Horses in the cloud: Big data exploration and mining of fossil and extant *Equus* (Mammalia, Equidae)

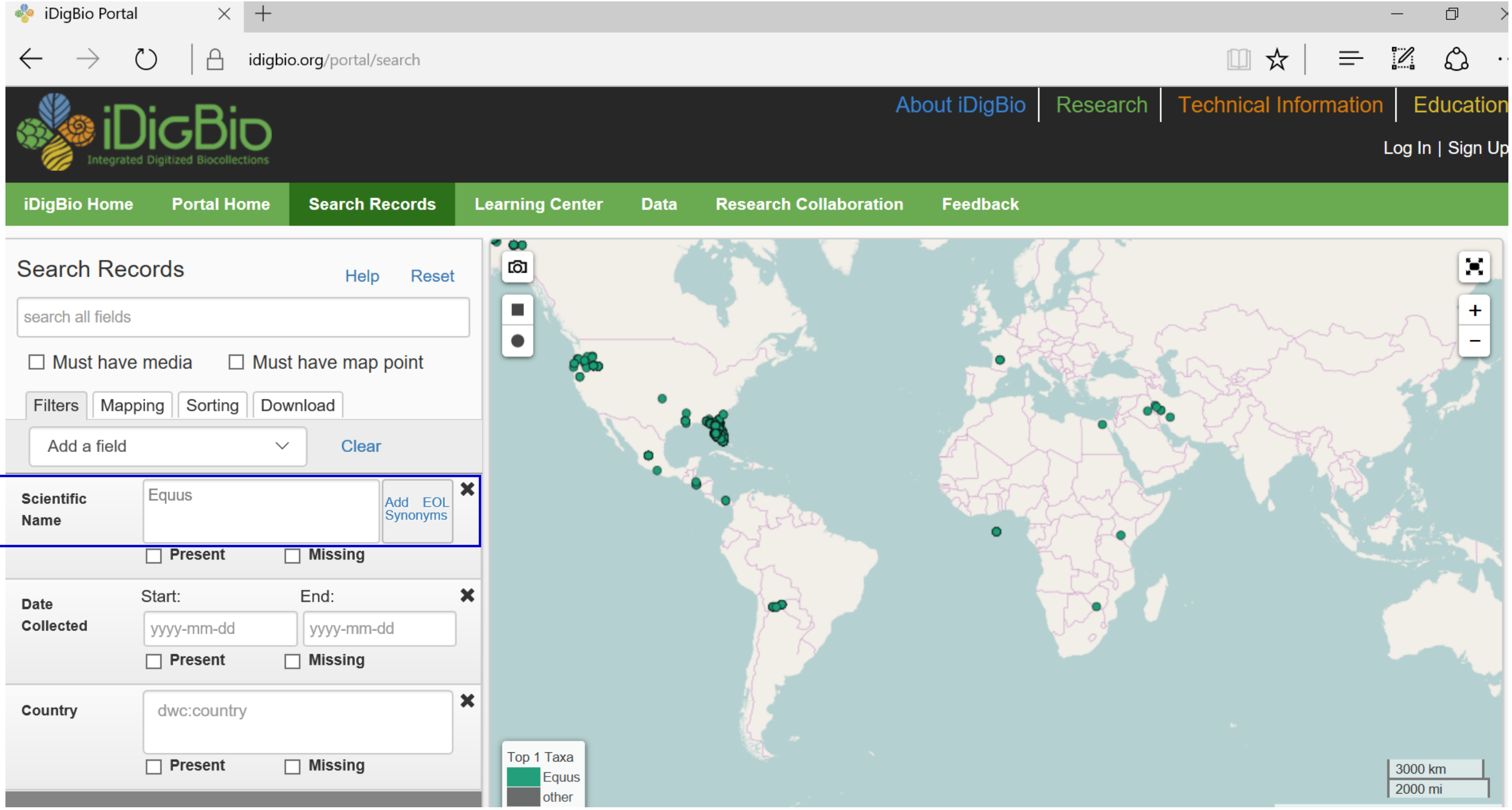
Bruce J. MacFadden & Robert P. Guralnick

