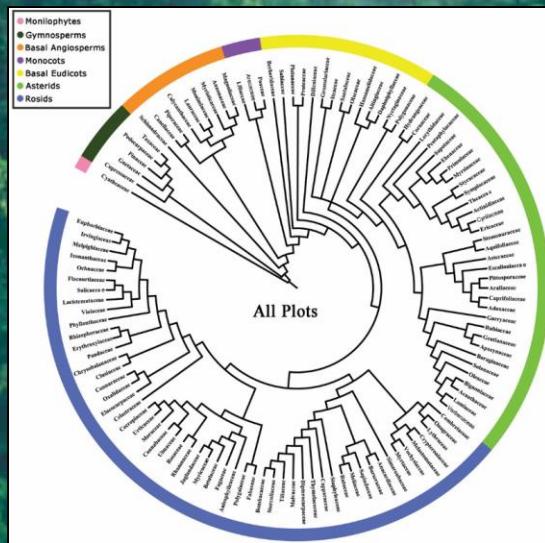


# TRACKING EVOLUTIONARY DIVERSITY AND PHYLOGENETIC STRUCTURE ACROSS GLOBAL FOREST DYNAMICS PLOTS USING PLANT DNA BARCODES



6<sup>th</sup> international  
Barcode of Life  
Conference  
Guelph, 2015

W. John Kress



Smithsonian Institution

# **50-ha Forest Dynamics Plot on Barro Colorado Island, Panama**



## **Vital statistics of BCI**

- **Island in Panama Canal**
  - Premier Ecological Plot
- **296 tree species**
  - 1035 specimens (~3 accession/species)
- **180 Genera**
- **49 Families**
- **~50% of genera have one species**

# 50-ha Forest Dynamics Plot on Barro Colorado Island, Panama

## Building the DNA Barcode Reference Library: *rbcL*, *matK*, and *trnH-psbA* for Species Identification

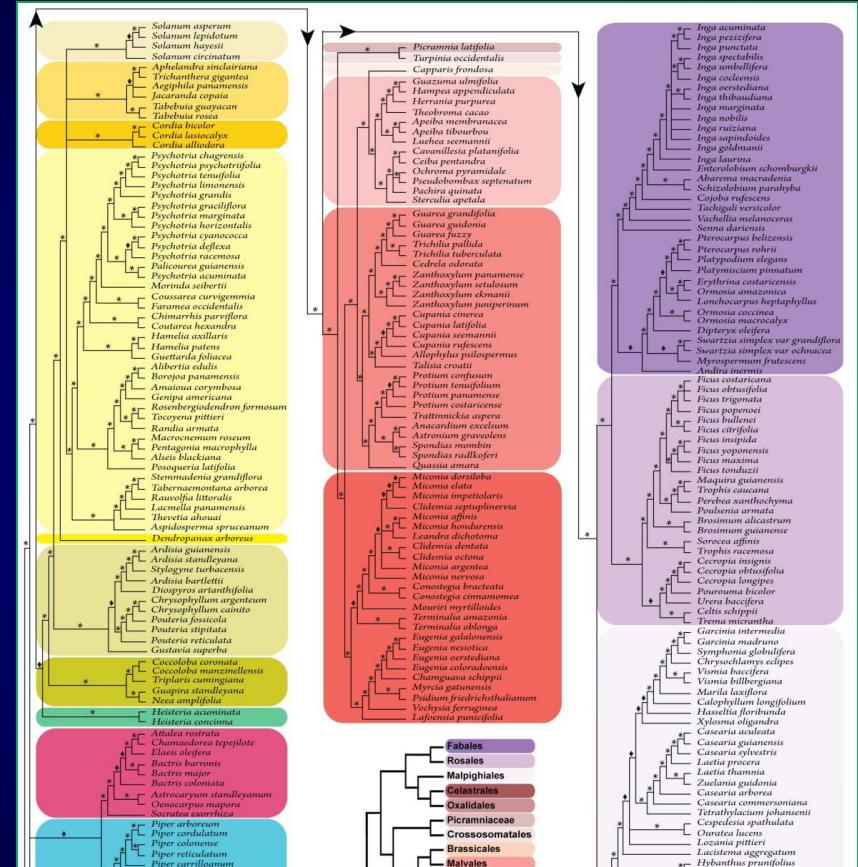
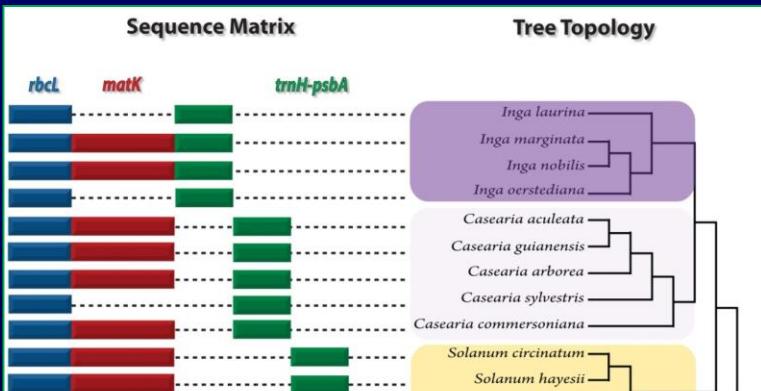


### RESULTS

- *rbcLa + trnH-psbA + matK*
  - **98% of all samples could be assigned to correct Species**
  - All ambiguity was in 4 genera: *Psychotria*, *Ficus*, *Inga*, *Piper*
  - **100% of sequences were assigned to correct Genus**
  - Partial sequences were assigned correctly

# 50-ha Forest Dynamics Plot on Barro Colorado Island, Panama

## Constructing a Community Phylogeny with DNA Barcodes: A Supermatrix of *rbcL*, *matK*, and *trnH-psbA*



Kress, W.J., D.L. Erickson, F.A. Jones, N.G. Swenson, R. Perez, O. Sanjur, and E. Bermingham. 2009. Plant DNA barcodes and a **community phylogeny** of a tropical forest dynamics plot in Panama. Proc. Nat. Acad. Sci. 106: 18621-18626.  
[www.pnas.org/cgi/doi/10.1073/pnas.0909820106](http://www.pnas.org/cgi/doi/10.1073/pnas.0909820106).

