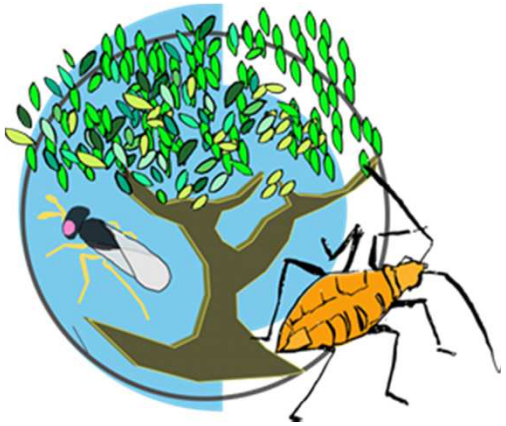
The Current State of Arthropod Biodiversity Data: Addressing Impacts of Global Change

Neil S. Cobb (Northern Arizona University) **Katja Seltmann**, (American Museum of Natural History), and **Nico Franz** (Arizona State University)

May 5, 2014



Tri-Trophic Thematic Collection Network

SCAN

Southwest Collections of Arthropods Network

The Current State of Arthropod Biodiversity Data: Addressing Impacts of Global Change

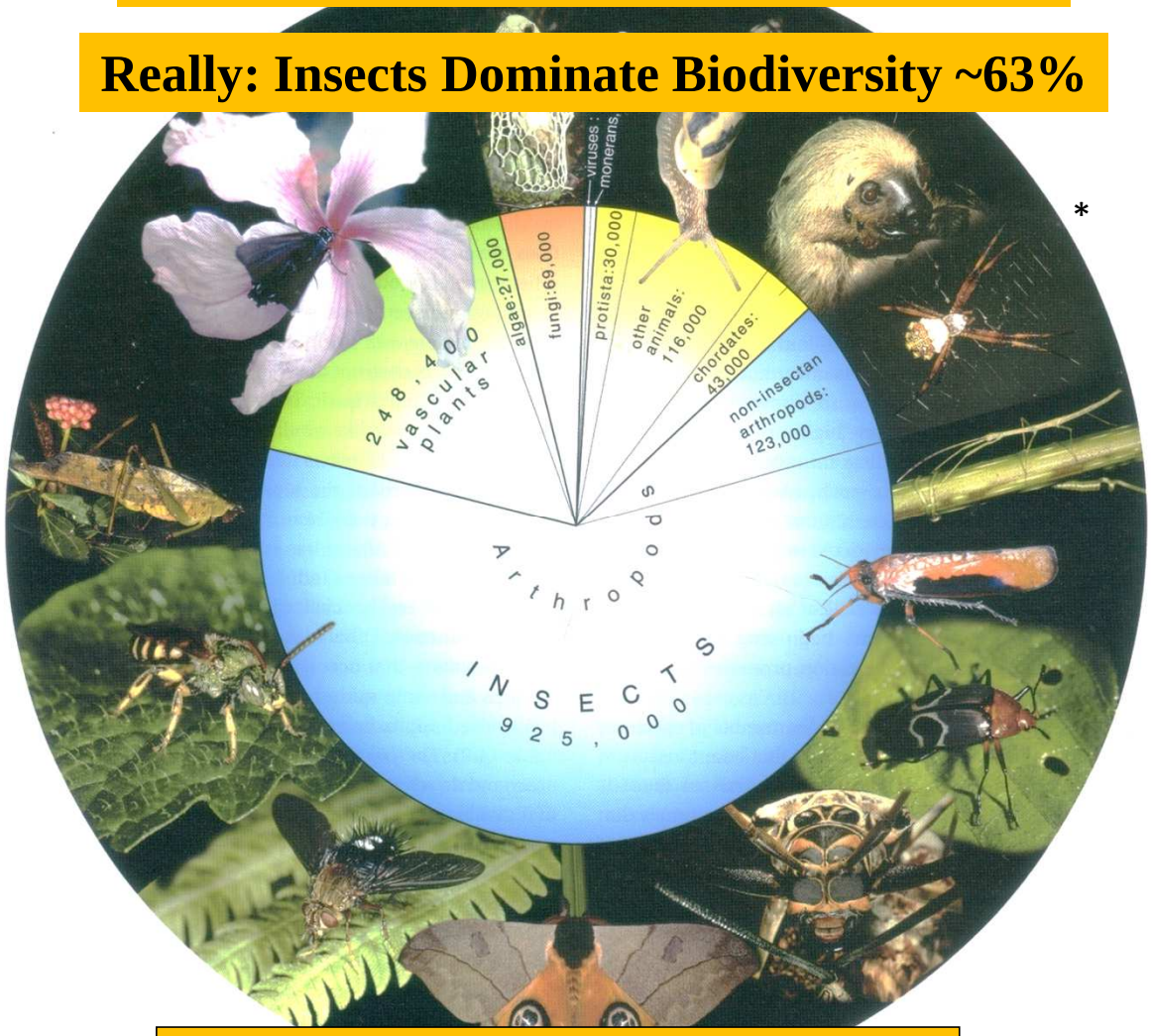
- **Focus on North America – United States > Canada**
- **How many species can we model future distributions under climate change? (n>30)**
- **Museum occurrence records:**
  - **Holdings in NA museums**
  - **Biogeography**
  - **Collection Timeline**
  - **Major taxonomic and functional groups**
  - **Linking trophic connections**

Race Against Time: Key Observations

- Arthropods comprise ~70% of described species, only 15% of climate impact studies
- ~15% of arthropod species have been described, 70% for North America(?)
- Less than 10% of arthropod species have “enough” occurrence data
- 600,000 million specimens worldwide, <50,000,000 digitized (8%)
- Cannot predict climate change impacts without knowing existing species distributions
- Arthropod occurrence data resides primarily in museum collections

Arthropods Dominate Biodiversity ~70%

Really: Insects Dominate Biodiversity ~63%



*

Or at least Binominal Biodiversity

* From Evolution of Insects

North American Arthropod Functional Diversity: Major Players

Seven Major Terrestrial Arthropod Orders

Economic & Health Impacts

Pests (Herbivores & Parasites)

