Why We Have Natural History Collections

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Smithsonian

Overview

- Observations
  - Species
  - Vouchers
  - Standards
- Suggestions
  - Focus on users
  - Think bigger
  - Connect more
- Collections meet science policy

Renaissance of “natural history”

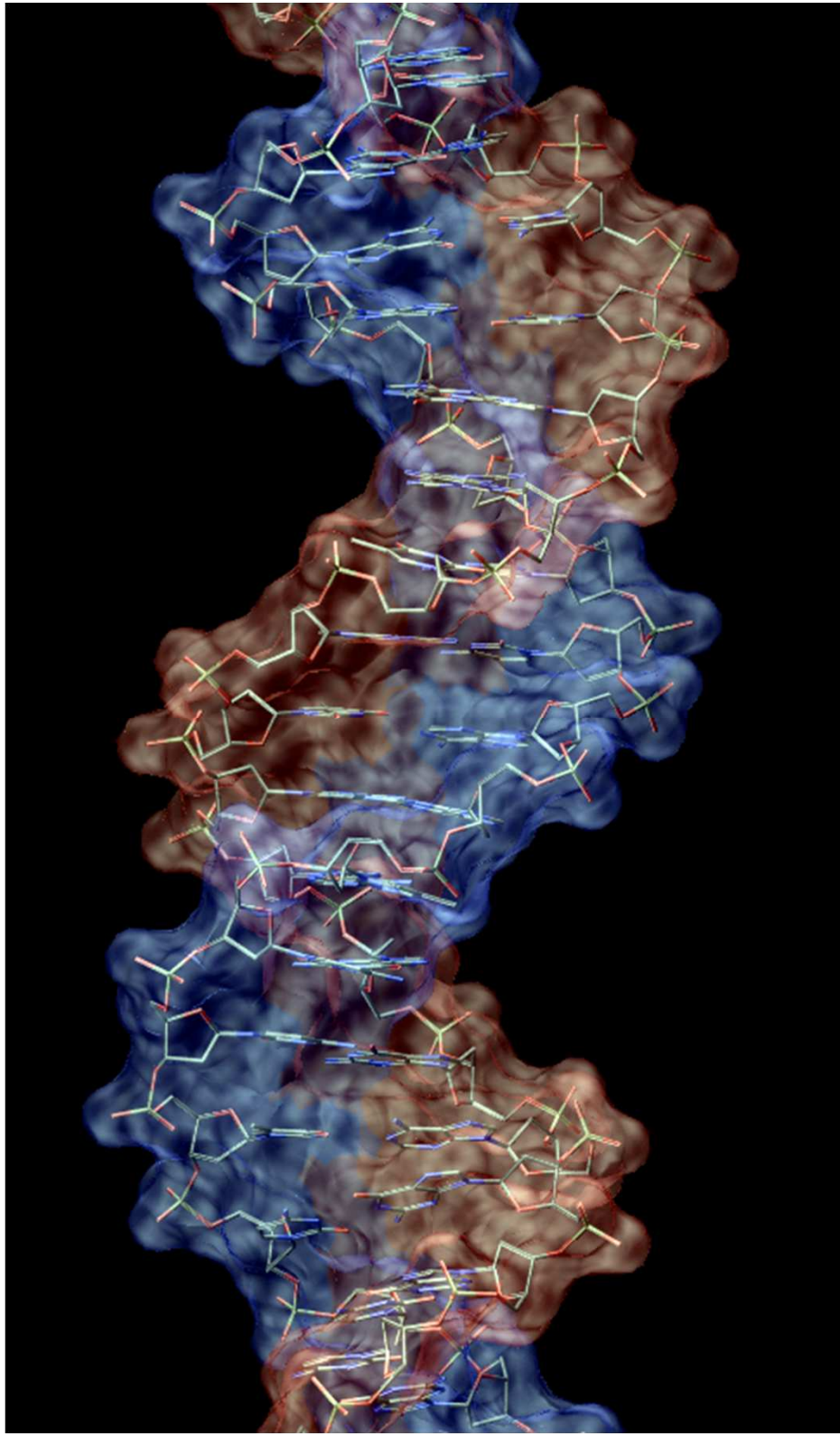
“observation and description of the natural world, with the study of organisms and their linkages to the environment being central”

