Berkeley Initiative in Global Change Biology

Rescuing and Integrating Biological and Environmental Data in the Face of Global Change

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Director, University California Museum of Paleontology
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GORDON AND BETTY MOORE FOUNDATION
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ciee California Institute for Energy and Environment
CALIFORNIA ENERGY COMMISSION
NSF
ALFRED P. SLOAN FOUNDATION 1934
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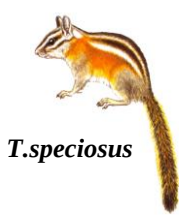
Aggregators & Applications

- iDigBio
- Senckenberg (‘World of Biodiversity’)
- Atlas of Living Australia
- Ecoengine
- GBIF
- Encyclopedia of Life
- Map of Life
- Morphbank
- GEO-BON
- GLOBIS-B
- Natureserve
- IUCN
- IPBES
- Neotoma
- iNaturalist
- eBird
- DataONE
- Open tree of life
- Biodiversity heritage library
- Pensoft (Zookeys, Phytokeys)
- Genbank
- Genomic Observatories Network
- Barcode of Life
- GeoPhyloBuilder
- iPhylo

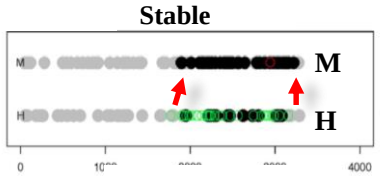
“Skinomics”: applying genomic tools to museum specimens to understand genomic response to climate change

Ke Bi, Tyler Linderoth, Dan Vanderpool, Rasmus Nielsen, Jeffrey M. Good, Craig Moritz

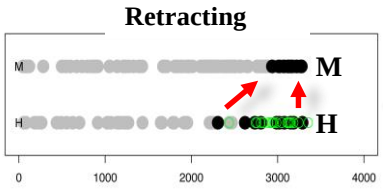
Study system



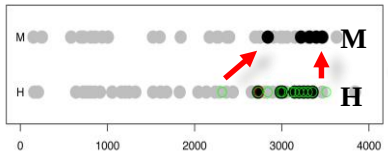
T.speciosus



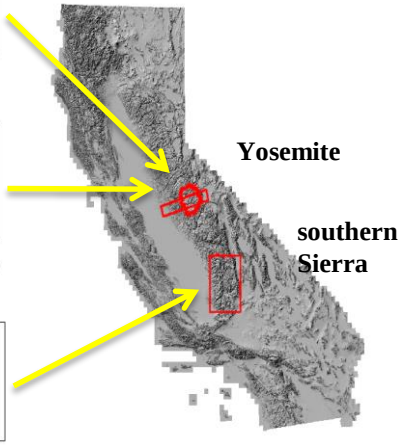
T. alpinus



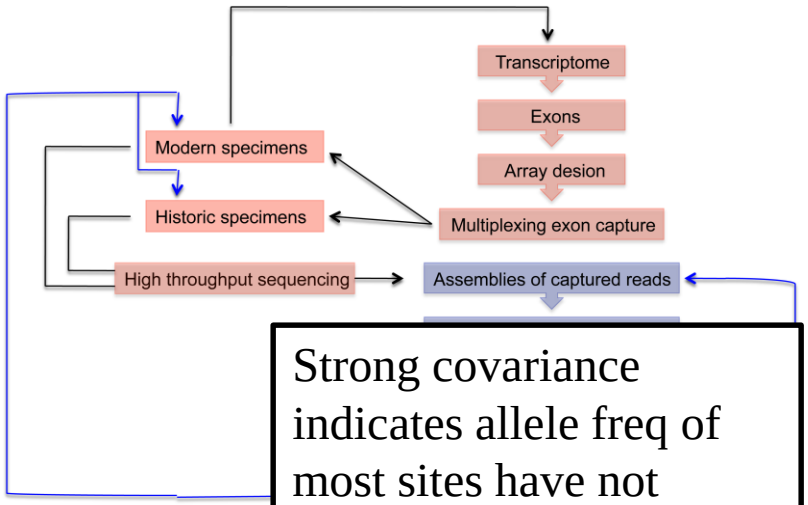
T. alpinus



M: Modern (2003-)
H: Historic (1915)



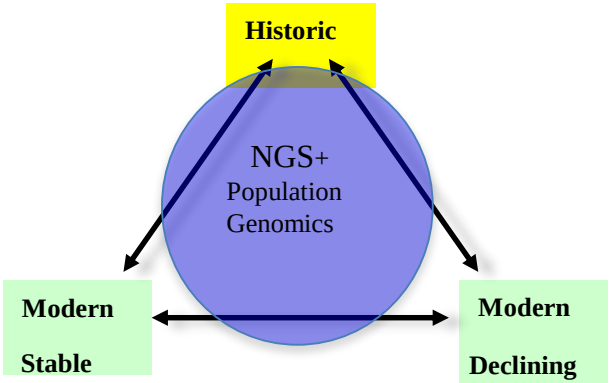
Pipelines



Transcriptome enabled exon capture

Strong covariance indicates allele freq of most sites have not changed. Sites showing freq differences may indicate selection.

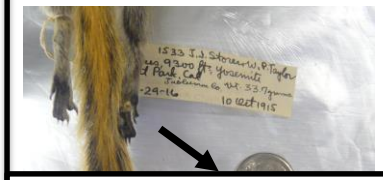
Strategy

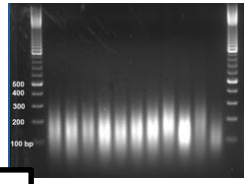


Genetic signatures of selection?

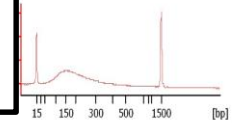
NO **YES**

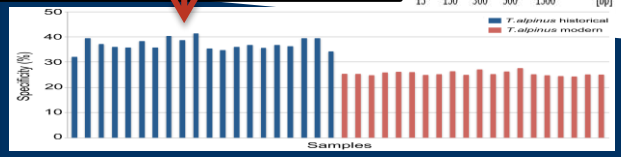
DNA & Sequencing

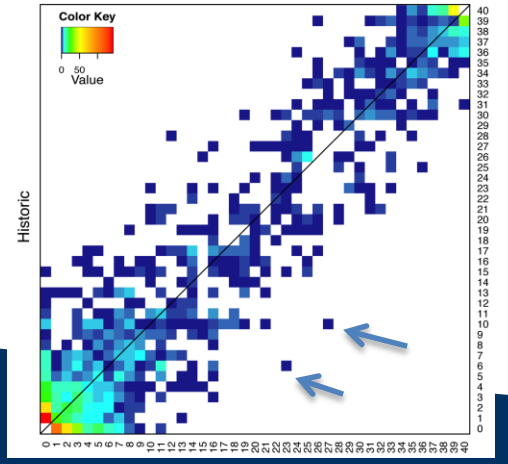




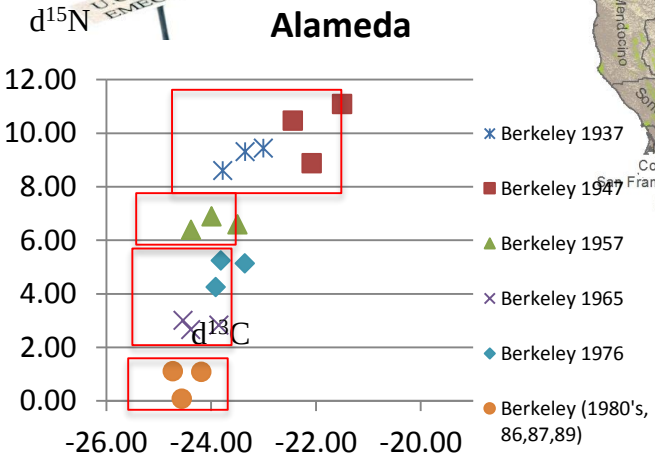
exon capture efficiency in historic samples higher than in modern samples.

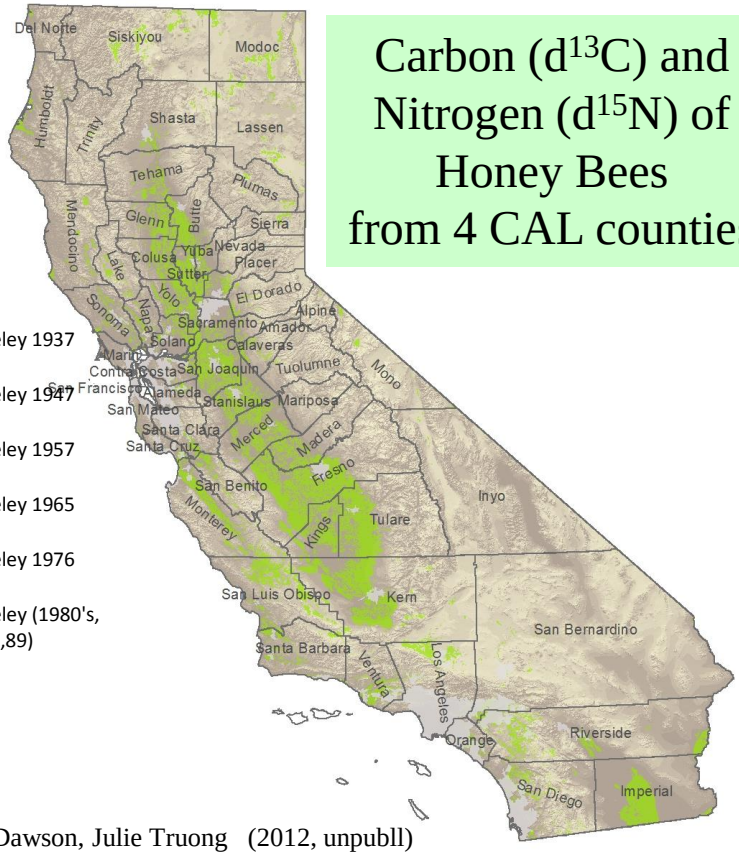






Genomics, isotopes and pollen: California bees





Carbon ($d^{13}C$) and Nitrogen ($d^{15}N$) of Honey Bees from 4 CAL counties

T. Dawson, Julie Truong (2012, unpubll)

Analysis of historical collections to document how honey bees, native bees, plants, and pollination activities have changed over the last ~100 years in response to urbanization, agricultural land conversion, etc.

Neil Tsutsui

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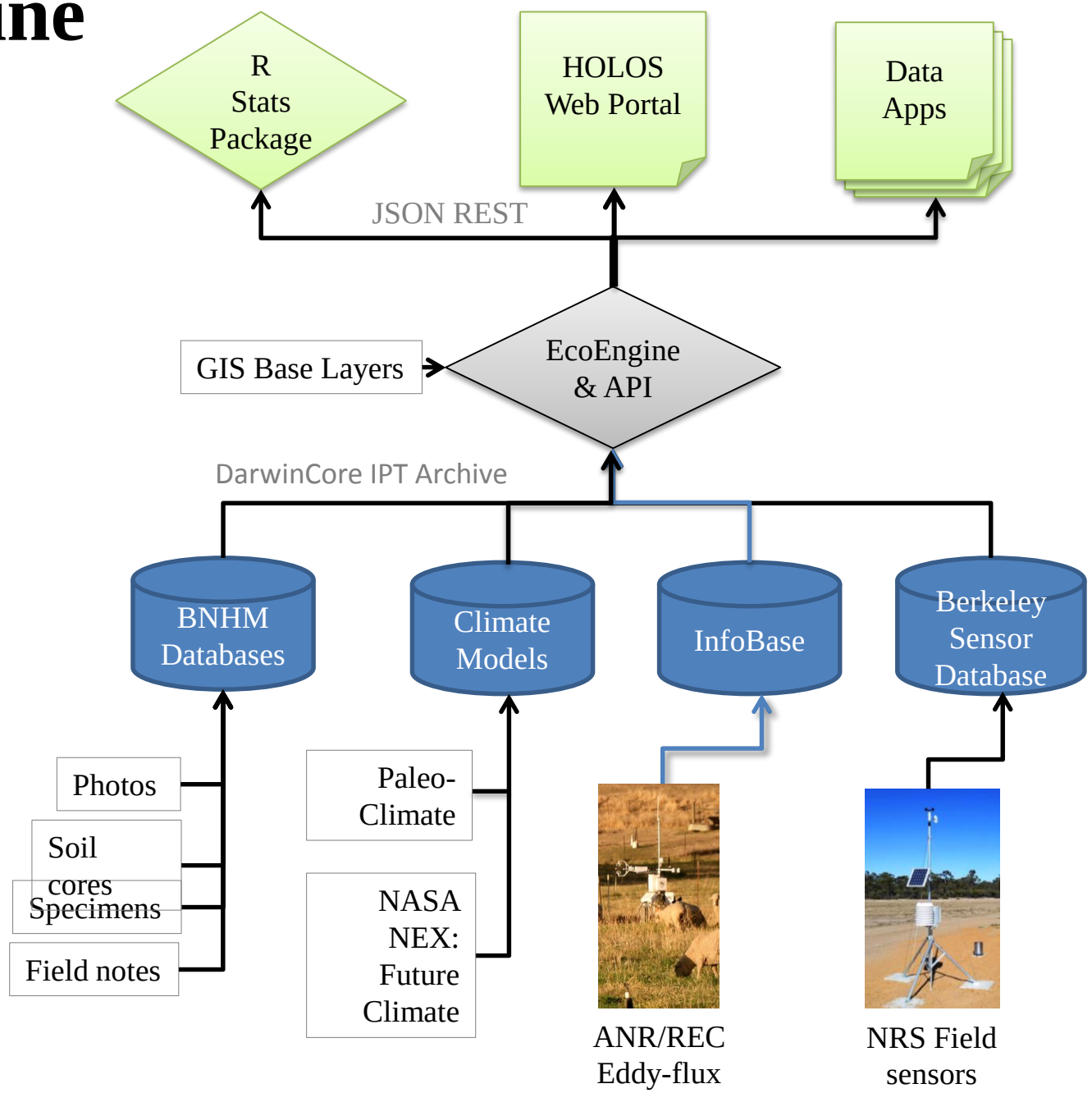
Ecoengine

User Interfaces

Web Services

Databases

Source Data



Ecoengine

Interoperability and Documentation

- Set out to develop an API serving heterogeneous data. Focused on **interoperability**
- Required many decisions, e.g.
  - how to transcribe field names,
  - what fields to include,
  - how to deal with obviously erroneous or incomplete records, exclude rarely used fields,
  - normalization or de-normalization of fields, etc.

Ecoengine

The Ecoengine is an implementation of a **REST*ful API§**.

- Machine-readable web-based representation of data resources using the functionality of HTTP protocol.
- **Simplicity, interoperability are main advantages**.
- API provides well documented, tested, persistent interface for applications to use data resources allowing for data search, aggregation, and extraction.

- * REST - Representational State Transfer
- § API - Application Programming Interface

Ecoengine

Engine vs. Archive

- Ecoengine is a directory and gateway to widely distributed data.
- Stores its own copy of data in order to allow for quicker access, processing, searching, and aggregating.
- First and foremost a tool for scientific data analysis; not an authoritative data archive.

Time and Geographical Place as Unifying Concepts

- Organizing concept of data in the Ecoengine is that events can be identified by occurrence in space & time.

Ecoengine

Data Types

Ecoengine is organized around two major data types:

1. Events - uses a shortened version of GBIF's DarwinCore fields.

2. Multidimensional rasters.

Ecoengine

User Interfaces

R Stats Package

HOLOS Web Portal

Data Apps

JSON REST

Web Services

GIS Base Layers

EcoEngine & API

DarwinCore IPT Archive

Databases

BNHM Databases

Climate Models

InfoBase

Berkeley Sensor Database

Source Data

Photos

Soil cores

Specimens

Field notes

Paleo-Climate

NASA NEX: Future Climate

ANR/REC Eddy-flux

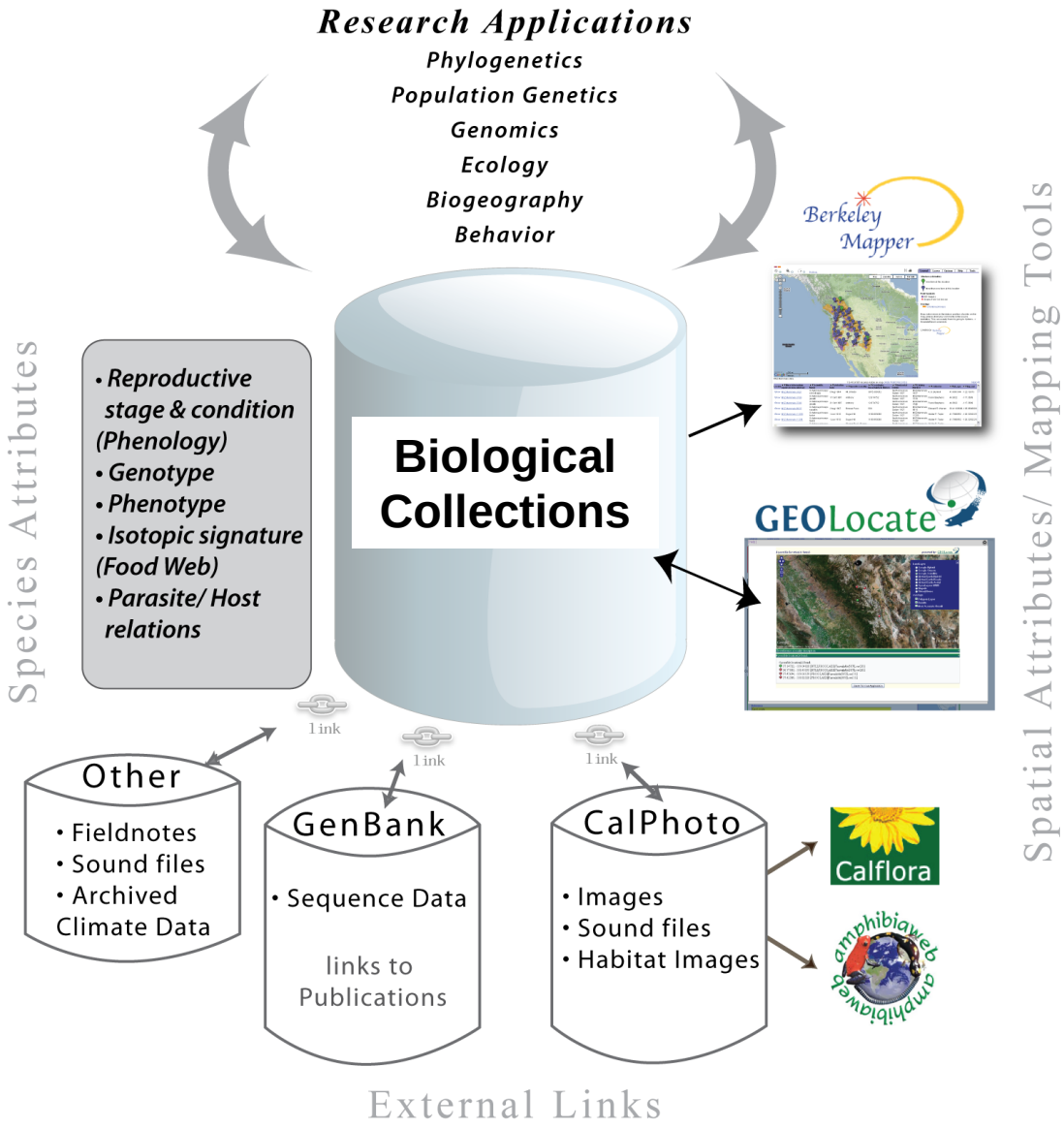
NRS Field sensors

The Museum of Vertebrate Zoology at Berkeley

UC & Jepson Herbaria

University of California Museum of Paleontology

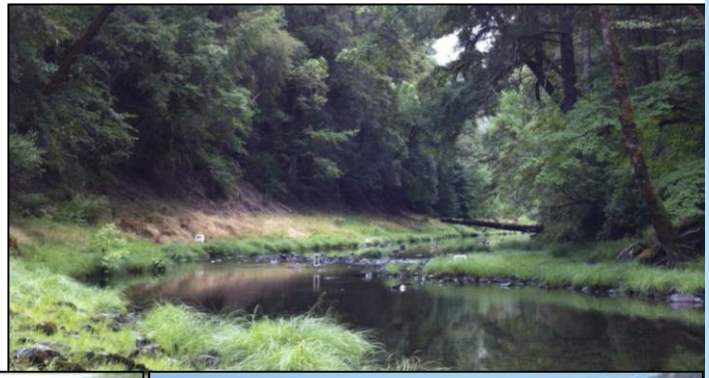
UCMP

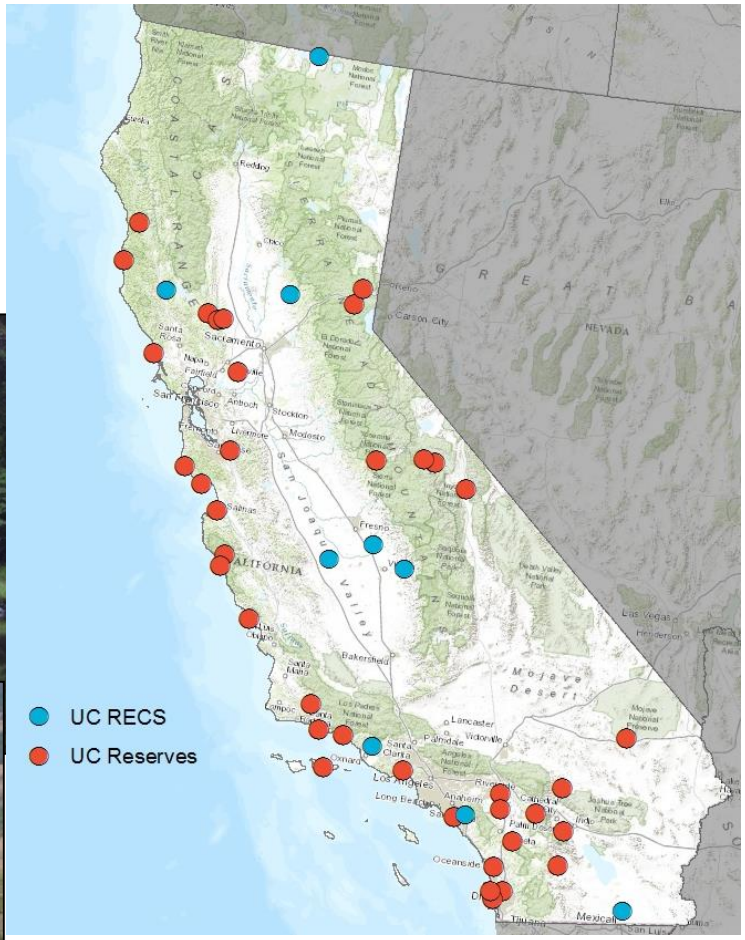

Research Applications
Phylogenetics
Population Genetics
Genomics
Ecology
Biogeography
Behavior
Berkeley Mapper
Biological Collections
GEOLocate
Species Attributes
• Reproductive stage & condition (Phenology)
• Genotype
• Phenotype
• Isotopic signature (Food Web)
• Parasite/ Host relations
Spatial Attributes/ Mapping Tools
1 ink
1 ink
1 ink
Other
• Fieldnotes
• Sound files
• Archived Climate Data
GenBank
• Sequence Data
links to Publications
CalPhoto
• Images
• Sound files
• Habitat Images
Calflora
amphibiaweb
External Links