Ecosystem Services

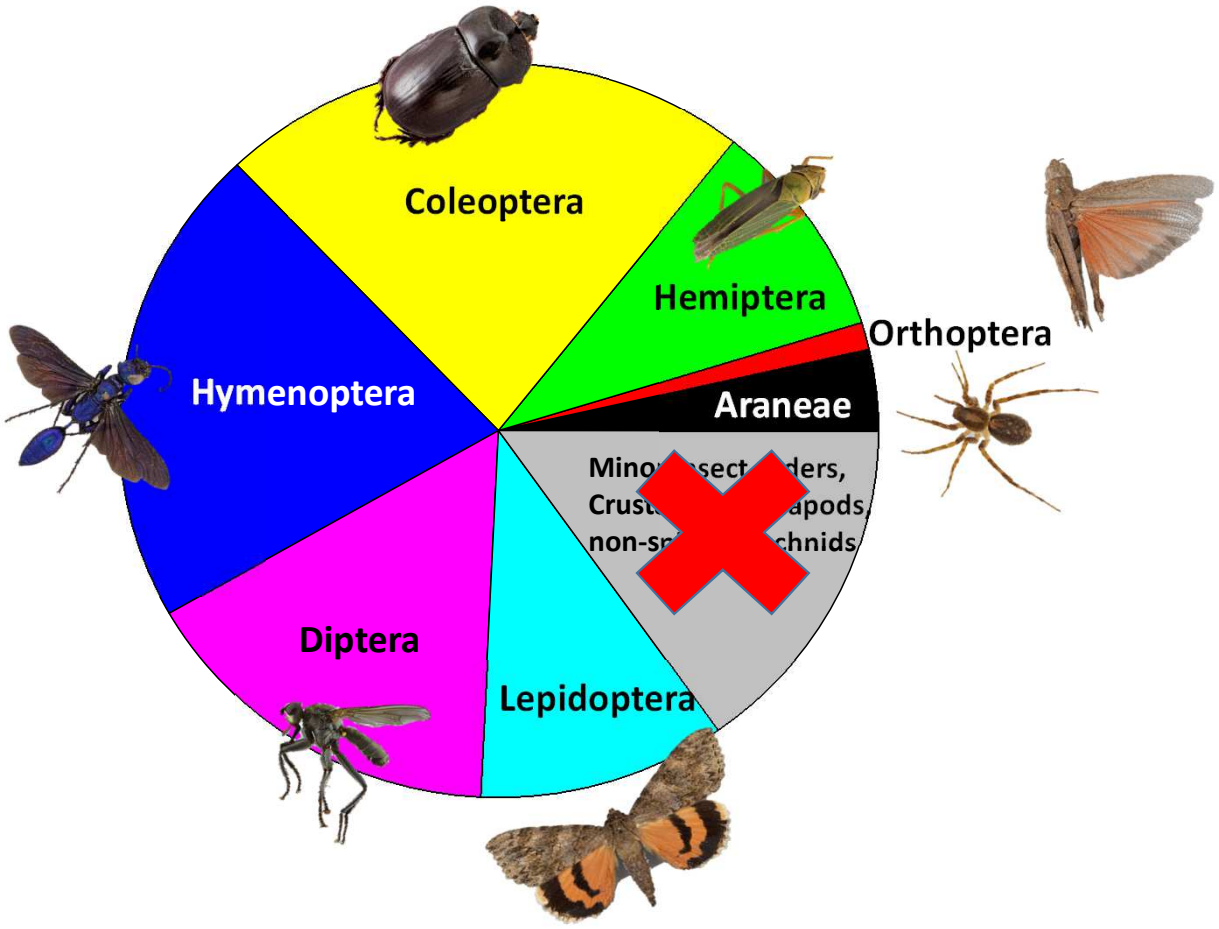
Parasitoids & Predators

Pollinators

Herbivores (Biocontrol & Food)

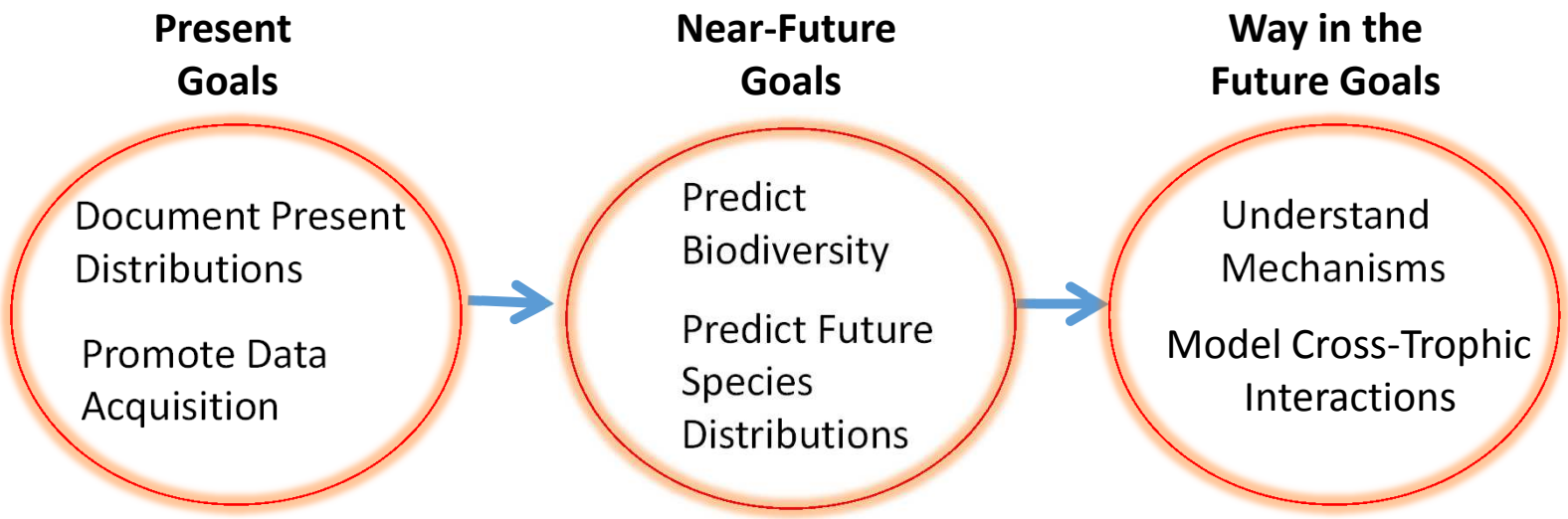
Ants*

Decomposers*



*Not showing data for this talk

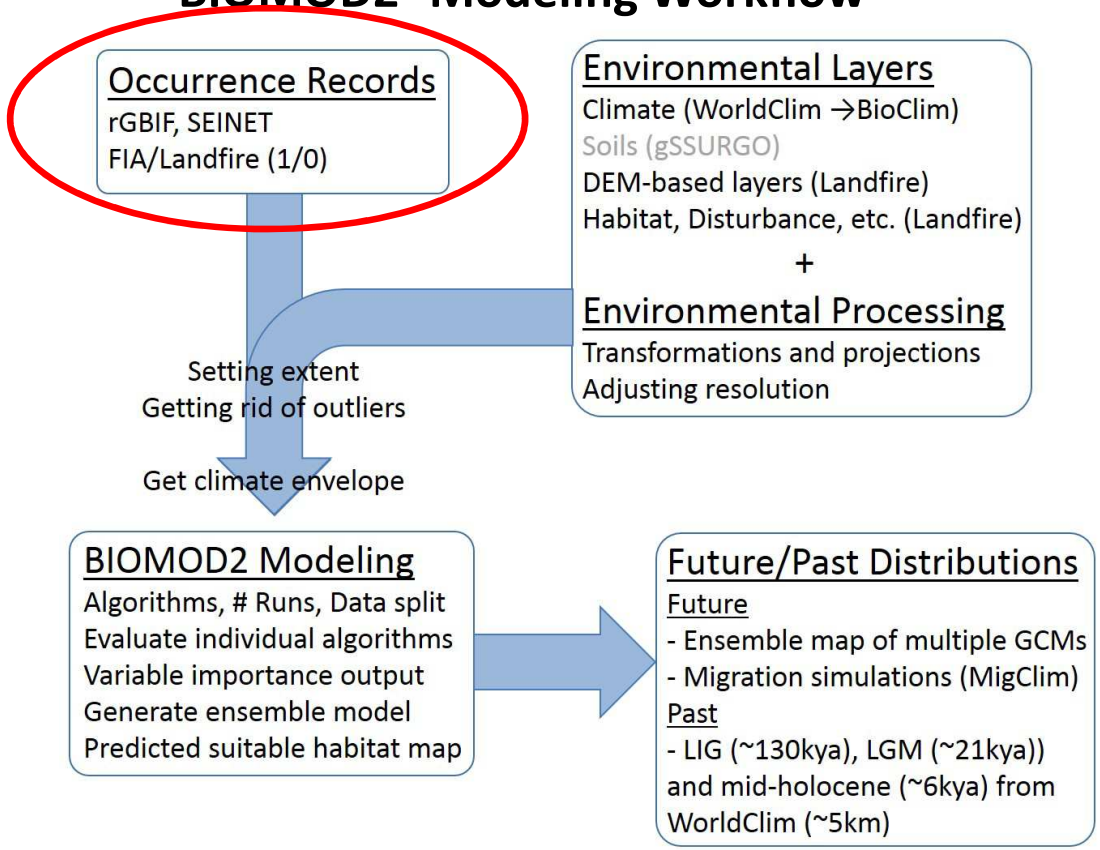
Understanding Climate Change Impacts on Arthropods
Ecological Niche Modeling, Species Distribution Modeling



Predicting Impacts of Climate Change on Species Distributions

- 30-100 occurrence localities
- Distributed over entire range

BIOMOD2+ Modeling Workflow



- **Museums currently hold the vast majority of arthropod occurrence data!!**
- **How many arthropod species are observable in the field?**

Field-observable arthropod taxa	**Projects that use observations**	**# of NA arthropod species that can be observed in field**
Dragonflies some damselflies	Odonata Central	
Butterflies	Butterflies & Moths of NA	
Ants	BugGuide	3,001 species
Grasshoppers		6,000 aquatic & miscellaneous species??
Mantids		9,000 total observable species
Crickets	Discoverlife (Bee Hunt)	
Cockroaches	Life on Loosestrife	
Earwigs	Cricket Crawl	95,000 total “unobservable” species
Vespid Wasps	Lost Ladybug	
	Great Sunflower Project	

The Data

- **Museum Occurrence Records for United States & Canada**
- **Three sources of data**