# Follow-up Papers on BCI DNA Barcode Work

- Kress, W.J., D.L. Erickson, F. A. Jones, N.G. Swenson, R. Perez, O. Sanjur, and E. Bermingham. 2009. Plant DNA barcodes and a **community phylogeny** of a tropical forest dynamics plot in Panama. Proc. Nat. Acad. Sci. 106: 18621-18626. ([www.pnas.org/cgi/doi/10.1073/pnas.0909820106](http://www.pnas.org/cgi/doi/10.1073/pnas.0909820106).)
- Schreeg, L. A., W. J. Kress, D. L. Erickson, N. G. Swenson. 2010. Phylogenetic analysis of local-scale tree **soil associations** in a lowland moist tropical forest. PLoS ONE 5(10): e13685 (doi:10.1371/journal.pone.0013685).
- Westbrook, J. W., K. Kitajima, J. G. Burleigh, W. J. Kress, D. L. Erickson, and S. J. Wright. 2011. **What makes a leaf tough?** Mechanistic and evolutionary analysis of leaf physical defense among 197 shade-tolerant woody species in a neotropical forest. Am. Nat. 177: 800-811.
- Jones, F. A., D.L. Erickson, M.A Bernal, E. Bermingham, W. J. Kress, E.A. Herre, H. C Muller-Landau, B. L. Turner. 2011. The **roots** of diversity: below ground species richness and rooting distributions in a tropical forest revealed by DNA barcodes and inverse modeling. PLoS ONE 6: e24506. Doi: 10.1371/journal.pone.0024506.
- Swenson·N. G., D. L. Erickson, X-C Mi, N. A. Bourg, J.Montana-Forero<sup>5</sup> X-J Ge<sup>6</sup> R. Howe, J. K. Lake, X-J. Liu, K-P. Ma, N-C. Pei, J. Thompson, M. Uriarte, A. Wolf, S. J. Wright, W-H Ye, J-L. Zhang, J. K. Zimmerman and W. J. Kress. 2011. Phylogenetic and **Functional Alpha and Beta Diversity** in Temperate and Tropical Tree Communities. Ecology 93:S112-S125.
- Swenson, N.G., J.C. Stegen, S.J. Davies, D.L. Erickson, J. Forero-Montana, A.H. Hurlbert, W.J. Kress, J. Thompson, M. Uriarte, S.J. Wright and J.K. Zimmerman. 2012. **Temporal turnover** in the composition of tropical tree communities: functional determinism and phylogenetic stochasticity. Ecology 93:490-499.
- Martin, A. R., D. L. Erickson, W. J. Kress, and S. C. Thomas. 2014. **Wood nitrogen concentrations** in tropical trees: phylogenetic patterns and ecological correlates. New Phytol. doi: 10.1111/nph.12943
- Lasky, J. R. M. Uriarte, V. Boukili, D. L. Erickson, W.J. Kress, R. L. Chazdon. 2014. The relationship between tree biodiversity and **biomass dynamics** changes with tropical forest succession. Ecol. Lett. 17: 1158-1167.

# Center for Tropical Forest Science and ForestGEO



## Purpose:

- \*Forest Dynamics
- \*Climate Change
- \*Conservation

**North American Temperate:** Haliburton Forest, SERC, Wabikon Lake, Wind River, Wytham Woods  
**Asian Temperate:** Dinghushan, Changbaishan, Gutianshan, Fushan, Lienhuachih, Nanjenshan

# Mega-Phylogeny of All Plots

## Vital statistics

**15 plots**  
**1,347 tree species**  
**553 Genera**  
**125 Families**

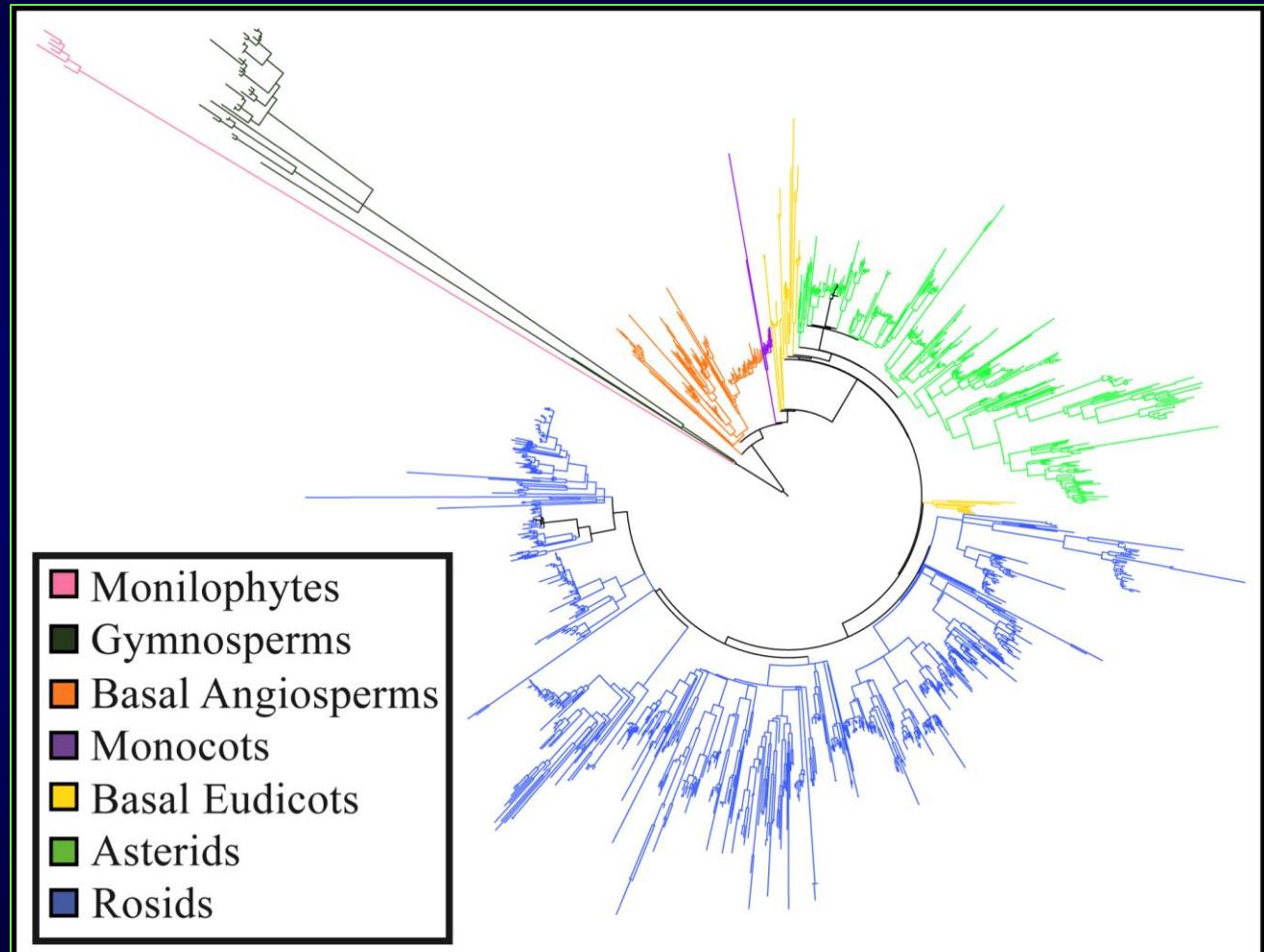
## Phylogeny:

*rbcL, MatK,  
trnH-psbA*

**Constraint Tree**  
**SATe Alignment**

**GARLI: ML**

**Resolution: 78%**  
**(81-100%)**



# Mega-Phylogeny of All Plots

**Vital statistics**

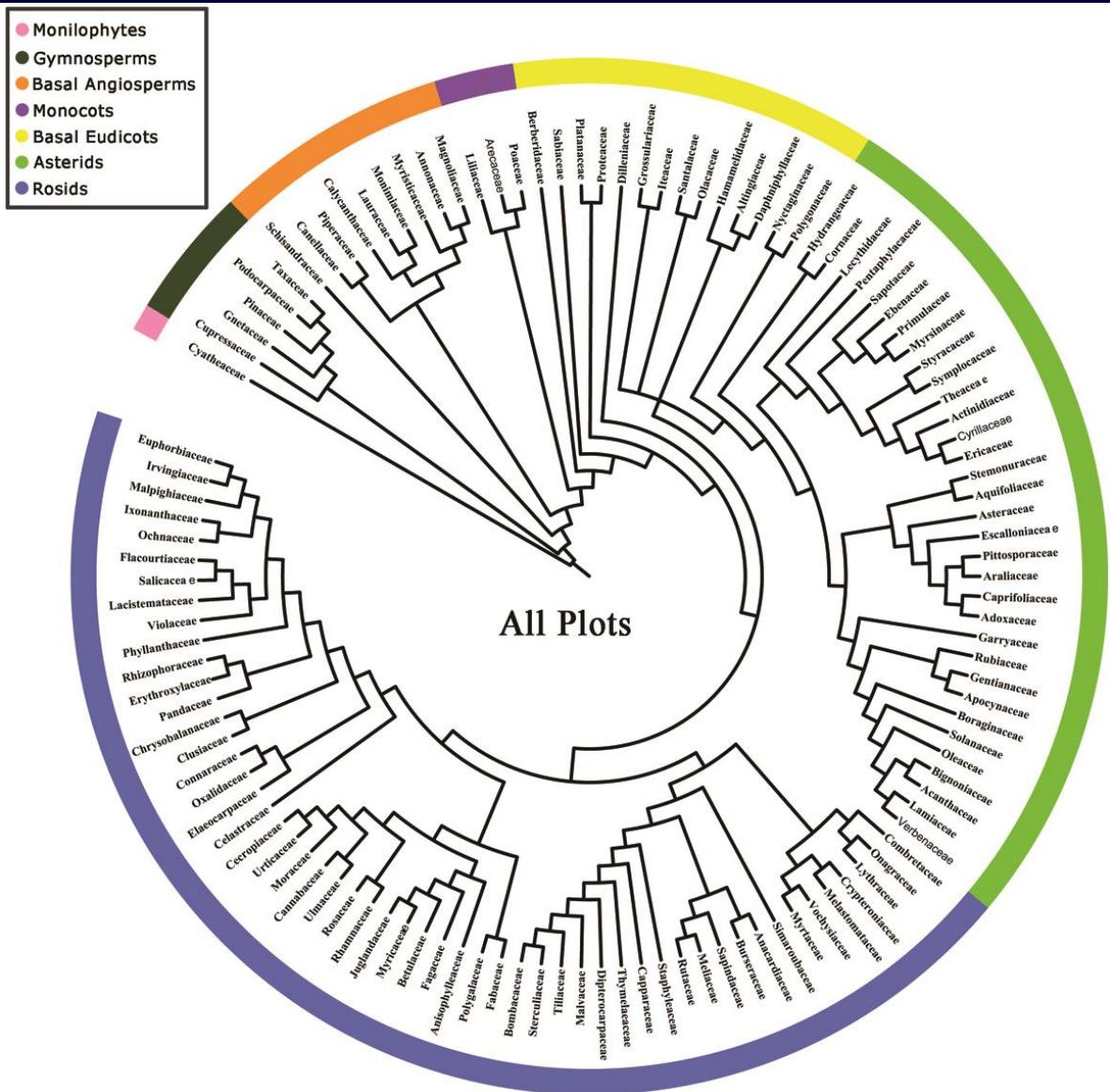
**15 plots**  
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**Phylogeny:**  
*rbcL, MatK, trnH-psbA*