Field station records

100+ years of data collection

- Field notes
- Species lists
- Photos

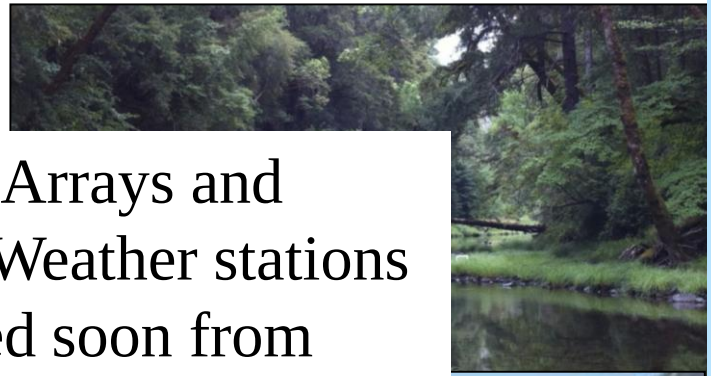




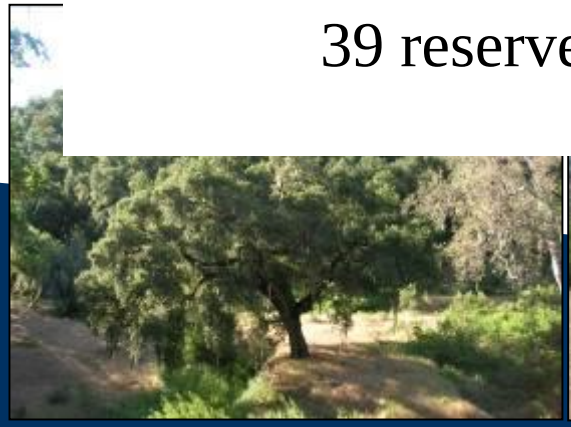
Field station records

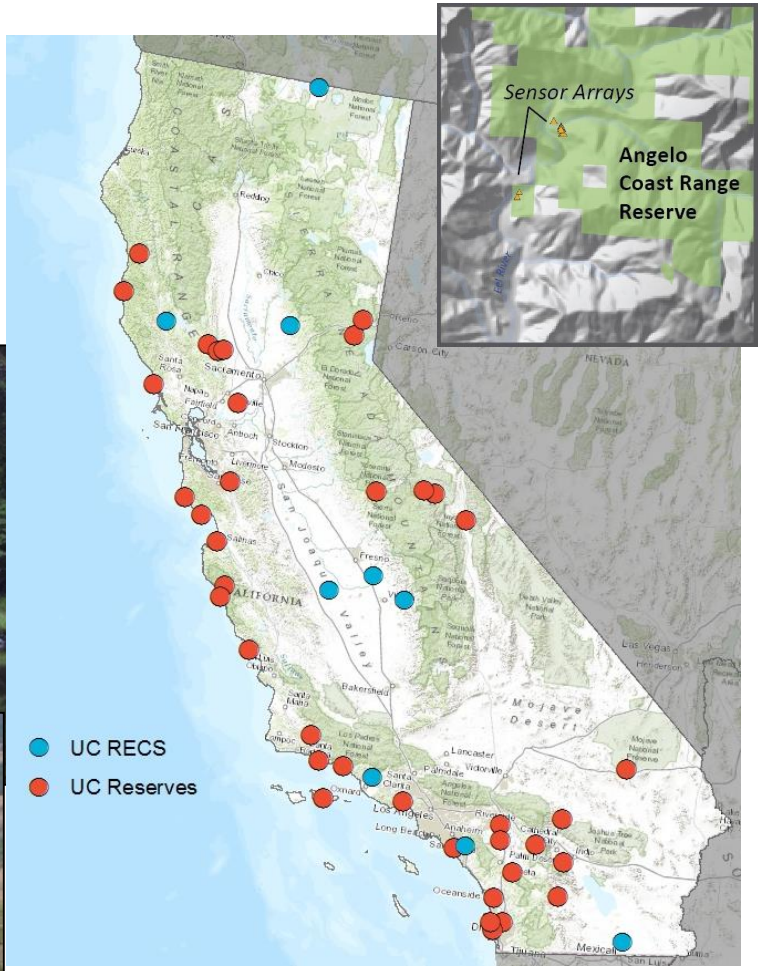
100+ years of data collection

- Field notes
- Species lists
- Photos

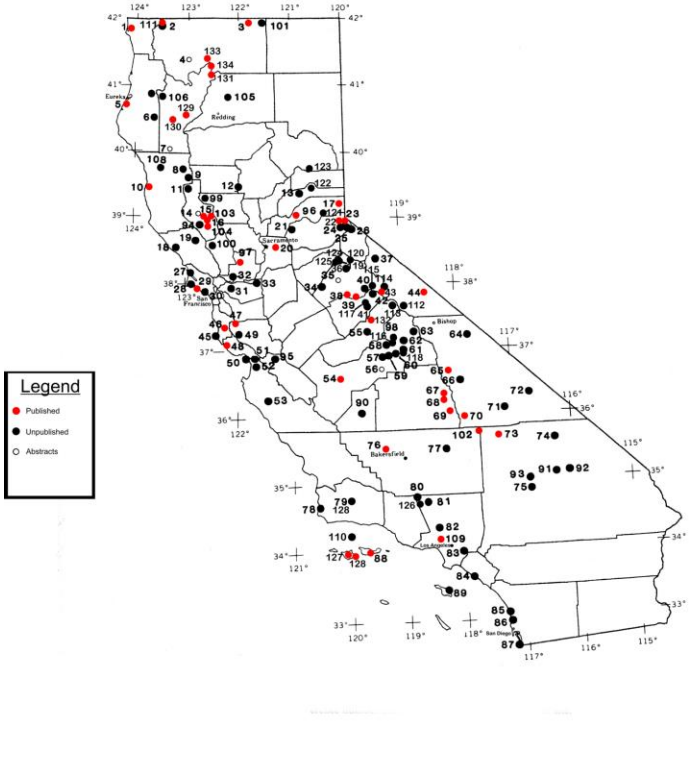


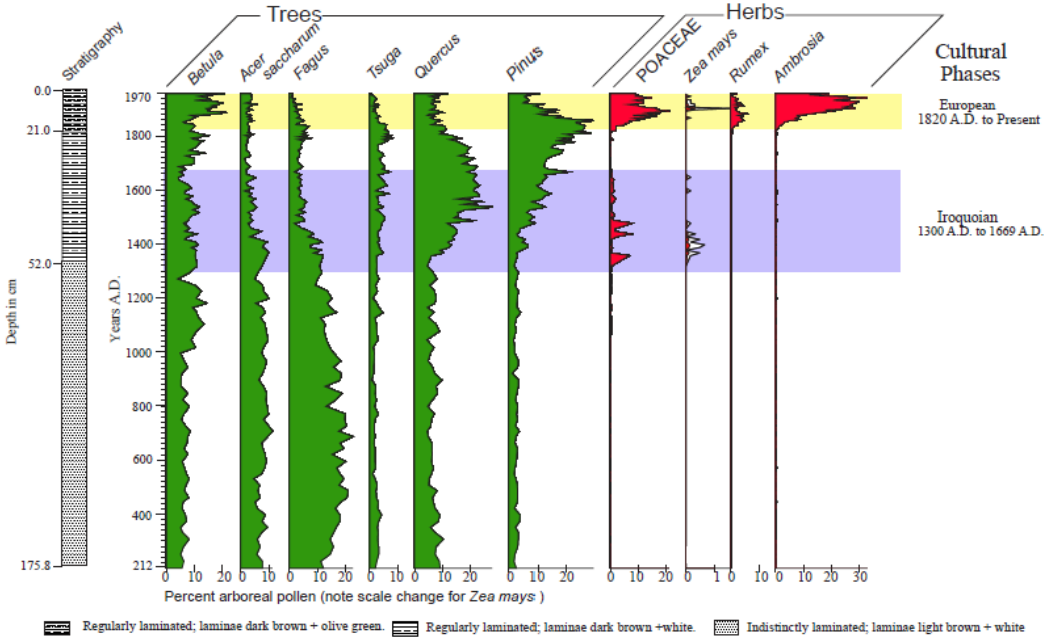
Sensor Arrays and
Networked Weather stations
-streamed soon from
39 reserves





Pollen Cores (history of vegetation)





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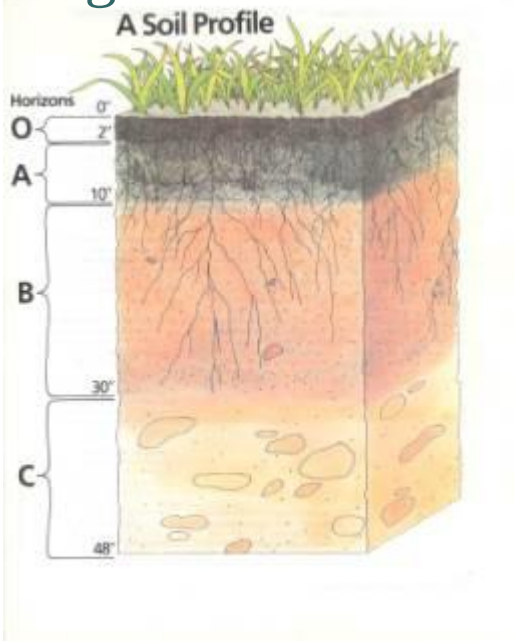
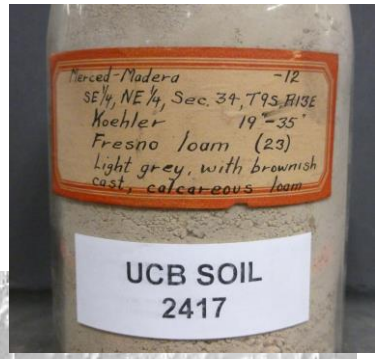
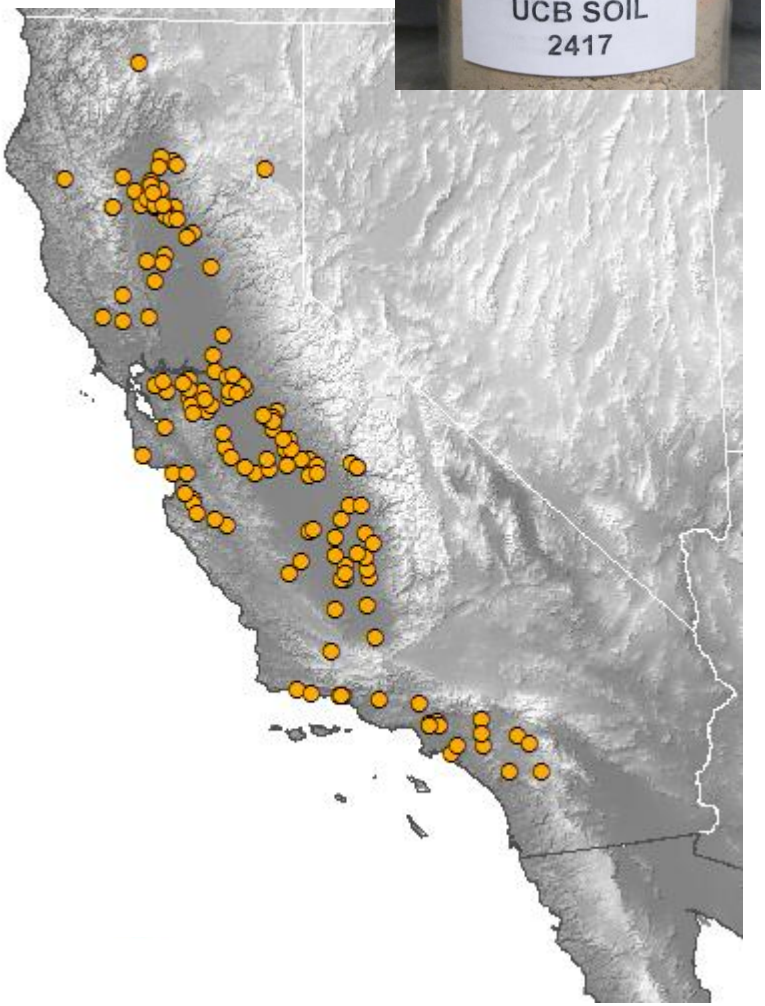
Soils in Jars

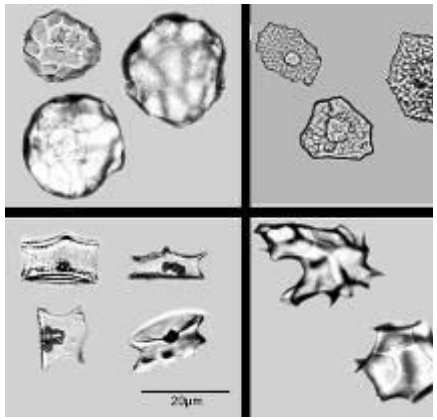
3,000 georeferenced sites (15,000 samples)







Soil phytoliths used to reconstruct vegetation/habitat



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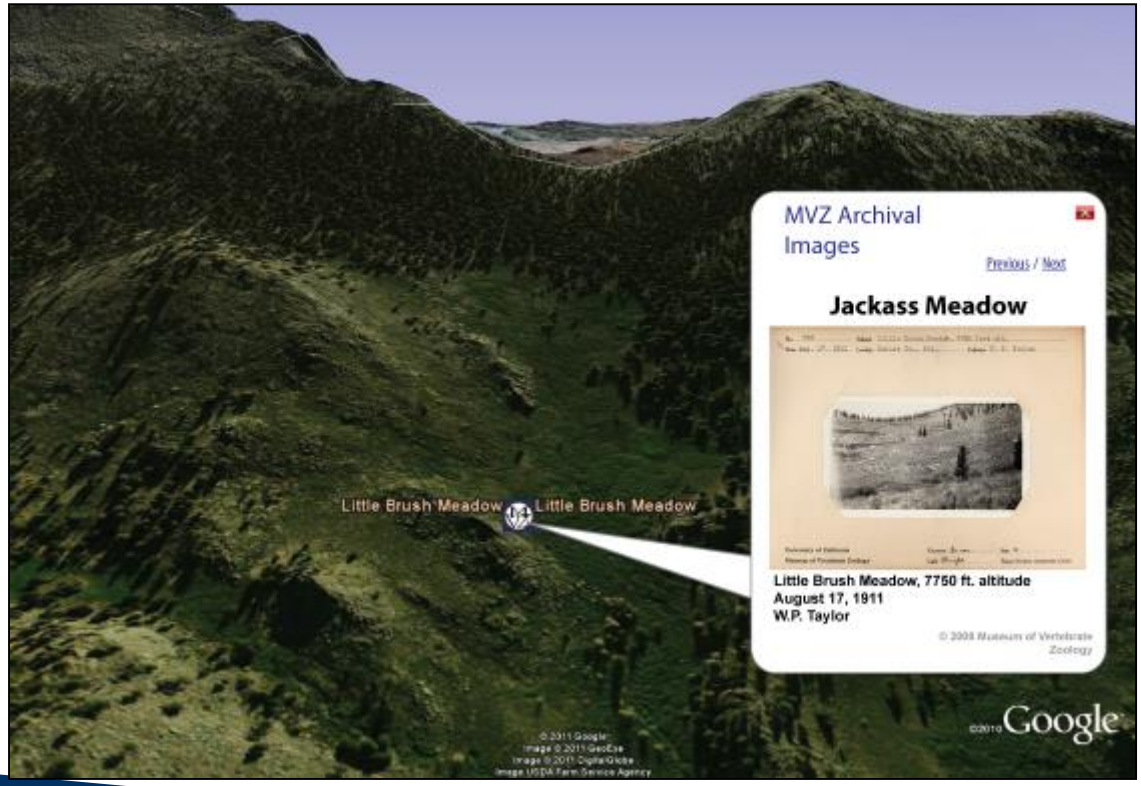
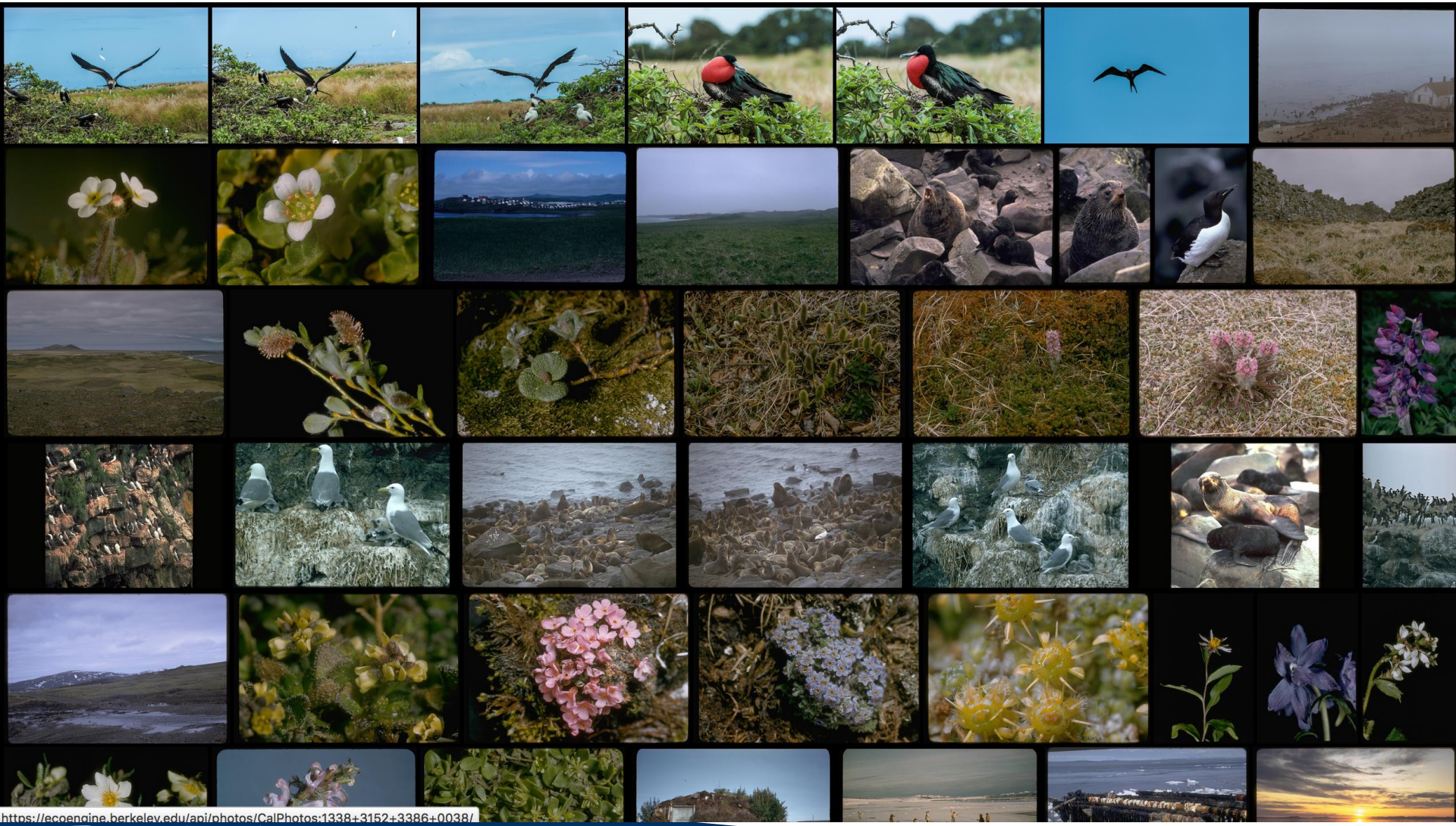
Photographs: CalPhotos

- Largely Californian field areas and taxa (> 300,000 images)
- Richly annotated
- Interoperable with other databases (e.g., Encyclopedia of Life)
- Historic images integrated with museum databases (see right)