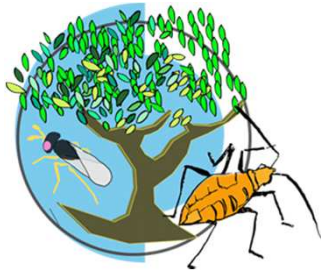
Southwest Collections of Arthropods TCN

SCAN
Southwest Collections of Arthropods Network

(500k)

+

Tri-Trophic TCN



(900k)

+

GBIF

GLOBAL
BIODIVERSITY
INFORMATION
FACILITY

(3.2 million)

= **4,606,160**

Methods

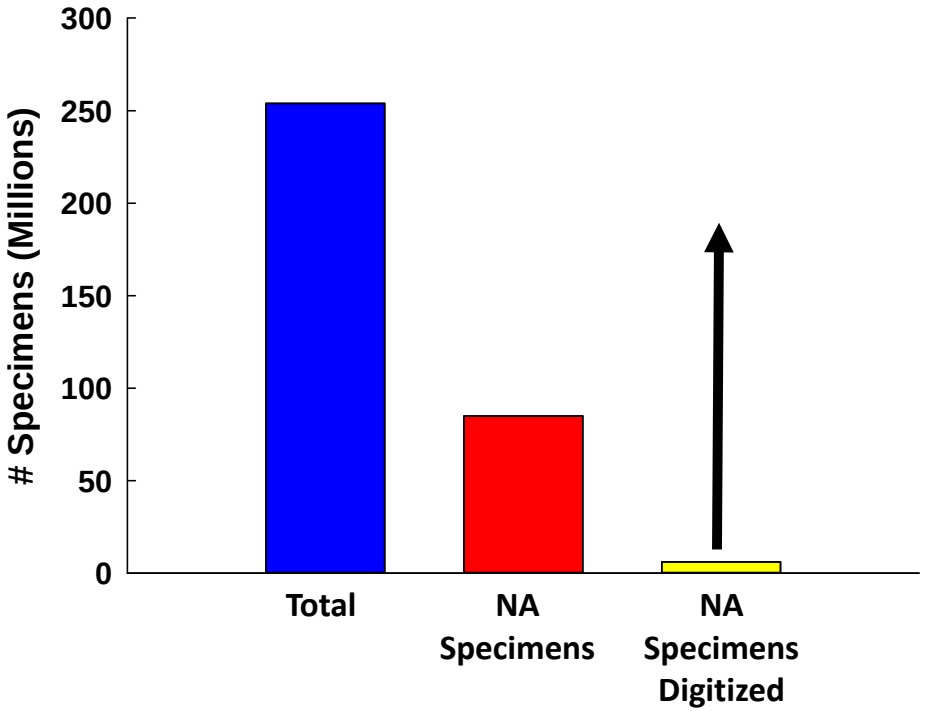
The “Seltmann model 865B” Biodiversity Cluster Array

1. Compile raw data
2. Clean data
3. Format data
4. Compile & run scripts

- **Museum Occurrence Records for United States & Canada**
  - **2,166 Families**
  - **20,153 Genera**
  - **80,161 Species (105,000 [?] total)**
  - **4,606,160 Specimen Records**
  - **3,7331,257 Georeferenced Records (81%)**
  - **2,803,956 Identified to Species (77%)**

North American Arthropod Collections

(USA-Canada-Mexico)



Key Estimates

Current Holdings

237 million specimens accounted for

>17 million not accounted for

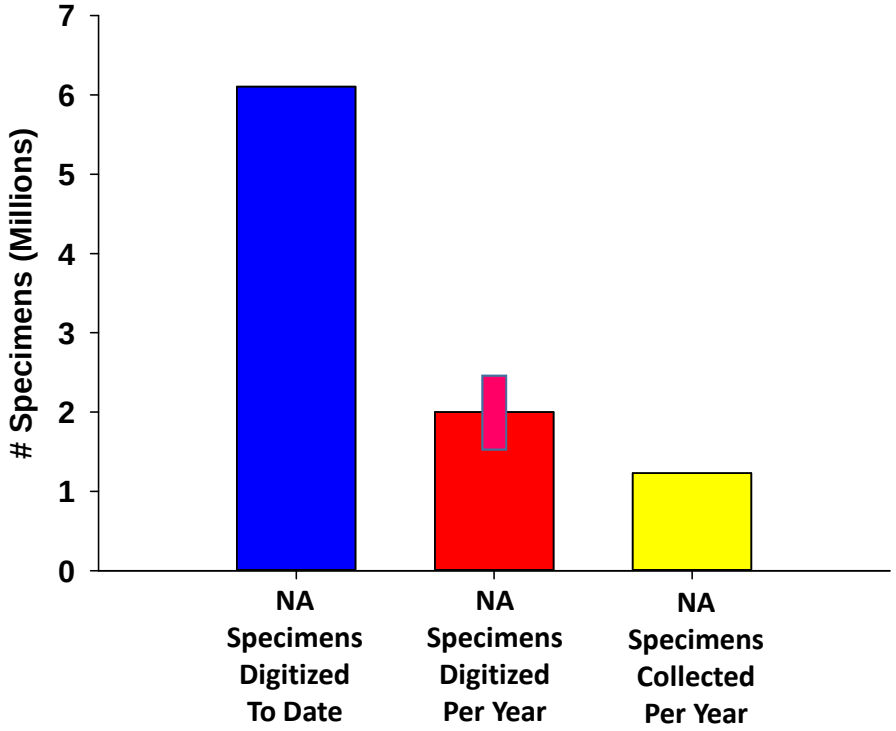
254 million Total specimens in NA collections

85 million Total North American specimens (?)

6 million digitized North American specimens (?)

North American Arthropod Collections
(USA-Canada-Mexico)

Can we catch up?



Key Estimates

Current Holdings

237 million specimens accounted for

>17 million not accounted for

254 million Total specimens in NA collections

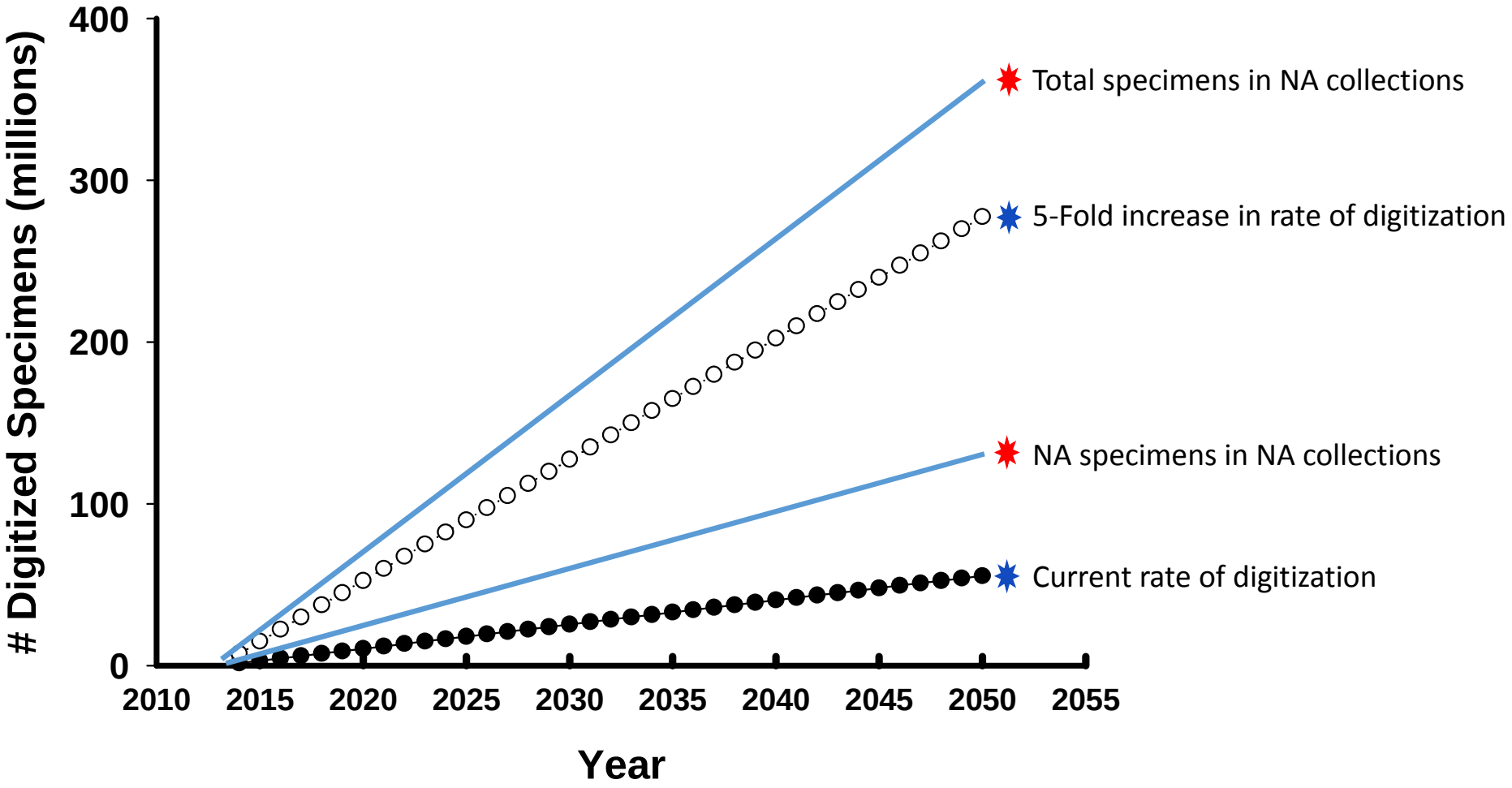
85 million Total North American specimens (?)

