Building Critical Scientific Infrastructure for Key Societal Issues

Significant questions are centered on our ability to assess change.

- Climate change
- Habitat conversion
- Pollutants
- Introduction of exotics
- Loss of biotic diversity
- Emerging pathogens & diseases

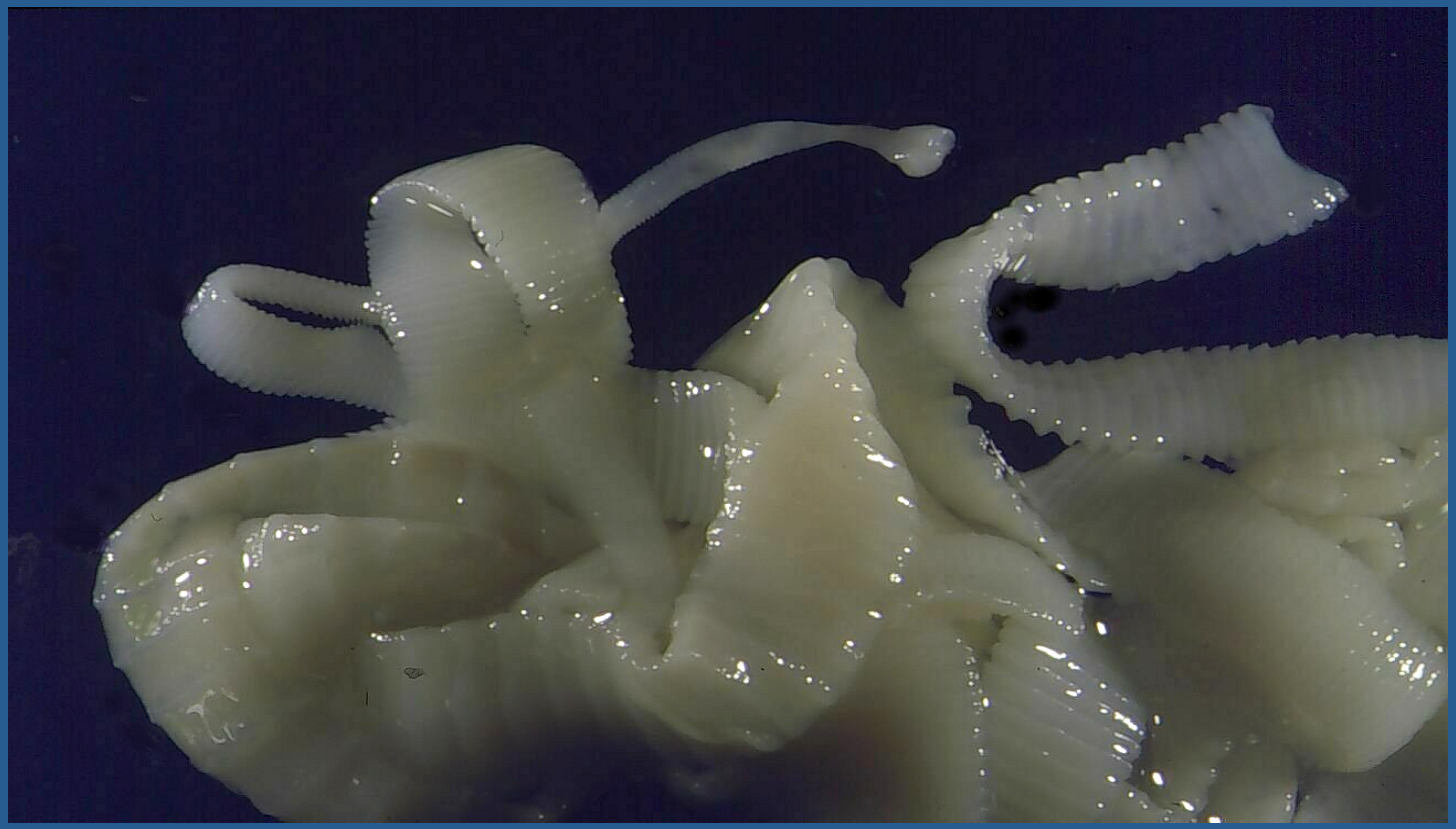
Baseline or historical information is crucial to documenting changing environments and emerging pathogens

Building Critical Scientific Infrastructure for Key Societal Issues

- Integrated Archives
- Building Human Capacity
  - Broadening Participation
  - Revitalizing Biology Undergrad Education
  - New Generation of Museum Professionals
- Growth of Collections (not just digitization)
  - Unintended Consequences

  - Think Bigger!

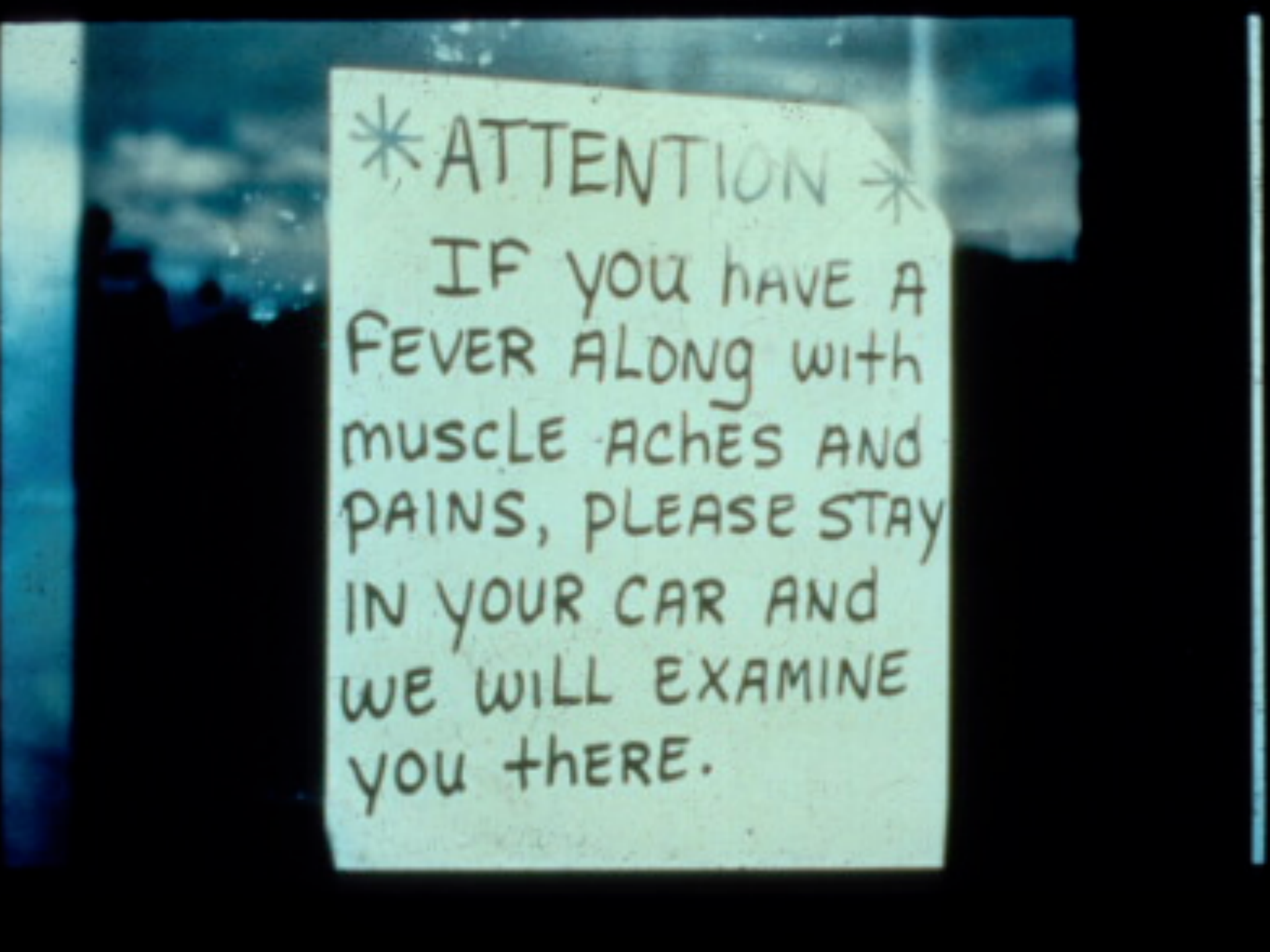
Integrated Archives: Training, Research, Surveillance, Management and Communication