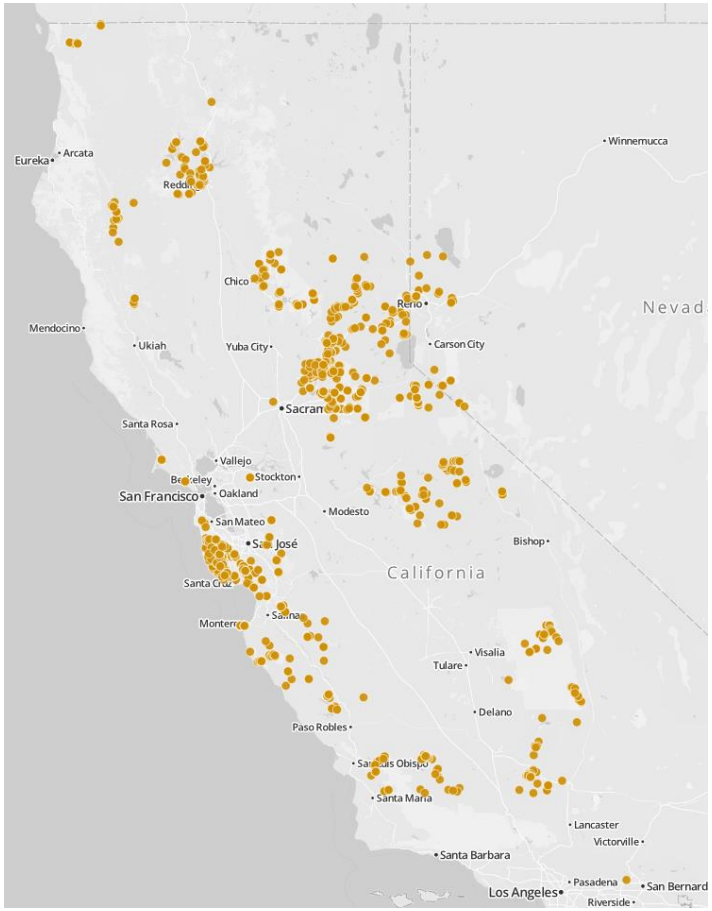


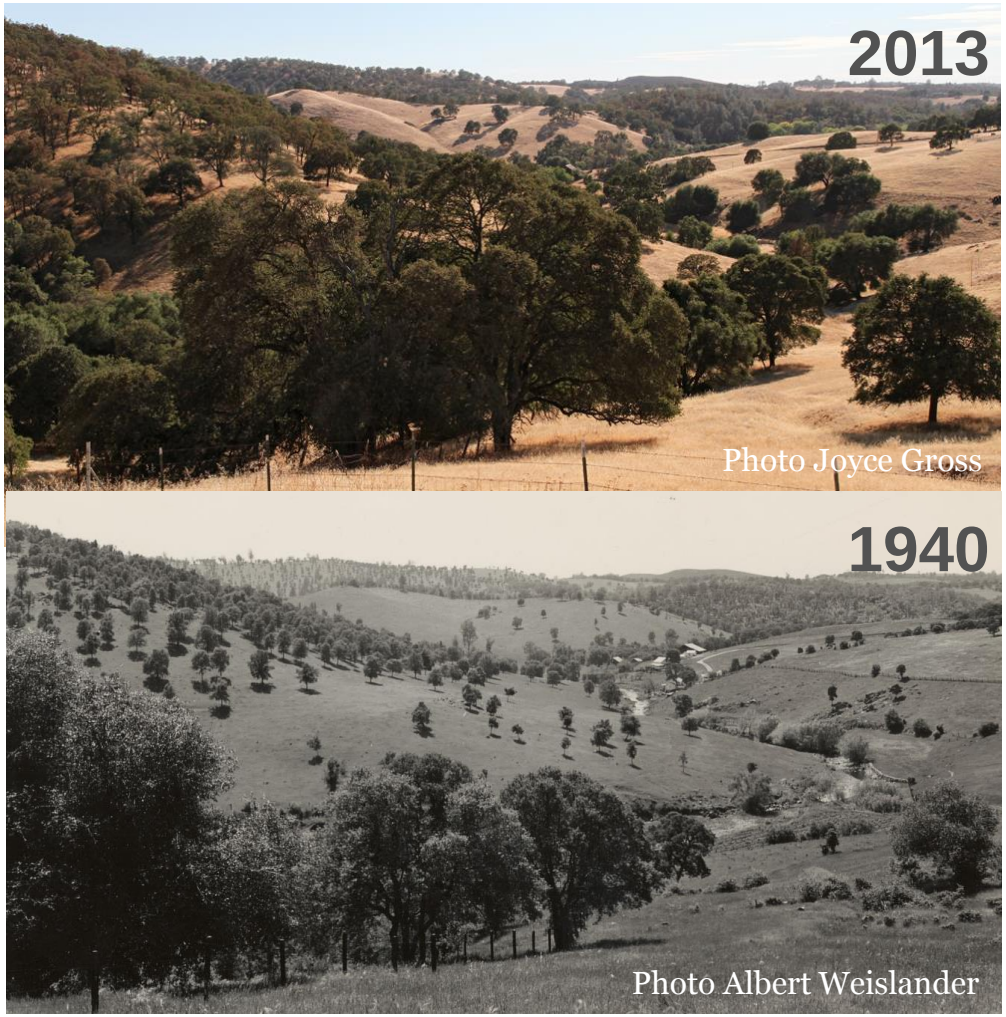
Photographs: CalPhotos



https://ecoengine.berkeley.edu/api/photos/CalPhotos:1338+3152+3386+0038/

Photos - Historical & Recent





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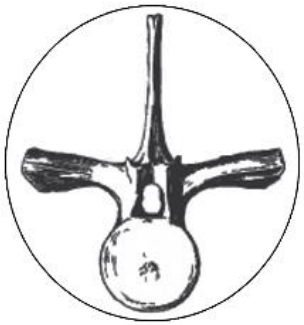
Wieslander Vegetation Map Project (VTM)

Natural Reserve System Field Station Data

Calphotos



VertNet

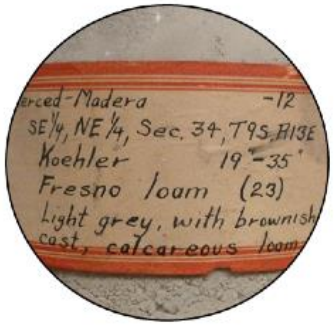
University and Jepson Herbaria

University Museum of Paleontology

Essig Museum of Entomology

Museum of Vertebrate Zoology

Pollen Core Data



Soil Database

Natural Reserve System Environmental Sensor Array

Climate Data

Ecoengine

User Interfaces

R Stats Package

HOLOS Web Portal

Data Apps

JSON REST

Web Services

GIS Base Layers

EcoEngine & API

DarwinCore IPT Archive

Databases

BNHM Databases

Climate Models

InfoBase

Berkeley Sensor Database

Source Data

Photos

Soil cores

Specimens

Field notes

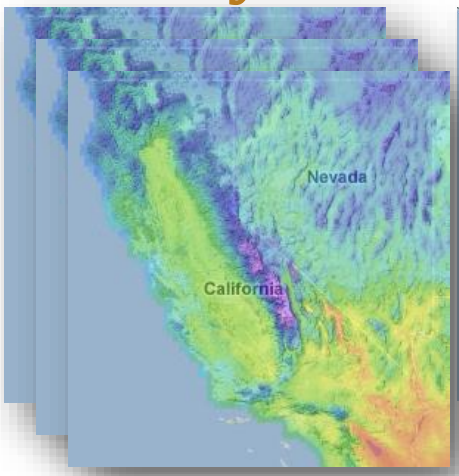
Paleo-Climate

NASA NEX: Future Climate

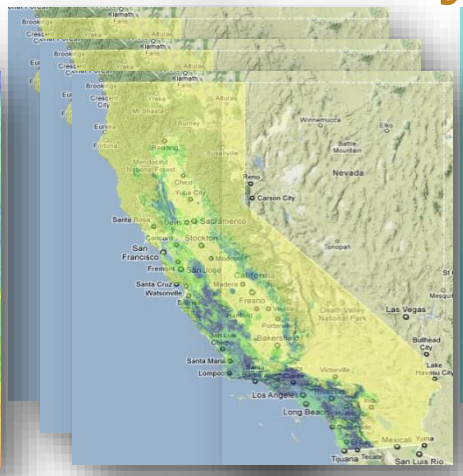
ANR/REC Eddy-flux

NRS Field sensors

Publicly available data layers



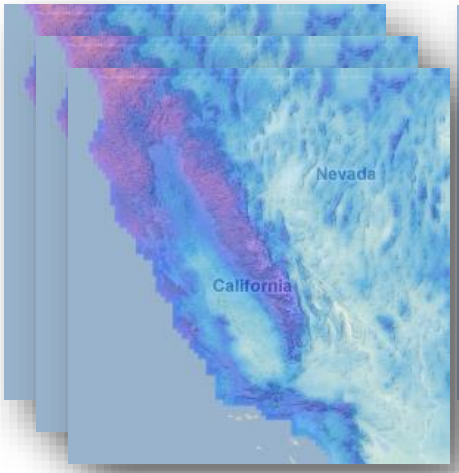
Temperature (max, min, mean)
Past, Present, Projected Future



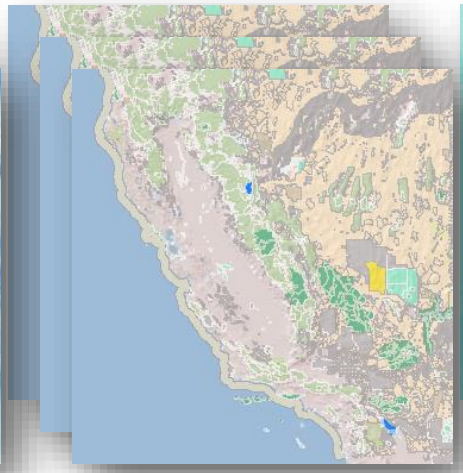
Species Distributions
Past, Present, Projected Future

Land Cover

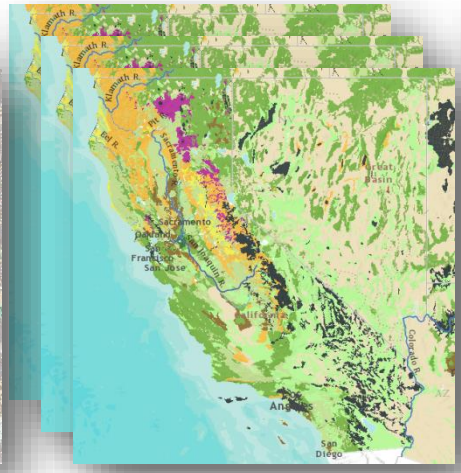
Topography



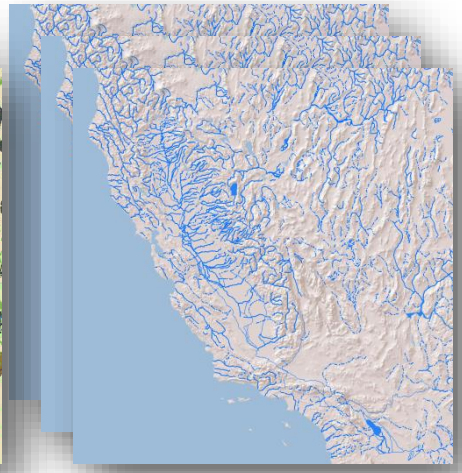
Precipitation
Past, Present, Projected Future



Land Use
Private, Public, and Protected



Soils



Hydrology

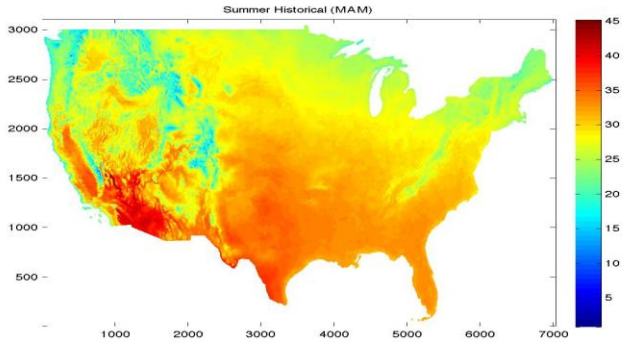
Paleo Climate Models

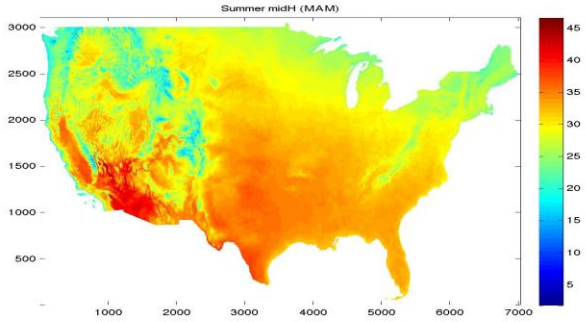
Downscaled Paleoclimate Models

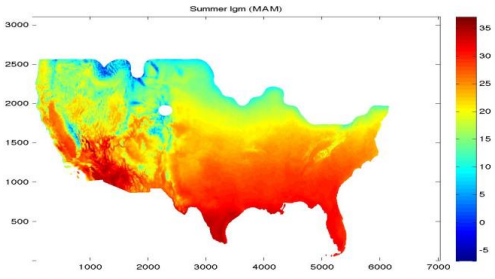
Now-ish

Mid-Holocene
(6,000 yr BP)

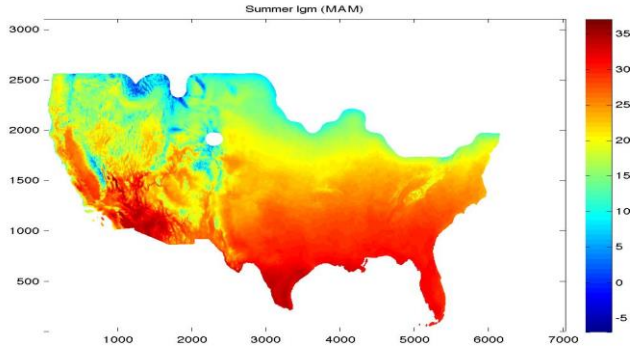
Last Glacial Max.
(21,000 yr BP)

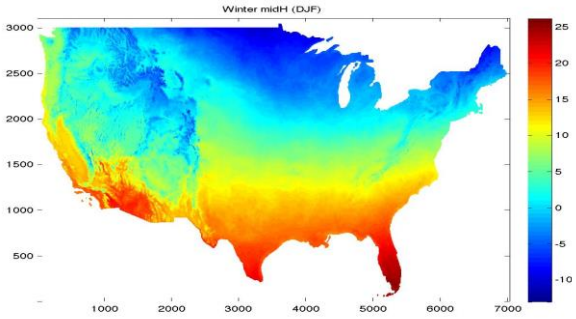


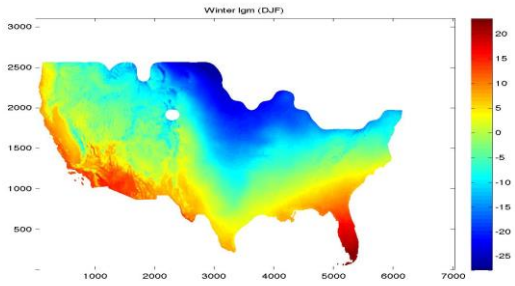




Summer







Winter

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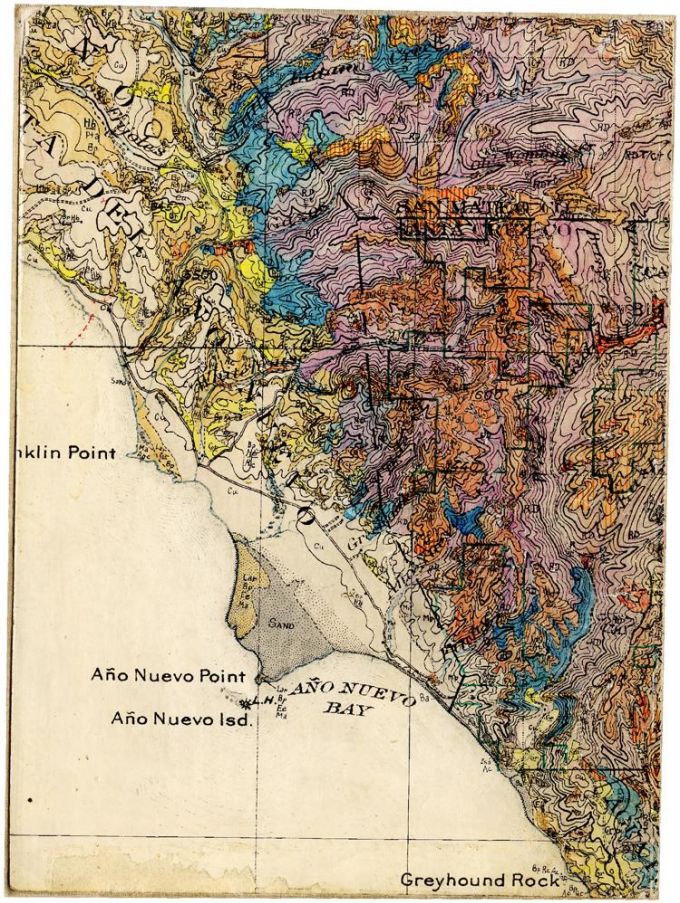
Wieslander Vegetation Survey 1928-1942



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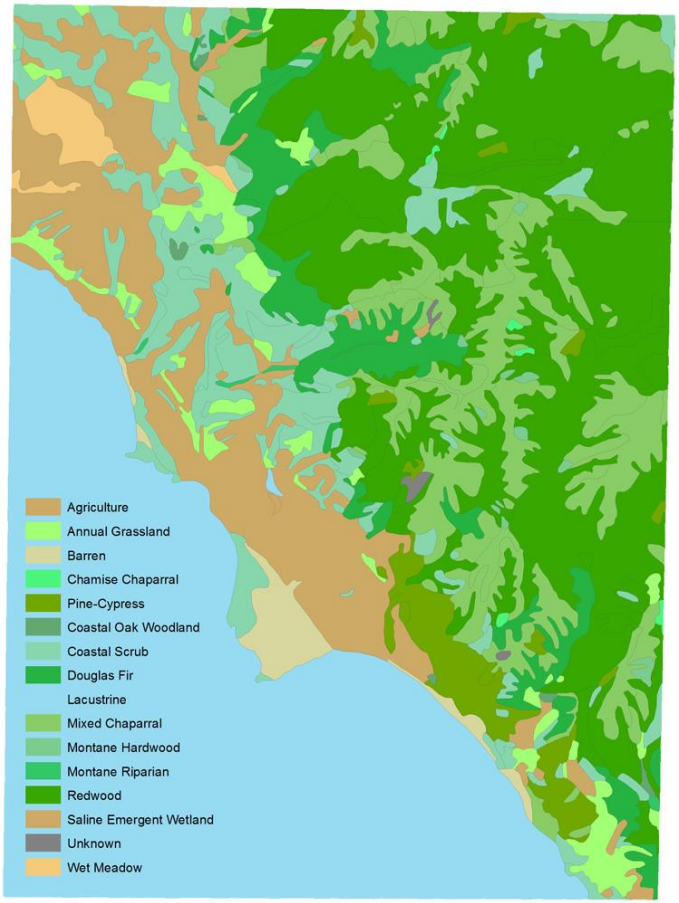
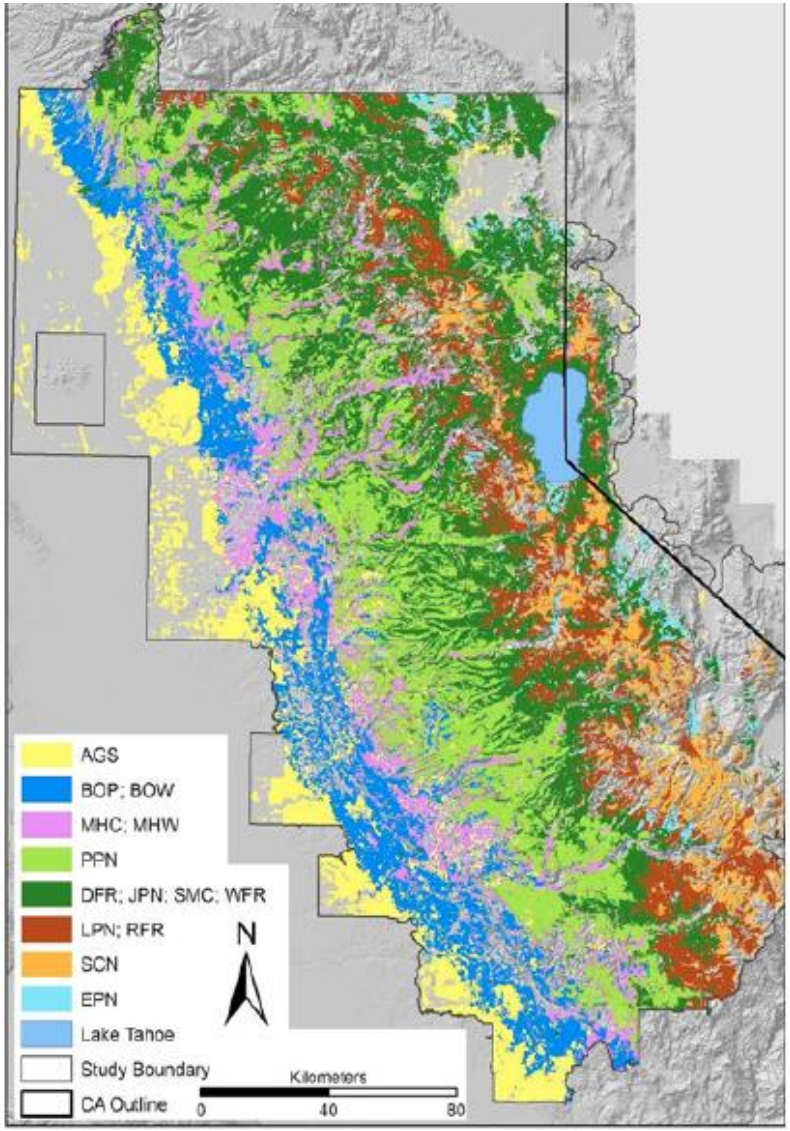
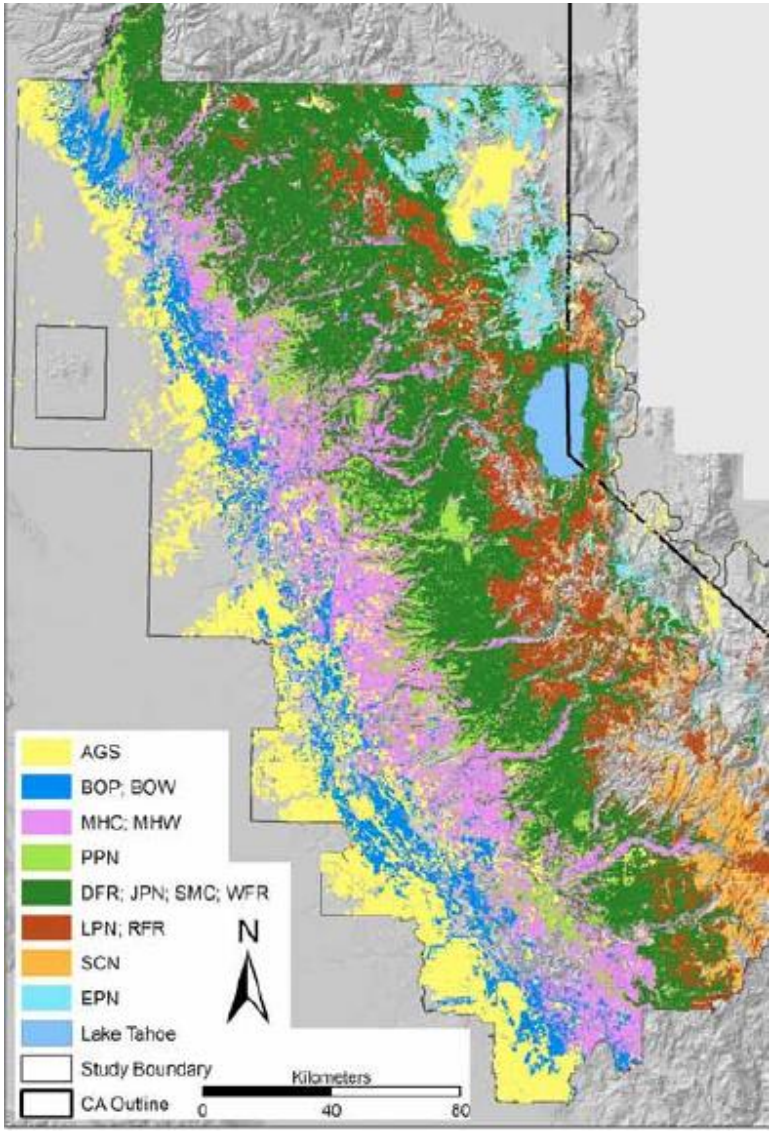
Wieslander Vegetation Survey 1928-1942

- All datasets fully digital and **unified to make new science possible**





Historic



Modern

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Thorne (2009) *Madroño*

Ecoengine

User Interfaces

R Stats Package

HOLOS Web Portal

Data Apps

JSON REST

Web Services

GIS Base Layers

EcoEngine & API

DarwinCore IPT Archive

Databases

BNHM Databases

Climate Models

InfoBase

Berkeley Sensor Database

Source Data

Photos

Soil cores

Specimens

Field notes

Paleo-Climate

NASA NEX: Future Climate

ANR/REC Eddy-flux

NRS Field sensors

To return to the Explore tool at any time, click the Holos icon.