Florida Museum of Natural History

University of Florida

Gainesville FL 32611

Initial query November 2015



Scientific Name: Equus

iDigBio
Integrated Digitized Biocollections

Talk outline—*Equus* use case

- Data exploration in 2016
- Big biodiversity databases and mining results
  - iDigBio, PBDB, GBIF
- Analysis
  - Integration
  - Geographic Bias
  - Holy Grail—integrated chronological data
- Future
  - *Equus* extinction geography
  - Ancillary data attached to vouchered specimens

MacFadden & Guralnick 2016 *Paleobiology* DOI: http://dx.doi.org/10.1017/pab.2016.42

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Equus: Initial exploration and metaresearch

- Question I wanted to answer:

What was the extinction geography of *Equus* since the Last Glacial Maximum?

Available databases did not have sufficient age data

- Then became a "metaresearch" analysis:

The scientific examination of how research is designed, carried out, and communicated (Kousta et al. 2016)

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Which big database is optimal?

- Depends upon
  - Taxon or taxa studied
  - Question to be asked
  - Chronological precision required

- Use case example
  - *Equus*, fossil and extant
  - Late Pleistocene extinction geography

- Perhaps best to integrate multiple databases?

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Big biodiversity databases

- Over past decade number has grown
- Goal: aggregate big data to ask novel questions
- Six were investigated here--

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The Paleobiology Database
revealing the history of life

GBIF
Global Biodiversity
Information Facility

VertNet

Neotoma Paleoecology Database

USGS
science for a changing world
Biodiversity Information Serving Our Nation (BISON)

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- Three were most useful for this study

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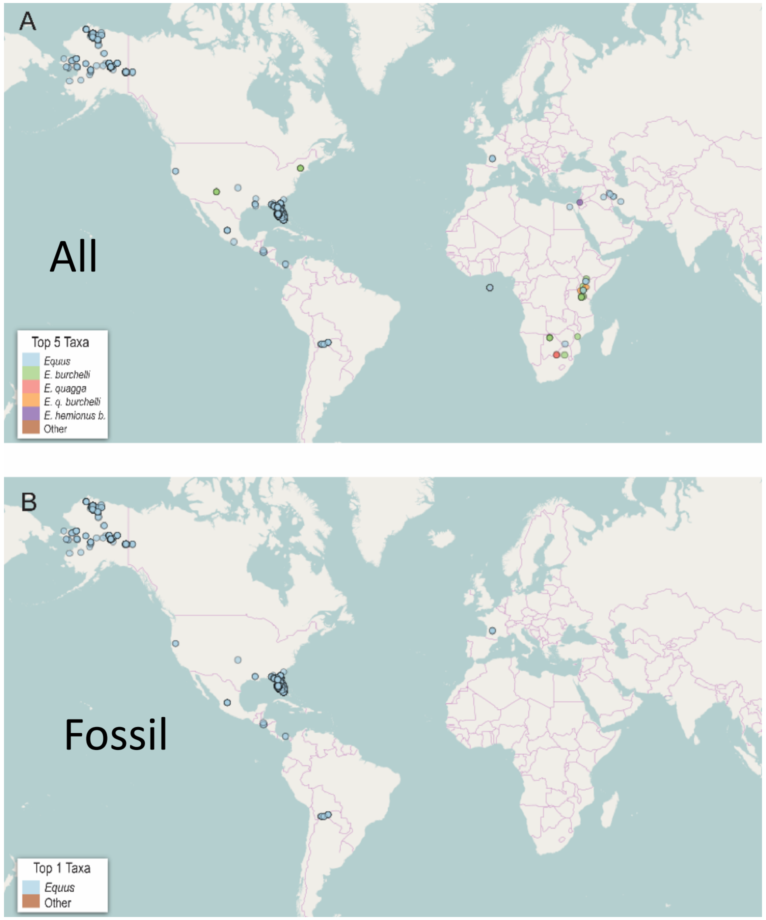
iDigBio (Integrated Digitized Biocollections)



- 64.6 million records
- vouchered specimens
- 22.4 K *Equus* records; 21.9 K fossil
- Concentrated (e.g., Alaska, Florida)
- Primary coverage North America