Annual Additions

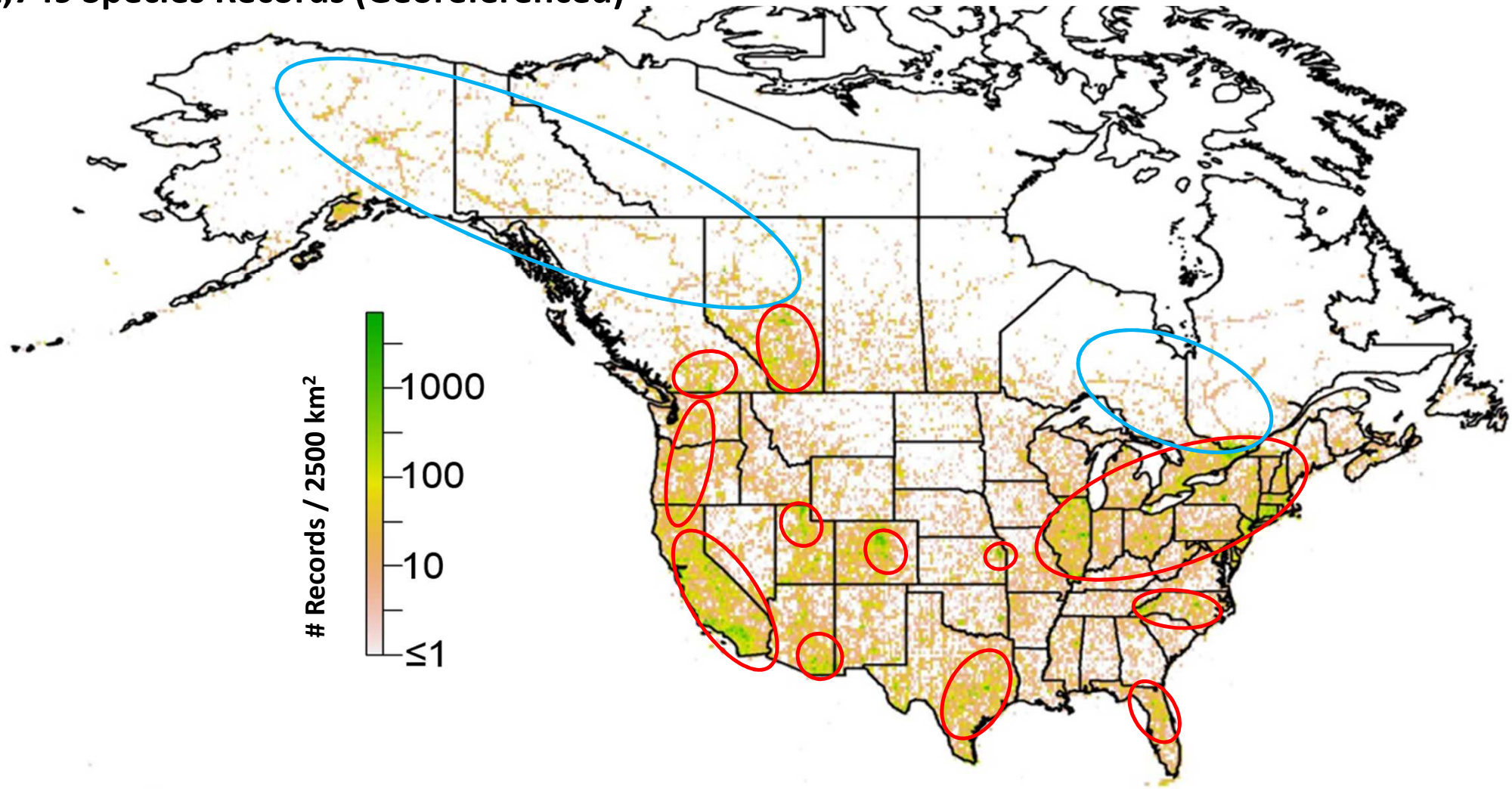
3.8 million total new specimens per year

1.2 million new North American specimens per year

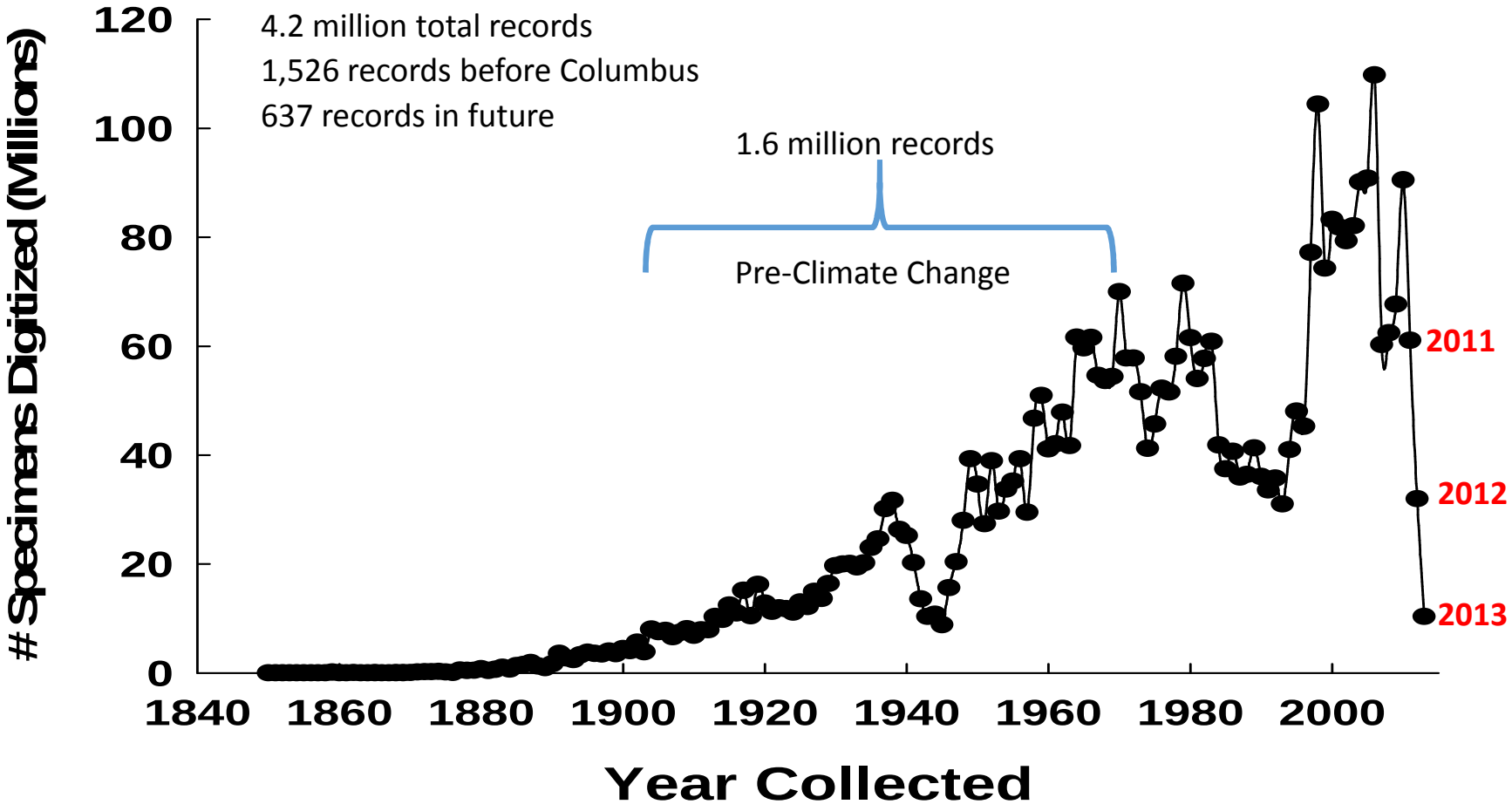
Can we catch up?