**Constraint Tree**  
**SATe Alignment**

**GARLI: ML**

**Resolution: 78%**  
**(81-100%)**



# Mega-Phylogeny: Species & Phylogenetic Diversity

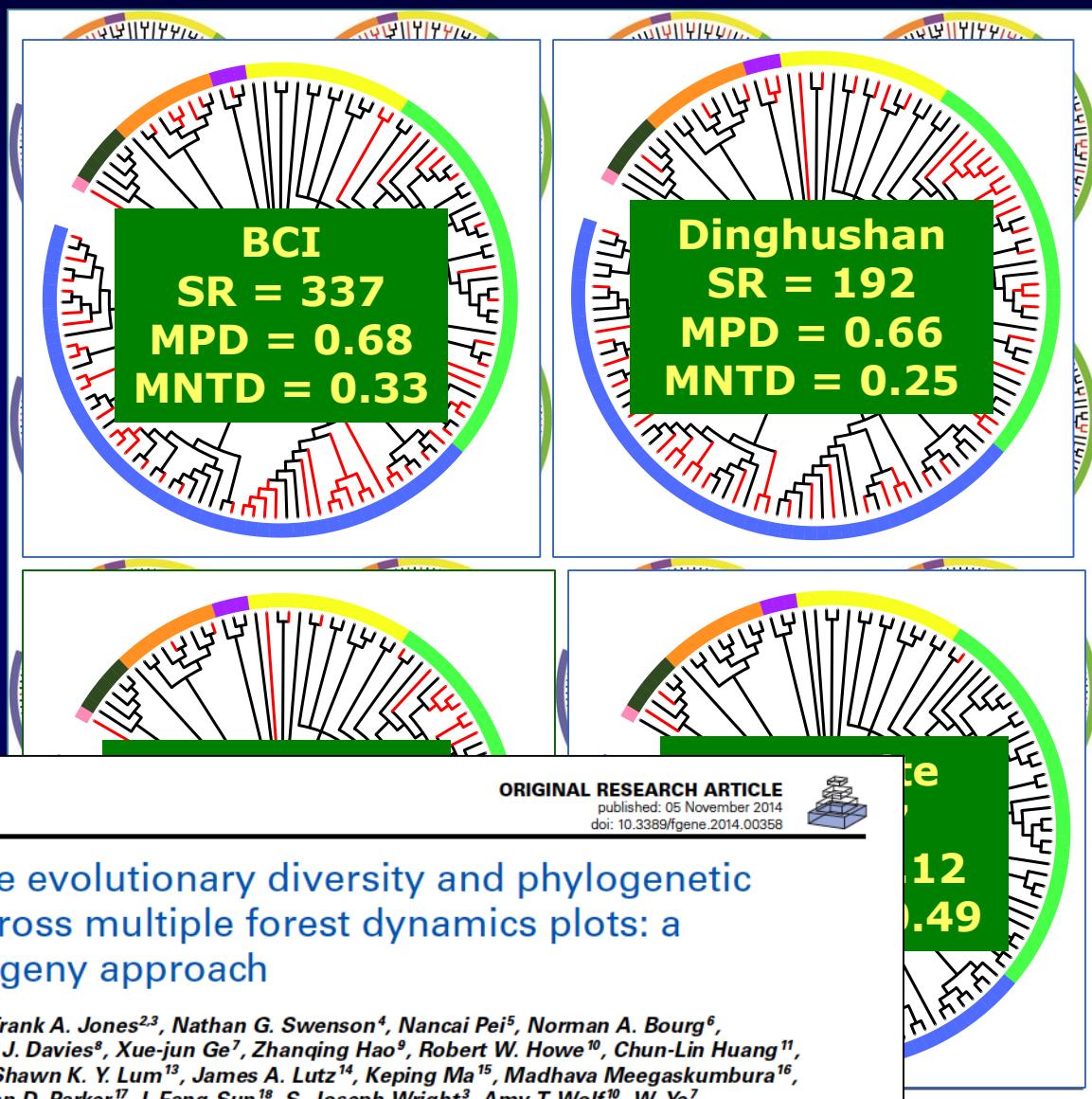
## Vital statistics

15 plots  
1,347 tree species  
553 Genera  
125 Families

SR = Species Richness

MPD = Mean Phylogenetic Distance

MNTD = Mean Nearest Taxon Distance  
(81-100%)