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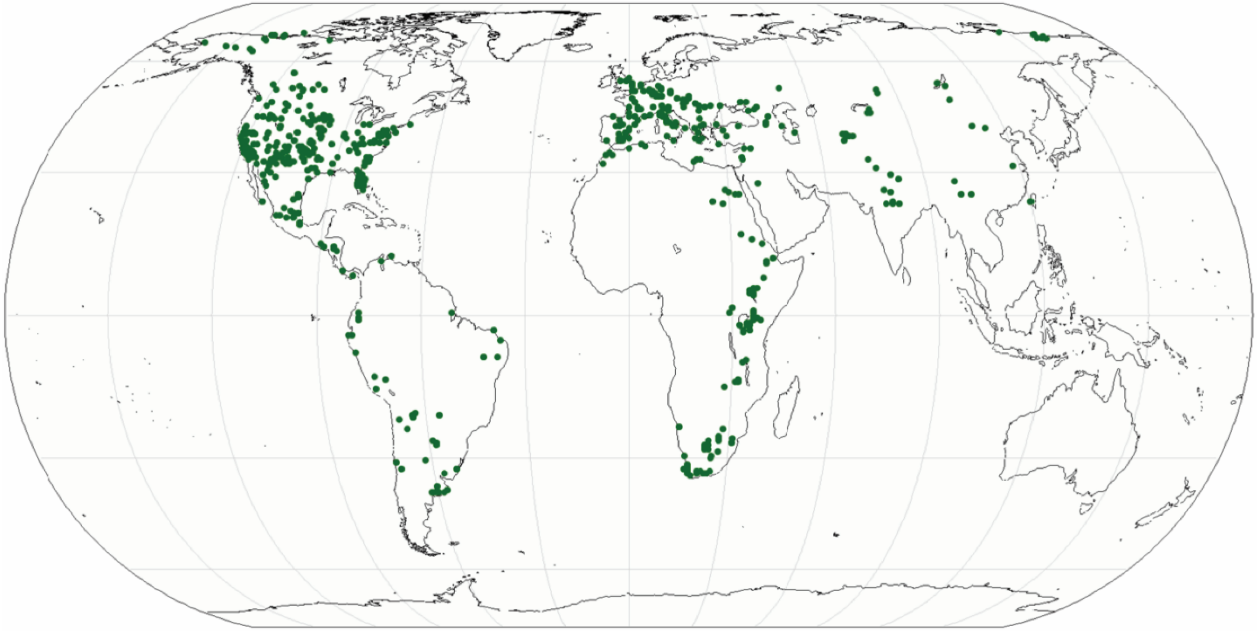
Paleobiology Database (PBDB)



- 1.3 million occurrence records; not directly vouchered specimens
- 1.6 K fossil records for *Equus*
- More global coverage
- Age data not sufficiently binned for late Pleistocene

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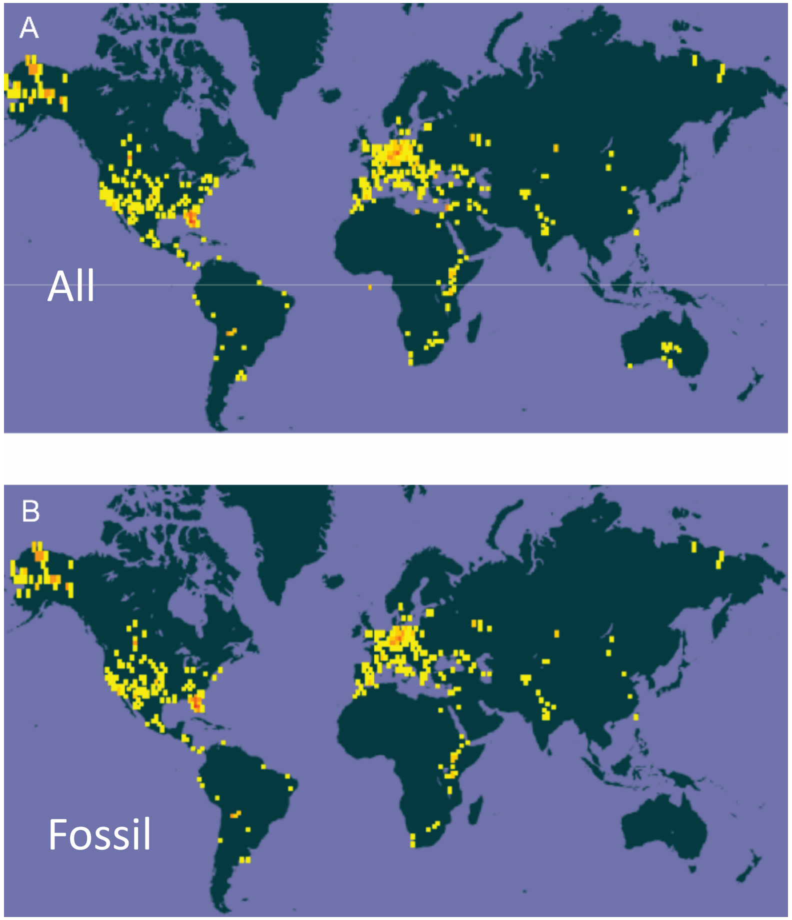
GBIF (Global Biodiversity Information Facility)