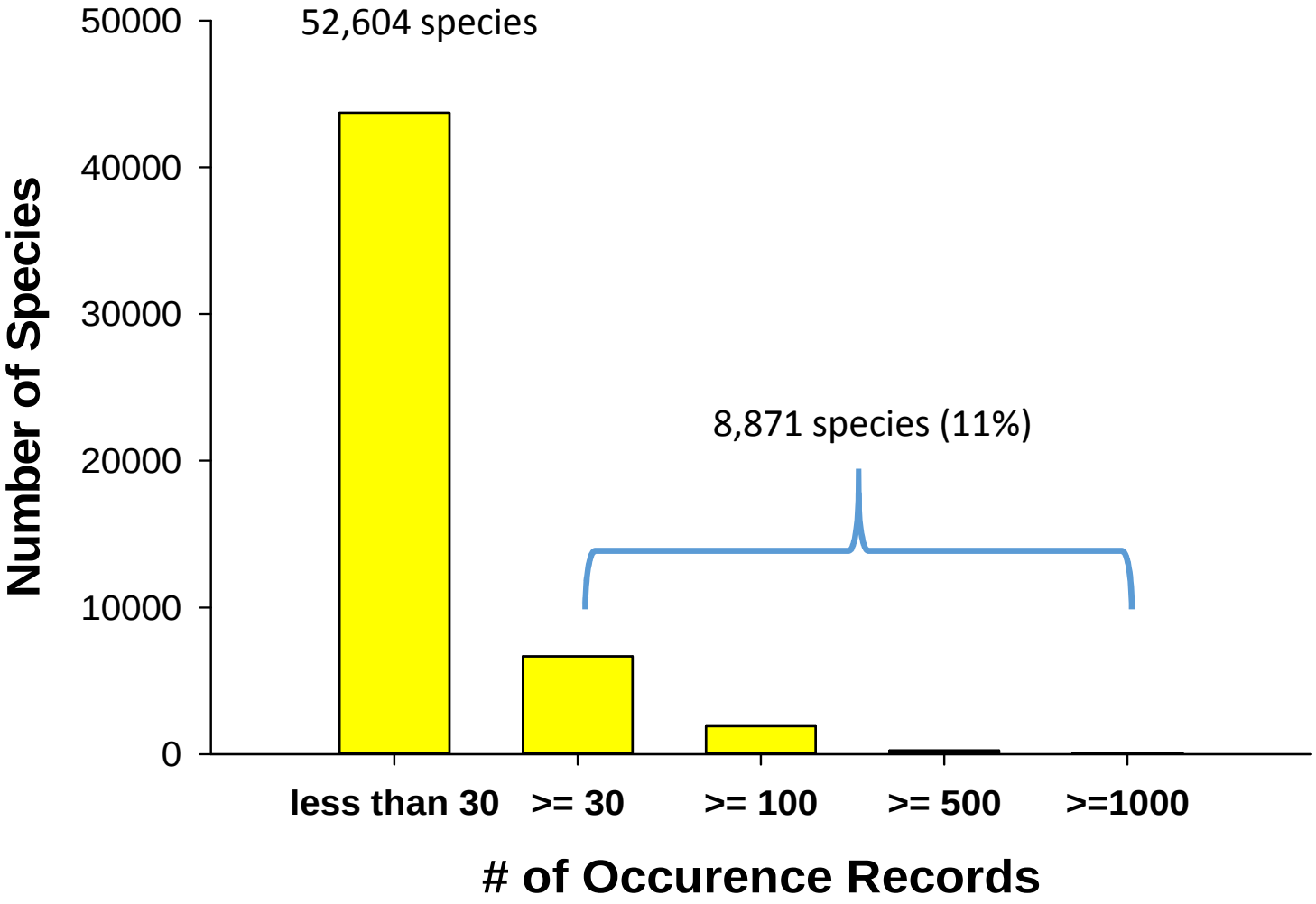
Biogeography of NA Arthropod Collections
692,749 Species Records (Georeferenced)