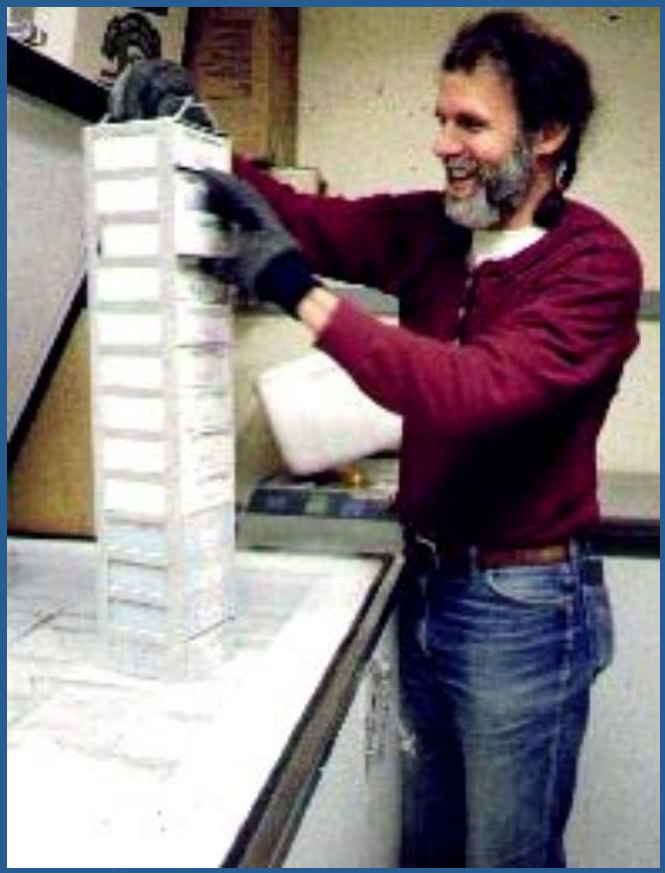
Integrated Archives

- Temporally Deep
- Geographically Broad, Site Intensive
- Geo-referenced
- Multiple Datasets tied to central voucher specimen
  - Frozen Materials for Molecular Biology
  - Parasites tied to Hosts

- Searchable Web-based Databases
  - Research, Policy, Education


ATTENTION
IF YOU HAVE A FEVER ALONG WITH MUSCLE ACHES AND PAINS, PLEASE STAY IN YOUR CAR AND WE WILL EXAMINE YOU THERE.

Ca. 75% of human pathogens are zoonotic
1993 > 20 deaths, from unidentified pathogen
Mostly young & rural