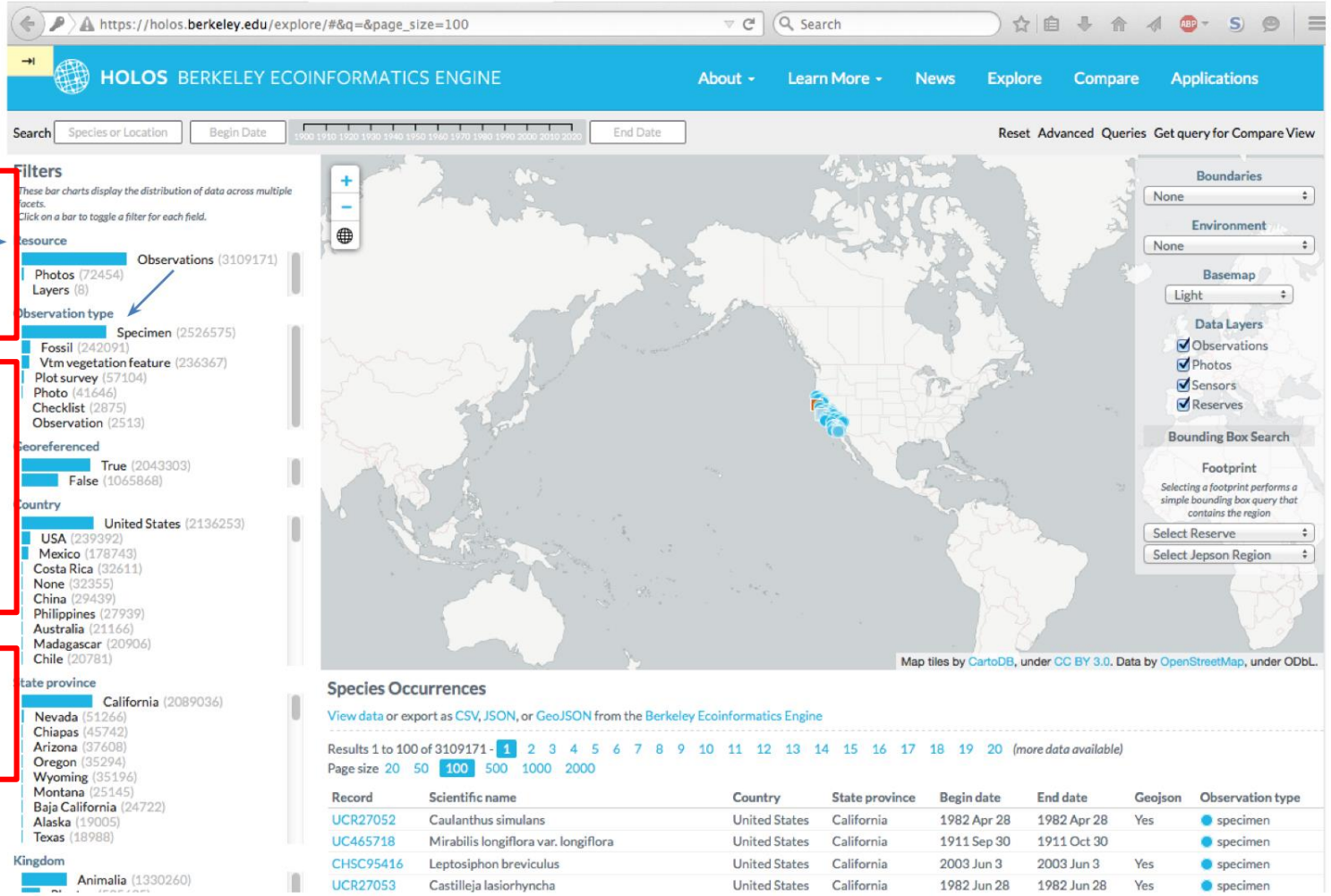
Explorer Interface: Resources

The majority of records are species occurrences, labeled Observations

Resources are divided into **Observations**, **Photos** and **Layers**.

The **Observations** are the majority of the data records in the Ecoengine. Under **Resources**, there are **Observation Types**.

The **Photos** are mostly from Calphotos.

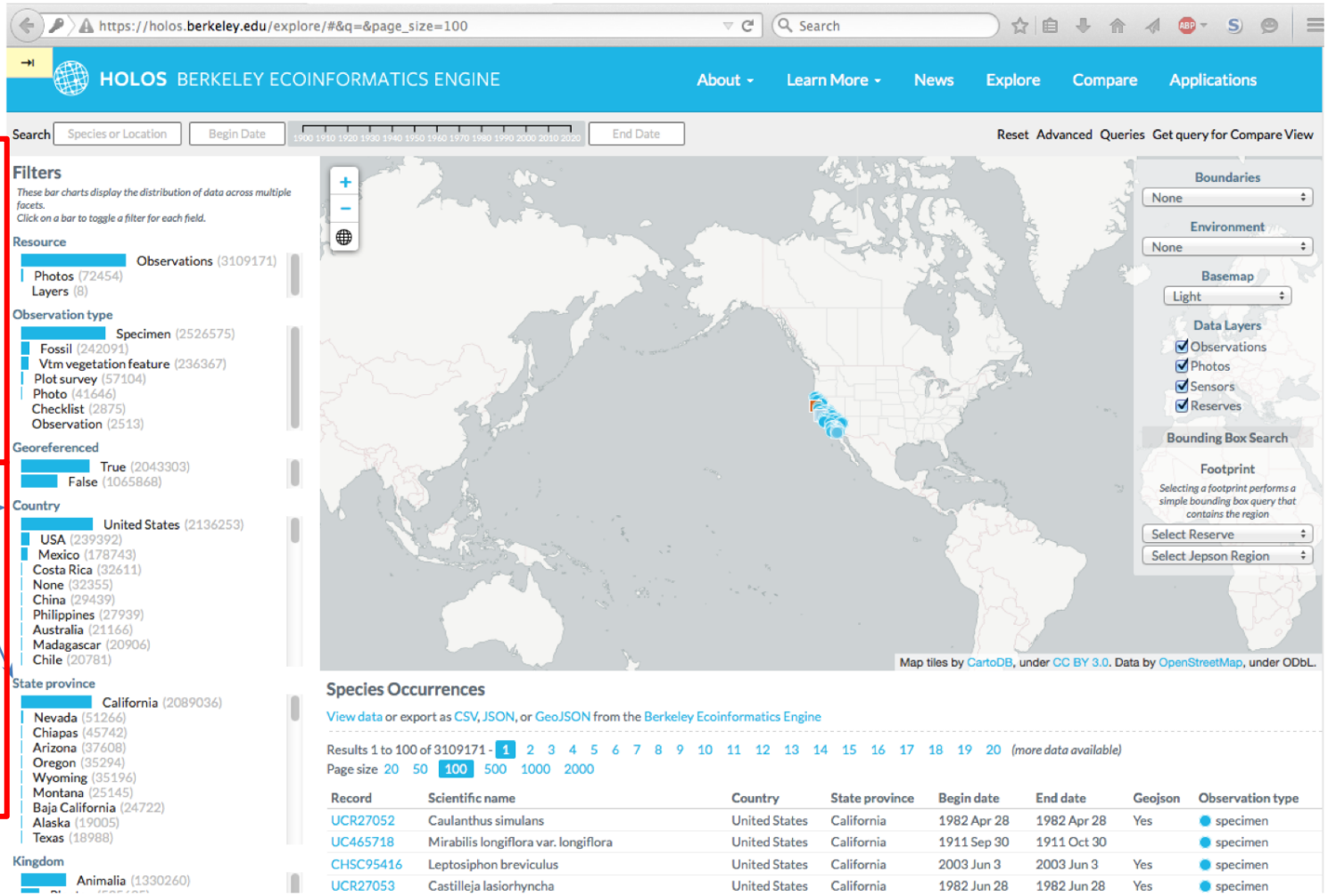


Filters: Geographic

Georeferenced = True indicates data that have latitude and longitude.

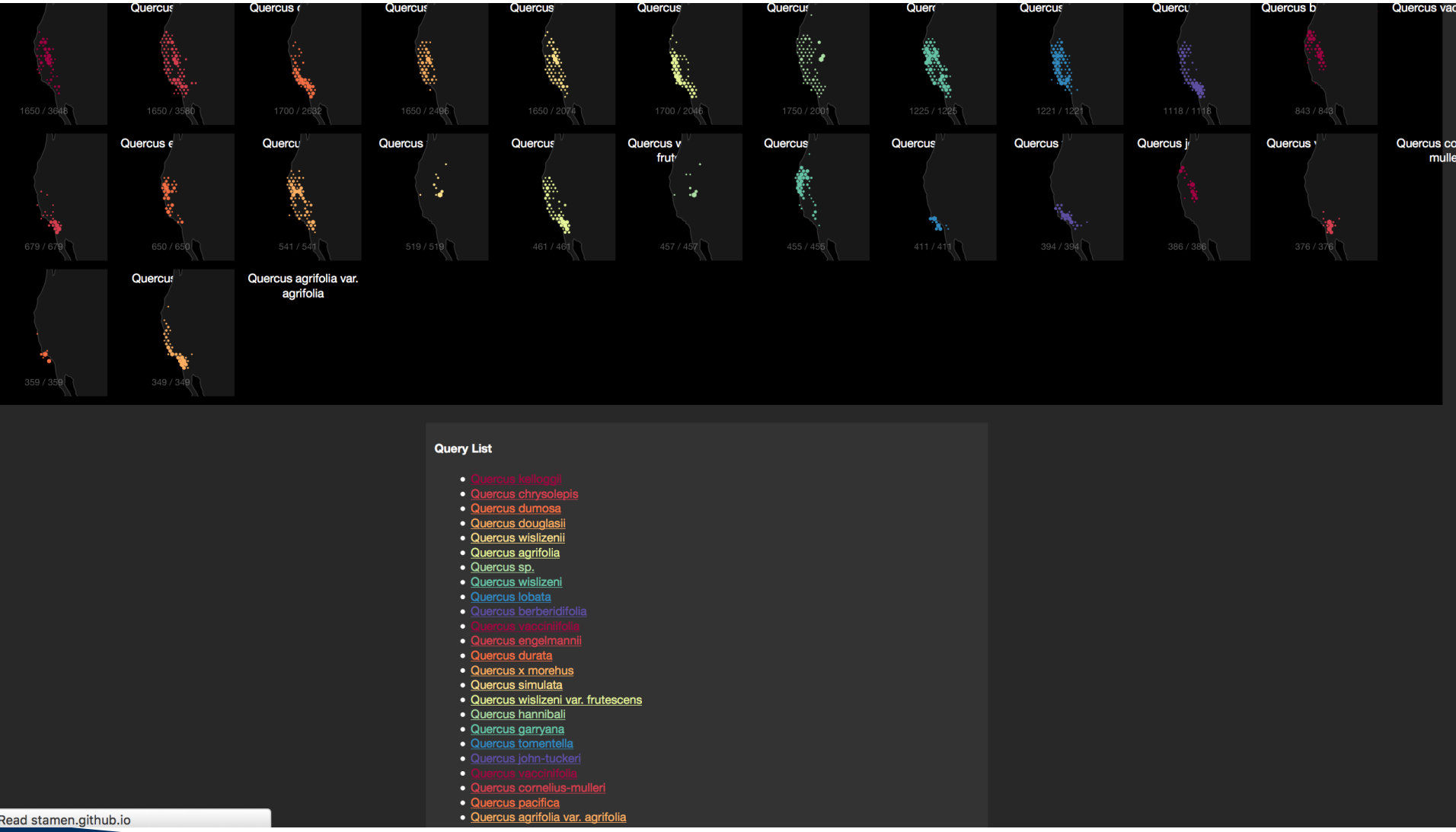
Georeferenced: True or False indicates the number of **Observations** that have latitude and longitude associated with the record.

Country and **State province** are geographic filters that can be used whether or not the records has latitude or longitude, as long as these fields are populated in the original record.



The latitude and longitude may have been recorded on GPS at the time of collection, but most specimens collected before 1993 were probably retrospectively georeferenced.
To learn more about georeferencing, visit here: http://georeferencing.org/.

Example of Mapped Data



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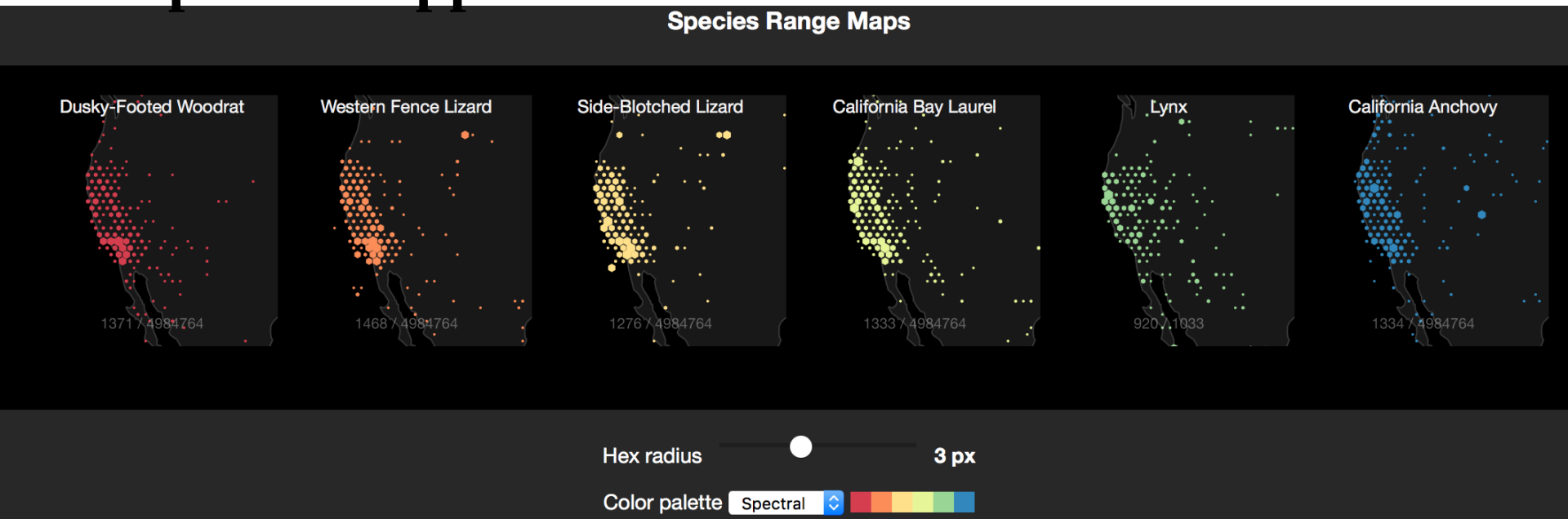
Example of Mapped Data



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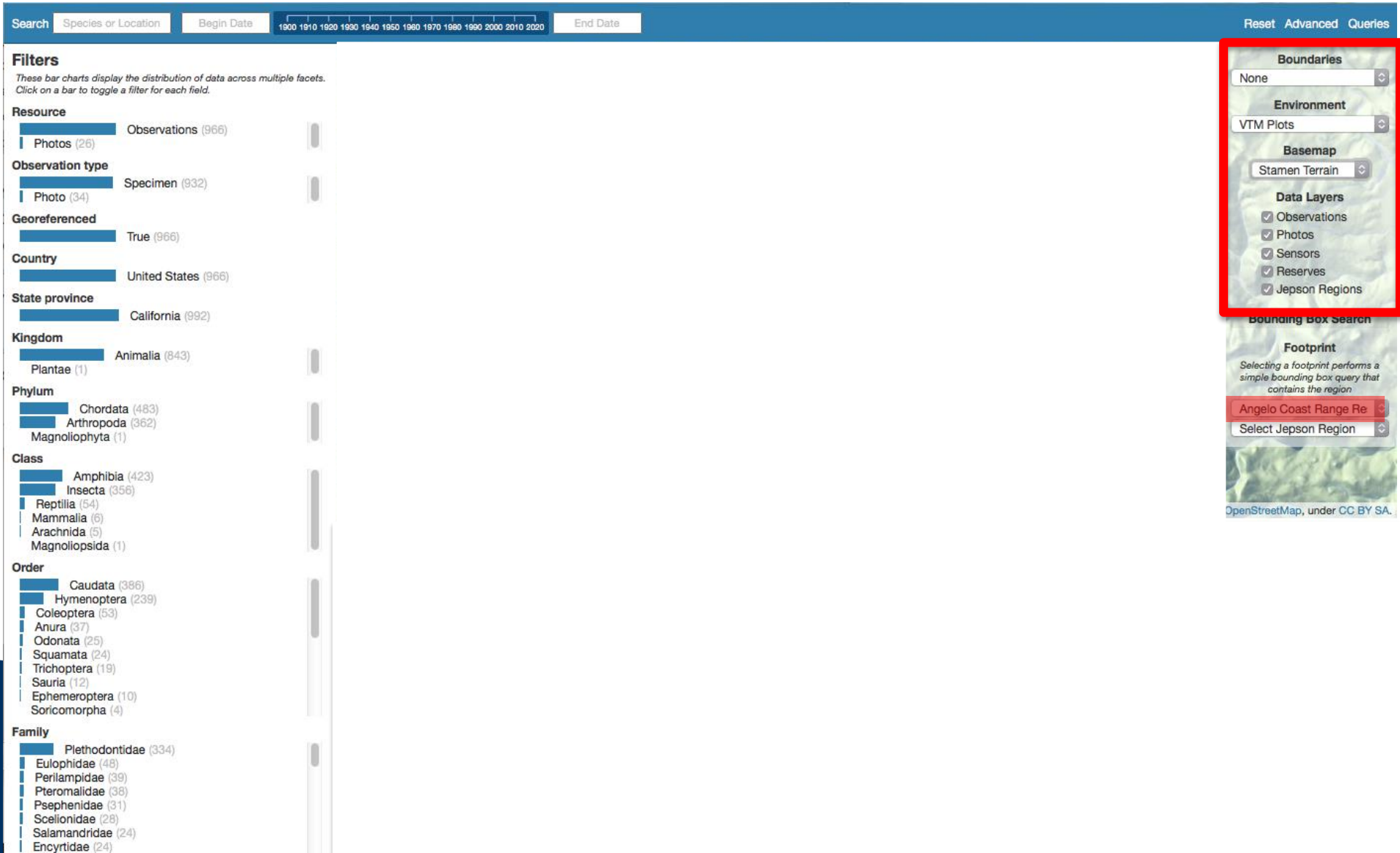
Explore tool



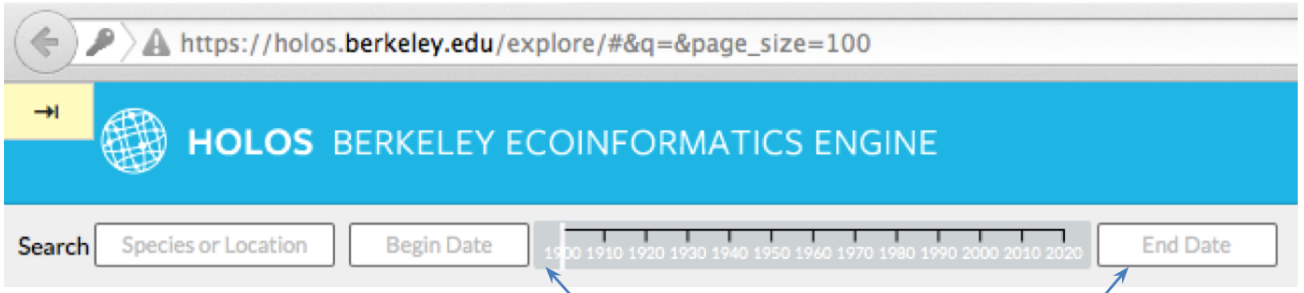
Filters: Decadal

There are three places to filter records by decade.

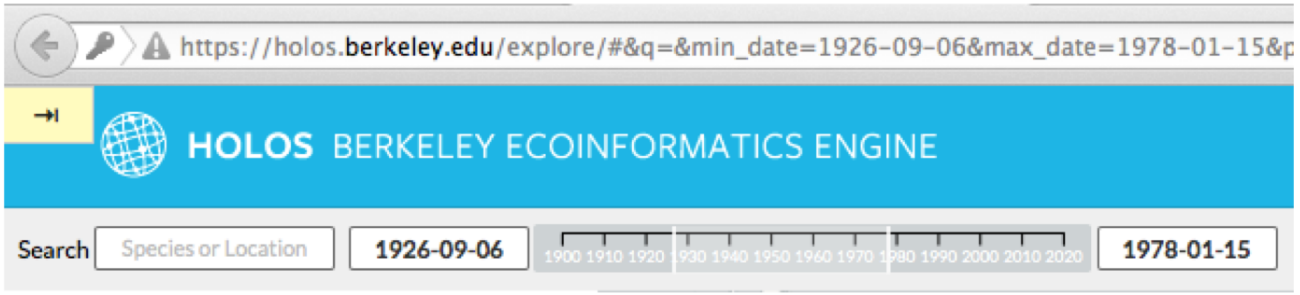
At the bottom of the left panel, you can filter records by **Decade** collected.

Decade

- 1961-1970 (374313)
- 1911-1920 (337079)
- 1931-1940 (335606)
- 1971-1980 (330262)
- 2001-2010 (276796)
- 1951-1960 (251853)
- 1981-1990 (196868)
- 1991-2000 (180075)
- 1941-1950 (163689)
- 1921-1930 (163586)



At the top next to the search bar, you can enter dates to narrow your search.



Or you can use your cursor to draw a box on the timeline.

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Explore tool

Time filter

Filters

These bar charts display the distribution of data across multiple facets.
Click on a bar to toggle a filter for each field.