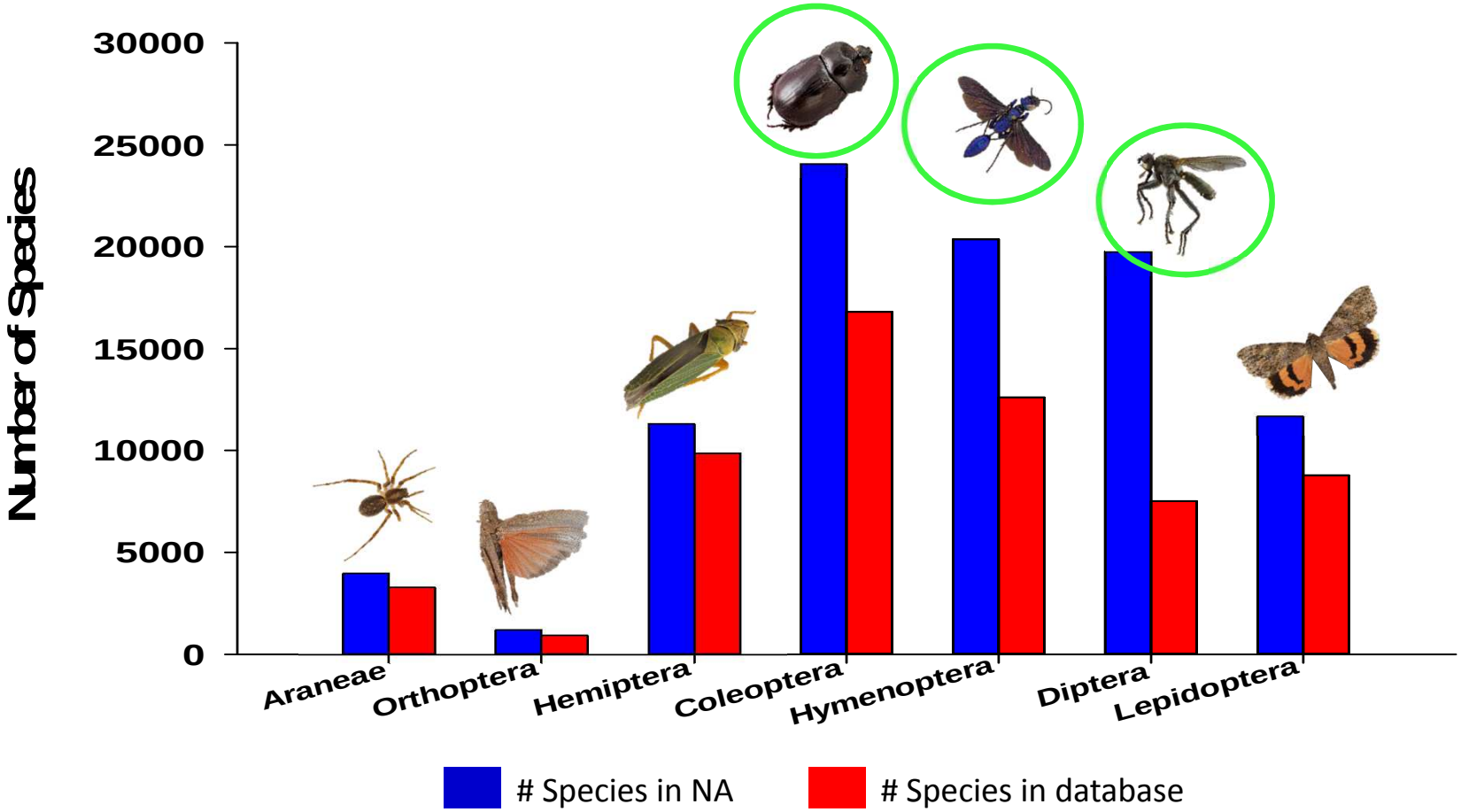
Timeline of Arthropod Collecting



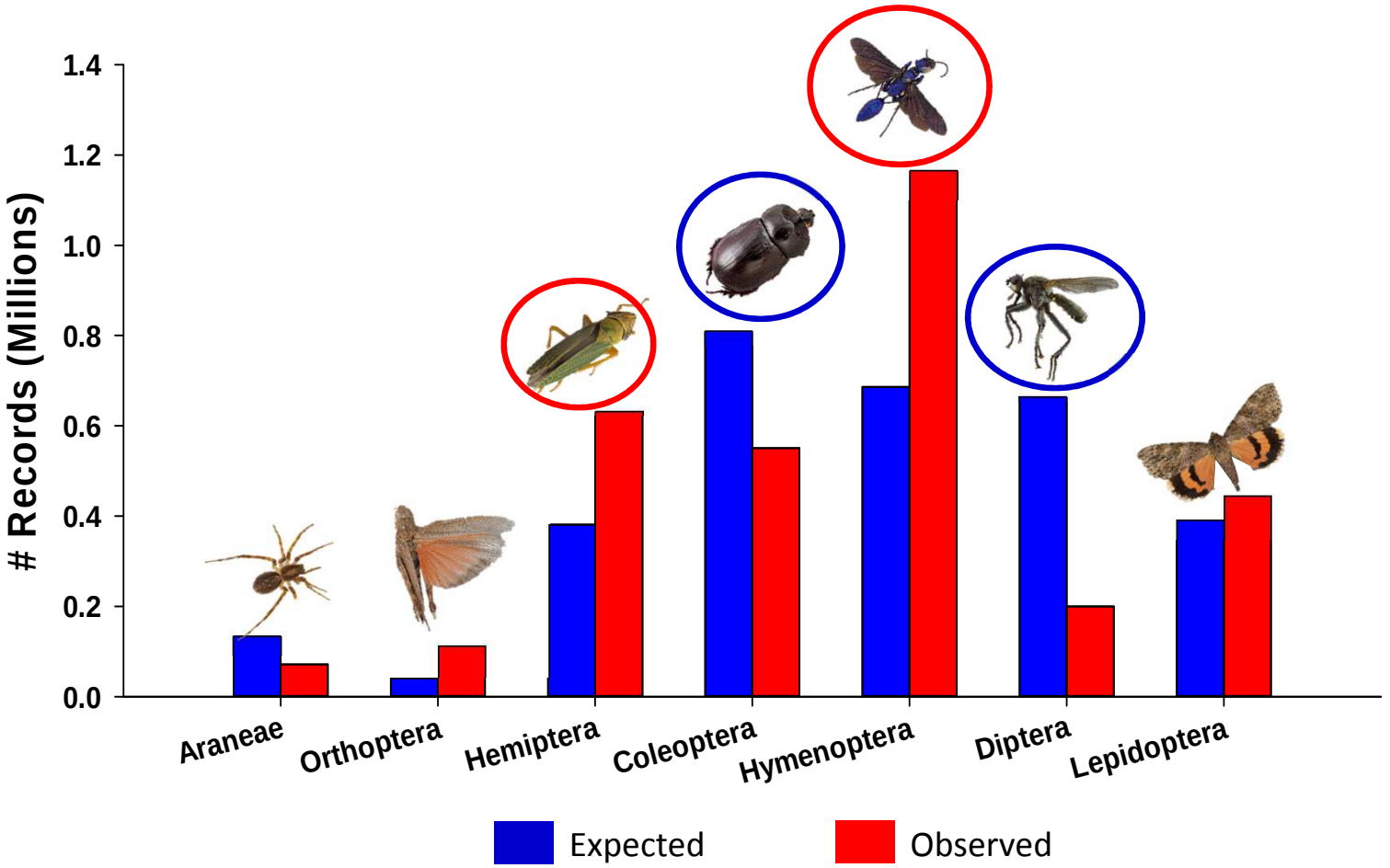
Research Ready Data (identified to species & georeferenced)



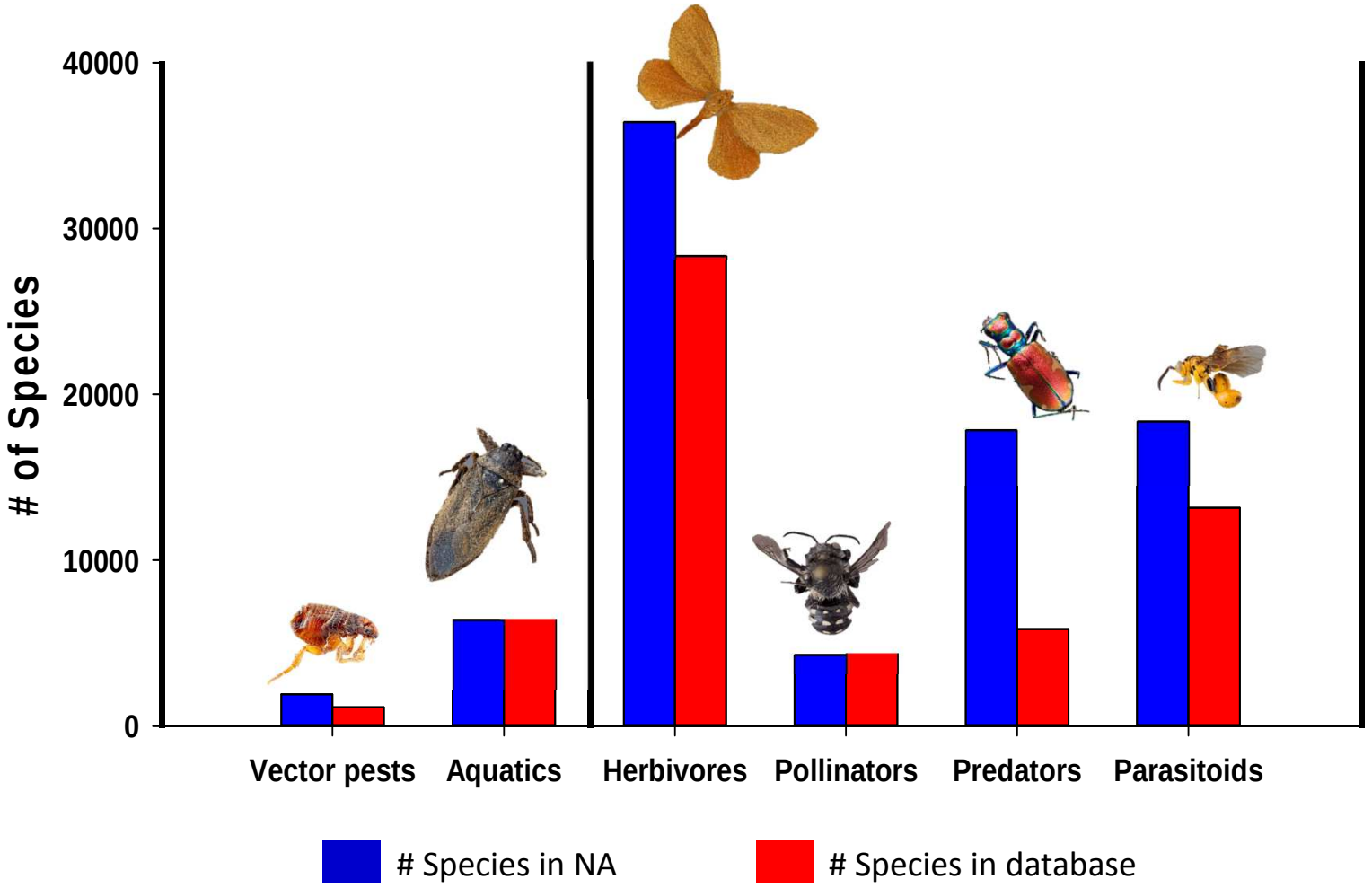
Taxonomic Distribution: Databased Species