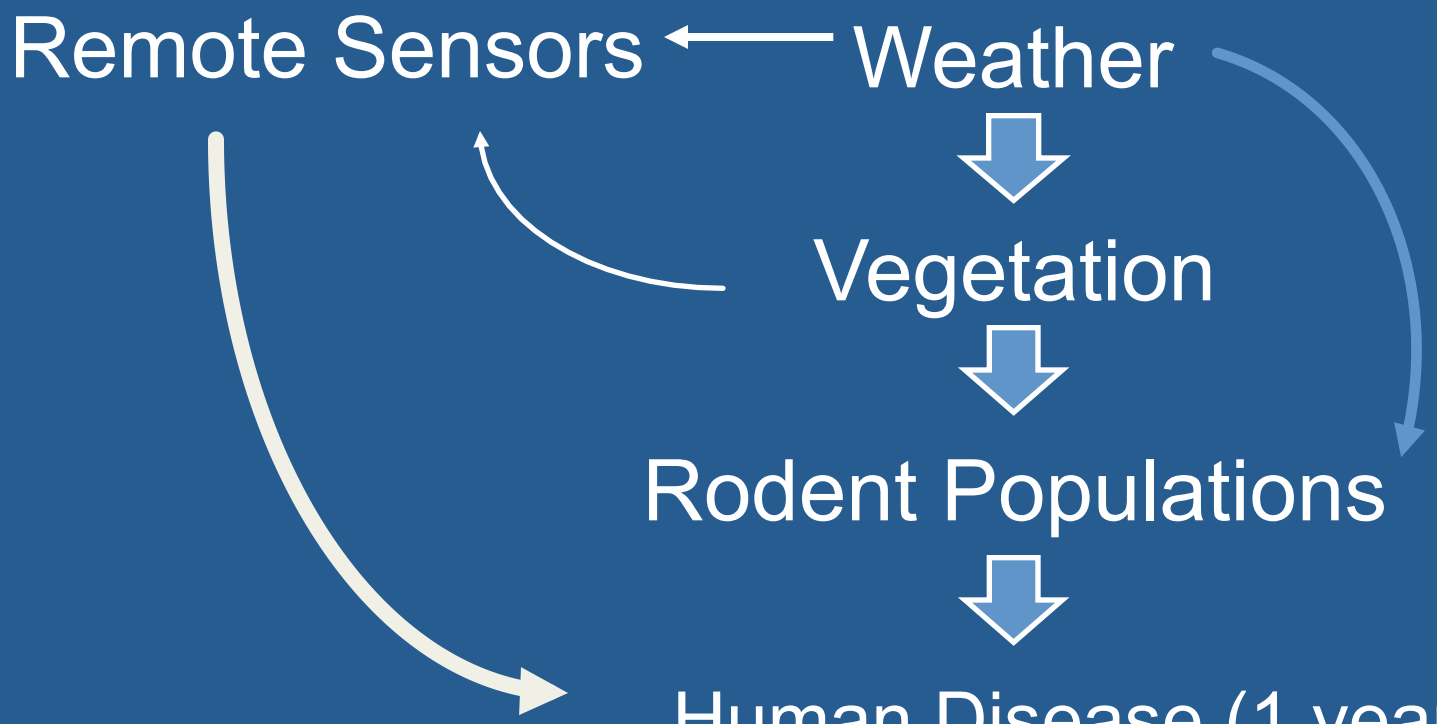


Terry Yates

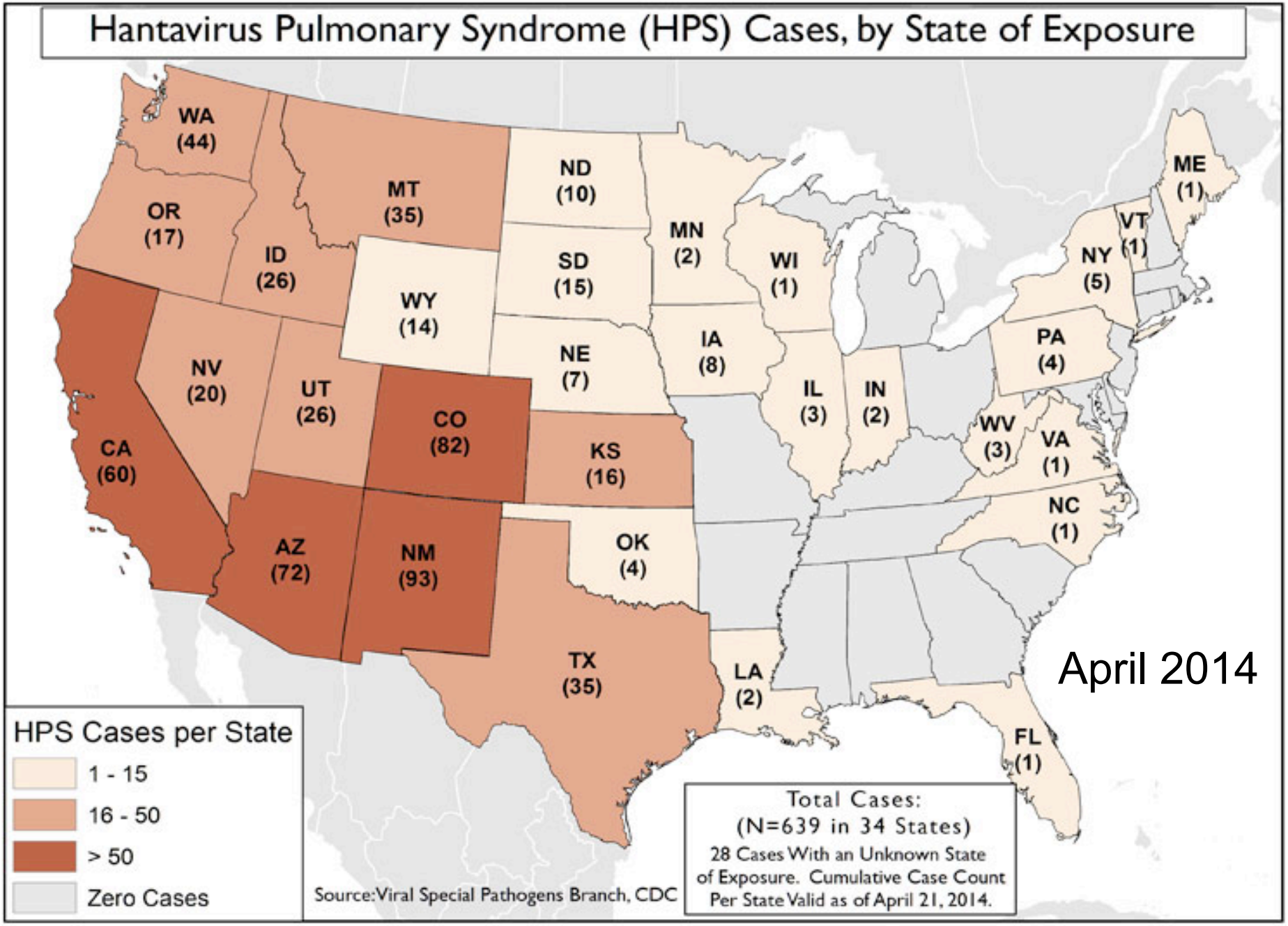
Field work—integrated archives

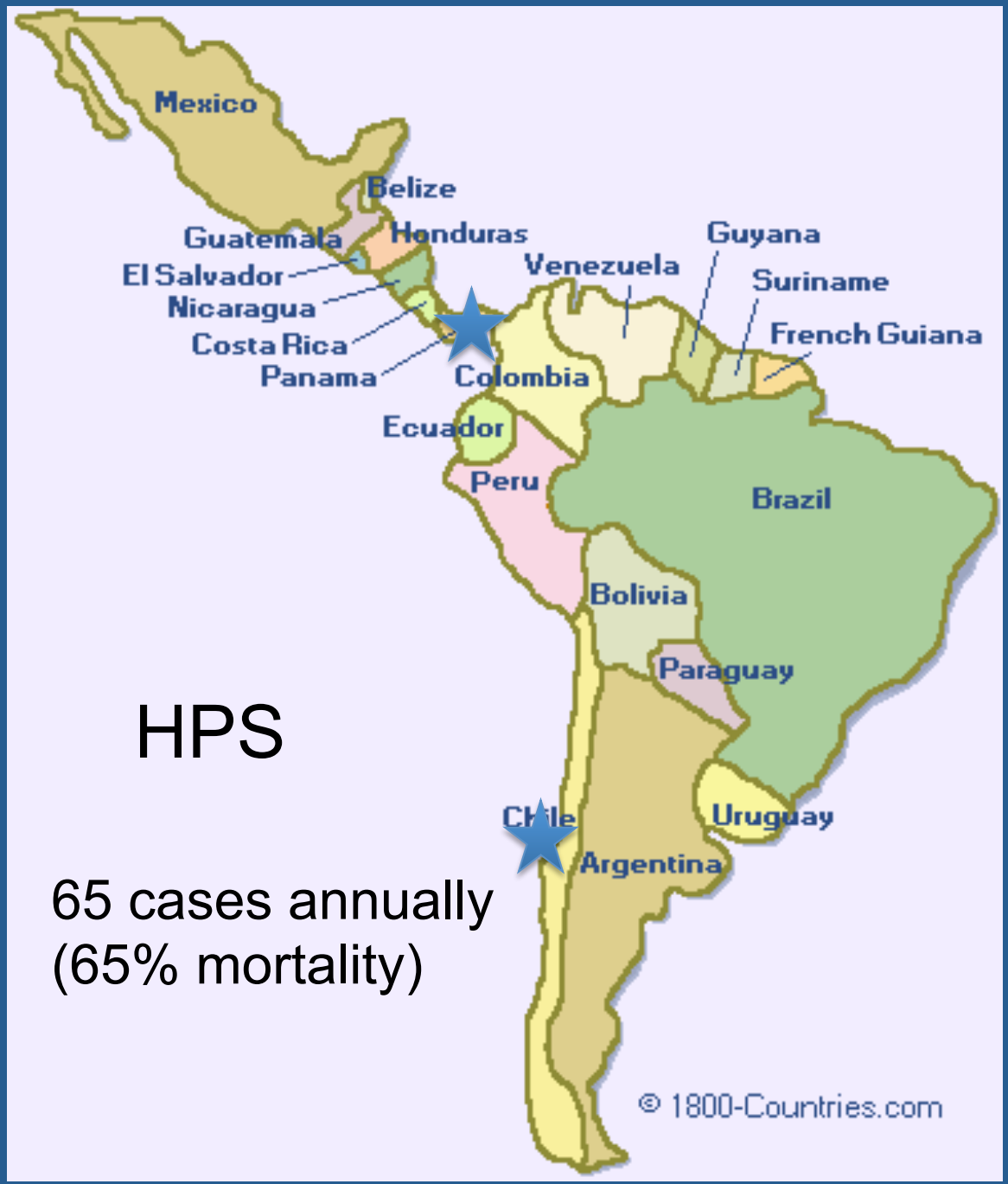
Unintended Consequences

Reservoir studies ⇨ Predictive models



Collaborations:
Systematists, Virologists, Public Health,
Geographers, Ecologists, Behavioral Biologists, etc

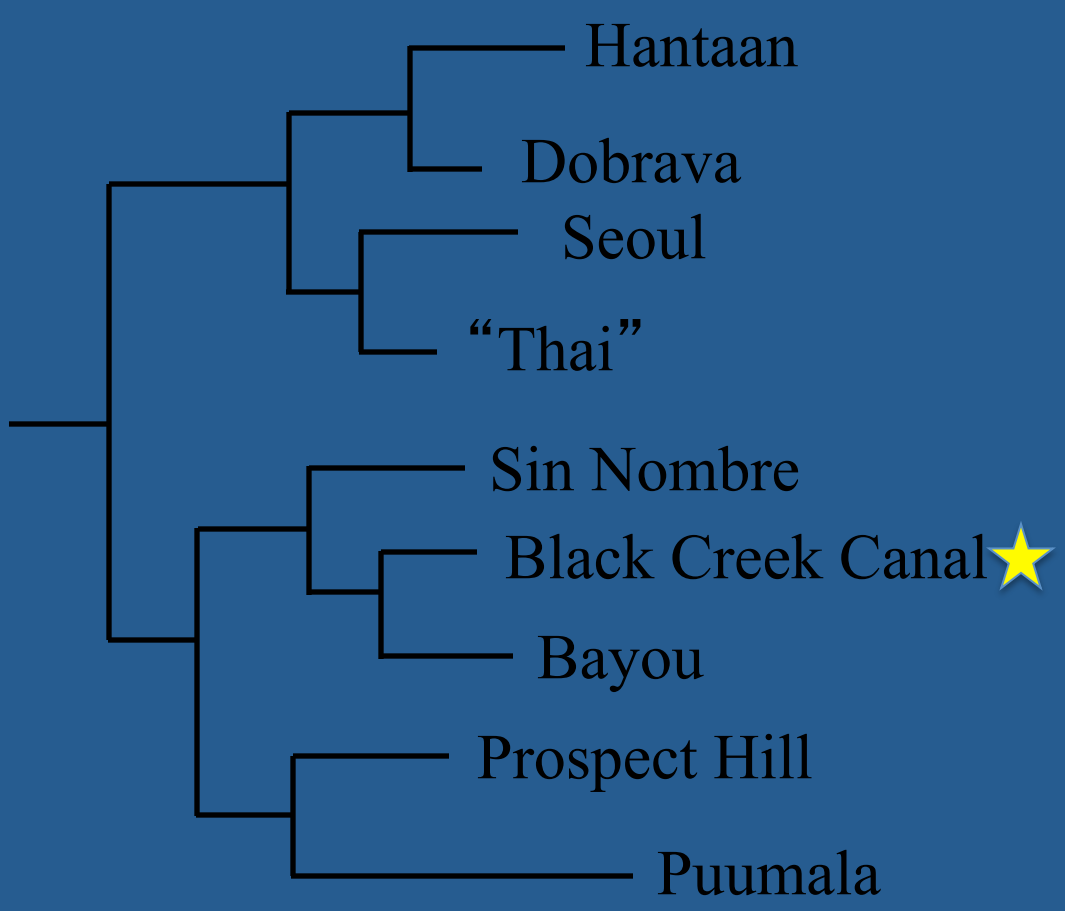

Hantavirus Pulmonary Syndrome (HPS) Cases, by State of Exposure
WA (44)
OR (17)
CA (60)
ID (26)
NV (20)
MT (35)
WY (14)
UT (26)
AZ (72)
CO (82)
NM (93)
ND (10)
SD (15)
NE (7)
KS (16)
OK (4)
TX (35)
MN (2)
IA (8)
MO
AR
LA (2)
WI (1)
IL (3)
MS
IN (2)
KY
TN
AL
GA
FL (1)
SC
NC (1)
VA (1)
WV (3)
PA (4)
NY (5)
VT (1)
ME (1)
April 2014
HPS Cases per State
1 - 15
16 - 50
> 50
Zero Cases
Source: Viral Special Pathogens Branch, CDC
Total Cases:
(N=639 in 34 States)
28 Cases With an Unknown State of Exposure. Cumulative Case Count Per State Valid as of April 21, 2014.