Resource
- Observations (9985)
- Photos (14)

Observation type
- Specimen (9024)
- Plot survey (949)
- Photo (12)

Georeferenced
- True (9985)

Country
- United States (9084)
- USA (901)

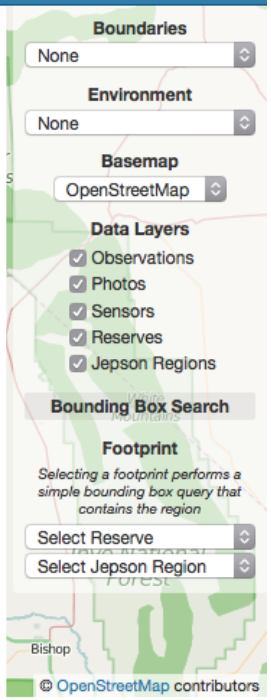
State province
- California (9999)

Kingdom
- Animalia (5059)
- Plantae (54)

Phylum
- Chordata (4959)
- Arthropoda (100)
- Magnoliophyta (52)
- Pteridophyta (1)
- Coniferophyta (1)

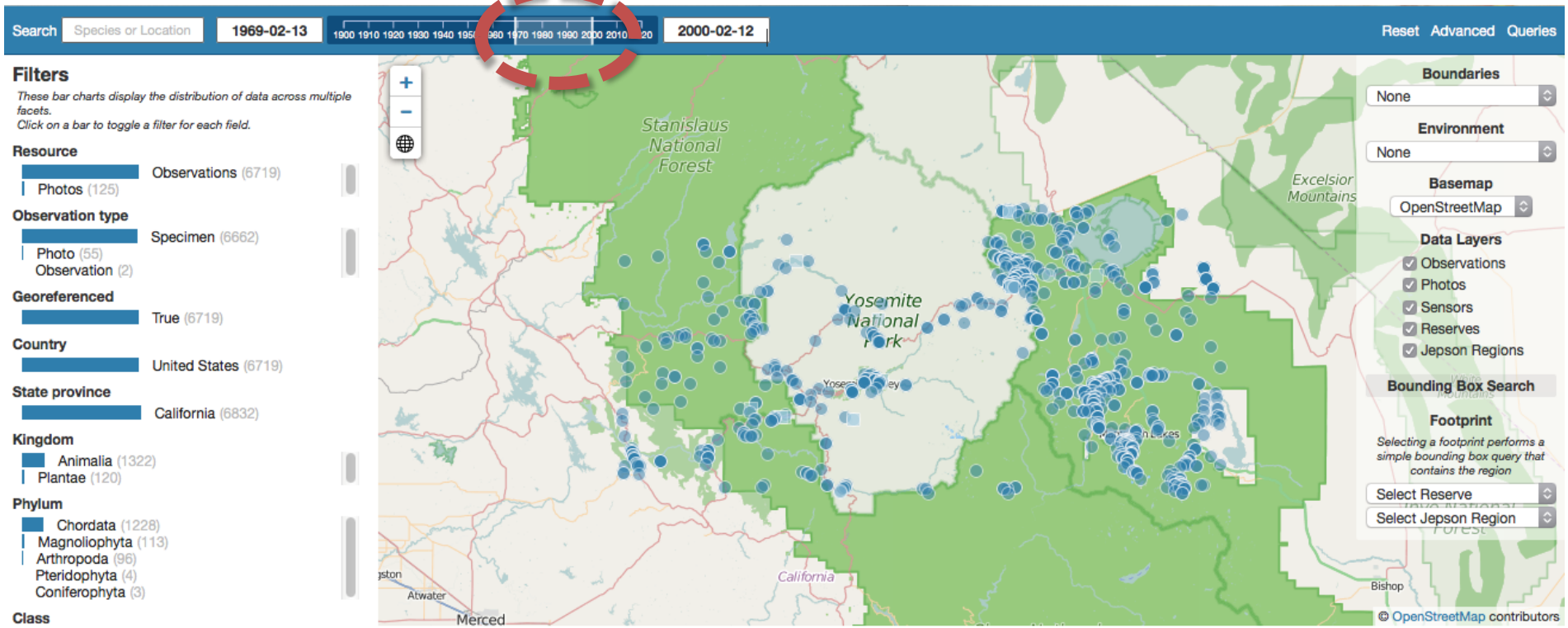
Class
- Mammalia (2314)
- Aves (1811)
- Amphibia (599)
- Reptilia (235)
- Insecta (100)
- Magnoliopsida (39)
- Liliopsida (13)
- Actinopteri (7)
- Pinopsida (1)
- Filicopsida (1)

Order
- Rodentia (1728)
- Passeriformes (1493)
- Anura (568)
- Carnivora (227)
- Soricomorpha (183)
- Squamata (157)
- Piciformes (115)
- Chiroptera (88)
- Lagomorpha (70)
- Sauria (65)



HOLOS Explore tool

BERKELEY ECOINFORMATICS ENGINE



Observations

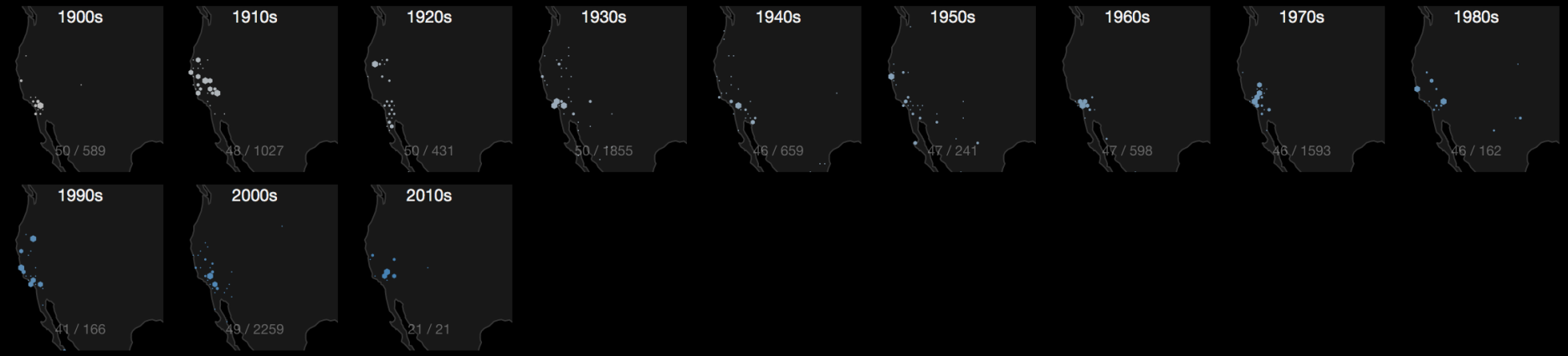
View data or export as CSV, JSON, or GeoJSON from the Berkeley Ecoinformatics Engine

Results 1 to 1000 of 6719 - 1 2 3 4 5 6 7 Page size 20 50 100 500 1000 2000

Record	Scientific name	Country	State province	Begin date	End date	Geojson	Observation type
SD106417	Hulsea brevifolia	United States	California	1980 Aug 14	1980 Aug 14	Yes	specimen
UCR104202	Erigeron coulteri	United States	California	1997 Aug 11	1997 Aug 11	Yes	specimen
SD93521	Veratrum californicum	United States	California	1975 Aug 10	1975 Aug 10	Yes	specimen
OBI64684	Cirsium arizonicum var. arizonicum	United States	California	1982 Aug 24	1982 Aug 24	Yes	specimen
HSC94957	Solidago elongata	United States	California	1994 Aug 9	1994 Aug 9	Yes	specimen
HSC94852	Ericameria nana	United States	California	1994 Aug 9	1994 Aug 9	Yes	specimen
POM369958	Betula occidentalis	United States	California	1970 Sep 9	1970 Sep 9	Yes	specimen
JEPS101530	Mimulus filicaulis	United States	California	1998 Aug 2	1998 Aug 2	Yes	specimen
RSA618293	Eriogonum umbellatum var. covillei	United States	California	1974 Jul 27	1974 Jul 27	Yes	specimen
CAS:BOT:821751	Salix lutea nutt.	United States	California	1981 Aug 10	1981 Aug 10	Yes	specimen
CAS:BOT:820766	Salix lutea nutt.	United States	California	1974 Oct 5	1974 Oct 5	Yes	specimen

Mapped Data x Time

Dusky-Footed Woodrats over Decades



Query List

- 1900s
- 1910s
- 1920s
- 1930s
- 1940s
- 1950s
- 1960s
- 1970s
- 1980s
- 1990s
- 2000s
- 2010s

Small multiples can be used to look for temporal gaps, trends or periodic phenomena.

Non-georeferenced points are discarded, so loading counts may not fill completely.

Possible Directions

- Pre-generate hexbins so galleries of 20+ taxa can be loaded quickly
- Bin Bioclim variables into a hexmap to compare with aggregated point data
- Watch this 5-minute talk by Aaron Steele on species modeling with Bioclim

See also Woodrats over Decades

https://holos.berkeley.edu/explore/#&q=Tamias alpinus&min_date=1900&max_date=1930&page_size=100

Search

HOLOS BERKELEY ECOINFORMATICS ENGINE

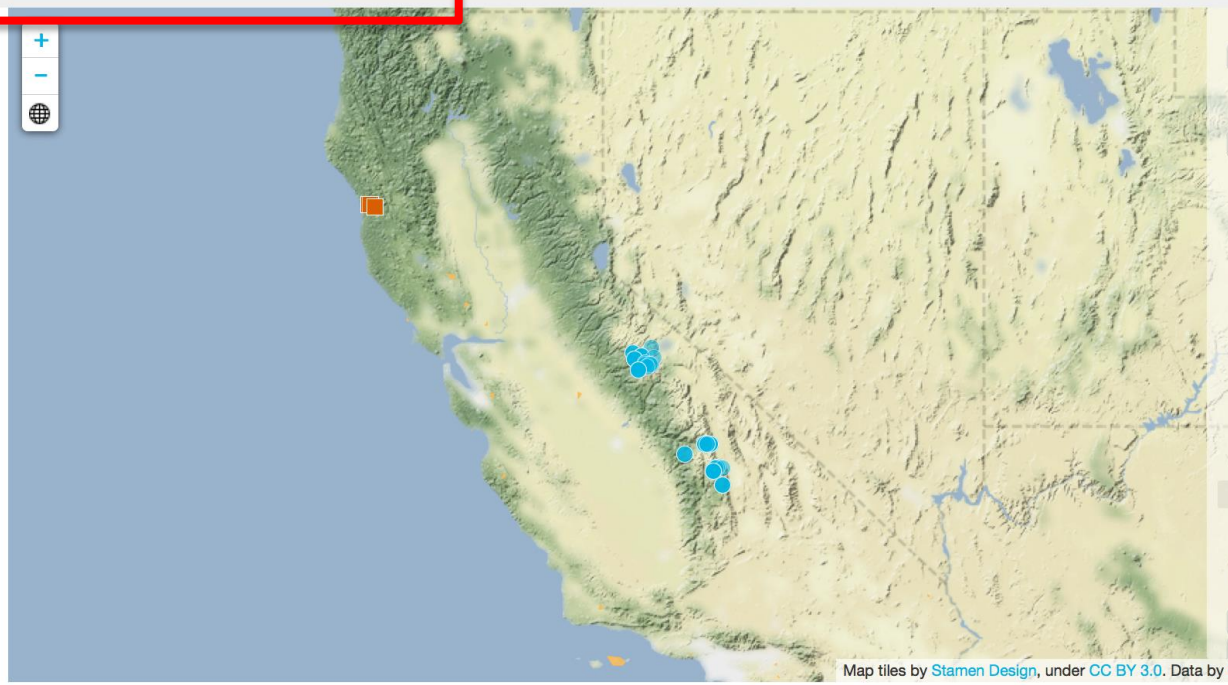
About | Learn More | News | Explore | Compare | Applications

Search: Tamias alpinus | 1900 | 1930 | Reset | Advanced | Queries | Get query for Compare

Filters

These bar charts display the distribution of data across multiple facets. Click on a bar to toggle a filter for each field.

- Resource: Observations (234)
- Observation type: Specimen (234)
- Georeferenced: True (234)
- Country: United States (234)
- State province: California (234)
- Kingdom: Animalia (234)
- Phylum: Chordata (234)
- Class: Mammalia (234)
- Order: Rodentia (234)
- Family: Sciuridae (234)
- Genus: Tamias (234)
- Scientific name: Tamias alpinus (234)
- Decade: 1911-1920 (234)

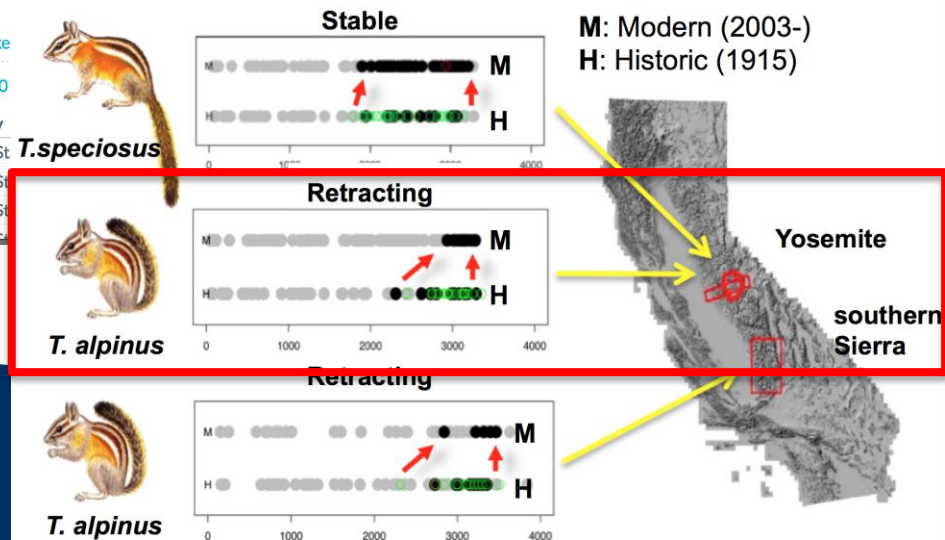


Species Occurrences

View data or DOWNLOAD as CSV, JSON, or GeoJSON from the Berke

Results 1 to 100 of 234 - 1 2 3 Page size 20 50 100 500

Record	Scientific name	Country
MVZ:Mamm:14930	Tamias alpinus	United St
MVZ:Mamm:14964	Tamias alpinus	United St
MVZ:Mamm:17603	Tamias alpinus	United St



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HOLOS BERKELEY ECOINFORMATICS ENGINE

About | Learn More | News | Explore | Compare | Applications

Search: Tamias alpinus | 2004-08-20 | 2020-01-01 | Reset | Advanced | Queries | Get query for Compare

Filters

These bar charts display the distribution of data across multiple facets. Click on a bar to toggle a filter for each field.

- Resource: Observations (161)
- Observation type: Specimen (161)
- Georeferenced: True (161)
- Country: United States (161)
- State province: California (161)
- Kingdom: Animalia (161)
- Phylum: Chordata (161)
- Class: Mammalia (161)
- Order: Rodentia (161)
- Family: Sciuridae (161)
- Genus: Tamias (161)
- Scientific name: Tamias alpinus (161)
- Decade: 2001-2010 (84), 2011-2020 (77)

Boundaries: None

Environment
Climate Model: precipitation yearly aver
Scenario: modern
Date: Select raster layer

Basemap: Stamen Terrain

Data Layers
- Observations
- Photos
- Sensors
- Reserves

Bounding Box Search

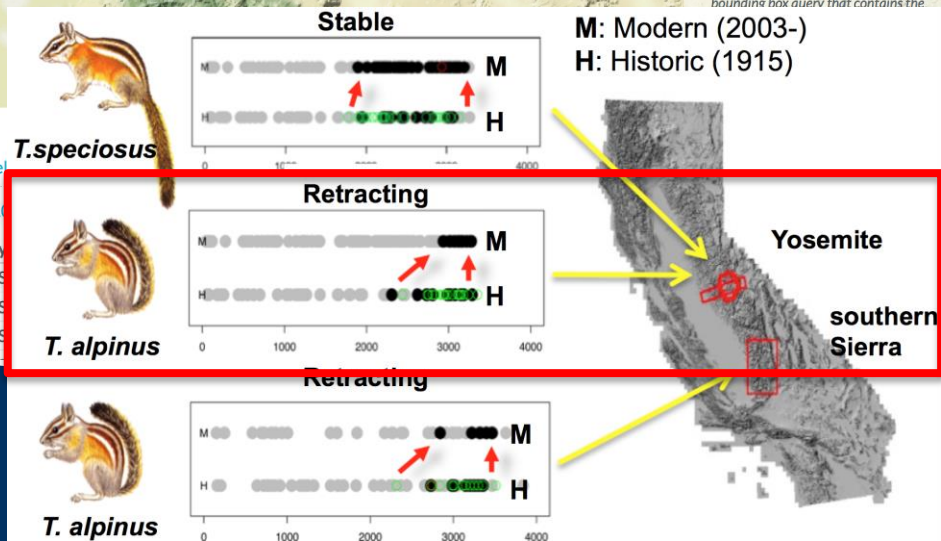
Footprint
Selecting a footprint performs a simple bounding box query that contains the

Species Occurrences

View data or DOWNLOAD as CSV, JSON, or GeoJSON from the Berkel

Results 1 to 100 of 161 - 1 2 Page size 20 50 100 500 1

Record	Scientific name	Country
MVZ:Mamm:222206	Tamias alpinus	United S
MVZ:Mamm:229635	Tamias alpinus	United S
MVZ:Mamm:229641	Tamias alpinus	United S



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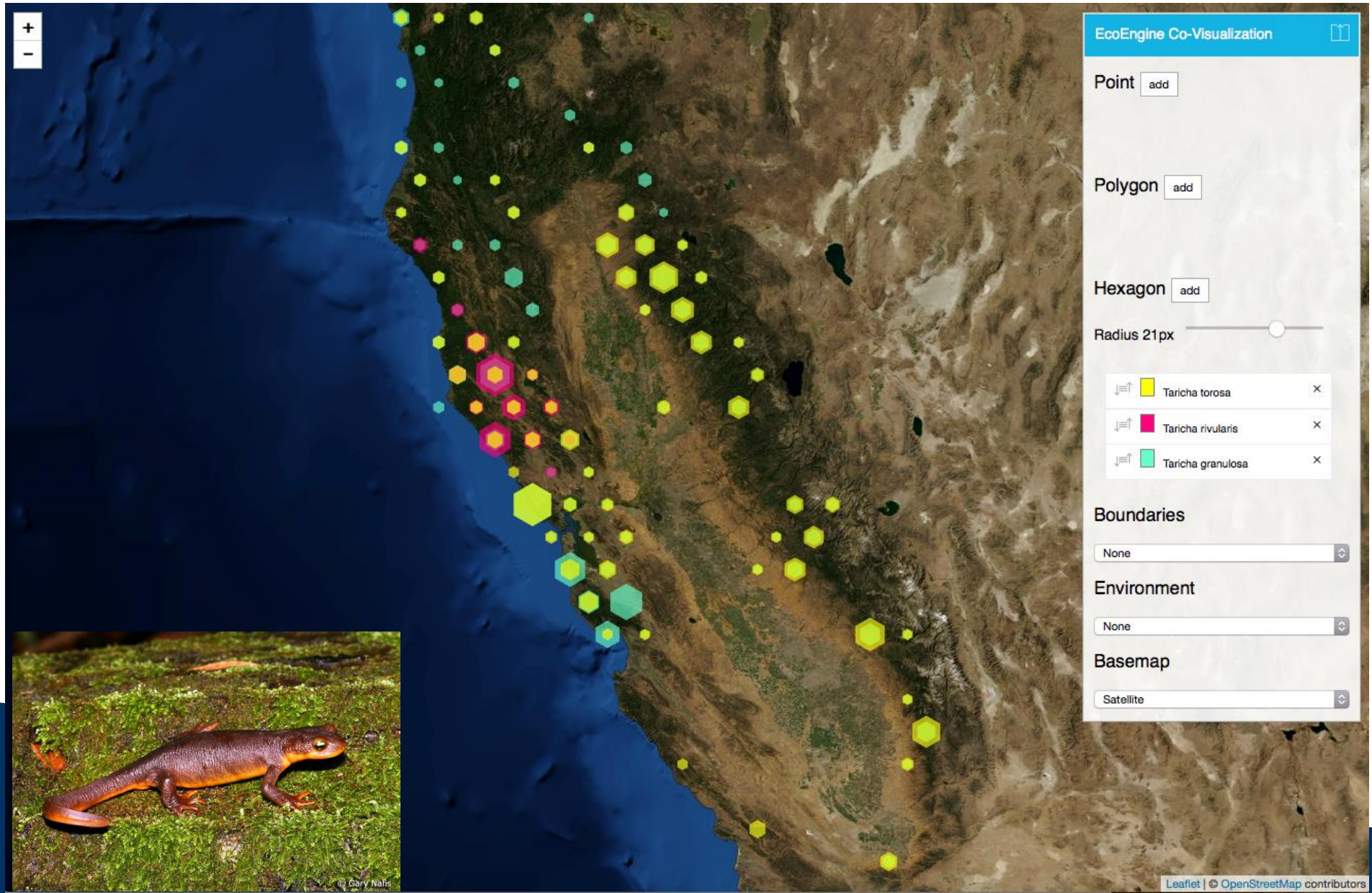
Compare tool



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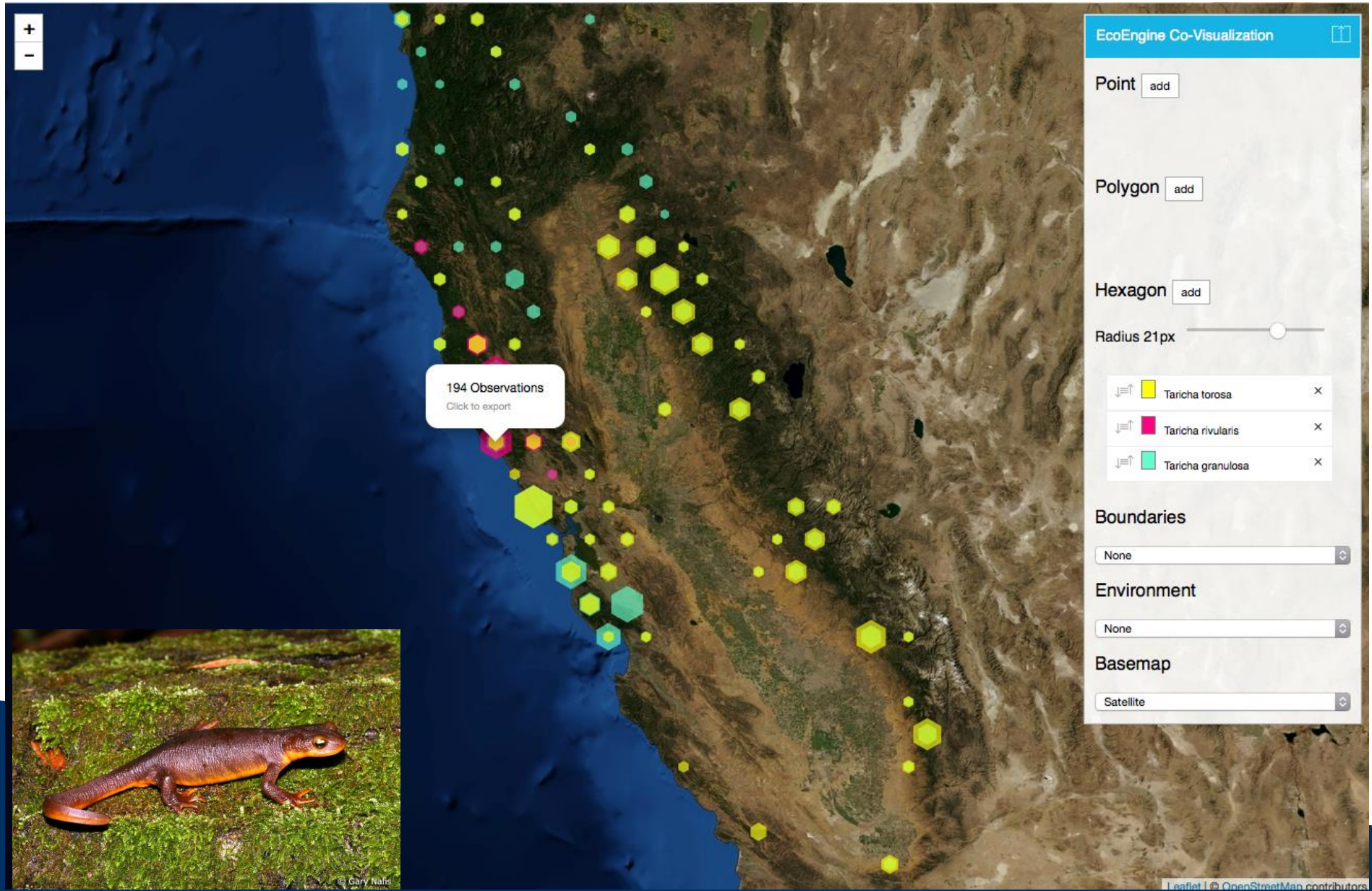
Compare tool