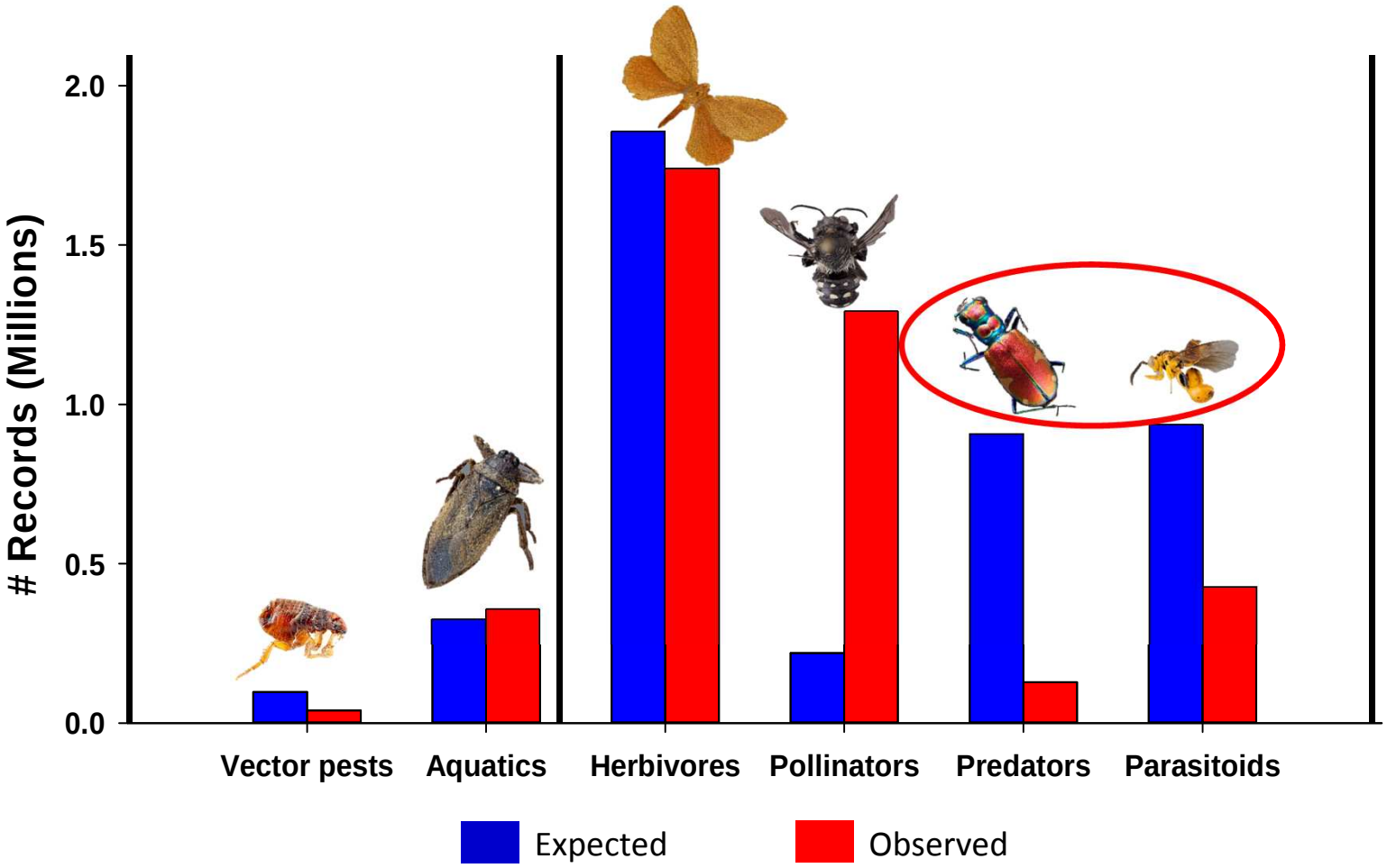
Taxonomic Distribution: Expected vs. Observed Records



Ecological Distribution: Databased Species



Ecological Distribution: Expected vs. Observed Records



Status of *Research-Ready* Arthropod Biodiversity Data

1. **Fraction of specimens digitized, but enough to model for climate change impacts.**

2. **Exponentially Increase current rate of digitization to fully utilize existing specimen data.**

3. **Biogeography of specimen records suggests significant bias.**

4. **Historical data indicate a enough taxa can be used to test for climate change responses NOW.**

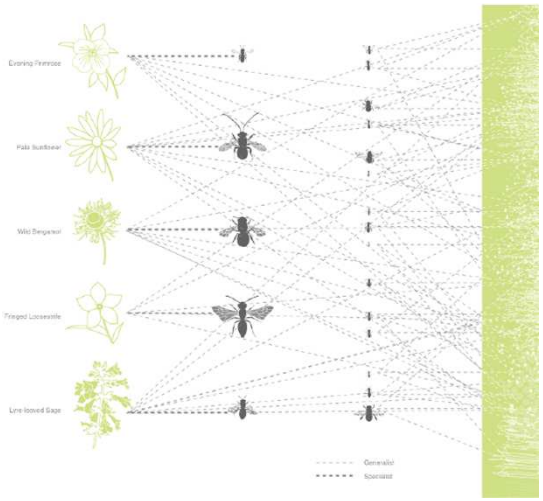
5. **Taxonomic breadth of data generally good (except Diptera).**

6. **Ecological breadth of data generally good (except predators & parasitoids).**

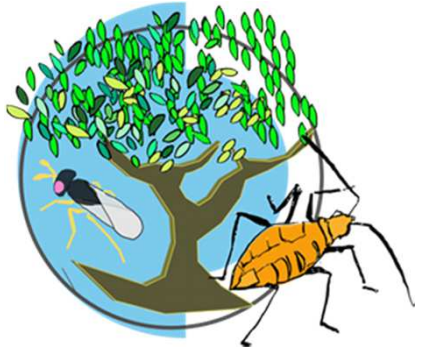
Stacked Species Distribution Models

- Can assess overlap among species
- Predicted community “types”
- Examine Biotic Interactions