- 642 million total location data from > 400 data providers
- Vouchered and non-vouchered observations
- 44.5 K *Equus* records, including 42.4 fossil
- Broader coverage than iDigBio
- Age data still problematical

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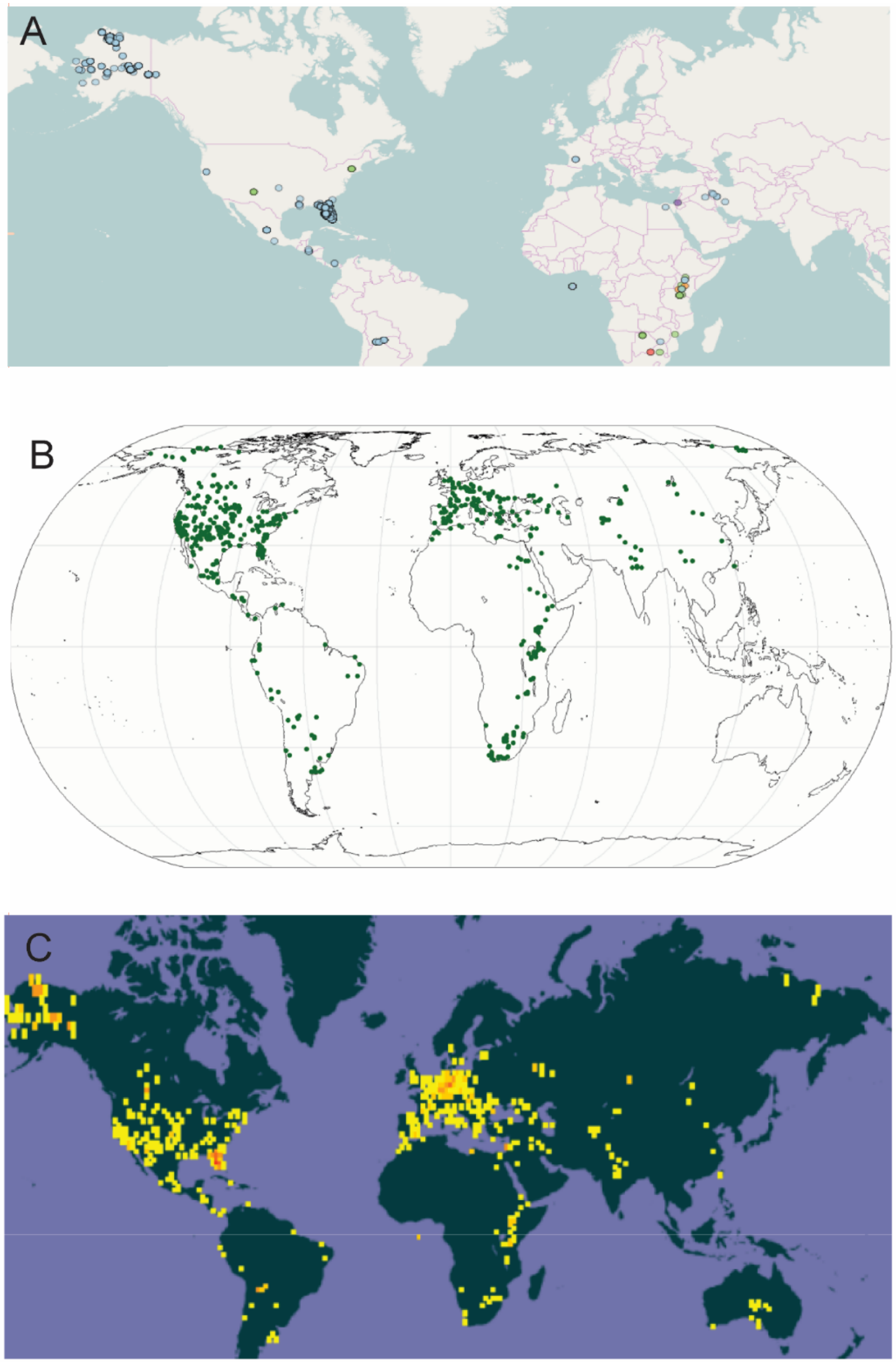