Tewksbury et al, 2014, BioScience 64: 300

Renaissance of Taxonomy

- Amazing **new tools** emerging
  - DNA barcoding
  - Phylogeography (origin/race/ecotype)
  - Genomics
  - Digital imaging and image analysis
  - Internet data sharing and analysis

- Collaboration and **integration** with other disciplines



Renewed interest in species

- **New understandings of species concepts**
  - For example, role of endosymbionts in evolution
- **New characters to characterize species**
  - DNA
  - Behavior, acoustics, etc.
- **Getting species right is vital to management**, especially biological control
  - Wrong species concepts major historic impediment to biological control

Species Identification has Real Economic Impact

Global:

- Arthropods destroy an estimated **18–26 %** of annual crop production worldwide, at a value of more than $ 470 billion (Culliney 2014)

Africa:

- **80% CGIAR impact in Africa ($17 billion) from 4 biocontrol programs** (Maredia & Raitzer 2006)
- Cassava mealybug, mango mealybug, water hyacinth, cassava green mite
- All involved significant taxonomic challenges in pest and/or biocontrol agent

Invasive species

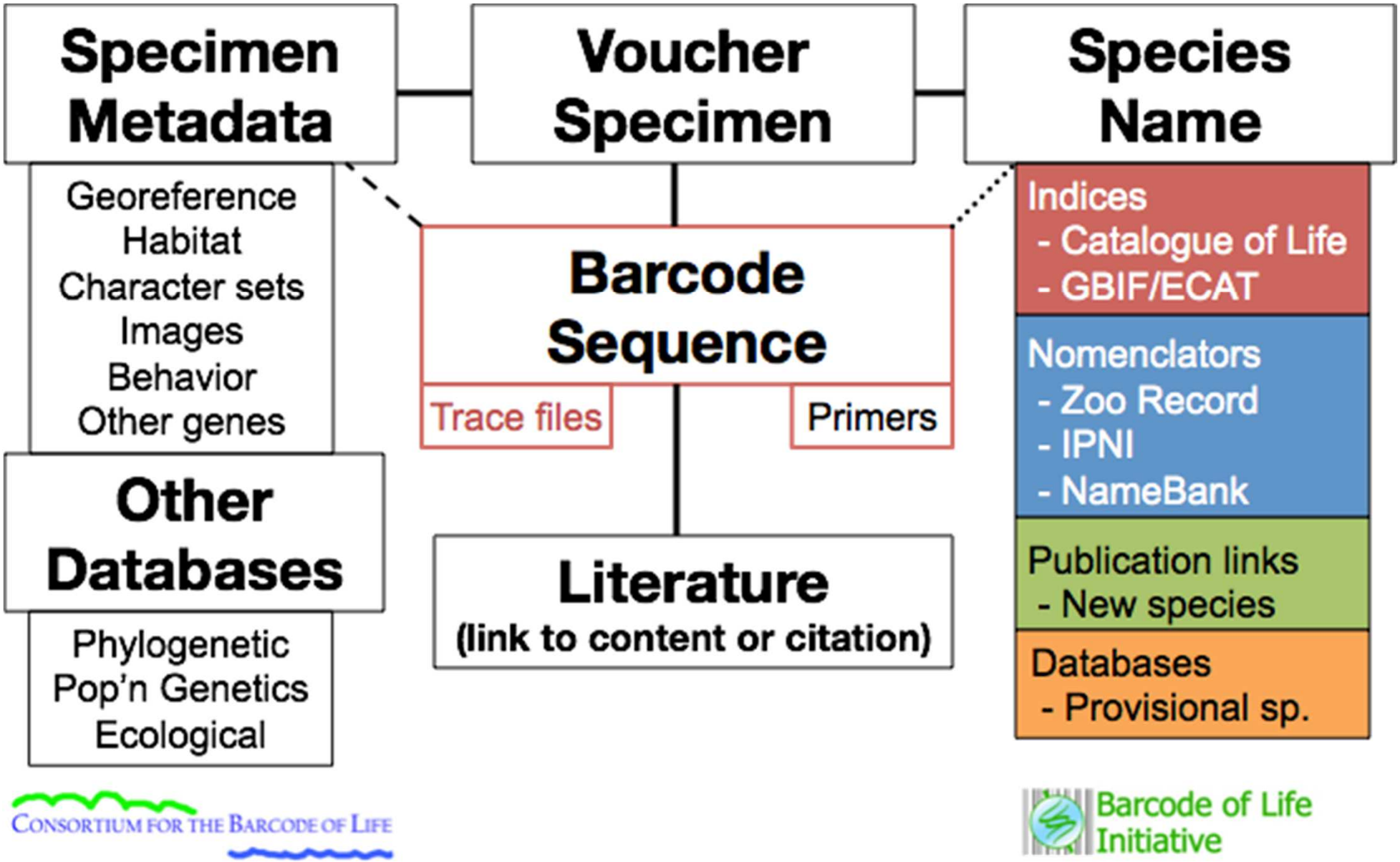
- The next invasive can be **anything from anywhere**
- Global commerce and climate change increase historic risks
- Huge costs – citrus greening, Emerald Ash Borer
- **Need to be able to rapidly place unknowns**
  - In a predictive, heuristic classification
  - In a species, if known
  - Link to existing knowledge [BHL, etc.]