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Compare tool - download

```
state_province,coordinate_uncertainty_in_meters,recorded_by,begin_date,end_date,source,url,country,scientific_name,locality,record,remote_resource,observation_type,long,lat
California,1000,None,1893-03-27,1893-03-27,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3ASUA%3A192/,United States,Taricha torosa torosa,Palo Alto,CAS:SUA:192,,
California,623,AH Brame,1957-03-03,1957-03-03,https://ecoengine.berkeley.edu/api/sources/2/,https://ecoengine.berkeley.edu/api/observations/LACM%3AHerps%3A29335/,United States,Taricha torosa torosa,Stanford; Golf
California,6046,None,1893-10-24,1893-10-24,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3ASUA%3A216/,United States,Taricha torosa torosa,Adobe Creek,CAS:SUA:216
California,623,AH Brame,1957-03-03,1957-03-03,https://ecoengine.berkeley.edu/api/sources/2/,https://ecoengine.berkeley.edu/api/observations/LACM%3AHerps%3A29333/,United States,Taricha torosa torosa,Stanford; Golf
California,6046,None,1893-10-24,1893-10-24,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3ASUA%3A217/,United States,Taricha torosa torosa,Adobe Creek,CAS:SUA:217
California,623,AH Brame,1957-03-03,1957-03-03,https://ecoengine.berkeley.edu/api/sources/2/,https://ecoengine.berkeley.edu/api/observations/LACM%3AHerps%3A29334/,United States,Taricha torosa torosa,Stanford; Golf
California,152,Collector(s): William J. Riemer,1953-04-04,1953-04-04,https://ecoengine.berkeley.edu/api/sources/14/,https://ecoengine.berkeley.edu/api/observations/MVZ%3AHerp%3A61416/,United States,Taricha granulo
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California,735,None,1937-05-28,1937-05-28,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3ASUA%3A3712/,United States,Taricha granulosa granulosa,upper reaches of
California,6046,None,1893-10-24,1893-10-24,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3ASUA%3A215/,United States,Taricha granulosa granulosa,Adobe Creek,CAS:SU
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California,6046,None,1893-10-24,1893-10-24,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3ASUA%3A210/,United States,Taricha granulosa granulosa,Adobe Creek,CAS:SU
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California,6046,None,1893-10-24,1893-10-24,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3ASUA%3A209/,United States,Taricha granulosa granulosa,Adobe Creek,CAS:SU
California,1781,"""F.E. Ely""",2001-01-23,2001-01-23,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3AHERP%3A218634/,United States,Taricha granulosa,"Alpine Rd, 3
California,1781,"""F.E. Ely""",2001-01-23,2001-01-23,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3AHERP%3A218637/,United States,Taricha granulosa,"Alpine Rd, 3
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California,1781,"""F.E. Ely""",2001-01-23,2001-01-23,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3AHERP%3A218636/,United States,Taricha granulosa,"Alpine Rd, 3
California,1781,"""F.E. Ely""",2001-01-23,2001-01-23,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3AHERP%3A218633/,United States,Taricha granulosa,"Alpine Rd, 3
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California,8862,"""V.C. Twitty""",1934-11-10,1934-11-10,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3ASUA%3A6238/,United States,Taricha granulosa granulosa,"Su
California,8862,"""V.C. Twitty""",1934-11-10,1934-11-10,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3ASUA%3A6244/,United States,Taricha granulosa granulosa,"Su
California,1000,"""J. Van Denburgh""",1911-04-27,1911-04-27,https://ecoengine.berkeley.edu/api/sources/6/,https://ecoengine.berkeley.edu/api/observations/CAS%3AHERP%3A40433/,United States,Taricha granulosa granulo
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```

Compare tool

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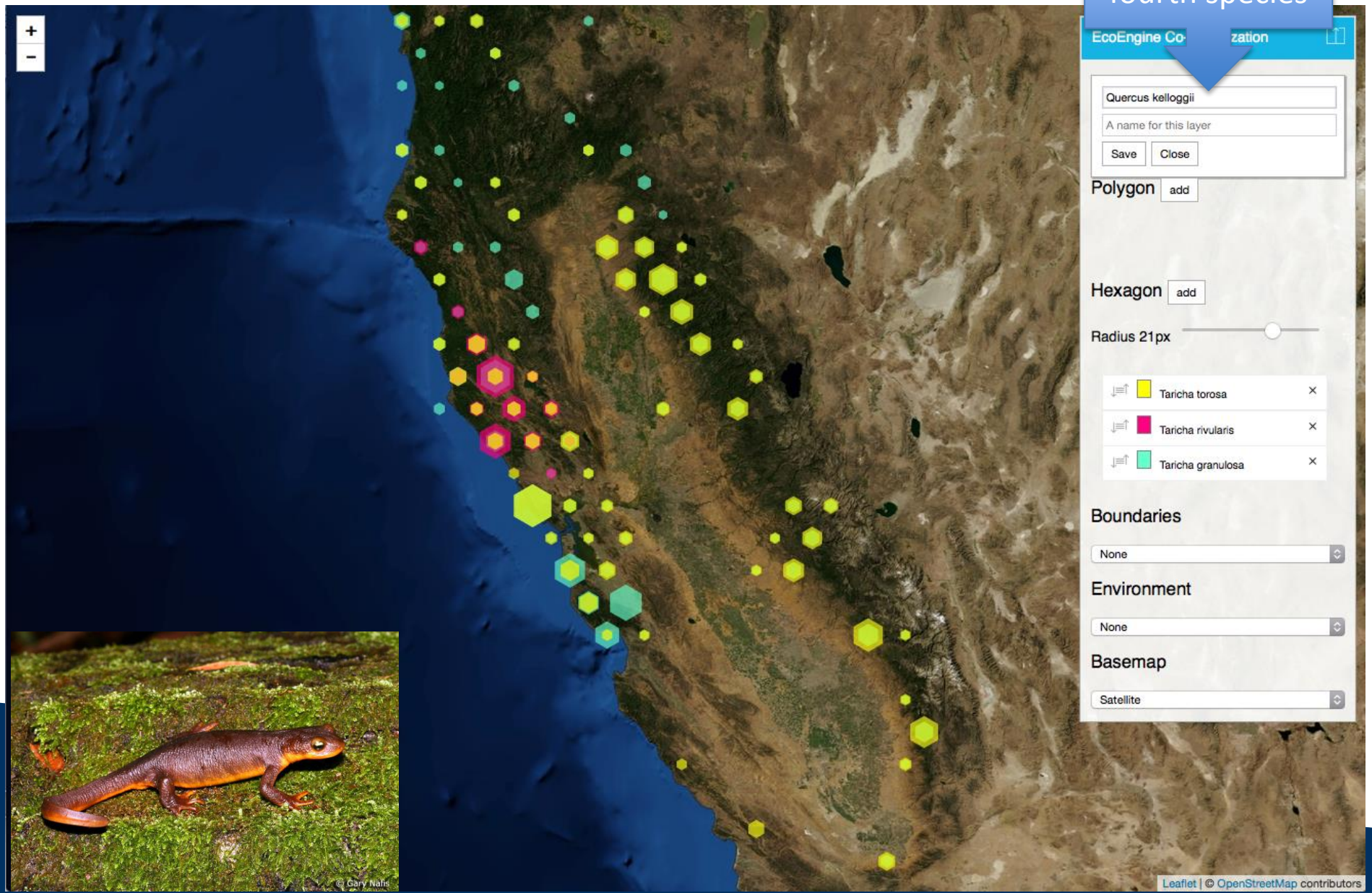
BERKELEY ECOINFORMATICS ENGINE

Easy to add a fourth species



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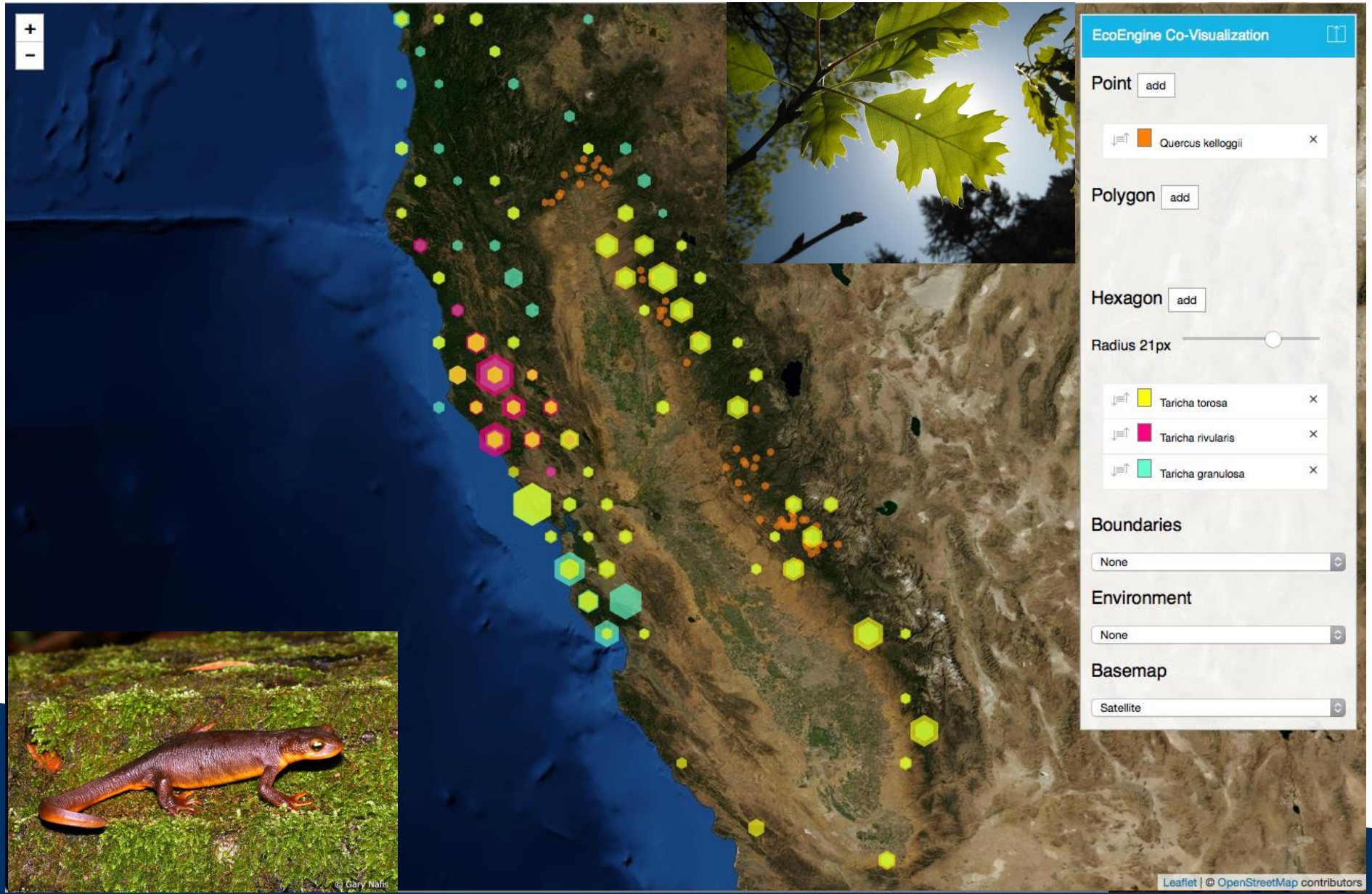
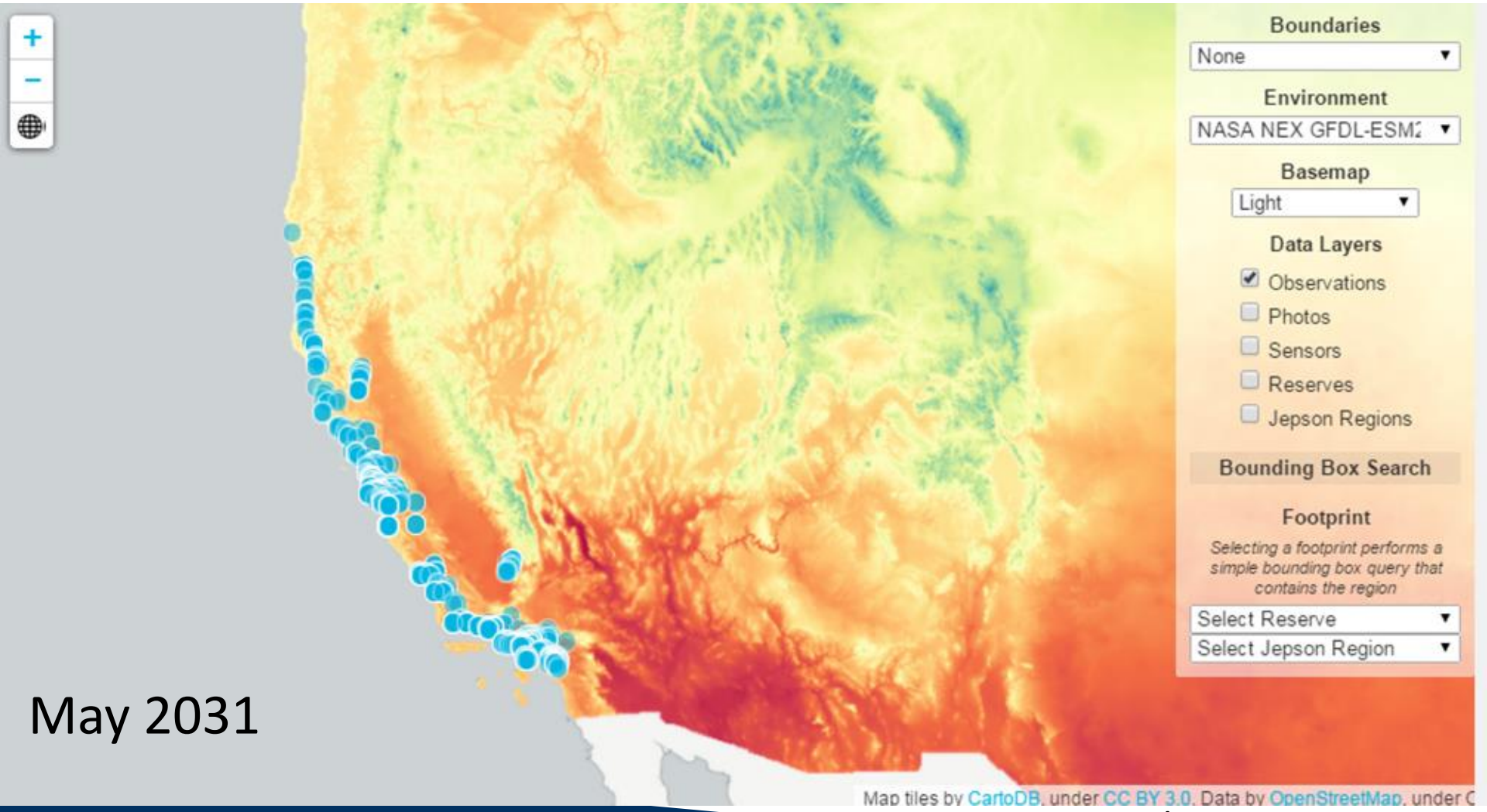
Compare tool



Can Dial-Up Projected Climates (here from NASA)

NASA NEX-DCP30 datasets



May 2031

Batrachoseps attenuatus

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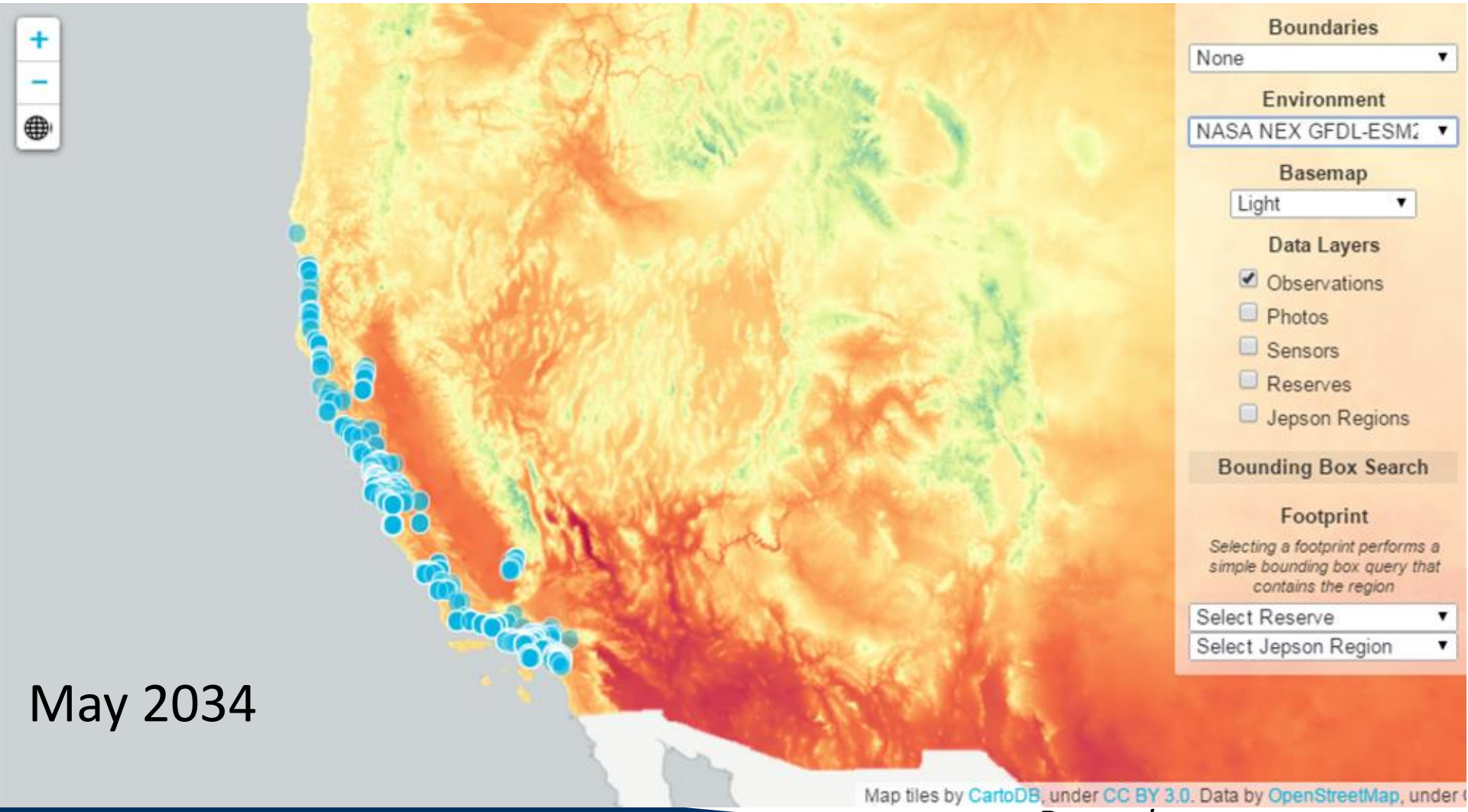
Can Dial-Up Projected Climates (here from NASA)

NASA NEX-DCP30 datasets



May 2034

Batrachoseps attenuatus

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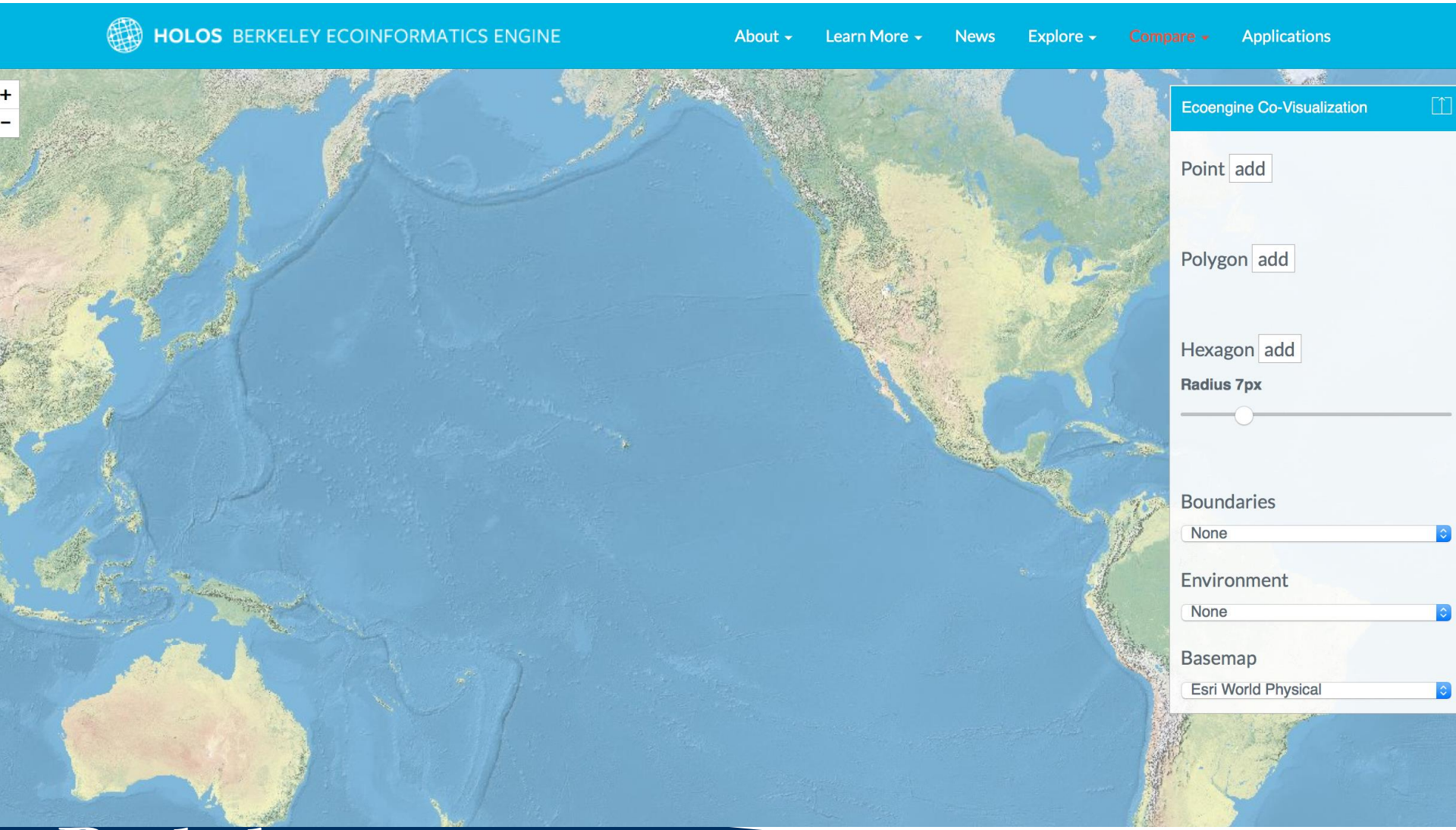
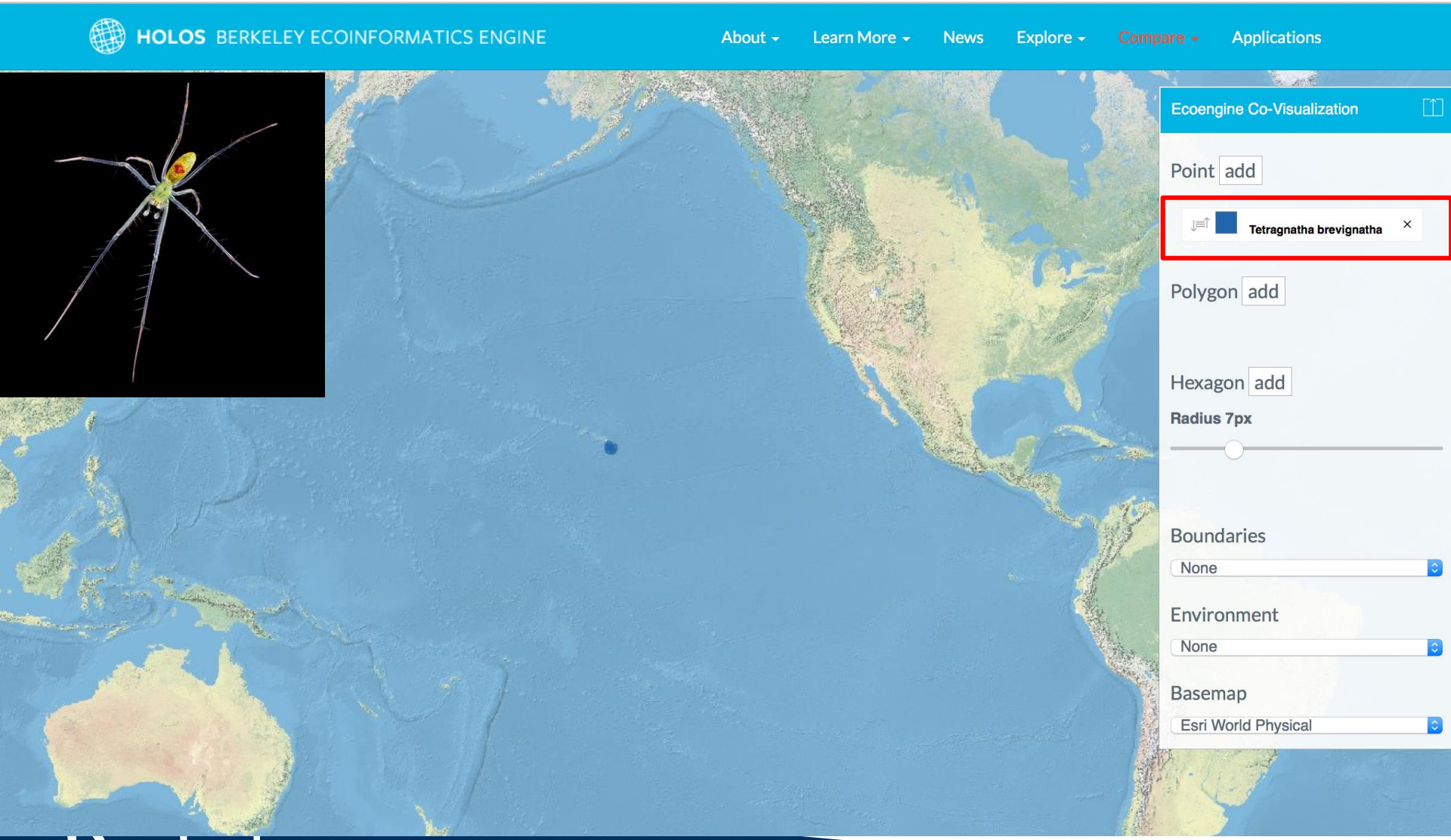
Ecoengine

- **Simplicity, interoperability – basis for extension to other systems.**

Arthropods on Islands



Arthropods on Islands Spiders - *Tetragnatha*



Arthropods on Islands Spiders - *Tetragnatha*

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About Learn More News Explore Compare Applications

Honolulu

Lahaina

Haleakalā

3055m

Mauna Kea

4205m

Hilo

Ecoengine Co-Visualization

Point add

Tetragnatha anuenue

Polygon add

Hexagon add

Radius 7px

Boundaries

None

Environment

None

Basemap

Stamen Terrain

Berkeley

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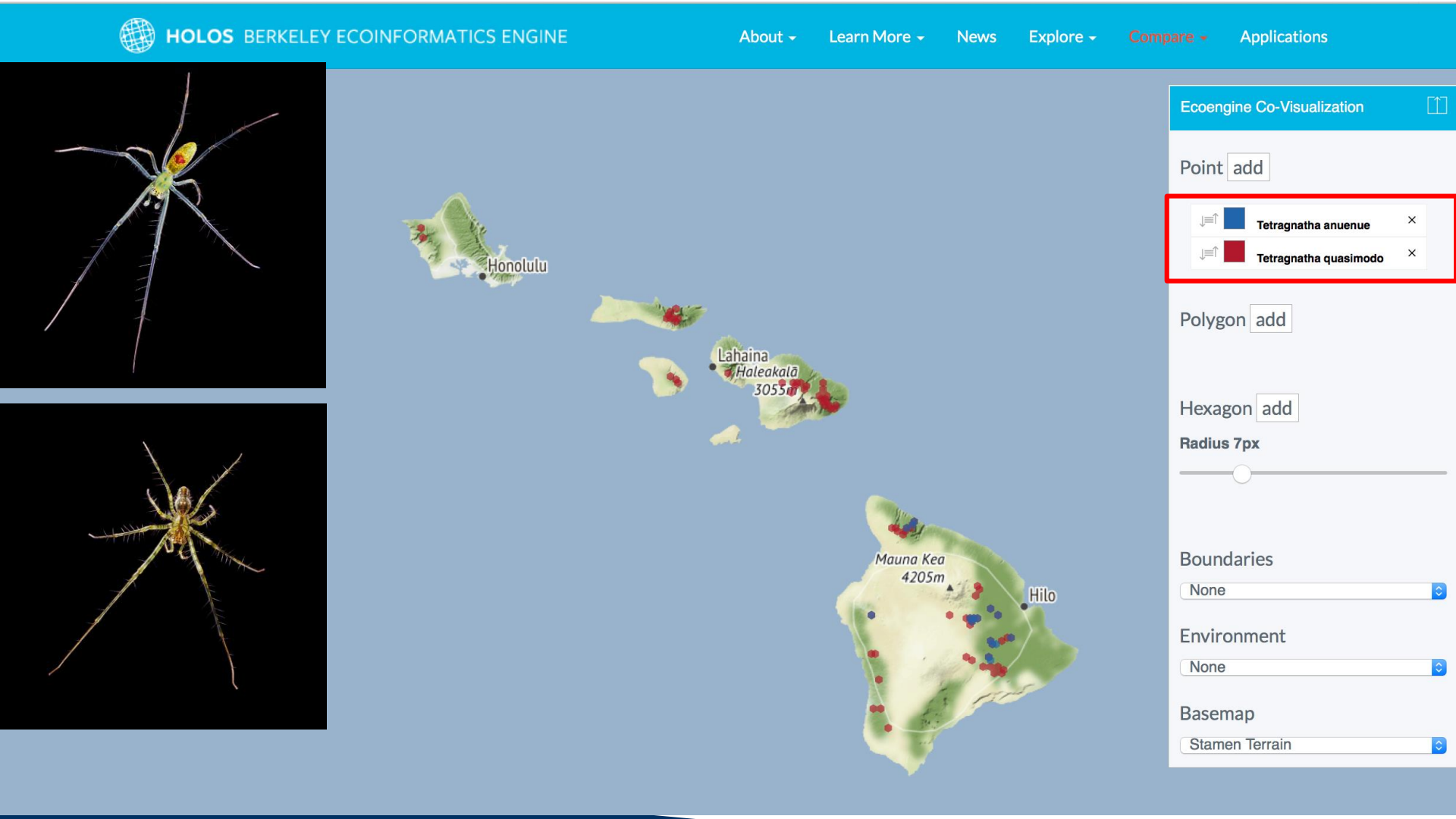
Arthropods on Islands Spiders - *Tetragnatha*



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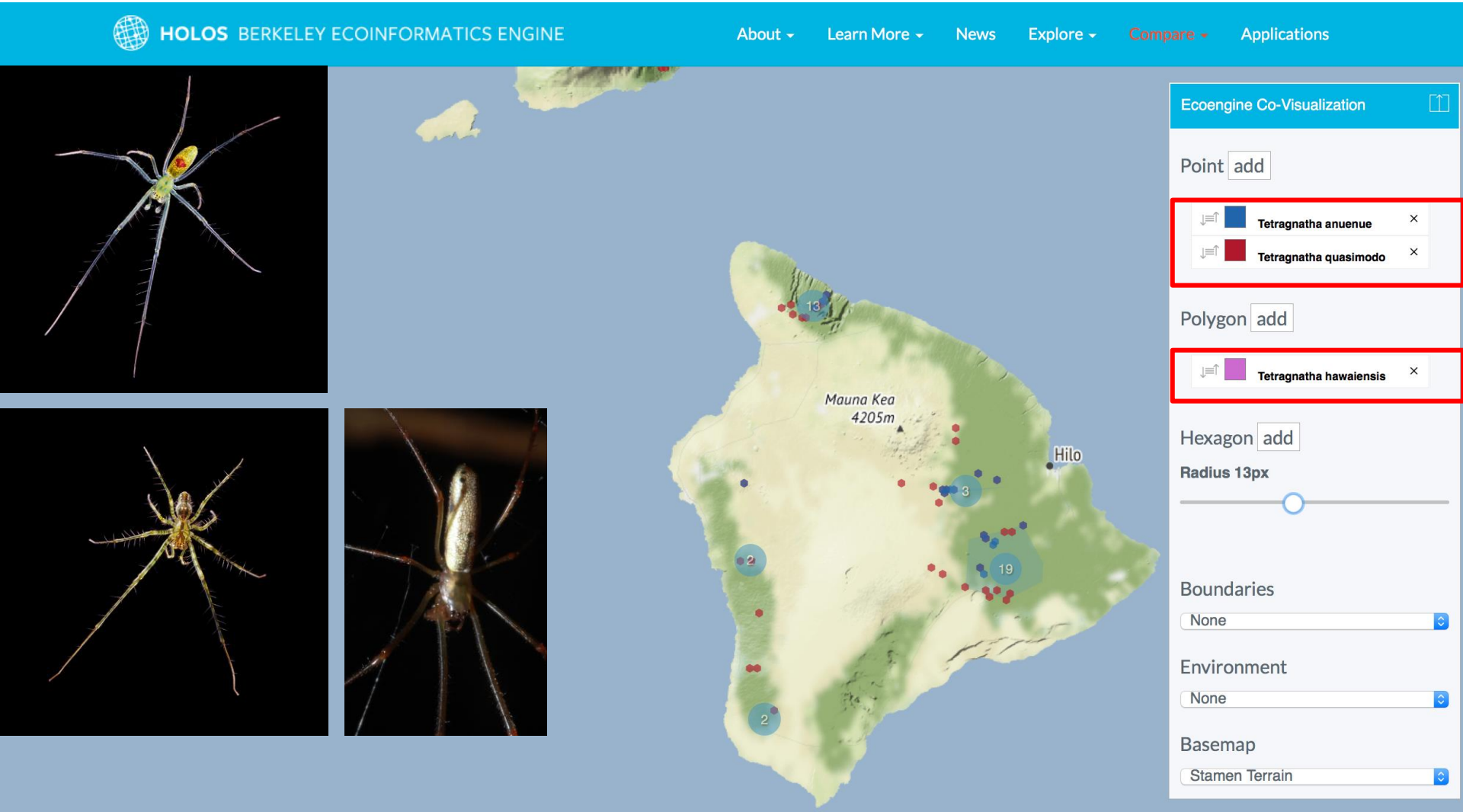
Arthropods on Islands Spiders - *Tetragnatha*



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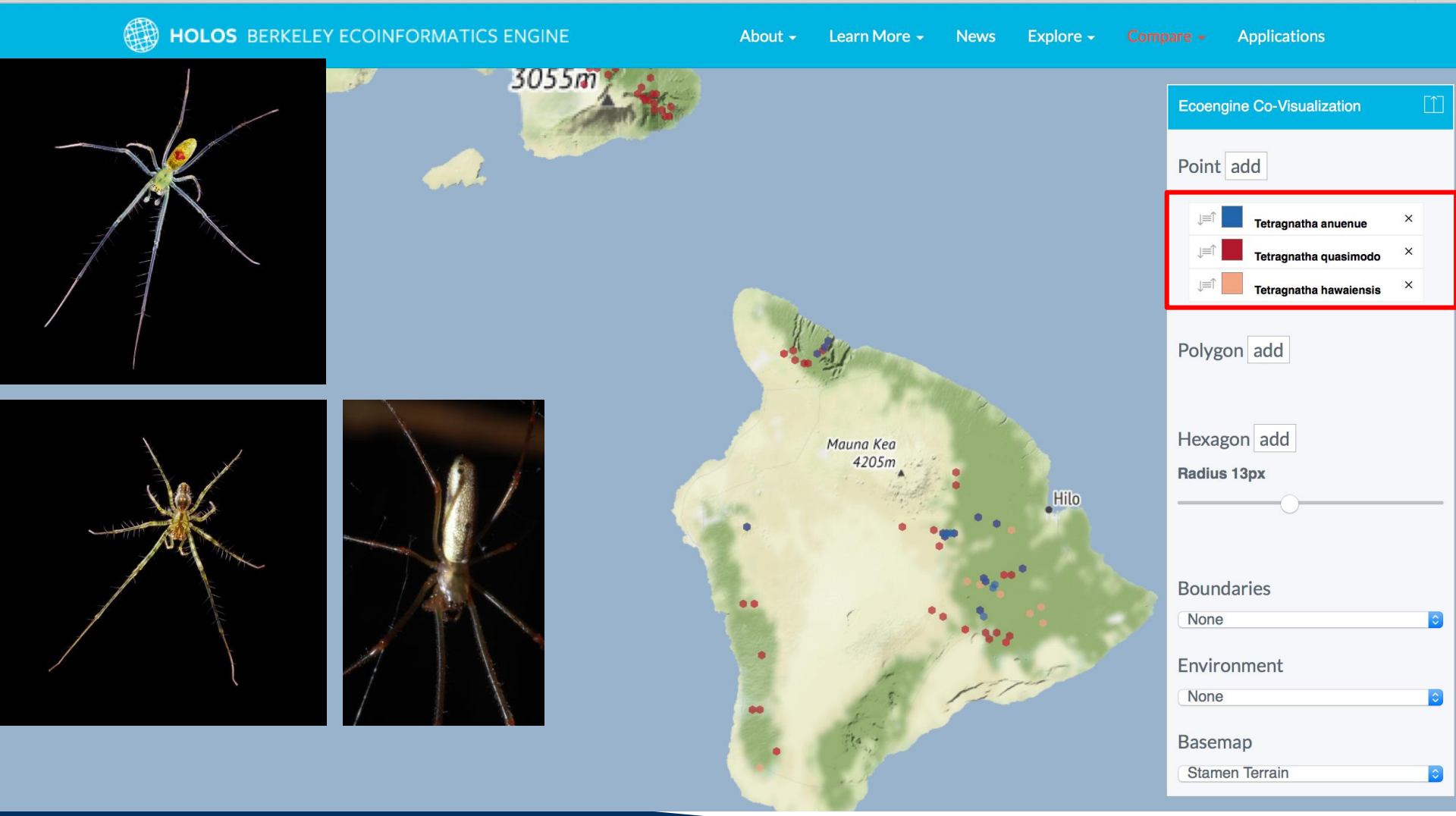
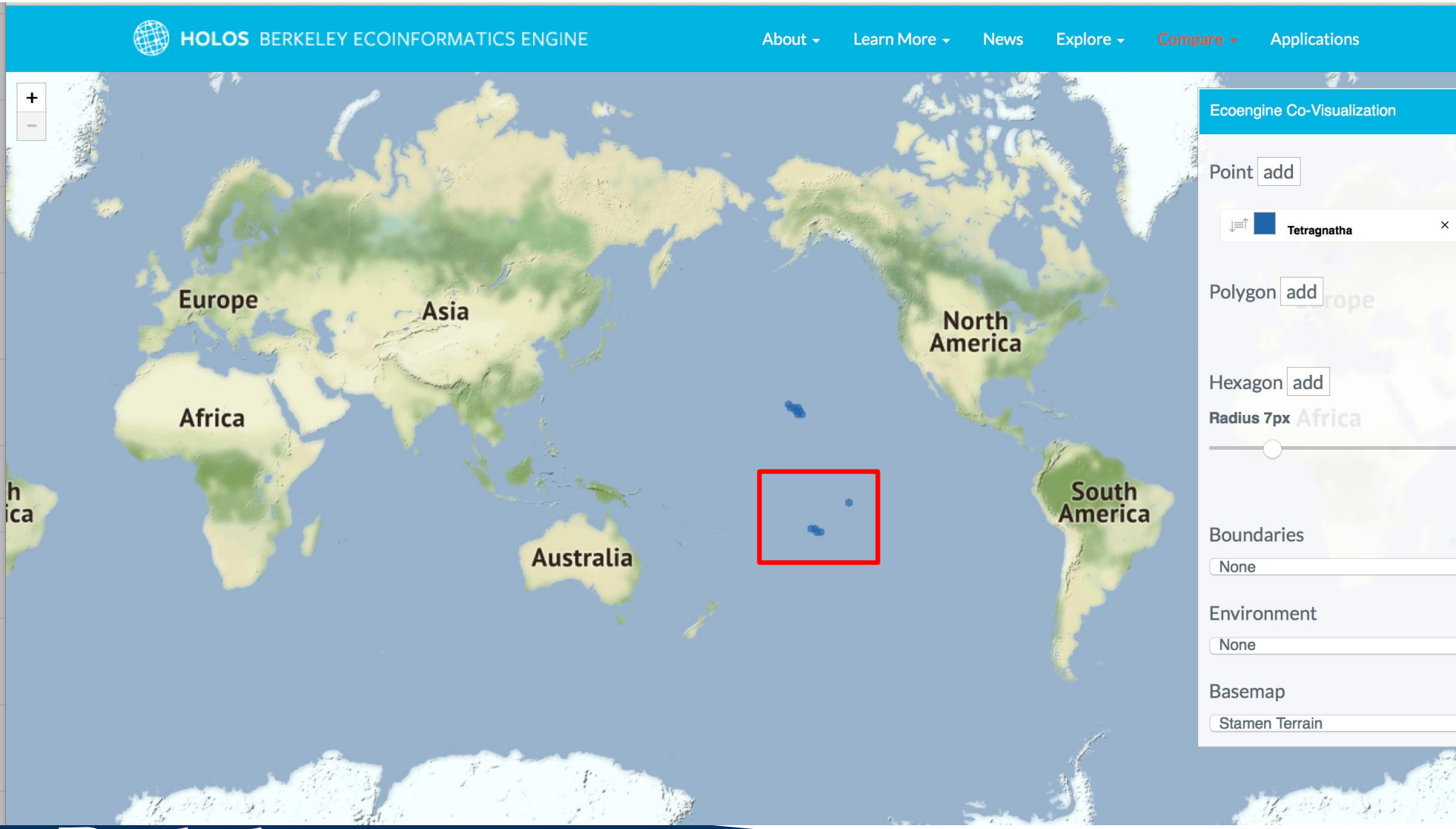
Arthropods on Islands Spiders - *Tetragnatha*



Arthropods on Islands Spiders - *Tetragnatha* South Pacific



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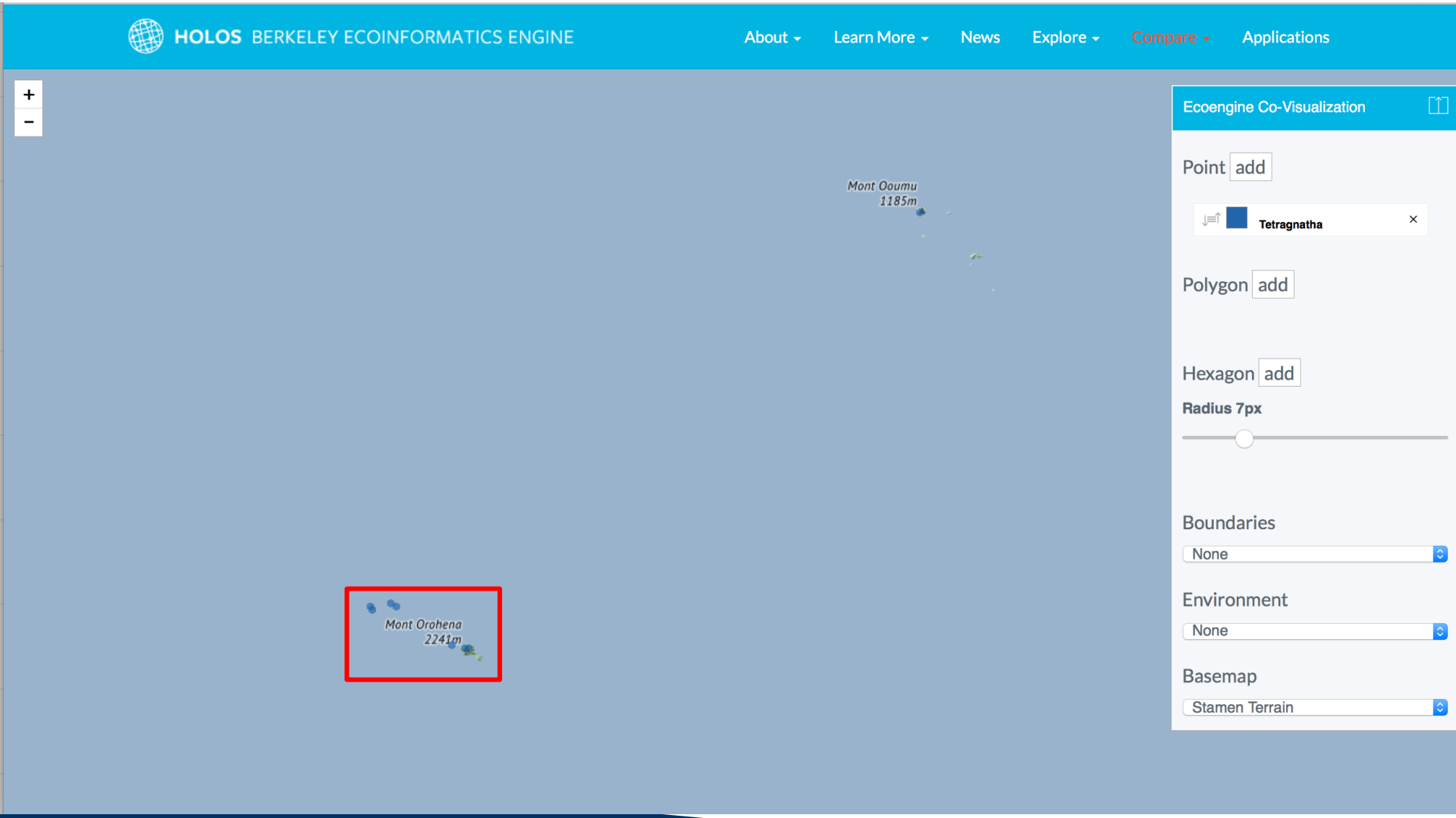
Arthropods on Islands Spiders - *Tetragnatha* South Pacific



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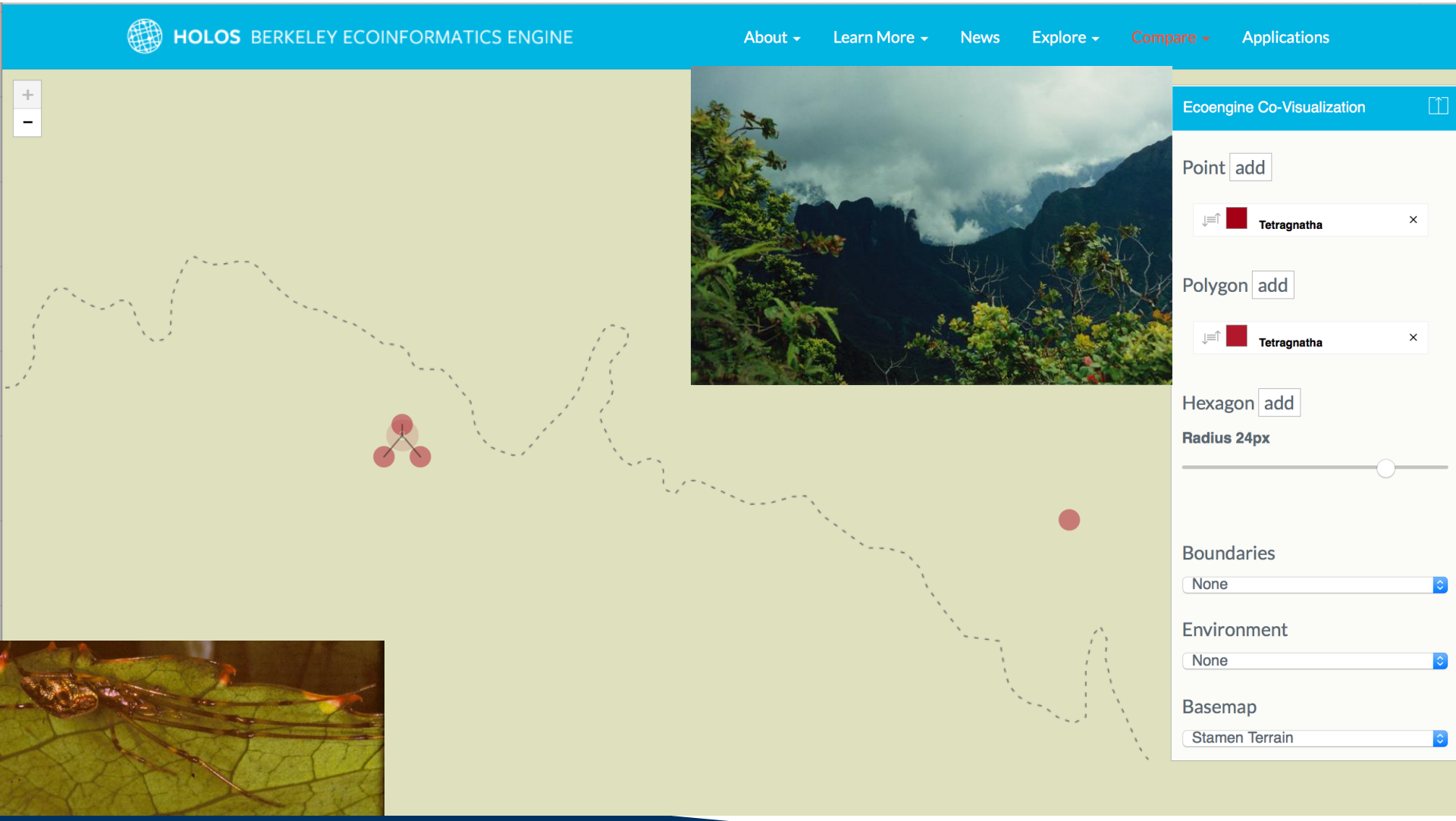
Arthropods on Islands Spiders - *Tetragnatha* South Pacific



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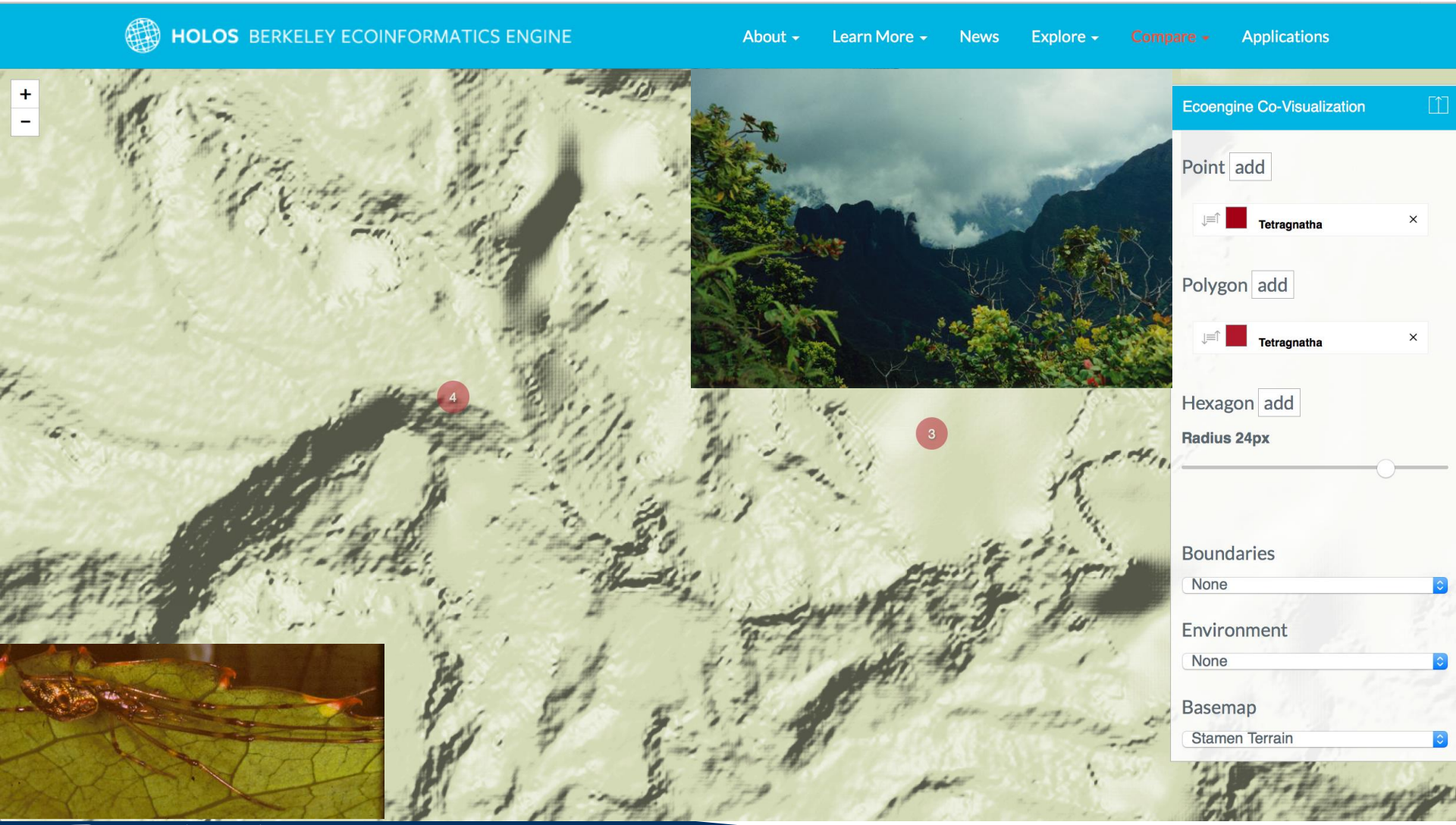
Arthropods on Islands Spiders - *Tetragnatha* South Pacific



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Arthropods on Islands *Rhyncogonus* South Pacific

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Mont Orohena

Ecoengine Co-Visualization

Point add

Tetragnatha

Rhyncogonus

Polygon add

Tetragnatha

Hexagon add

Radius 24px

Boundaries

None

Environment

None

Basemap

Stamen Terrain

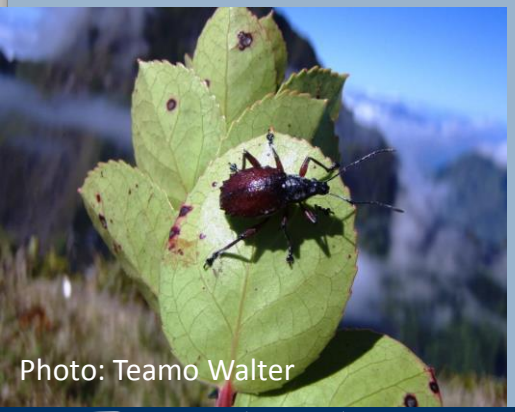

Photo: Teamo Walter

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Arthropods on Islands *Tetragnatha* - *Rhyncogonus* South Pacific

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+
−

Ecoengine Co-Visualization

Point add

Tetragnatha ×

Rhyncogonus ×

Polygon add

Tetragnatha ×

Hexagon add

Radius 24px

Boundaries

None

Environment

None

Basemap

Stamen Terrain

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Arthropods on Islands *Rhyncogonus* South Pacific

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Ecoengine Co-Visualization

Point add

Tetragnatha

Rhyncogonus

Polygon add

Tetragnatha

Hexagon add

Radius 24px

Boundaries

None

Environment

None

Basemap

Stamen Terrain

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Ecoengine

User Interfaces

R Stats Package

HOLOS Web Portal

Data Apps

JSON REST

Web Services

GIS Base Layers

EcoEngine & API

DarwinCore IPT Archive

Databases

BNHM Databases

Climate Models

InfoBase

Berkeley Sensor Database

Source Data

Photos

Soil cores

Specimens

Field notes

Paleo-Climate

NASA NEX: Future Climate

ANR/REC Eddy-flux

NRS Field sensors

Applications

The API is not just a powerful tool for developers building web applications,
also provides data access in a wide range of contexts.

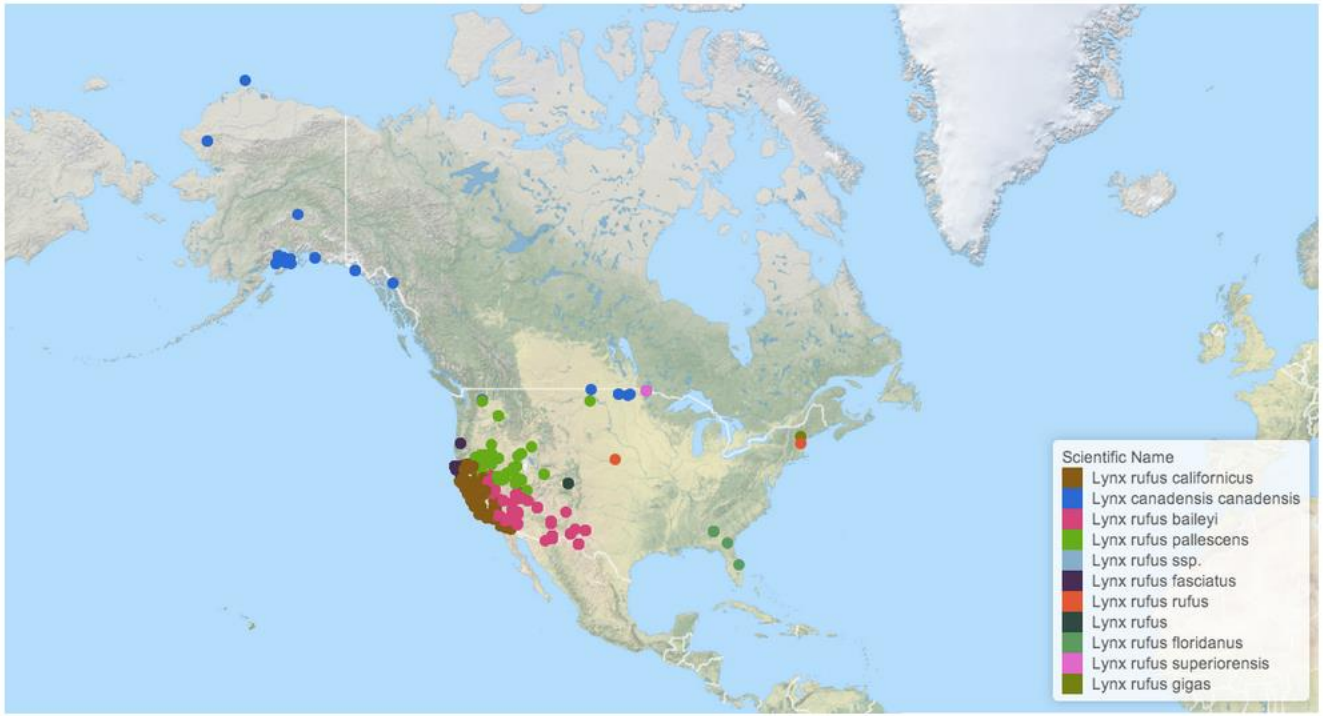
- within any application that can communicate over the https protocol.

Ecoengine package

Mapping observations

The development version of the package includes a new function `ee_map()` that allows users to generate interactive maps from observation queries using Leaflet.js.