Pollinator Networks

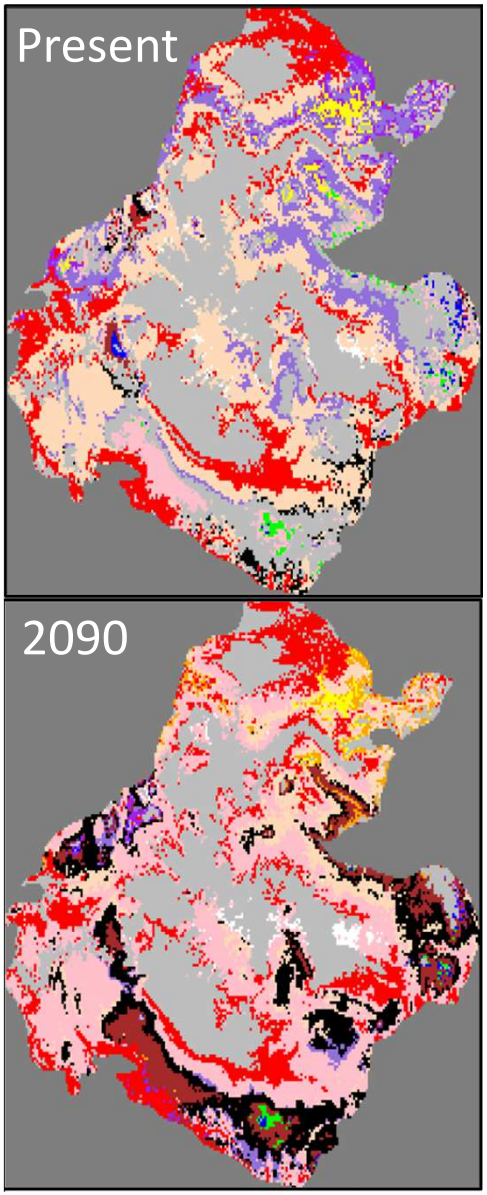


Tri-Trophic Thematic Collection Network



Plants Enemies

Herbivores

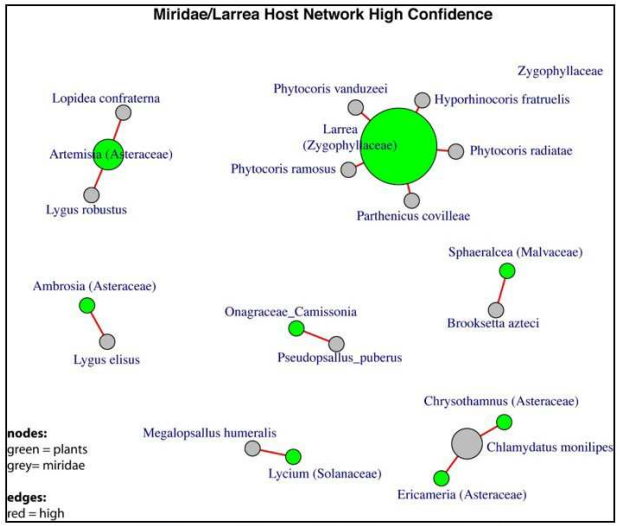


Modeling Biotic Associations

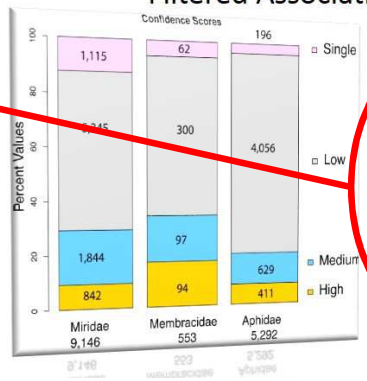
Assessment of Trophic Network Data

1. Rigorous data-filtering framework

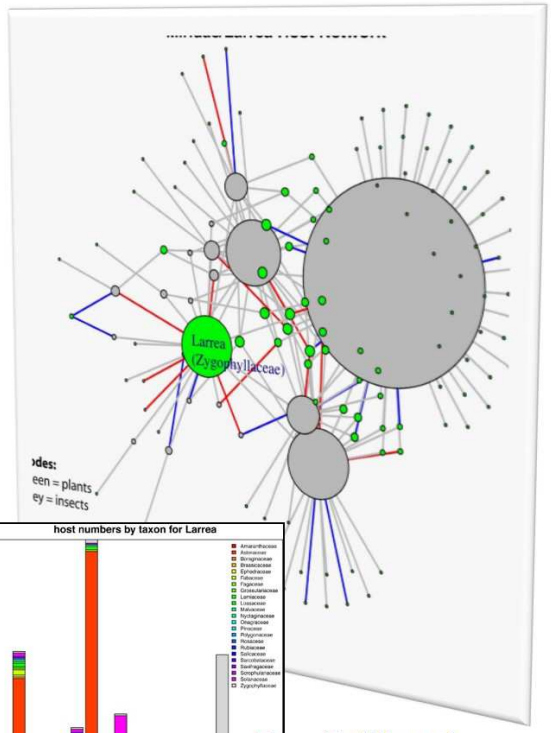
2. High confidence in < 20% of recorded associations

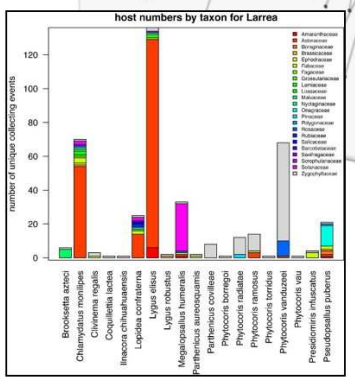


Filtered Association Network



High confidence in < 20% of recorded associations





Unfiltered Association Network (Raw Data)

Interim Conclusions

TCN Collaboration

SCAN
Southwest Collections of Arthropods Network

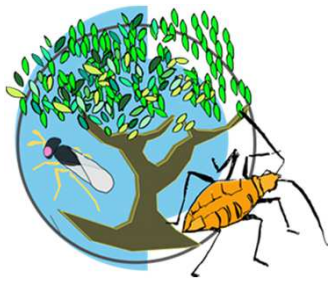
Lots to do

Take Your Pick

Lots to work with

Next Steps

- Extend analyses to Mexico and Central America.
- Compare with other continents and oceans as well as other phyla in North America.
- Create a website that provides near real time statistics to identify gaps and advertise research-ready data.
- Promote novel digitization-based opportunities for expert contributions (floras, faunas, “e-revisions”)



Tri-Trophic
Thematic
Collection
Network

SCAN
Southwest Collections of Arthropods Network

Conclusions: A few suggestions

Promote **interoperability** of **user-friendly** databases & software (Symbiota, Arthropod Easy, Arctos [GBIF], CalBug?)

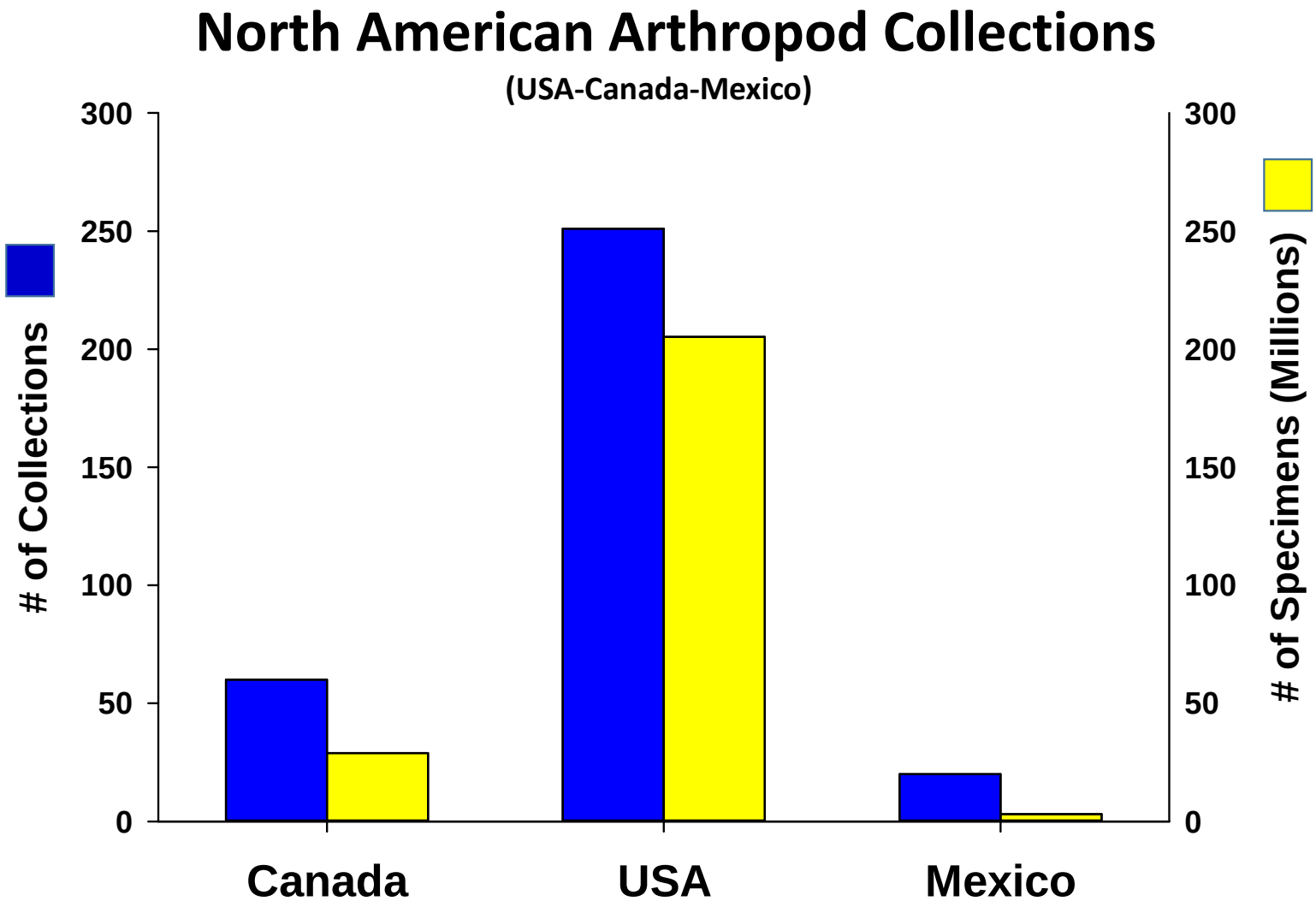
Push for technological advances (InvertNet imaging [100's to >1000 specimens per image])

Crowd-sourcing (Notes from Nature)

Increase # of observable species (DiscoverLife)

Extend beyond political boundaries (SpeciesLink, GBIF)

Timeline Biogeography of NA Arthropod Collections
692,749 Species Records (geo-referenced)


North American Arthropod Collections
(USA-Canada-Mexico)
# of Collections
# of Specimens (Millions)
300
250
200
150
100
50
0
Canada
USA
Mexico

Specific ways museums can address climate change impacts on Arthropods

1. Provide occurrence records from museum specimens
2. Provide expertise
    - A. Monitoring Programs
    - B. Observational Inventories
    - C. Taxonomic Revisions
    - D. Identification Services through Loans
    - E. Training Taxonomists and Parataxonomists