Voucher specimens

- Vouchers vital to the scientific method
- Supports integration of systematics and ecology
- New tools to link collateral data
- Sometimes need proxies for vouchers, e.g., images, cultures, non-invasive samples, when appropriate
- For new vouchers, need to preserve maximum information content for future uses (GGI)
- When not to voucher – rare species (Minteer et al, 2014, Science 344: 260)

BARCODE Data Standard

- A set of required elements for a reserved Keyword (‘BARCODE’) in GenBank
- A set of sequence quality requirements
- Required or recommended formats for data interoperability with:
  - Voucher specimens in biorepositories
  - Georeferenced data
  - Taxonomic literature



BARCODE Records in GenBank

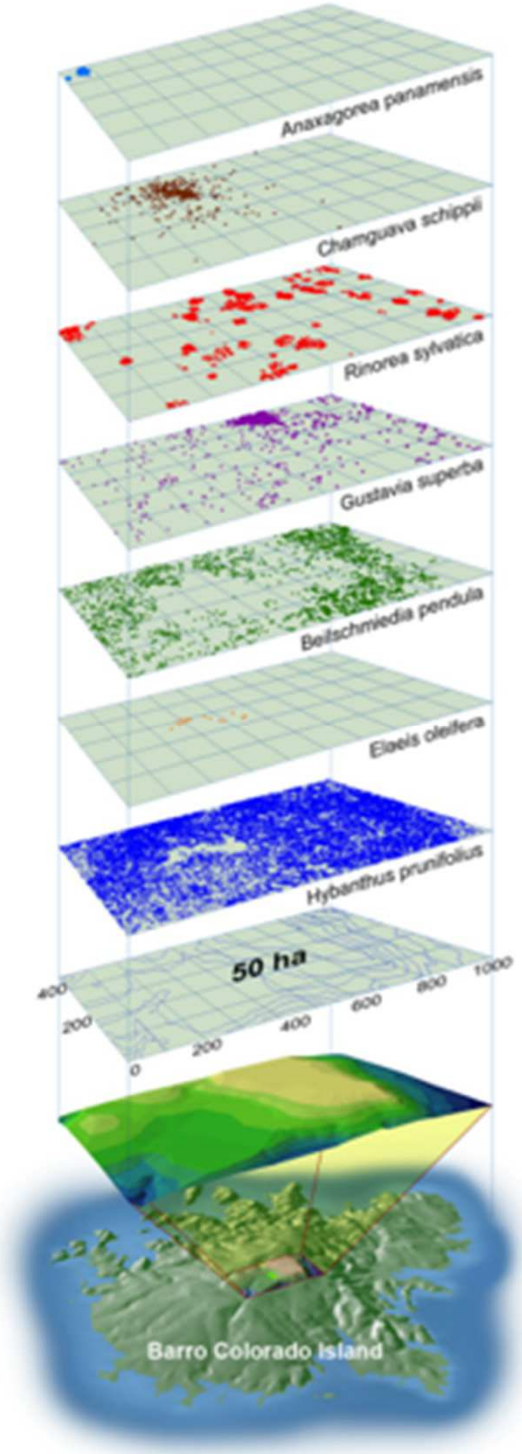
Impact of the BARCODE data standard in Genbank