HPS

65 cases annually
(65% mortality)

Phylogeny of Hantaviruses (1998)

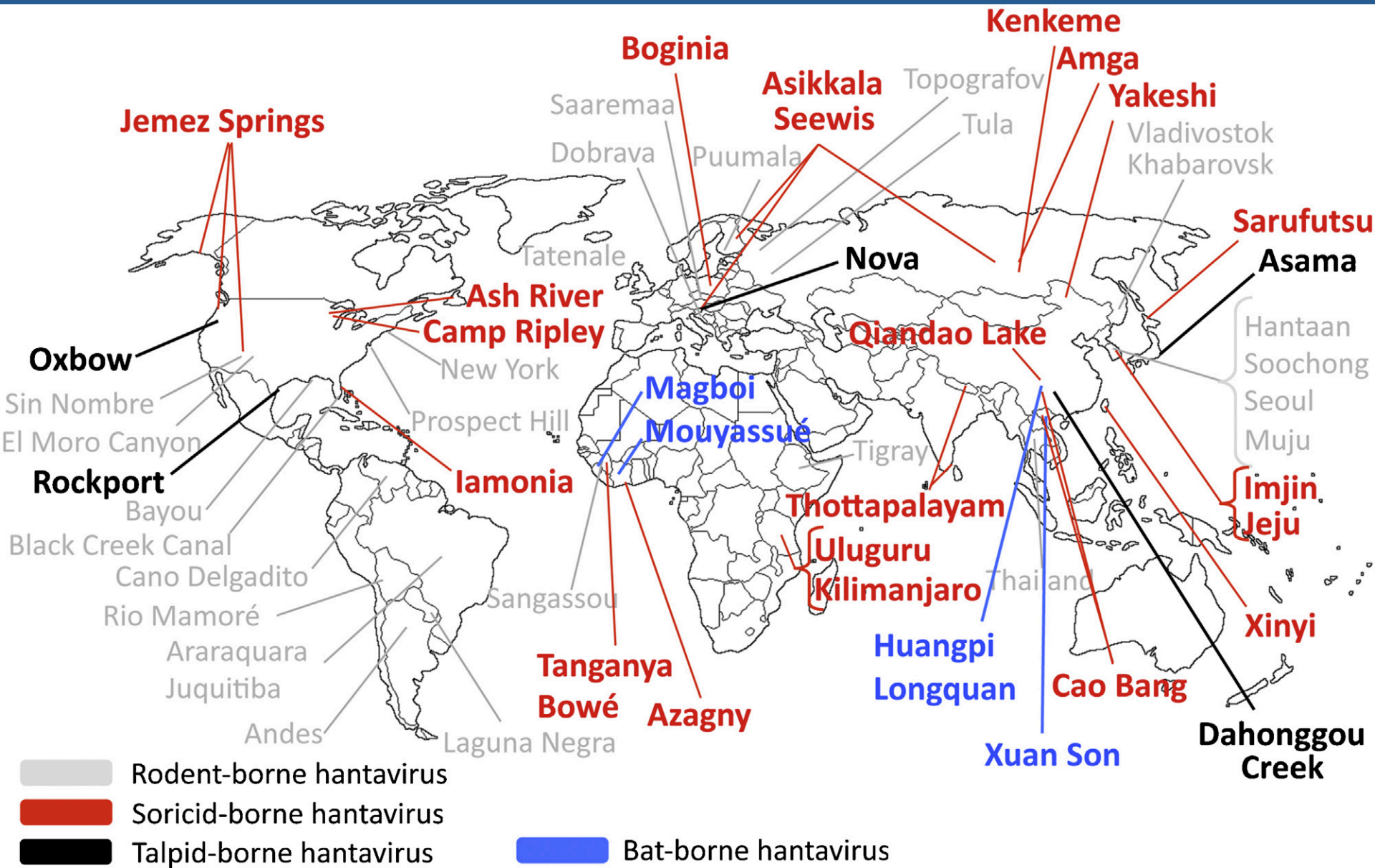


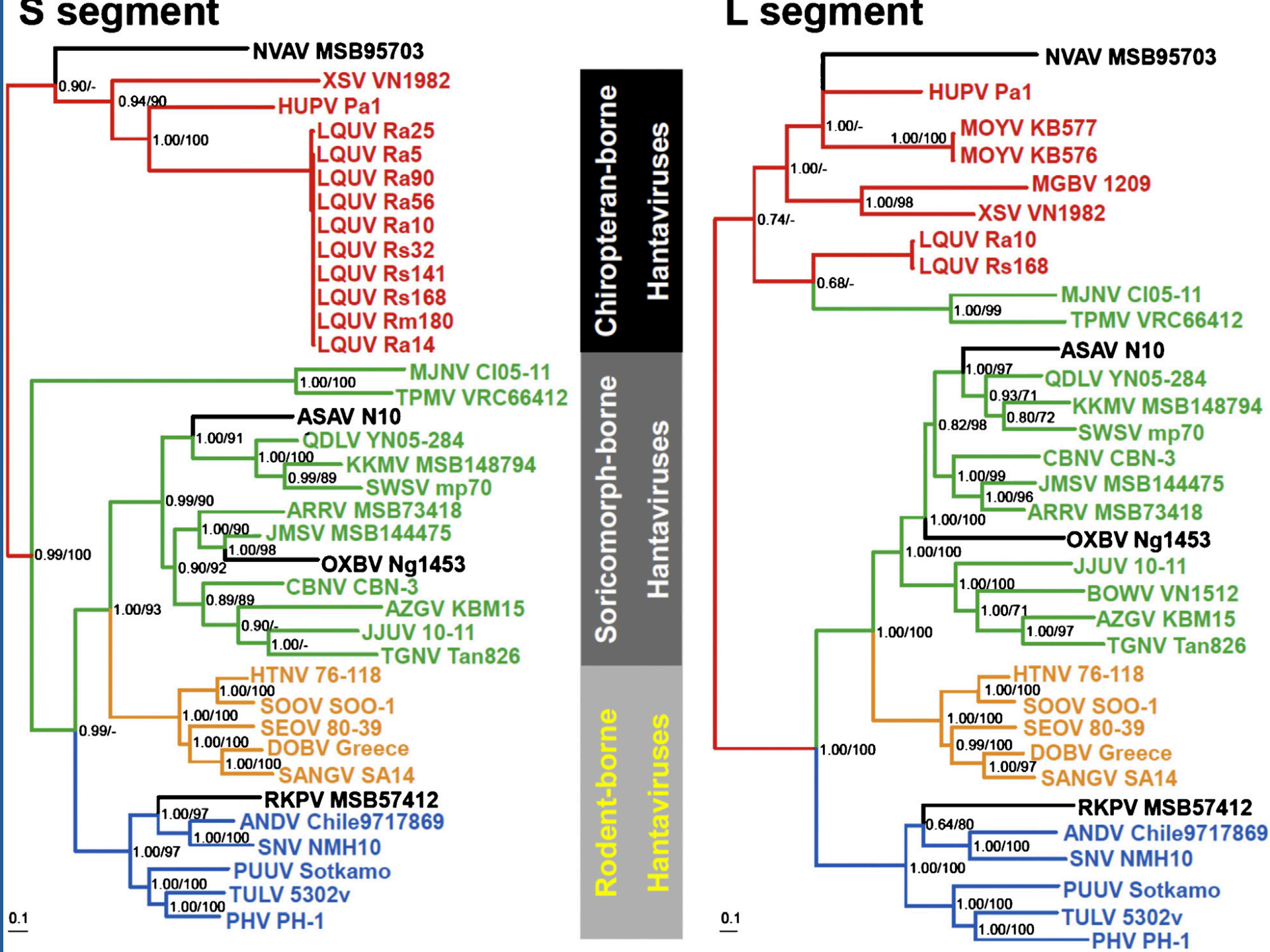

New World Hantaviruses-in 2003
Sin Nombre
eromyscus maniculatus
Mule Shoe
Sigmodon hispidus?
Isla Vista
Microtus californicus
El Moro Canyon
Reithrodontomys megalotis
Cano Delgadito
Sigmodon alstoni
Rio Mamore
Oligoryzomys microtis
Oran
Oligoryzomys longicaudatus
Bermejo
Oligoryzomys chacoensis
Andes
Oligoryzomys longicaudatus
New York
Peromyscus leucopus
Prospect Hill
Microtus pennsylvanicus
Bloodland Lake
Microtus ochrogaster
Bayou
Oryzomys palustris
Black Creek Canal
Sigmodon hispidus
Rio Segundo
Reithrodontomys mexicanus
Juquitiba
Unknown
Laguna Negra
Calomys laucha
Maciel
Bolomys obscurus
HU39694
Unknown Host
Lechiguanas
Oligoryzomys flavesce
Pergamino
Akodon azarae

Many new hosts for new Hantaviruses

New discoveries possible with deep, integrated specimen archives

Hantavirus Discovery----multiple mammalian hosts




S segment
L segment
NVAV MSB95703
XSV VN1982
HUPV Pa1
LQUV Ra25
LQUV Ra5
LQUV Ra90
LQUV Ra56
LQUV Ra10
LQUV Rs32
LQUV Rs141
LQUV Rs168
LQUV Rm180
LQUV Ra14
MJNV CI05-11
TPMV VRC66412
ASAV N10
QDLV YN05-284
KKMV MSB148794
SWSV mp70
ARRV MSB73418
JMSV MSB144475
OXBV Ng1453
CBNV CBN-3
AZGV KBM15
JJUV 10-11
TGNV Tan826
HTNV 76-118
SOOV SOO-1
SEOV 80-39
DOBV Greece
SANGV SA14
RKPV MSB57412
ANDV Chile9717869
SNV NMH10
PUUV Sotkamo
TULV 5302v
PHV PH-1
MOYV KB577
MOYV KB576
MGBV 1209
Chiropteran-borne Hantaviruses
Soricomorph-borne Hantaviruses
Rodent-borne Hantaviruses
0.1

What is the Time-Scale of Hantavirus Evolution?