# The Smithsonian Institution

## Established in 1846



**19 Museums**

**9 Research Institutes**

**30 Million Visitors per Year**

**135 Million Specimens  
and Objects**

**350 Research Scientists**

**Tropical and Temperate Field  
Stations**

INSPIRING GENERATIONS  
THROUGH KNOWLEDGE AND DISCOVERY



STRATEGIC PLAN

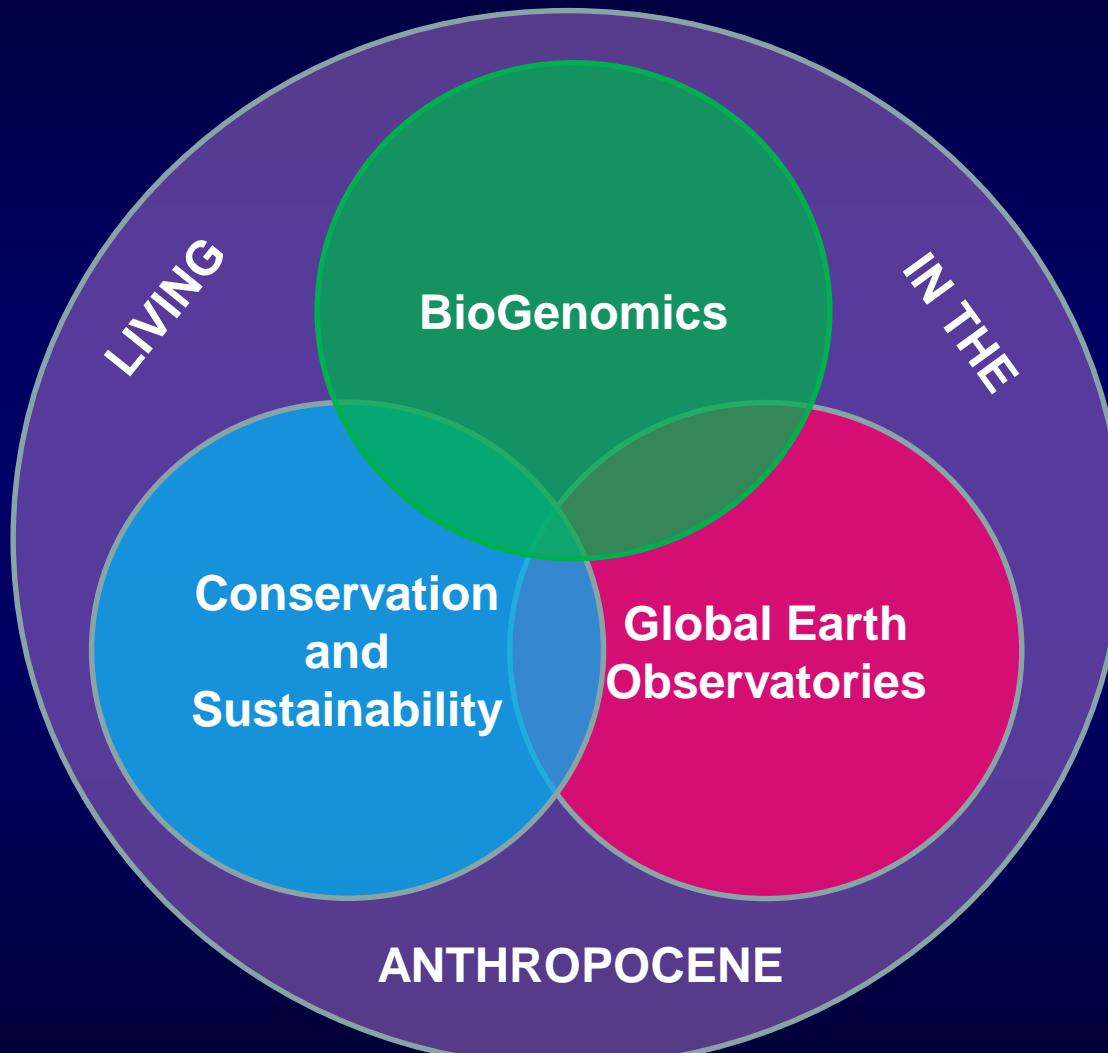


Smithsonian Institution

*Fiscal Years 2010–2015*



# BIODIVERSITY INITIATIVES ACROSS THE SMITHSONIAN



# Global Earth Observatories



Global Earth  
Observatories

# Smithsonian ForestGEO



# Smithsonian ForestGEO



Global Earth  
Observatories

# Smithsonian MarineGEO

## Tennenbaum Marine Observatories Network



Global Earth  
Observatories

# Smithsonian MarineGEO

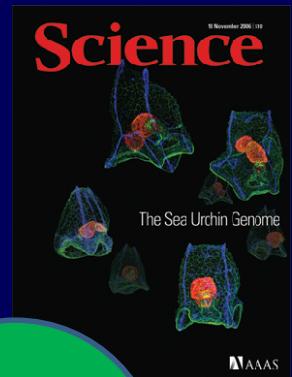
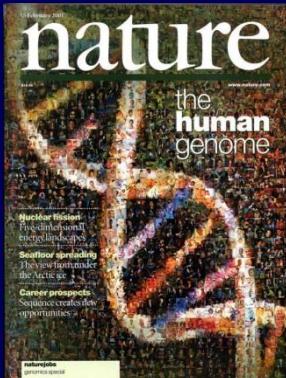
## Tennenbaum Marine Observatories Network