Summary of metadata for GPS coordinates and voucher specimens associated with all data records

Categories of data records	Total number of GenBank records	With Latitude/ Longitude	With Voucher or Culture Collection Specimen IDs
BARCODE	347,349	286,975 (**83%**)	347,077 **(~100%)**
All COI	751,955	365,949 (**49%**)	531,428 (**71%)**
All 16S	4,876,284	461,030 (**9%**)	138,921 (**3%)**
All cytb	239,796	7,776 (**3%**)	84,784 (**35%)**

Center for Tropical Forest Science vegetation plots

- Understanding the ecology of thousands of species in forests across the world
- 5.5 million trees of 10,000 species
- Species coexistence and the maintenance of diversity:
  - Dispersal limitation
  - Niche
  - Density-dependence
  - Neutral

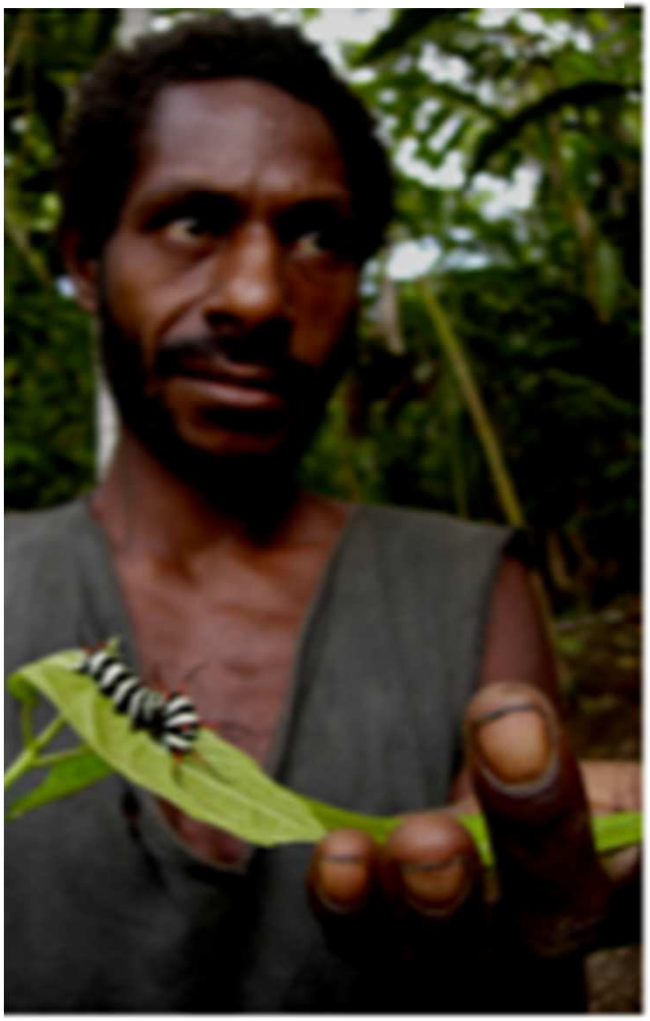


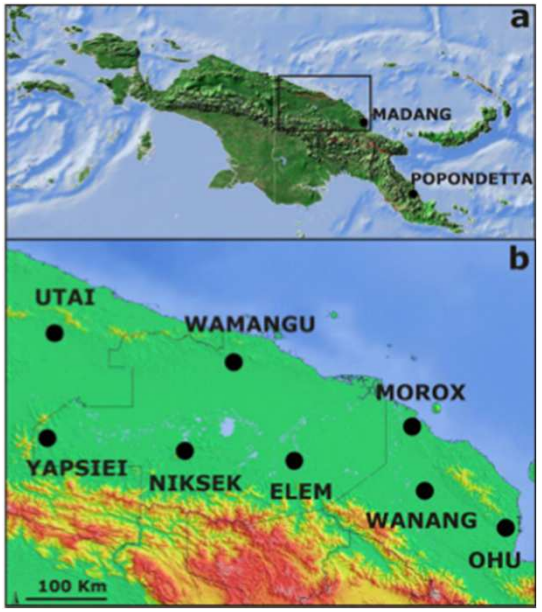
***Neotropical*: BCI, Luquillo**
***Neotemperate*: SCBI, SERC, Wabikon Lake, Yosemite, Wytham**
***Asian Tropical*: Bukit Timah, Xishuangbanna**
***Asian Temperate*: Dinghushan, Changbaishan, Gutianshan, Fushan, Lienhuachih**

CTFS

Community Phylogenies to Mega-trees [John Kress et al.]