Summary Comparison

- All databases yielded 124 K *Equus* records; 116 K fossil
- Massive amounts of data
- iDigBio—vouchered specimen records, DarwinCore standards
- PBDB—relatively good (fossil) coverage despite only 1.6 K *Equus* records
- GBIF—Most complete fossil and extant coverage for *Equus;* mixed records perhaps problematic.

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Database integration

- Optimal scenario would be to simultaneous mine data from all relevant databases.
- But, current problem is that data semantics and standards are not universal across platforms.
- For example, ‘occurrence’ in PBDB equals DarwinCore ‘location’ in iDigBio and GBIF.
- These need to be made equivalent.

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iDigBio
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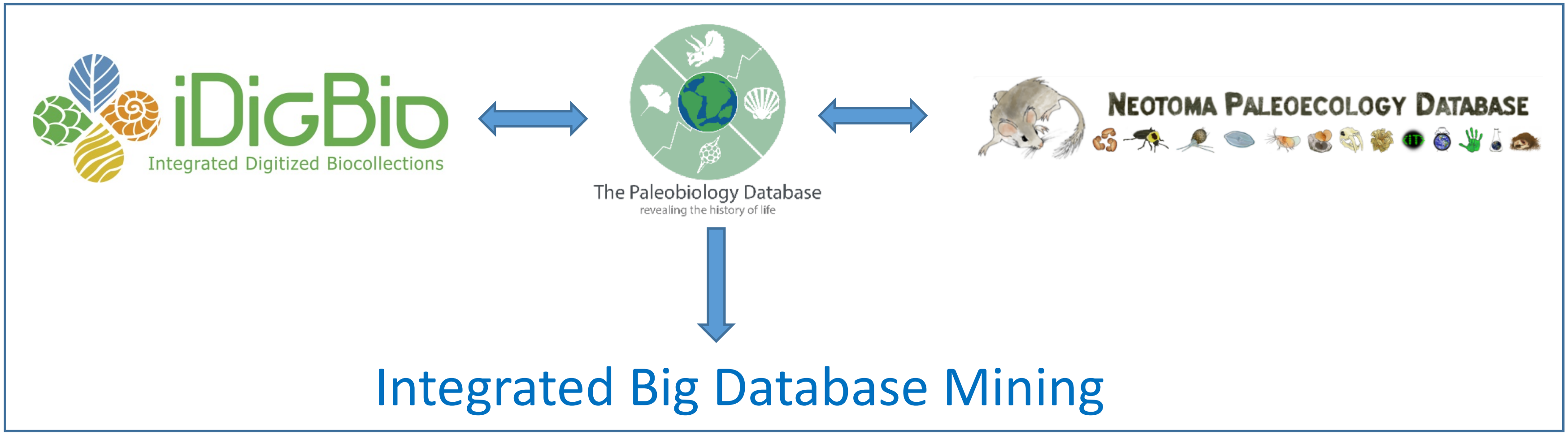
Which database is optimal?

- Depends upon the question being asked
- Perhaps a better approach would be to integrate multiple relevant databases.
- ePANDDA is currently doing this.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Integrated Big Database Mining

Holy grail—integrated age data

To study extinction geography of *Equus*—

- Big biodiversity databases need to integrate precise and binned chronological data.
- Neotoma currently has the lead in this regard, although with only a few hundred relevant records.
- The big advances in paleo will come once this is done; or other research is envisioned that does not require precise chronology (e.g., distributions).