**BioGenomics**

# Genomics is revolutionizing biodiversity sciences



BioGenomics

# Smithsonian Areas of Scientific Excellence

Evolution



Diversity



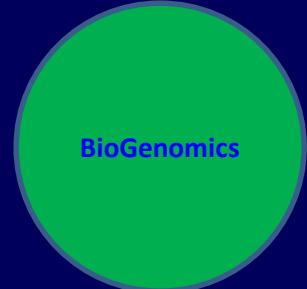
Conservation



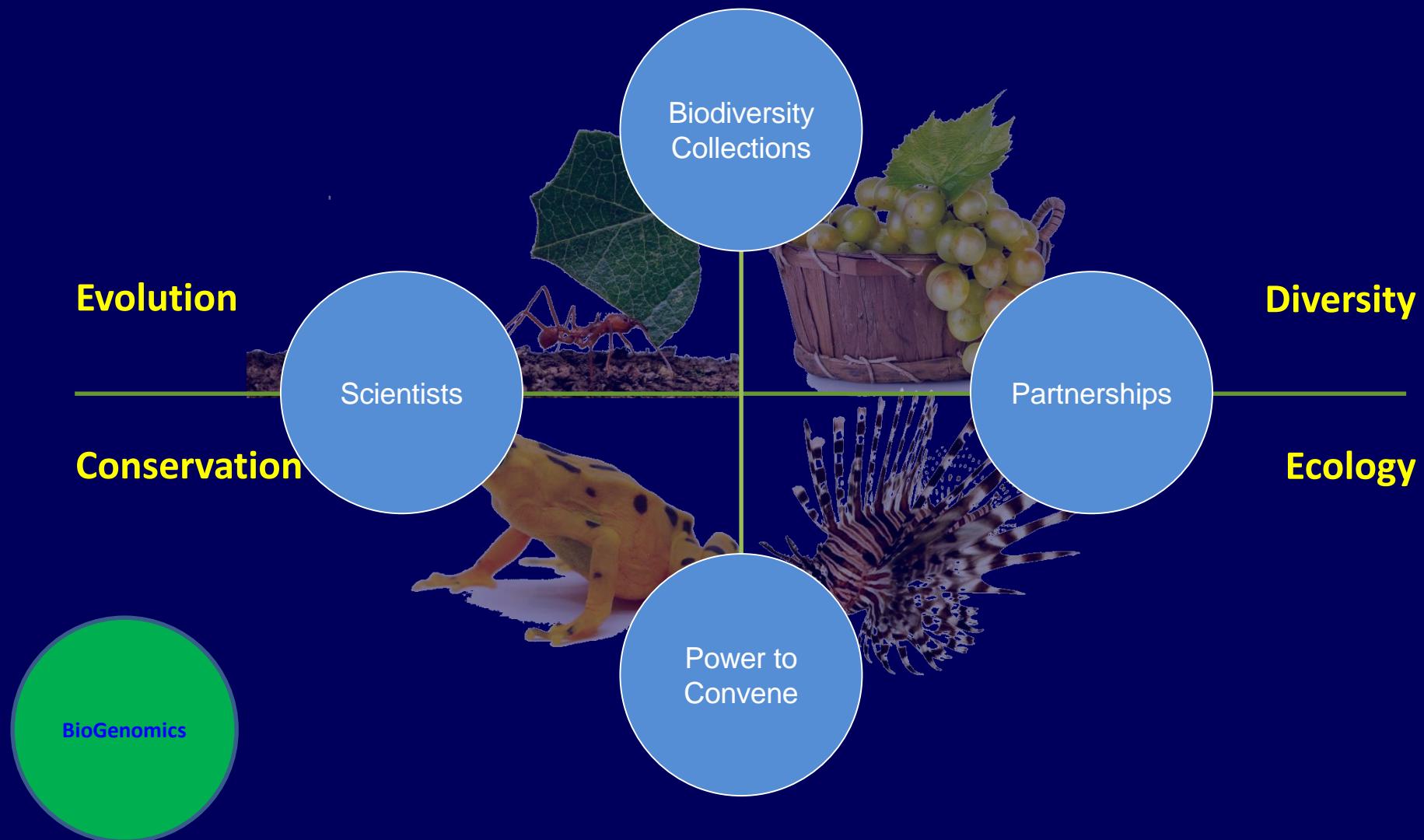
Ecology



BioGenomics

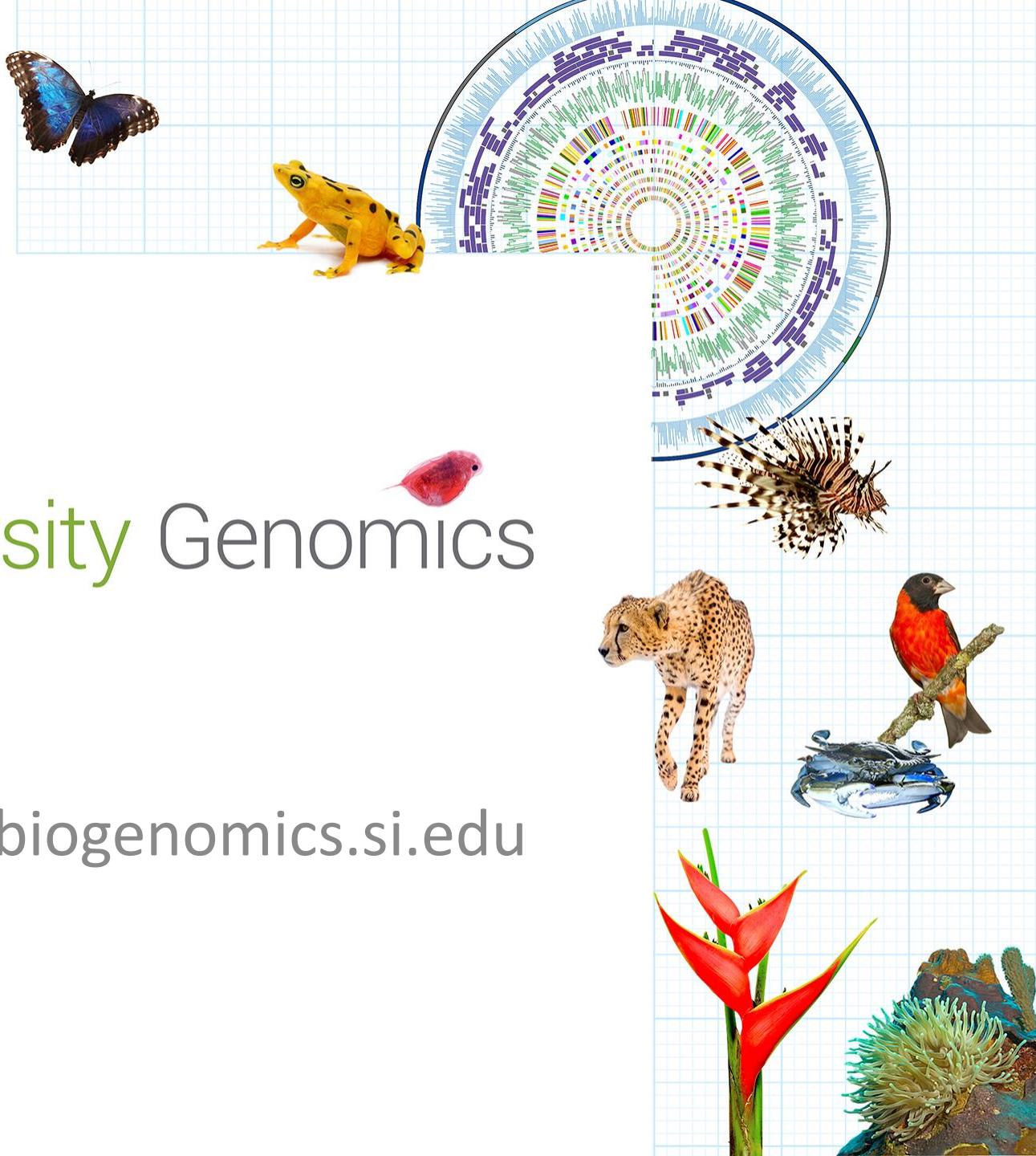


# Smithsonian Core Foundations





Smithsonian



Institute for  
**Biodiversity Genomics**

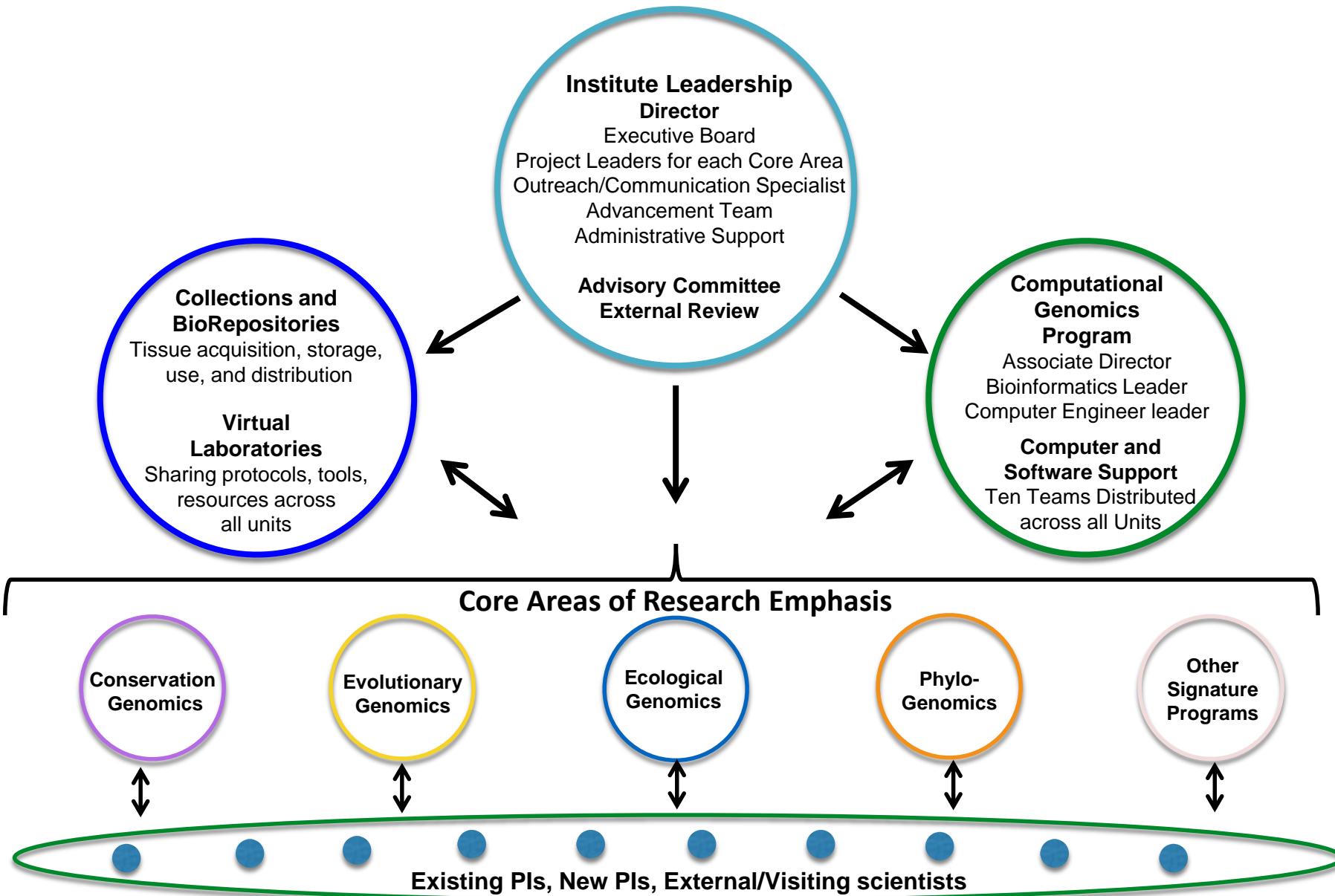
[biogenomics.si.edu](http://biogenomics.si.edu)

BioGenomics