Binatang Research Center





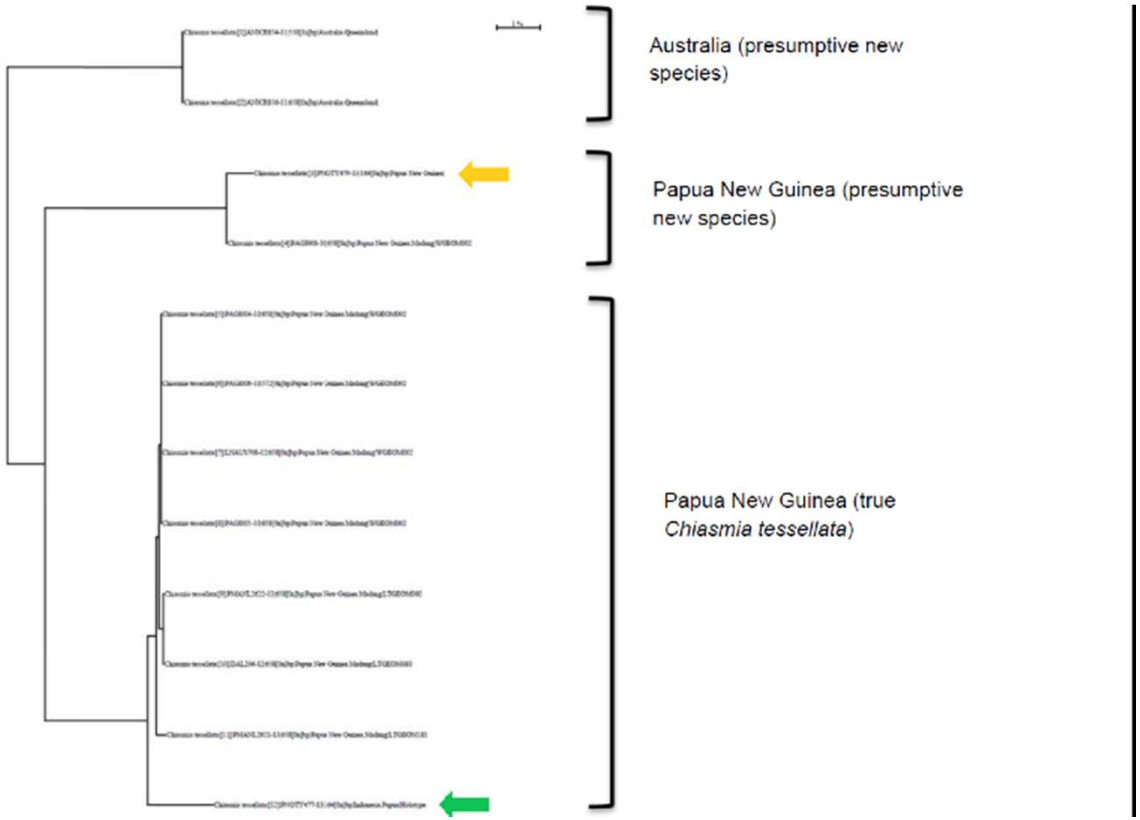
Papua New Guinea Binatang Research Center

Putting it all together: DNA barcoding of types, reared specimens, museum specimens

Sequencing old types of New Guinea Geometridae
1031 samples, 72% success
Target 164 bp, some 94 bp, some full barcodes re-assembled

Opportunity to integrate historic names (types), biology (rearings), & distribution (museums), to apply to future monitoring surveys PLUS caterpillars & hosts & parasites

Type DNA data from Sean Prosser



Credit: Peter Delaney

Connecting with users actually want versus what we think they should want …

Barcode of Wildlife Project and the wildlife trafficking legal community

Reconstruct the context of old specimens

Teddy Roosevelt Kenya Expedition retrospective

NMNH with NMK, KWS, NPG

Inspired by MVZ Grinnell project

Credit: Trey Haun

Engage the public

How to get kids back to nature?