```
lynx_data <- ee_observations(genus = "Lynx", georeferenced = TRUE, page = "al
l", quiet = TRUE)
ee_map(lynx_data)
```



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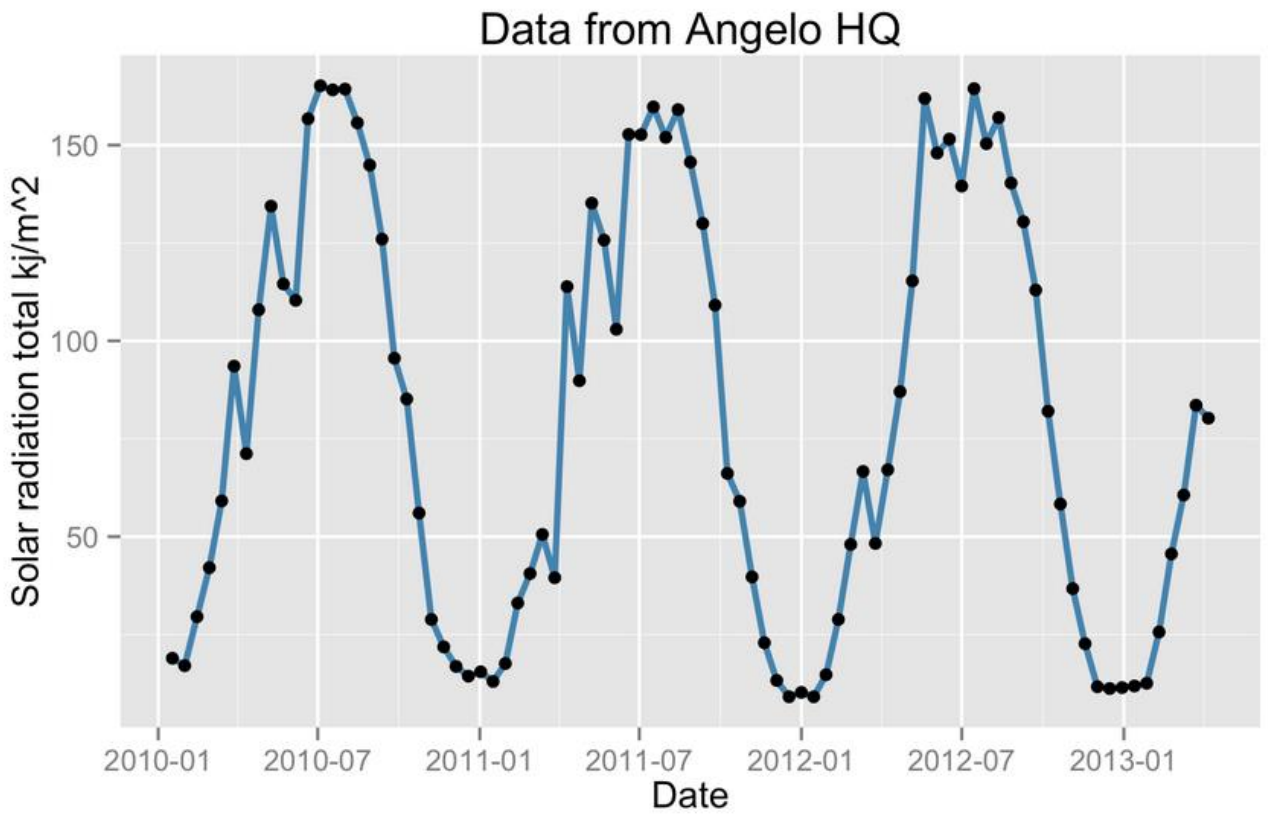
Ecoengine package