Zhang, Y-Z., Holmes, E.C., 2014.
What is the Time-Scale of Hantavirus Evolution?
Infection, Genetics and Evolution

2000 years to 50 million years?

Building Critical Scientific Infrastructure for Key Societal Issues

- Integrated Archives
- **Building Human Capacity**
  - **Broadening Participation**
  - **Revitalizing Biology Undergrads**
  - **Next Gen Museum Professionals**
- Growth of Collections (stimulated by digitization)
  - Unintended Consequences

Stimulate change in biology education

Vision and Change—AAAS (2009)

PULSE – (2012) Partnership for Undergraduate Life Sciences Education (NSF, HHMI and NIH)

40 Leadership Fellows

PCAST (Feb 2012) Engage to Excel

Advocate and provide support for replacing standard laboratory courses with discovery-based research courses.

What do collections-based approaches add to undergrad education?

- Scale—time and space
- Integration
  - biotic and abiotic
  - genomic to organismal to ecosystems
- Complexity-multiple views
- Web-based Discovery
- Database exposure
- Scientific Process
  - Experiential vs passive

Challenges

- Few educators (& fewer students) seem to know:
  - about natural history collections
    or their role in development of key concepts
  - how to access museum information
  - how to incorporate specimen data in teaching

A Few More Challenges

- Collections (and databases) have limitations
  - Specimen availability
  - Narrow view of possibilities
    - **Systematics,** now to other disciplines
      - (samples plus time and space stamps)
    - "Unintended Consequences"
  - Collections developed for **research**,
    - How do we unleash potential for teaching?
      - (formal and informal)
  - Databases developed for **collection management**, not education or outreach.

RCN-UBE

- RCN-Undergraduate Biology Education

---focuses on improved participation and learning in undergraduate biology curricula.

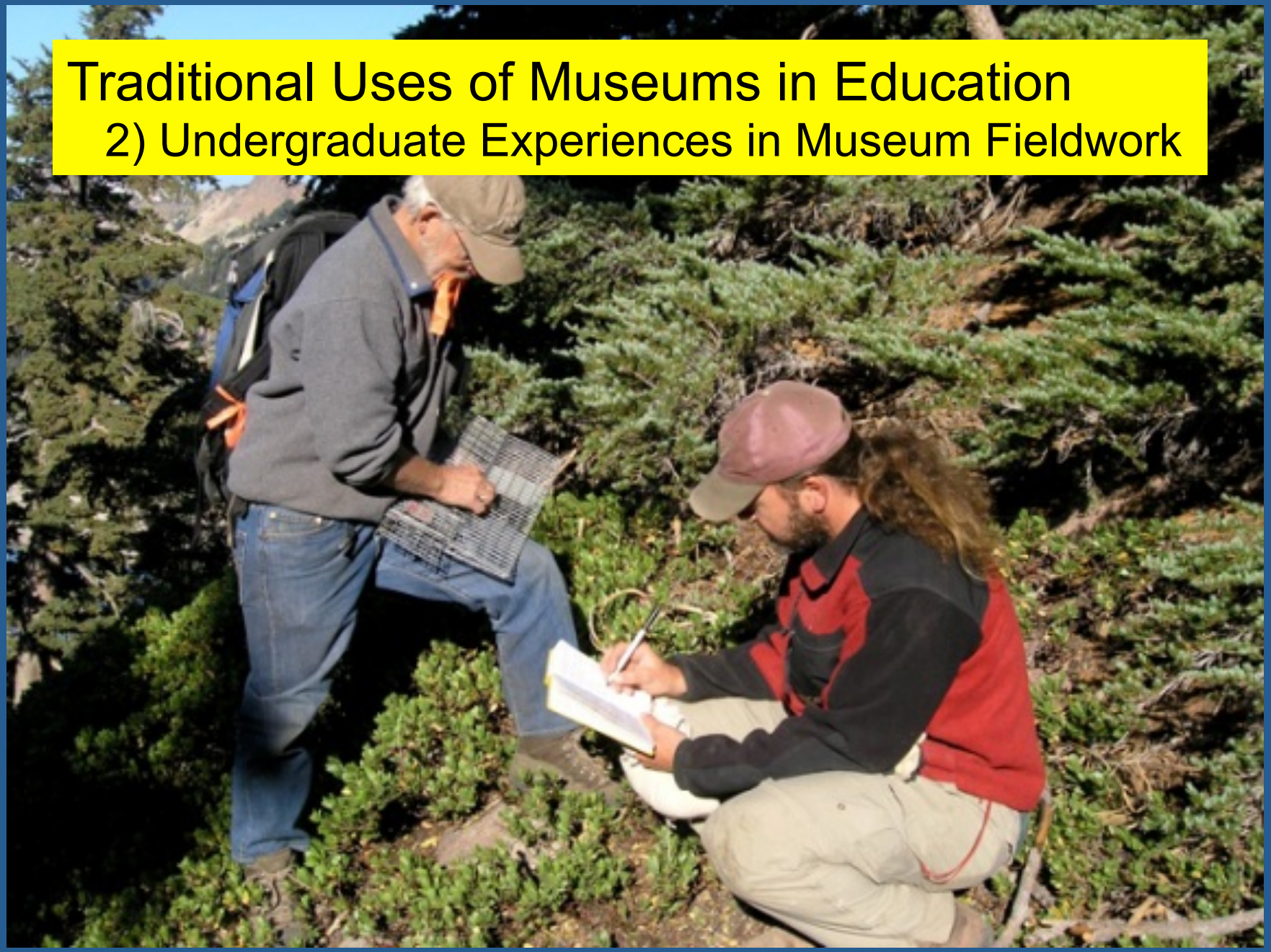
AIM-UP!
Advancing Integration of Museums into Undergraduate Programs

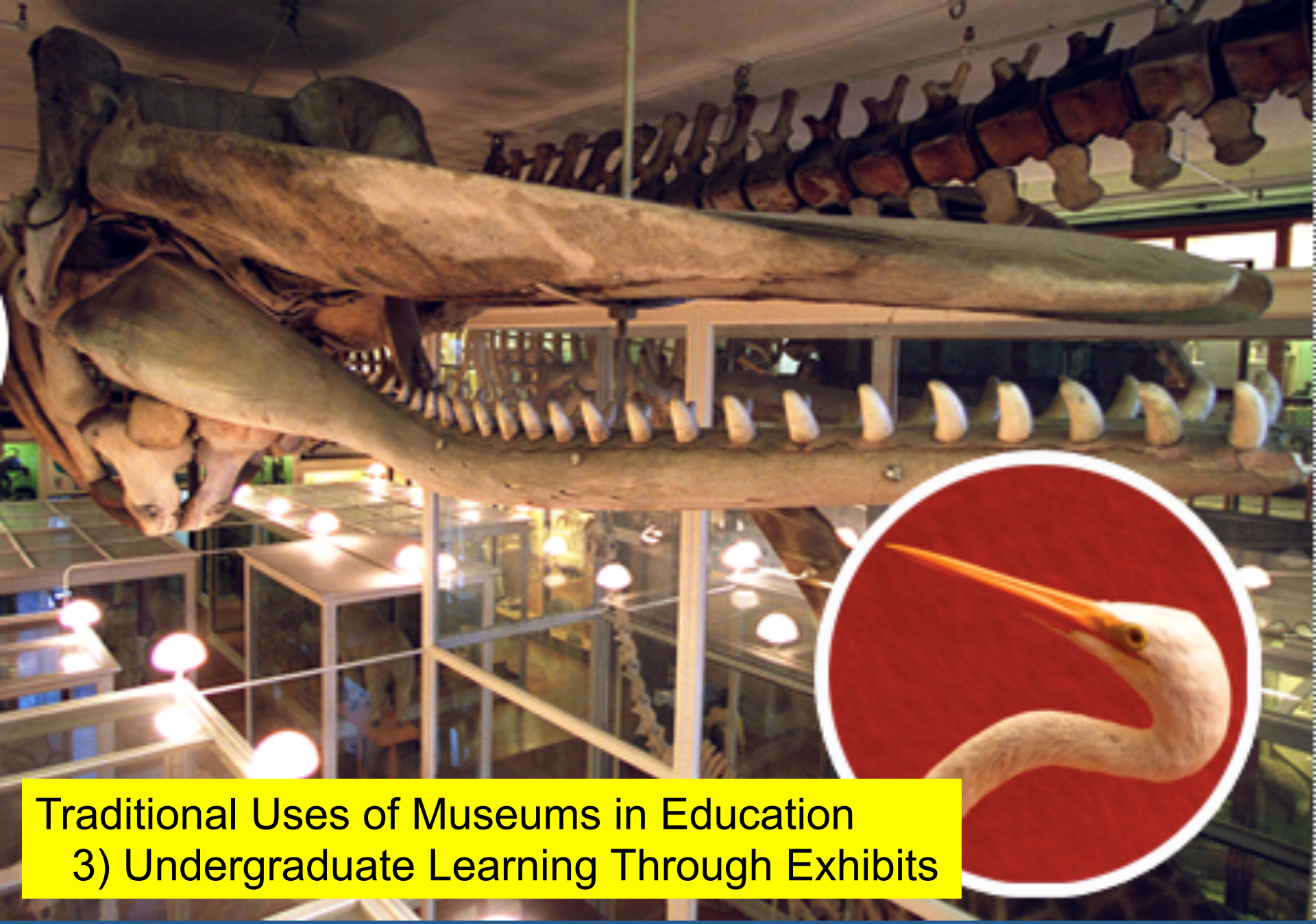
Traditional Uses of Museums in Education