Q?rius

New uses for old stuff: Recovering Voices

Enhancing collaboration among museums: NIBA and beyond…

Pilots in networking biodiversity collection information:

iDigBio, GGBN

- Biodiversity Heritage Library a model of collaborative digitization (50 million pages)
- ISBER a model in collections standards, training and networking
- AZA Species Survival Programs a model of sharing collections and expertise

Interagency Working Group on Scientific Collections (IWGSC)

- Established by White House in 2005
- Coordination among 15 Federal agencies and sub-agencies with scientific collections and/or granting programs
- Covers full spectrum of collection types
- Survey of object-based scientific collections owned by Federal government, 2007-8
- Parallel National Science Foundation (NSF) Survey
- **2009 IWGSC Report with seven recommendations**
- Mandate to implement first three from:
  - OSTP Director Dr. John Holdren
  - **America COMPETES Act renewal of 2010**

OSTP scientific collections policy

- "Improving the management of and access to scientific collections"
- Issued March 20, 2014
- "**Scientific collections … an essential base for developing scientific evidence and … resource for scientific research, education, and resource management**."
- Goal is "systematic improvement of the development, management, accessibility, and preservation of scientific collections …"

OSTP policy - Scope

- Federal agencies that own, maintain, or financially support permanent scientific collections
- Must develop collection policy within six months
- Applies to “institutional collections” = permanent = archival = museum = voucher = long-term assets
- Does **not** apply to “project collections” not intended for long-term preservation
- Agencies need to be able to define and review institutional versus project collections
- Also limited by law, agency mission, resource constraints, national security, etc.

Collections Policy Elements

- Collection mission and scope
- Standards for managing collections, including accessioning, inventory, deaccession
- Standards for access and use
- Budgeting and cost projection

Also “federally funded” collections

- [OSTP 3h] “… describe how the agency will apply its scientific collections policy as a term and condition, **as appropriate**, of providing funding for the acquisition and stewardship of scientific collections … being managed by a third party or that the agency does not own, but supports or for which it has oversight responsibilities”

- Parallel to NIBA goal 5.2

Clearinghouse for collections information

- OSTP 3b = NIBA 1.6
- Expansion of ***www.biorepositories.org***, created by CBOL in 2007 in collaboration with GenBank, GBIF
- Multiple portals for multiple users, including SciColl
- Merger with Index Herbariorum, Biodiversity Collections Index

- Potential merger with ISBER, WFCC, GGBN registries
- Planned linkages to NCBI and GBIF registries

Natural history as our shared roots

- **Here we see who we are, why we are, the forces that shape humans, and our impact on the natural world**
- New technology has led to new understandings in ways we could have never imagined
- Art and other museums will always reflect human interaction and experience
- But natural history museums offer the raw material for understanding the world we live in
- **That never goes out of style…**

Thanks

- Interagency Working Group on Scientific Collections
- Consortium for the Barcode of Life
- Biodiversity Institute of Ontario
- Binatang Research Center
- Center for Tropical Forest Science
- Smithsonian Institution
- David Schindel, Mike Trizna, Amy Marino, Kirk Johnson, and many other colleagues
- Funders: Sloan, Google, NSF

Role of endosymbionts and parasites

- Endosymbionts have major roles in evolution of arthropods & nematodes
  - Nutrition, defense, development, reproduction
  - Wolbachia and more
- Parasite/host ranges shift with climate [Hoberg & Brooks]
- Endosymbionts also important in plants
- Multiple levels, e.g., bacteria on ants protect Acacia *[Gonzalez-Teuber et al., 2014, New Phytologist]*
- Only beginning to understand diversity, distribution and function *[Functional Ecology 28(2), 2014]*

Strategic partnerships

- Examples promoting synergy in applied systematics…
- Smithsonian National Museum of Natural History hosts USDA, USGS, DOD, and NOAA
- Florida Natural History Museum collaboration with Florida Department of Agriculture