```
library(ggplot2)
ggplot(sensor_df$data, aes(begin_date, mean)) +
geom_line(size = 1, color = "steelblue") + geom_point() +
theme_gray() + ylab("Solar radiation total kj/m^2") +
xlab("Date") + ggtitle("Data from Angelo HQ")
```



ROpenSci Ecoengine package

shinyapps.io Powered by RStudio

Taxa over time

Number of records in the Berkeley Ecoinformatics Engine for six major taxa in California from 1900-present

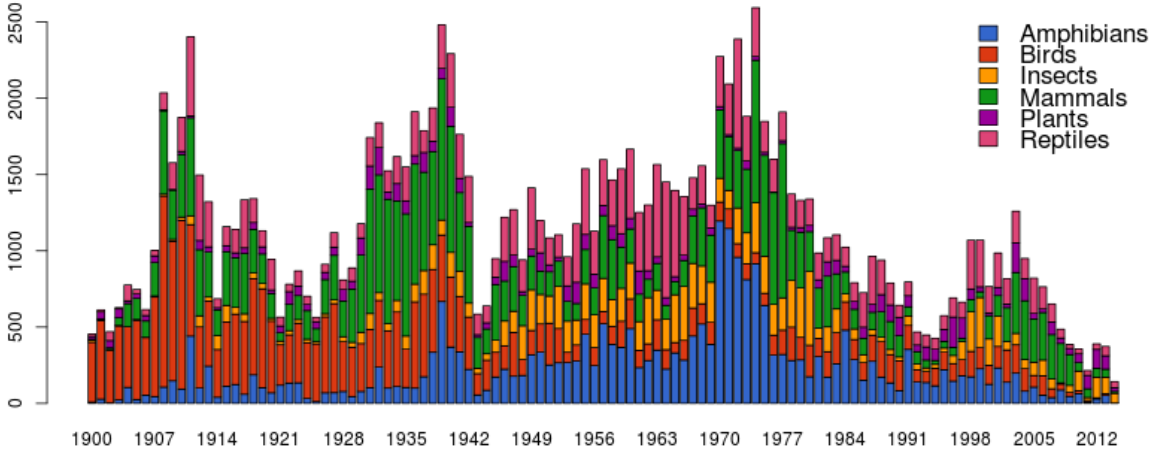
Taxon to show:

- [x] Amphibians
- [x] Birds
- [x] Insects
- [x] Mammals
- [x] Plants
- [x] Reptiles

Year range:

1,900 — 2,015

1,900 1,912 1,924 1,936 1,948 1,960 1,972 1,984 1,996 2,008 2,015



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Bioinformatics Collaboratory

- Building and leveraging **technological advances**
- Developing and implementing **universal data standards**
- Forging technical, ***social*** **and** ***cultural*** **bridges**

GIF workshop participants complete a GIS exercise

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API makes it straightforward to

Holos Online Portal

Access to the Data Engine, via the Explore Tool, with its own charting and visualization tools.

Use the Compare Tool to build your maps and share with collaborators.

Advanced users may build their own applications

The Data API lets R users access data in the Engine from the R console.

Data API & Library

Developer Tools

R Statistics Tools

Ecoengine

Data Engine

Data Assets

Events

Specimen

Observed

Sensor

Baselayers

Thematic

Continuous

Vector

Specimen records are harvested from UC Museums, herbaria, soil collections Natural Reserve System checklists, sensor databases and Calphotos.

Specimens records are harvested via GBIF's IPT, the Integrated Publishers Toolkit, facilitating DarwinCore Standards.

GIS data layers are from both the customized Baselayer database as well as from external web services.

Ecoengine

- Allows for unprecedented integration of data and expertise necessary to address the **challenge of identifying the interactions and feedbacks between different species and their environment**.
- Key features include
  - easy and **rapid access to vast amounts of disparate data**,
  - ability to perform rapid exploratory analyses and tests for correlations
  - ability to visualize & communicate results to a broad community of users.
- Promotes the type of multi-disciplinary building that will lead to breakthroughs in our understanding of the **biotic input and response to global change**.
- Serves to **unite previously disconnected perspectives** from paleo-ecologists, population biologists, and ecologists
- Makes possible the testing of **predictive models of global change**, a critical advance in making the science more rigorous

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