1) Undergraduate Experiences in Curation

Traditional Uses of Museums in Education

2) Undergraduate Experiences in Museum Fieldwork





Traditional Uses of Museums in Education
3) Undergraduate Learning Through Exhibits

Traditional Uses of Museums in Education

4) Research Experiences Based on Collections

Traditional Uses of Museums in Educatio

5) Specimens Used in Classrooms

Newer Uses of Museums in Education

Specimens Used in Classrooms

NSF-RCN
Research Coordinating Network

- Goal: create new directions in research & education by communicating and coordinating activities across disciplinary, organizational, geographic and international boundaries.
- Crossing Taxonomic Borders
- Educators-Museum Staff
- Biologists-Education Specialists
- Informatics--Databases
- Art and Geography
- Others (GenBank, Agencies)

Arctos

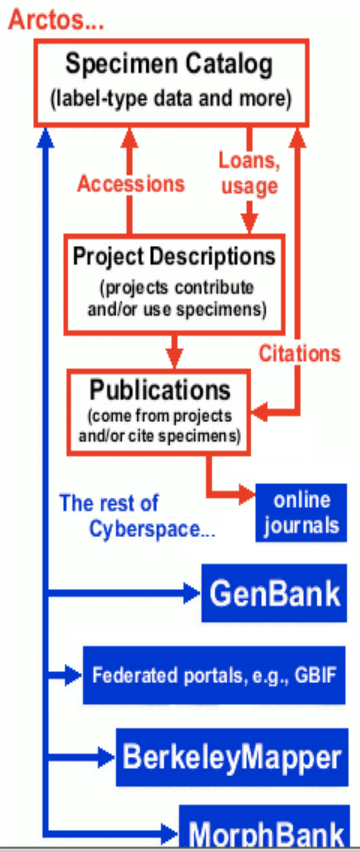
Multi-Institution, Multi-Collection Museum Database

- Participation
- Components
- System Requirements
- Browser Compatability
- Data Usage
- FAQ
- Suggestions?
- Search:
  - All Collections
  - University of Alaska Museum
    - UAM Bird more...
    - UAM Bryophytes more...
    - UAM Earth Science more...
    - UAM Fish Observation more...
    - UAM Fishes more...
    - UAM Herbarium more...
    - UAM Herpetology more...
    - UAM Insect Observation more...
    - UAM Insects more...
    - UAM Insects and Observations
    - UAM Invertebrates more...
    - UAM Mamm Observation more...
    - UAM Mammals more...
  - Museum of Southwestern Biology

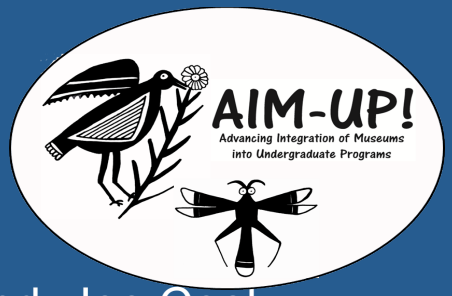
Arctos is an ongoing effort to integrate access to specimen data, collection-management tools, and external resources on the internet. Nearly all that is known about a specimen can be included in Arctos, and, except for some data encumbered for proprietary reasons, data are open to the public.

Features:

- Vaporware-free since 2001. All this stuff and much more really exists in a usable state, and we'll never claim proposed or limited funtionality exists.
- Media link images, movies, sound files, and documents to specimens, taxonomy, publications, projects, events, or people.
  Multi-page documents organize, paginate, and print PDFs of scanned media such as field notes. TAGs comment on specific areas of images, or relate them to nodes such as specimens, places, and people.
- Users may annotate specimens, taxonomy, projects, publications, and media.
- Virtual Private Databases (VPD), also known as Row-Level Security (RLS), allow collections to maintain control of their data while sharing certain nodes, such as Agents and Taxonomy. The cool kids call this Cloud Computing or Grid Computing. It allows us to confidently support most any application, not just the ones we write.
- Everything is over the web in real time, and independent of client-side operating systems. You need moderate bandwidth, a modern browser,



AIM-UP!--the network



PIs -- Eileen Lacey, Scott Edwards, Stefanie Ickert-Bond, Joe Cook

Universities, Community Colleges and Tribal Colleges:

U Alaska, UC Berkeley, Harvard U, U New Mexico
U Michigan, Texas A&M, U Texas, U Colorado, U Arizona, U Kansas, UAS, UAA, CNM, NM Highlands University, Ohio State U, Occidental College, Northern Arizona University, U of Florida, Massachusetts College of Liberal Arts, University of Idaho, Arizona State U, Oglala Lakota

Agencies and Free-standing Museums: USDA National Parasite Lab, USGS Molecular Ecology Lab, USNM, Denver Museum of Nature & Science, NY State Museum

International: U Guelph, U Nacional Montevideo,

Extension to High Schools and Citizens: Highland High (urban) and Sitka High (rural)

CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
MEXICO
GULF OF MEXICO
THE BAHAMAS
CUBA
Lake of the Woods
Rainy Lake
Red Lake
Mille Lacs Lake
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Lake Champlain
Columbia
Snake
Yellowstone
Great Salt Lake
Salton Sea
Colorado
Gila
Republican
Kansas
Arkansas
Canadian
Red
Brazos
Ohio
Cumberland
Tennessee
Alabama
James
Lake Okeechobee
ARCTIC OCEAN
BERING SEA
GULF OF ALASKA
PACIFIC OCEAN
Yukon
CANADA

Annual Conceptual Themes:

1) Integrative Inventories: Exploring Complex Biotic Associations Across Space and Time (MSB)
2) Making Sense of Geographic Variation (UAM)
3) Evolutionary Dynamics of Genomes (MCZ)
4) Biotic Response to Climate Change (MVZ)
5) Coevolving Communities and the Human Dimension (MSB)

AIM-UP!
Advancing Integration of Museums into Undergraduate Programs

5 Annual All-Hands Meetings

- Exchange Perspectives on Teaching about *Climate Change and the Museum*
- Explore Educational Modules & Dissemination
- Evaluation

AIM-UP!
Advancing Integration of Museums into Undergraduate Programs

Workshops & Seminars

1) Fluid Taxonomy -- on the dynamic practice of classification (Susan Anker)

2) Cataloguing Wonder -- collecting through the senses (Brandon Balengée)

3) Morphology and Evolution -- investigating change in nature and culture through place and time (Brian Conley)

Art and Natural History Collections

Educational Modules

Island Biogeography:
Species Richness Across a Northern Archipelago

Key Concepts and Skills:

Evolution & Ecology

- Body size on islands
- Competitive exclusion/release
- Isolation and Divergence
- Island biogeography

Conservation biology

Scientific process & hypothesis testing

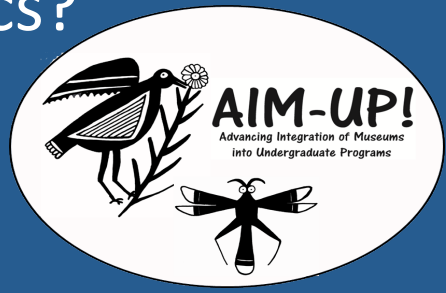
Statistical methods

Management & analyses of large-scale databases

Evolutionary Genomics and the Museum

Potential Topics for Educational Modules

- Tree of Life
- Spatial and Temporal Genetic Variation
- Scientific Process (Replication--without vouchers, difficult to impossible)
- Connecting Big Data (GenBank to GIS Applications)
- Genes and Developmental Biology
- Are Museums Supermarkets for Genomics?
- Founder Effects, Island Syndrome



Climate Change Educational Modules

- With warming conditions individuals/populations
  - Move
    - up in elevation—(Grinnell Project)
    - to higher latitudes (musk-ox parasite)
    - Explore Velocity of Change
    - Species distributions
    - Niche envelops
  - Adapt
    - Life history changes
    - Phenology