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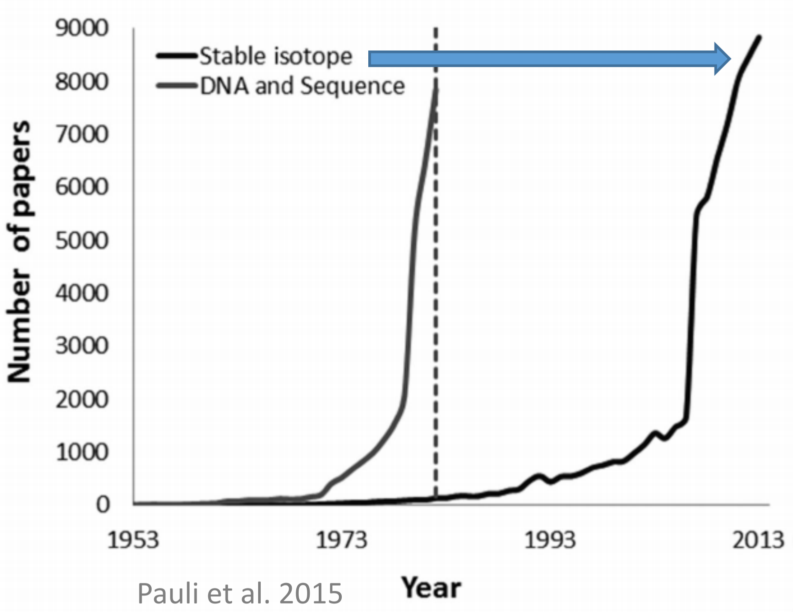
Leveraging big data: ancillary fields

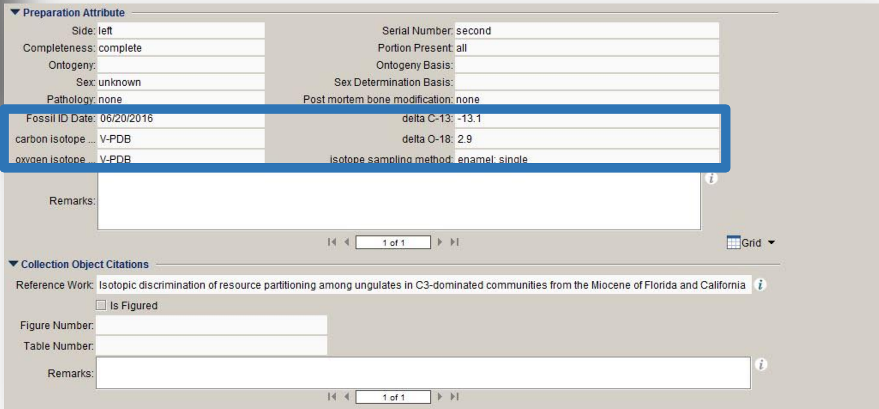


Pauli et al. 2015

Specify

ISOBANK

Our insertion of isotope data fields



Preparation Attribute

Side:	left	Serial Number:	second
Completeness:	complete	Portion Present:	all
Ontogeny:		Ontogeny Basis:	
Sex:	unknown	Sex Determination Basis:	
Pathology:	none	Post mortem bone modification:	none
Fossil ID Date:	06/20/2016	delta C-13:	-13.1
carbon isotope ...	V-PDB	delta O-18:	2.9
oxygen isotope ...	V-PDB	isotope sampling method:	enamel; single
Remarks:			

Collection Object Citations

Reference Work: Isotopic discrimination of resource partitioning among ungulates in C3-dominated communities from the Miocene of Florida and California

□ Is Figured

Figure Number:

Table Number:

Remarks:

Moran et al. 2016. GSA Annual Meeting talk, Denver

Concluding comments

- Big biodiversity databases in paleontology
    - Massive amounts of data (*Equus* use case 124 K records)
    - **Potential** to answer new questions
- *Equus* paleo(geographic) data are dense, but biased towards N America.
- Ancillary data fields will greatly increase utility
- “Big data” Museum bioinformatics will advance with
    - More precise age data
    - Standards integration (Darwin Core), ePANDDA, etc.