Smithsonian Institution

# Institute for Biodiversity Genomics





# Global Genome Initiative

## Vision

Preserving the genomic diversity of life on Earth

## Mission

Global network

Evolutionary & Ecological Research

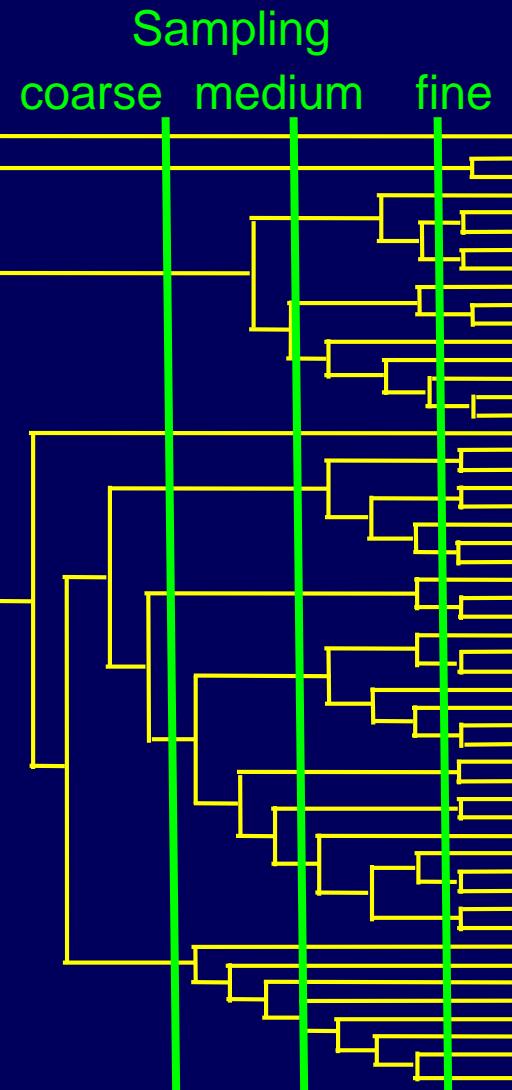
Genomic biorepositories

Genomes of key branches of tree of life

Public Awareness and Understanding

# Feasibility: Taxonomy

- DOMAINS
- PHyla / DIVISIONS
- CLASSES
- ORDERS
- FAMILIES
- “GENERA”     $\sim 160,000$
- SPECIES                 $>15,000,000$