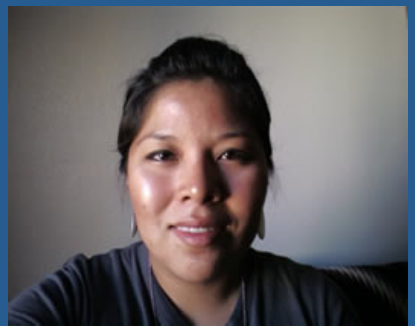
Products

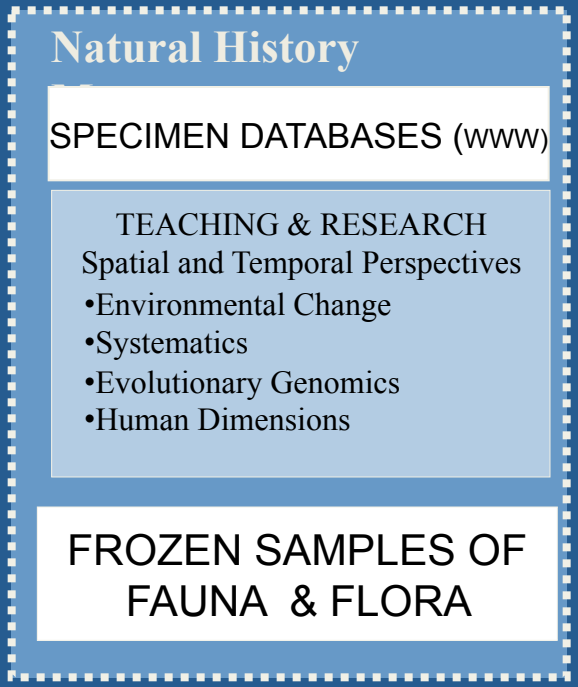
- **Better Understanding of Existing Programs**
- **Survey of Educators and Students**
- **Stimulate Interdisciplinary Use of Specimens**
- **Publications—**
  - Perspectives, Surveys, Educational Venues, Texts
- **Educational (Dispersion) modules** centered around themes

Grow the Community of Users

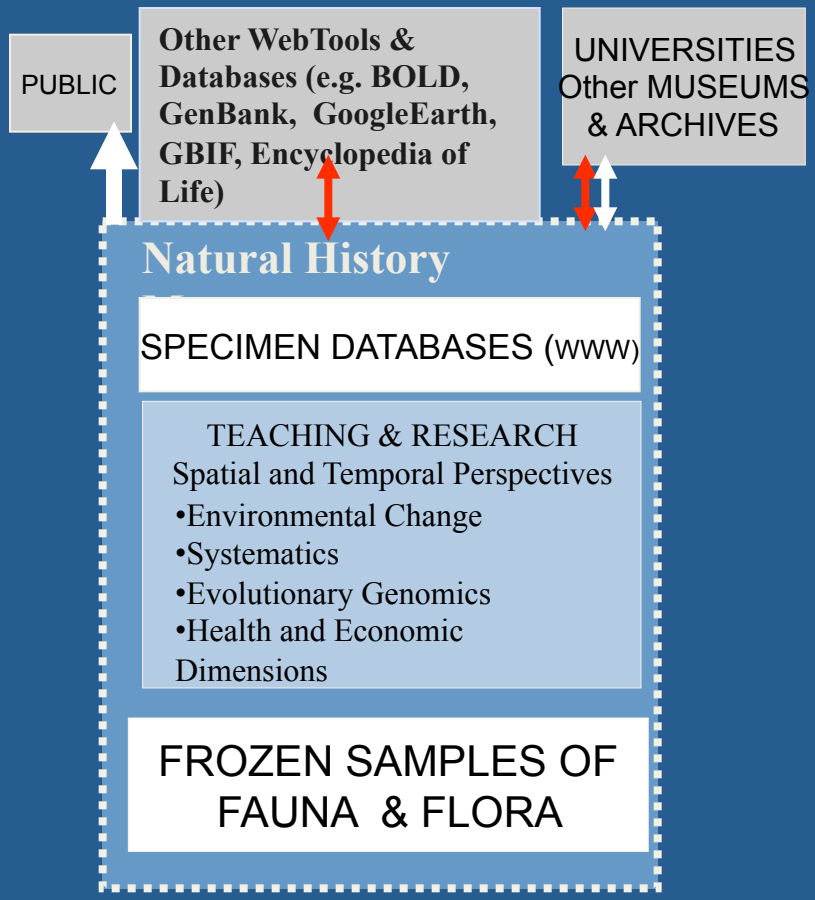
Challenges for Museums

- Natural History Collections need to..
  - Grow
    - Large sample sizes, well distributed over time and space
  - Integrate Multiple Data Sets
    - standard specimens & frozen tissues
    - parasites and hosts
  - Implement Protocols to Facilitate Material Availability
    - Networks for connecting managers, scientists, general public
    - Cyberinfrastructure for Informatics (GIS, GenBank)
  - Train Future Investigators
  - Cutting Edge Research
  - Respond to Societal Needs





