ❑ <http://www.dlib.org>
- ❑ <http://knb.ecoinformatics.org>



Resources

- ❑ Michener, W.K. 2000. Metadata. In: *Ecological Data: Design, Management and Processing*. (eds. W.K. Michener & J.W. Brunt), pp. 92-116. Blackwell Science, Oxford, United Kingdom.
- ❑ Michener, W.K., J.W. Brunt, J.J. Helly, T.B. Kirchner, and S.G. Stafford. 1997. Nongeospatial metadata for the ecological sciences. *Ecological Applications* 7(1):330-342.