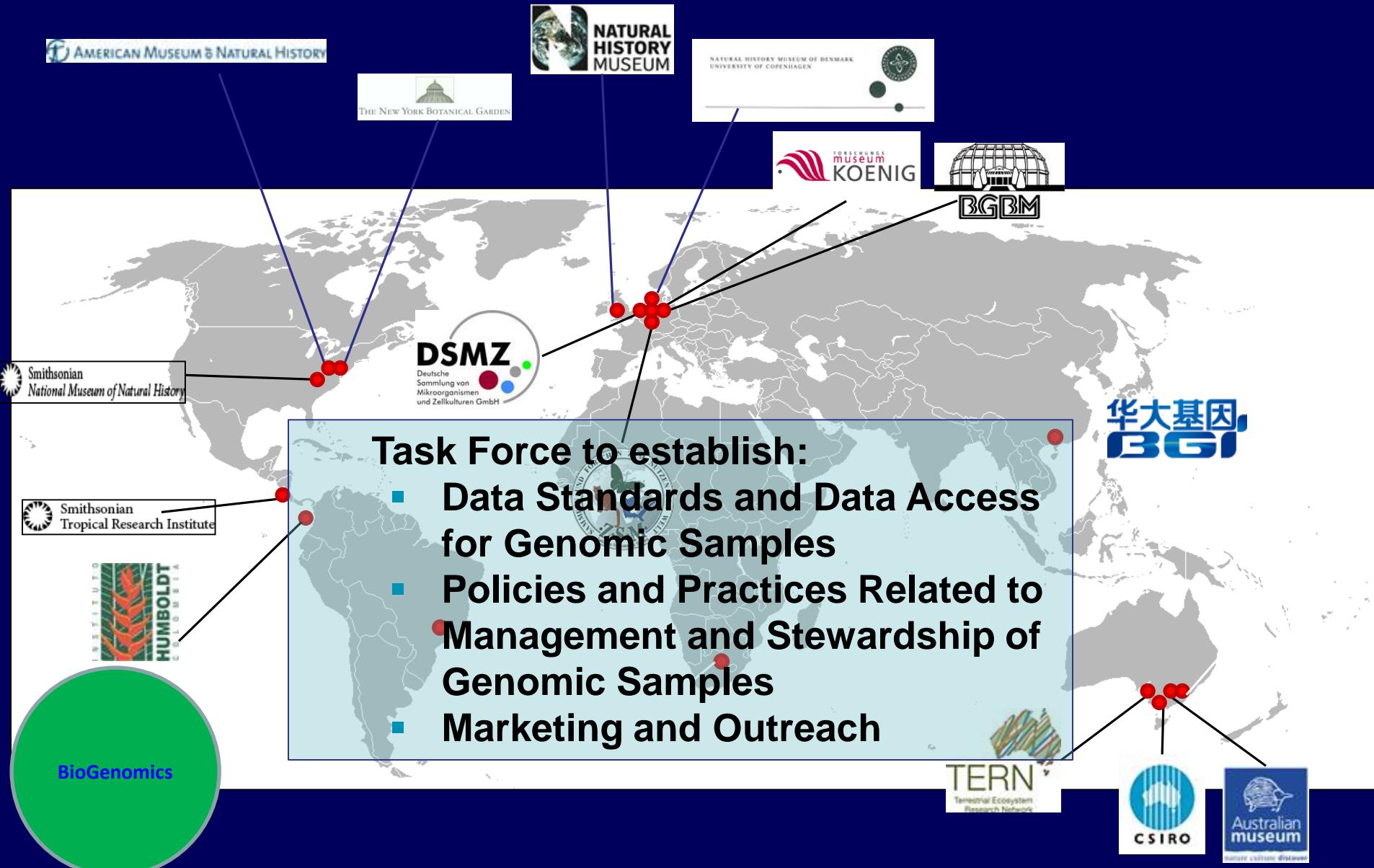
58  
Freezers



24  
Nitrogen Tanks

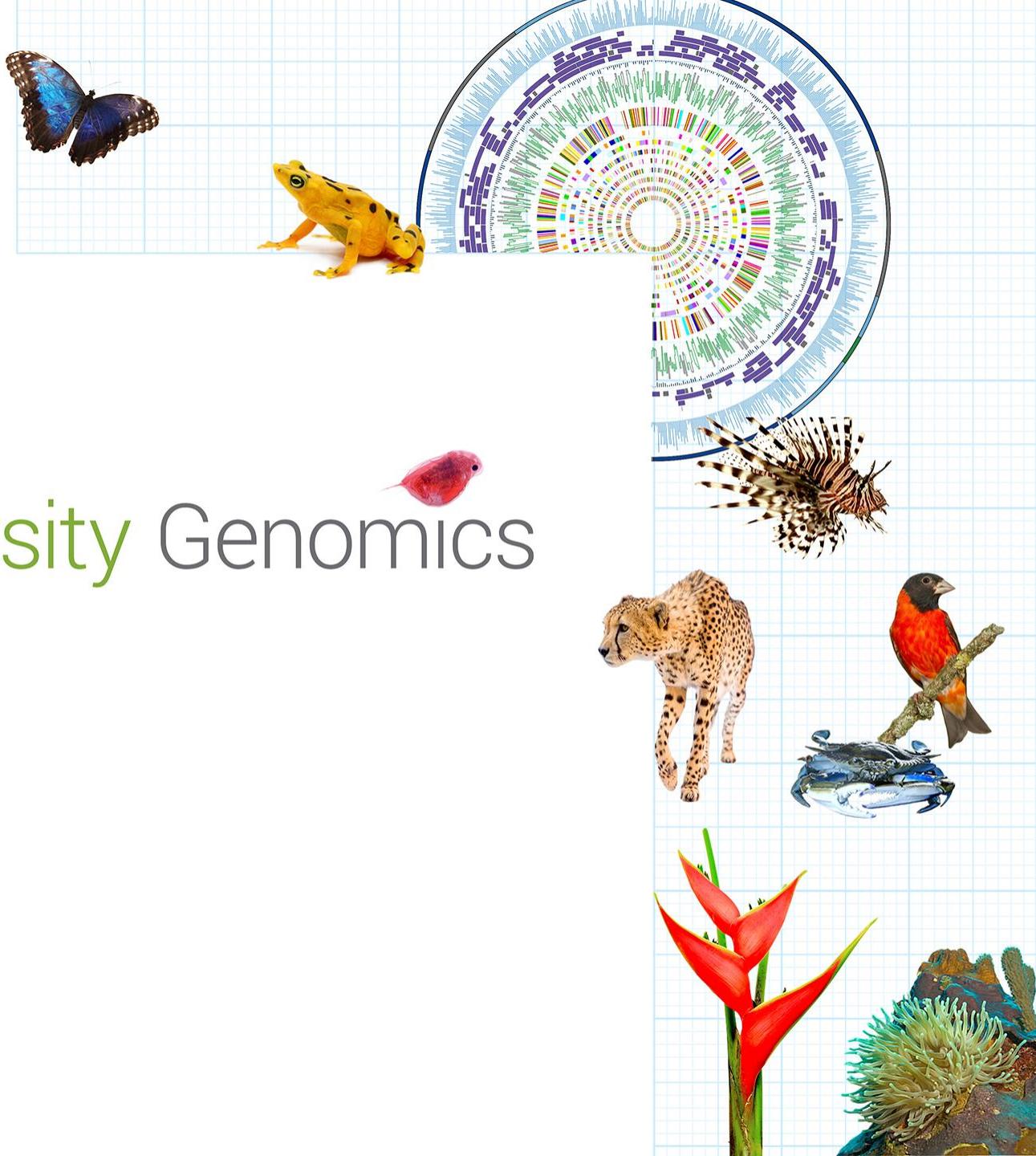
NMNH Biorepository  
4-5M 2ml tube  
capacity

# Global Genome Biodiversity Network





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**Biodiversity Genomics**