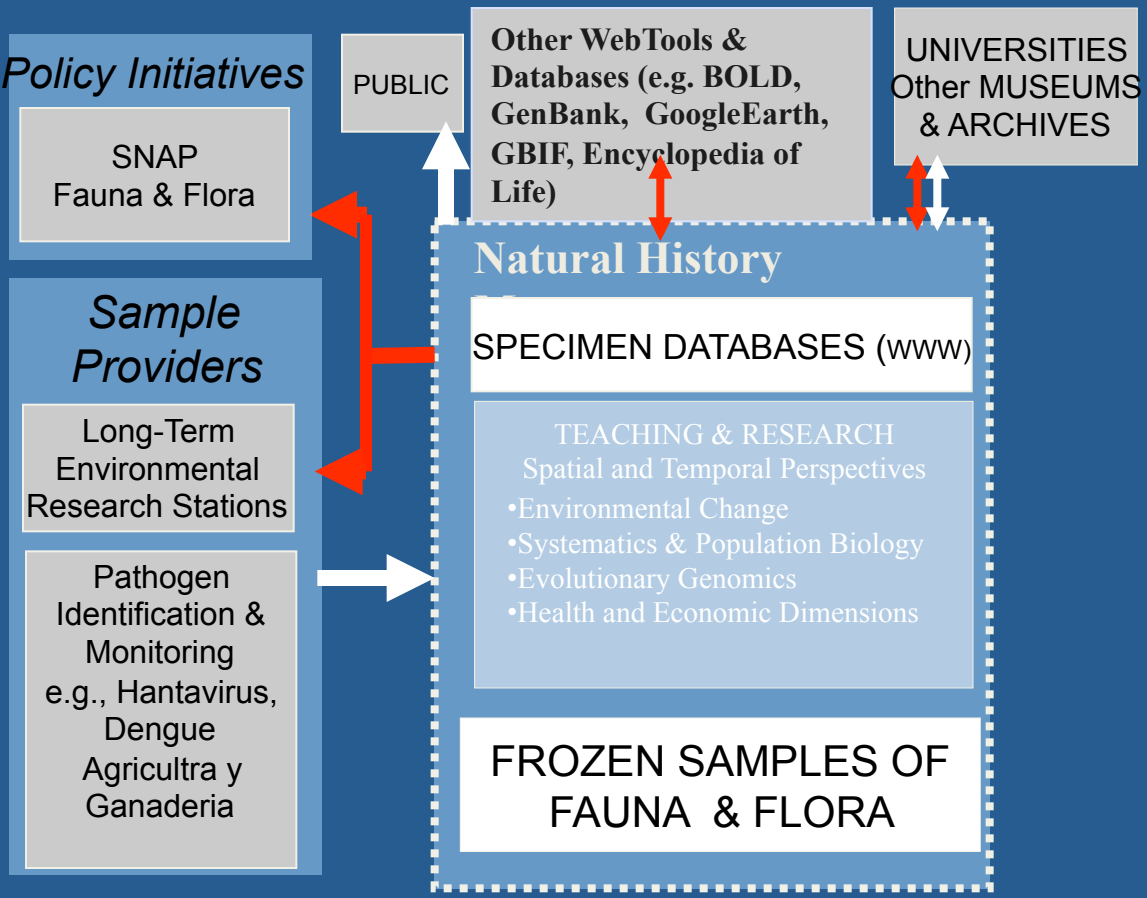
A Museum Approach to Observatories



specimens & samples

specimen data and project metadata

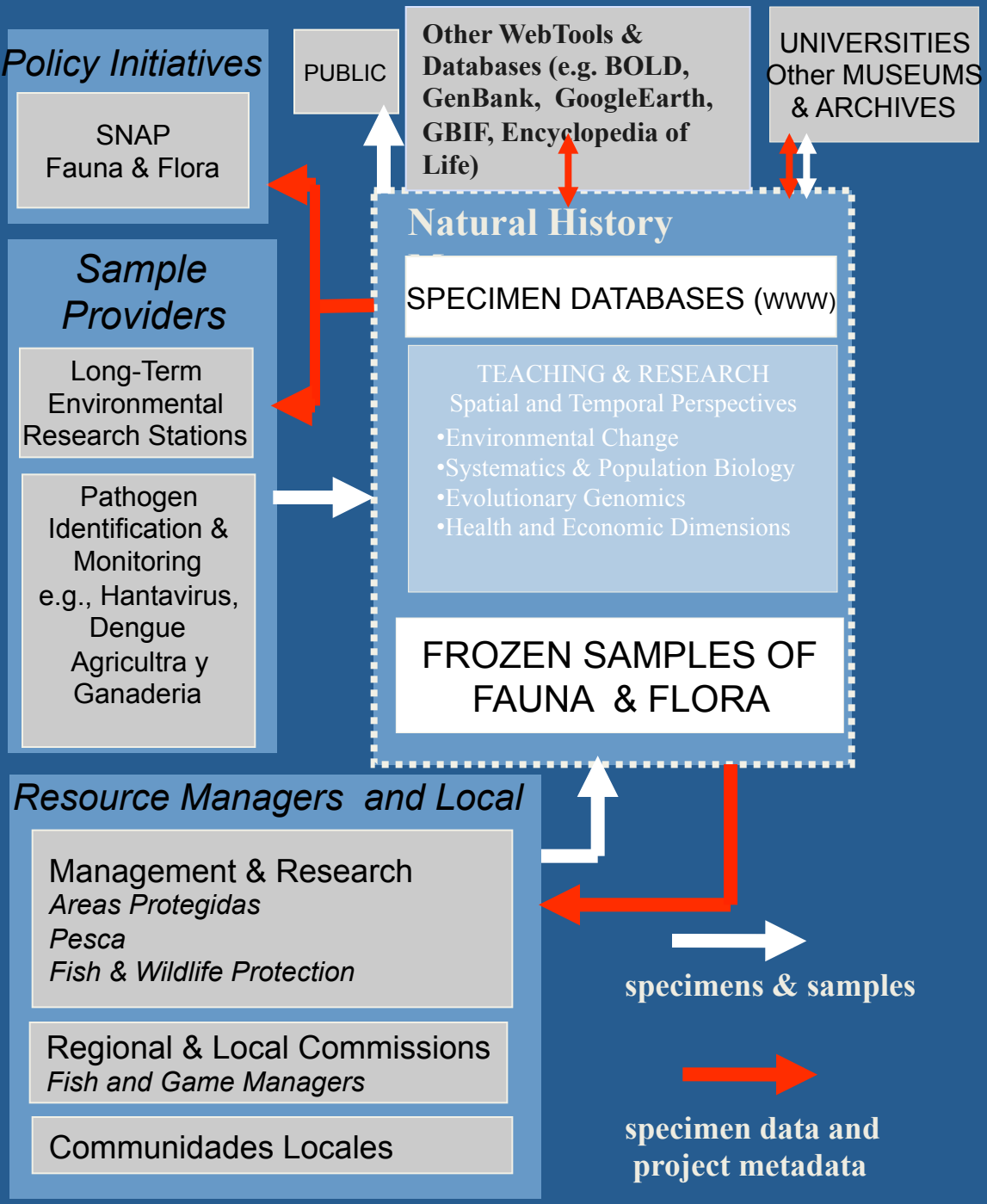
A Museum Approach to Observatories



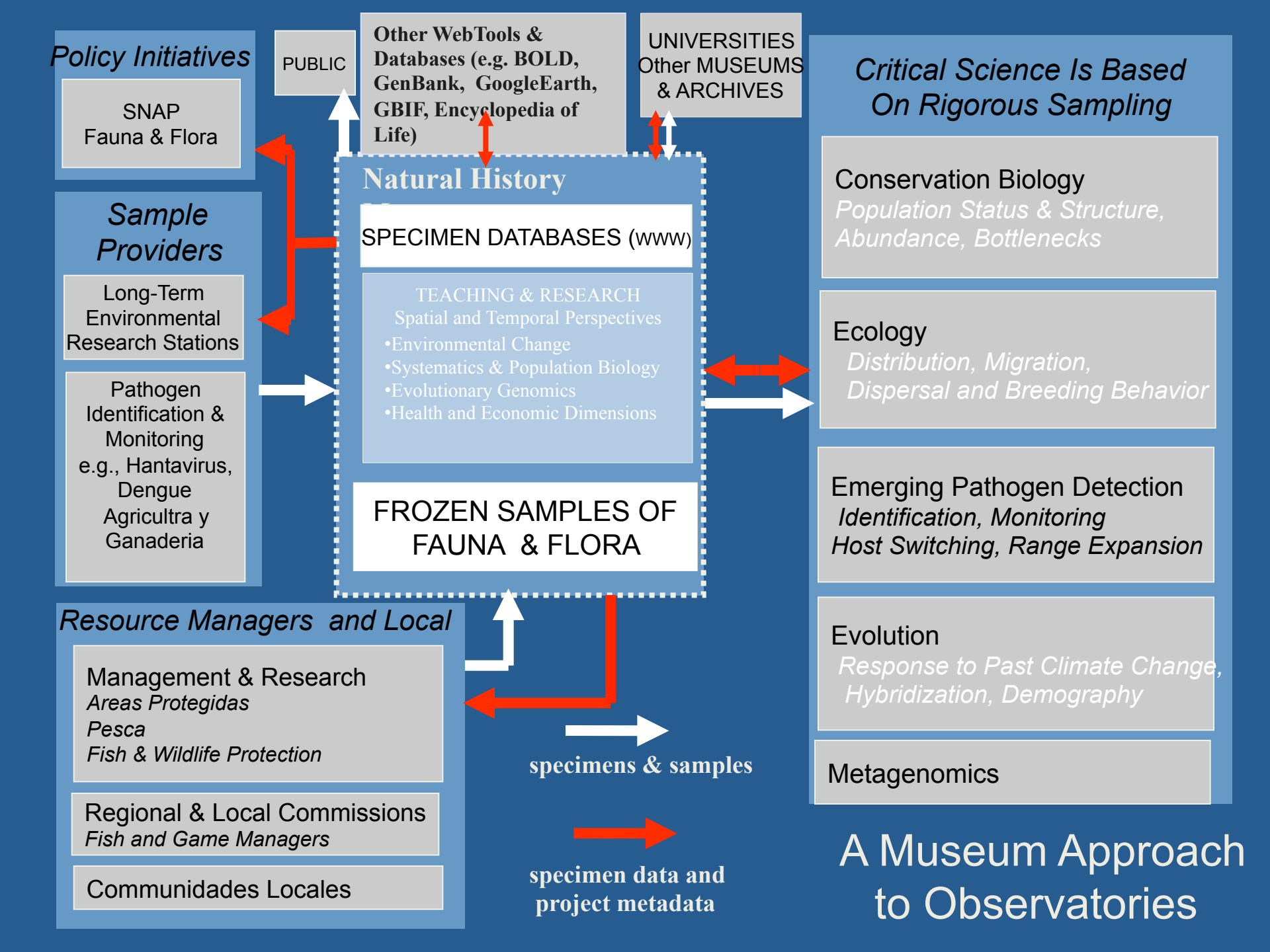
specimens & samples

specimen data and project metadata

A Museum Approach to Observatories



A Museum Approach to Observatories


Policy Initiatives
SNAP
Fauna & Flora
PUBLIC
Other WebTools & Databases (e.g. BOLD, GenBank, GoogleEarth, GBIF, Encyclopedia of Life)
UNIVERSITIES
Other MUSEUMS & ARCHIVES
Critical Science Is Based On Rigorous Sampling
Natural History
SPECIMEN DATABASES (www)
TEACHING & RESEARCH
Spatial and Temporal Perspectives
•Environmental Change
•Systematics & Population Biology
•Evolutionary Genomics
•Health and Economic Dimensions
FROZEN SAMPLES OF FAUNA & FLORA
Sample Providers
Long-Term Environmental Research Stations
Pathogen Identification & Monitoring
e.g., Hantavirus, Dengue
Agricultra y Ganaderia
Conservation Biology
Population Status & Structure, Abundance, Bottlenecks
Ecology
Distribution, Migration, Dispersal and Breeding Behavior
Emerging Pathogen Detection
Identification, Monitoring
Host Switching, Range Expansion
Evolution
Response to Past Climate Change, Hybridization, Demography
Metagenomics
Resource Managers and Local
Management & Research
Areas Protegidas
Pesca
Fish & Wildlife Protection
Regional & Local Commissions
Fish and Game Managers
Communidades Locales
specimens & samples
specimen data and project metadata
A Museum Approach to Observatories

"At this point I wish to emphasize what I believe will ultimately prove to be the greatest value of our museum. This value will not, however, be realized until the lapse of many years, possibly a century, assuming that our material is safely preserved. And this is that the student of the future will have access to the original record of faunal conditions in California and the west, wherever we now work."

Joseph Grinnell, 1910
"The Uses and Methods of a Research Museum"
Popular Science Monthly